The Global LPG Partnership

KfW

The European Union

Clean Cooking for Africa Program

Rwanda National LPG Master Plan, Feasibilty, and Investment Report

Prepared by the Global LPG Partnership

June 2021

LPG cylinders queued for home delivery

Photo credit: Tash Perros / MESHPower

,

Citation

GLPGP (2020). Rwanda National LPG Master Plan. New York: The Global LPG Partnership.

Disclaimer

The findings and recommendations in this document reflect the available data and the inputs and views provided by cooperating stakeholders, which may not be comprehensive, may contain errors, and may reflect unstated biases. Where possible, the weight given to the information provided took into account applicable and verified benchmarks, norms and industry and market data from other East African and Sub-Saharan African countries.

The recommendations herein do not necessarily reflect the current policy positions of the Government of Rwanda, except as explicitly stated.

The purpose of this document is to serve as the national master plan for LPG scale-up in Rwanda. The final document was delivered to the Government of Rwanda (GoR) in June 2021 and was subsequently validated by GoR's designated stakeholders. As of Q4 2021, it is pending formal GoR approval as the national LPG Master Plan. Certain of its recommendations have nonetheless begun to be implemented. Prior to formal GoR approval, readers should utilize this document solely as a reference report, not as an official plan of the GoR. The title of this edition adds the phrase "Feasibility and Invesment Report" to reflect that status.

Contents

Each Volume contains its own detailed table of contents and lists of tables and figures.

Acknowledgements

This Master Plan, Feasibility and Investment Report was developed by a team comprising international and local experts of the Global LPG Partnership and collaborating partners including the **Rwanda Ministry of Infrastructure (MININFRA)**. **Rwanda Utilities Regulatory Authority (RURA)**, the Energy Air Pollution and Health research group at the **Universtiy of Liverpool**, UK (demand and impact analysis) and concultancy **IHS Markit** (supply security and supply-demand balance analysis), all of whose contributions were invaluable.

The two organizations whose financial cooperation and related support made this Plan possible are the **European Union** through its **Infrastructure Trust Fund**, and the German development bank **KfW**, which has acted as the primary financial underwriter and funds administrator for the Clean Cooking for Africa Program.

Important cooperation and information were gratefully obtained from Rwandan stakeholders including **Energy Development Corporation Ltd, Rwanda Energy Group, Rwanda Revenue Authority, Rwanda Standards Board,** the **Development Bank of Rwanda, Rwanda Correction Services**, and other Rwandan state agencies and public sector and private sector organizations as referenced throughout this Master Plan document.

Innumerable other organizations and individuals inside and outside Rwanda also contributed to this Plan, regrettably too many to list individually here.

Thanks and gratitude are given to all who contributed knowledge, data, scrutiny, criticism, suggestions, resources and efforts from desks and in the field. Wherever applicable, these contributions are cited throughout this document.

Glossary and Abbreviations

AD	Anaerobic digestion
AfDB	African Development Bank
AGOL	Africa Gas and Oil Ltd
ASSIMPER	Association for Petroleum Products Importers
BAU	Business-as-usual A demand scenario under this Master Plan
BC	Black Carbon
BCRM	Branded Cylinder Recirculation Model Best-practice model for the structuring and regulation of LPG markets for growth, safety and bankability[1]
Blended capital	A combination of concessional debt with non-concessional debt and/or equity
BioLPG	LPG produced from renewable sources (as biopropane and/or biobutane)
BPS	Bulk procurement system (used in Tanzania to procure petroleum products)
BRD	Development Bank of Rwanda
BTWG	Biomass Technical Working Group
CCA	Clean Cooking Alliance (formerly, the Global Alliance for Clean Cookstoves)
CCAP	Clean Cooking for Africa Program
CCCM	Consumer-Controlled Cylinder Model
CCF	Clean Cooking Fund (a World Bank results-based financing facility)
CDC	Centers for Disease Control (USA) or Centre for Diseases Control (UK)
CDM	Clean Development Mechanism
CFET	National Survey: Cooking Fuel Energy and Technologies in Households, Commercial and Public Institutions in Rwanda
CNG	Compressed natural gas
CO	Carbon monoxide
CO_2	Carbon dioxide
Concessional debt	Debt at a below-market rate of interest
CP	Contract Price (see Saudi CP)
CRM	See BCRM
DALYs	Disability-adjusted life years
DEG	Deutsche Investitions- und Entwicklungsgesellschaft
DHS	Demographic and Health Survey

1 See www.wlpga.org/wp-content/uploads/2015/09/wlpga-guidelines-for-the-development-of-sustainable-lp-gas-markets.pdf

DFI	Development finance institution
EA	East Africa
EAC	East African Community
EDCL	Energy Development Corporation Ltd
EICV	Integrated Household Living Conditions Survey
EPD	Energy Private Developers A professional association of Rwanda energy sector companies
ESWG	Energy Sector Working Group
EU	European Union
EUCL	Energy Utility Corporation Ltd
EU-ITF	European Union Infrastructure Trust Fund Primary source of financial cooperation funds supporting the Clean Cooking for Africa Program
EWURA	Energy, Water Utilities Regulatory Authority (Tanzania)
FONERWA	Rwanda Green Fund
FMO	Nederlandse Financierings-Maatschappij voor Ontwikkelingslanden Dutch development bank
FNGO	Financial Non-Governmental Organization
FNRB	Fraction of Non-renewable Biomass
GACC	See CCA
GBD	Global Burden of Disease
GHG	Greenhouse gases
GLPGP	The Global LPG Partnership The Project Execution Agency for the Clean Cooking for Africa Program
GoR	Government of Rwanda
GS	Gold Standard
GWP	Global warming potential
HAP	Household air pollution
HH	Households
IAQG	Indoor Air Quality Guidelines (defined by the World Health Organization)
IFC	International Finance Corporation
IFI	International Financial Institution
Institutional capital	Pension funds, sovereign wealth funds, foundations, large family offices, DFIs, IFIs, MDBs, banks and proprietary capital
ISLE	Indicators of Sustainable LPG Expansion (a GLPGP-developed M&E framework)
ISS	Integrated strategic storage

KfW	KfW Development Bank Administrator of the EU-ITF financial cooperation funds supporting the Clean Cooking for Africa Program
kge or kgeq	Kilogram-equivalent A measure used in expressing weighted-average cylinder sizes
KPA	Kenya Ports Authority
KOJ 1	Kurasini Oil Jetty 1
KOJ 2	Kurasini Oil Jetty 2
KT	Kilotonnes
LMICs	Low and Middle Income Countries
LMC or LPGMC	LPG Marketing Company
LPG	Liquefied Petroleum Gas LPG is comprised of propane (C_3H_8), butane (C_4H_{10}), or a blend of both. LPG combusts to give heat with near-zero emissions. LPG is a gas when unpressurized and becomes a liquid under modest pressure across a wide range of temperatures. LPG is created as a by-product of oil and gas production and oil refining, and from renewable sources (called bioLPG)
LPGMC	See LMC
M&E	Monitoring and Evaluation
MDB	Multilateral Development Bank
MICS	Multiple Indicator Cluster Surveys
MFI	Microfinance Institution
MJd	Megajoules delivered to a cooking pot
MIGEPROF	Ministry of Gender and Family Promotion
MINALOC	Ministry of Local Government
MINECOFIN	Ministry of Finance and Economic Planning
MININFRA	Ministry of Infrastructure
MOE	Ministry of Environment
MOH	Ministry of Health
MT	Metric tonnes
NAMA	Nationally Appropriate Mitigation Action Climate change mitigation measures proposed by developing country governments to reduce emissions below 2020 business-as-usual levels and to contribute to domestic sustainable development, as called for in the Bali Action Plan of the UN Climate Change Conference of the Parties
NCV	Net calorific value
NG	Natural gas Natural gas is comprised primarily of methane (CH_4) and may contain fractional quantities of other gases such as LPG

NGLs	Natural gas liquids Components of natural gas other than methane, which may be separated and handled distinctly from natural gas. LPG is a type of NGL
N_2O	Nitrous oxide
NISR	National Institute of Statistics of Rwanda
NISS	Non-integrated strategic storage
NSS	National strategic storage
NST-1	Rwanda National Strategy for Transformation 2017-2024
Non-concessional debt	Debt at a market rate of interest
OC	Organic carbon
OMC	Oil Marketing Company
OPIC	U.S. Overseas Private Investment Corporation; see also US DFC
OTS	Open Tender System
PAYG	Pay-as-you-go
PDC	Private and development capital
$PM_{2.5}$	Particulate matter of a diameter of up to 2.5 micrometers
PRG	Partial risk guarantee
PSS	Private sector strategic storage
Quasi-equity	Convertible debt, convertible securities, revenue shares, warrants
RBF	Results-based financing
RDB	Rwanda Development Board
RDF	Rwanda Defence Force
REF	Rwanda Energy Fund
REG	Rwanda Energy Group
REMA	Rwanda Environment Management Authority
RFA	Rwanda Forestry Authority
RICA	Rwanda Inspectorate, Competition, and Consumer Protection Authority
RNP	Rwanda National Police
ROT	Republic of Tanzania
RRA	Rwanda Revenue Authority
RSB	Rwanda Standards Board
RURA	Rwanda Utilities Regulatory Authority
RwF	Rwanda Franc

Filled LPG cylinders on display at a retailer

Photo credit: GLPGP

LPG Master Plan Impact Potential

NST-1 Biomass Reduction Target	• 50% or more of the NST-1 Target by 2024 • 100% or more by 2029
Trees Saved	• Up to 354 million trees saved through 2030
Lives Saved	• Up to 7,700 lives saved by 2030
Climate Protection	• Up to 40 million tonnes of CO_2eq averted through 2030
New LPG Users Created	• At least 2 million new users by 2024 • At least 6 million by 2030
Consumer Savings on Cooking Costs	• Over RWF 15,000/year per household by 2024
Industry Growth	• 900% or more by 2030
Financing to Be Mobilized	• US $94 million 2021-24 • US $103 million 2025-30

Rwanda National LPG Master Plan

Volume 1

National LPG Master Plan Overview

Contents

List of Tables

List of Figures

I. Executive Summary

Current situation

Rwanda's National Strategy for Transformation (NST-1) of 2017 set a target of reducing the number of Rwandans cooking with biomass from 83% of the population in 2017 to 42% by 2024 (Target). Key reasons are to reduce pressure on forests, achieve Sustainable Development Goal (SDG) 7 (universal access to clean, modern energy), and improve the health and lives of Rwanda's people.

The Government of Rwanda (GOR) selected Kigali, six secondary cities, and public institutions (e.g., schools) as priority targets for accelerated rollout of LPG. GOR appointed GLPGP, supported by EU funding administered by German development bank KfW, to collaborate in developing a National LPG Master Plan (Plan) to accomplish the roll-out.

LPG was used for cooking by 6% of Rwanda's national population (residential and institutional) in 2020 (CFET, 2020) at a usage level of 2.4 kg per inhabitant, a tenfold increase over the 2015 level. By comparison, several West African countries have achieved 15 kg/capita and above. To achieve the Target, Rwanda's LPG use must increase to approximately 40% of the population and 14 kg per inhabitant. The residential sector consumed 73% of 2020 LPG volume. This share is projected to grow to at least 80% by 2030. Switching households to LPG is thus central to the Plan, supplemented by institutional and industrial switching.

Action options

The Plan examines three action options to accelerate LPG market development faster than existing demographic, market and industry trends would achieve. The Plan and its analyses assume commencement of implementation of the chosen option by the end of Q2 2021. The speed and scale of LPG uptake will depend on GOR's choice of which action option to follow.

- A "low intervention" option, potentially accomplishing 45% of the Target in 2024, requires GOR to put in place new policies to improve access to LPG, to implement fully and enforce the Branded Cylinder Recirculation Model (BCRM, the global best practice for LPG market structuring, bankability and safety) in law and regulation, to direct public institutions to transition to LPG use from firewood and charcoal, to mobilize industry and the financial sector to expand LPG cylinder inventories and distribution networks, and to promote LPG switching nationally.
- A "high intervention" option, potentially achieving 50% of the Target in 2024, requires GOR to implement all elements of the "low intervention" option plus demand stimulation measures, including creation of consumer LPG equipment financing and subsidy schemes.
- An "NST-1 Target" option, which might be able to achieve the Target in 2024, requires GOR implementation of all "high intervention" elements, plus requiring urban residential and institutional users to switch to LPG and prohibiting biomass supply and use for cooking in these markets.

<u>The "high intervention" set of policies and actions is recommended, to achieve a projected 50% of the Target with LPG by 2024 and 100% of the Target with LPG by 2029</u>.

This will require major investment and timely action by the private sector supported by financing and substantial GOR interventions. GOR must

1. Implement necessary policy and regulatory changes;
2. Mobilize adequate investment in and financing for private sector infrastructure and distribution expansion, cylinder inventory, national strategic LPG storage, technical assistance, and demand stimulation measures; and

3. Educate and support consumers to switch to LPG.

The estimated financing need for 2021-2024 under this option is USD 94 million, to expand LPG use by an additional 2 million persons and serve in total 20% of the Rwandan population by 2024, up from today's 6%. Further financing of USD 103 million from 2025 to 2030 would expand LPG use by an additional 4.4 million, reaching the Target by 2029 and serving in total 45% of the Rwandan population projected in 2030.

Key aspects of the Plan

1. Import supply of LPG via Tanzania and Kenya under normal political and economic conditions is expected to be secure, sufficient and within reasonable price ranges to at least 2030, under all demand scenarios.
2. MINICOM policy requires national strategic LPG fuel reserves equal to 90 days of consumption. A reserve of 90 days can be achieved efficiently by counting toward the reserve requirement 50% of the LPG inventory held in the commercial supply chain (in cylinders, filling plants and truck fleets, equal to approximately 58 days of projected consumption), with the remainder provided by GOR-held strategic reserves.
3. All scenarios require Rwanda's complete and effective practice of BCRM. Essential to BCRM are (i) the swap of filled cylinders for users' empty ones, which are recirculated to the responsible filling plant for safety checks, refill, and return to the distribution network; and (ii) definition of Marketers as the central players, exclusively responsible for investing in branded cylinders, importing LPG, developing distribution and sales networks, and safely refilling and adequately maintaining their cylinders. Implementation and enforcement of BCRM are keys to achievement of LPG sector safety, growth, and financeability.
4. GOR needs to define, publish, implement and enforce an enabling environment for the LPG supply chain, which determines how the Marketers and other actors will operate effectively and sets conditions needed for sector bankability. The enabling environment provides:
    i) BCRM distribution regulations that (a) allocate roles, rights, obligations and sanctions for licensing Marketers, intermediate Distributors, and last mile and home delivery Retailers, and (b) have effective enforcement mechanisms;
    ii) Enhanced LPG safety requirements, including the specifications, standards, norms and rules to be used for the construction, certification, repair and maintenance, filling, transport, and handling of all LPG in cylinders and in bulk; and
    iii) Competitive and predictable consumer pricing and industry margins.

    Financial modeling indicates acceptable rates of return if recommended policies are enacted and enforced.
5. Efforts to attract public sector concessional capital to blend in with private sector capital should be explored as soon as possible upon approval of the Plan. This should include seeking funding for technical assistance programmes, for a Rwanda LPG Financing Mechanism (RLM) (an LPG-focused non-bank financing vehicle to mediate capital and grants for private sector investments), and for consumer demand support measures.
6. There is potential in Kigali and perhaps other cities to produce renewable LPG (bioLPG) from the biogas emitted by properly handled municipal solid waste. Such bioLPG would be green, not require use of US dollars for importing LPG, and likely cost less than imported LPG. It also would provide additional supply security, because it would be produced within Rwanda.

Achievement of all or a major part of the Target with LPG, based on the option GOR chooses, would produce substantial, positive, measurable progress toward achievement of multiple SDGs regarding climate change mitigation, preservation of scarce forest resources, reduction in harmful air pollution, and Nationally Determined Contributions.

II. Overview of the LPG Market

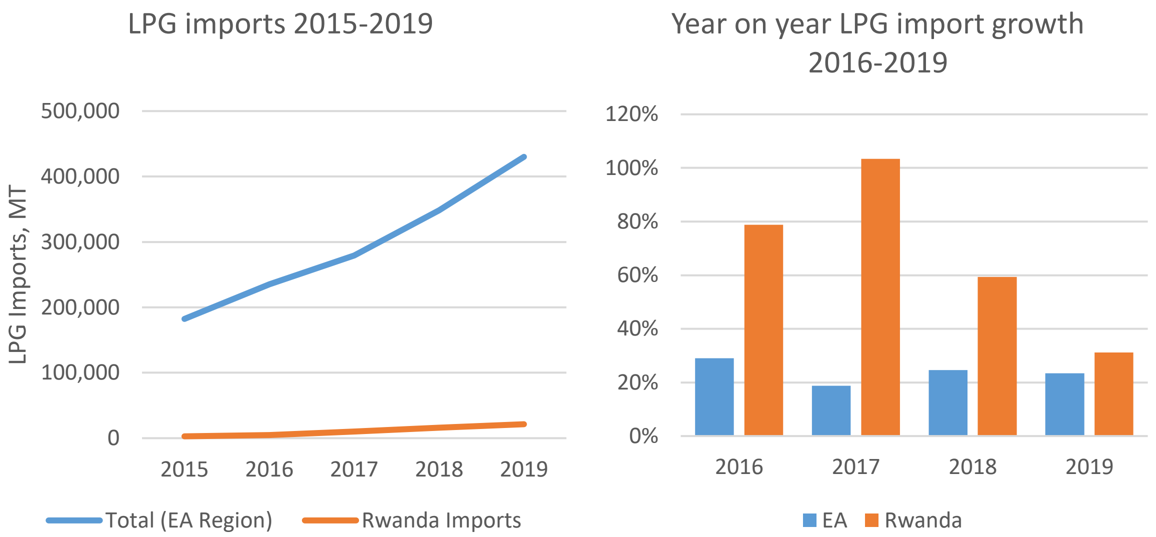
1. Market Development 2015-2020

Regional market context

For the foreseeable future, East African LPG demand will dominate over Rwandan LPG demand in determining regional market conditions.

The entire East Africa region has experienced steady growth in LPG usage, with a combined imported volume for the last five years depicted in Figure 1 and Table 1:

Figure 1. LPG imports and growth rates in Rwanda and East Africa, 2015-2019



For Rwanda, starting from a much smaller base, the growth rate has consistently exceeded the regional growth rate.

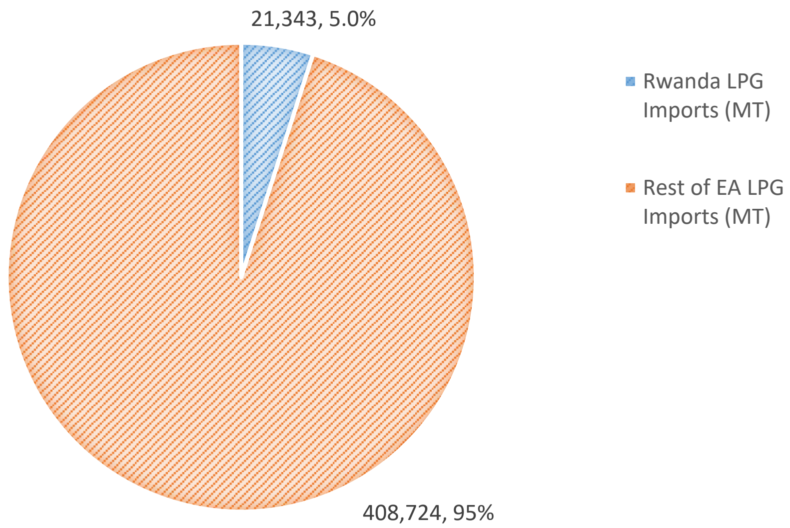
Table 1. Estimated LPG consumption in East Africa, 2015-2019
in MT

Year	Tanzania imports	Tanzania exports to Kenya	Kenya imports	Total (EA region)
2015	70,063	17,165	129,396	182,293
2016	90,296	22,123	167,057	235,230
2017	107,263	26,279	198,482	279,465
2018	142,939	35,020	240,484	348,403
2019	166,435	40,777	304,408	430,066

Source: Governments of Tanzania and Kenya

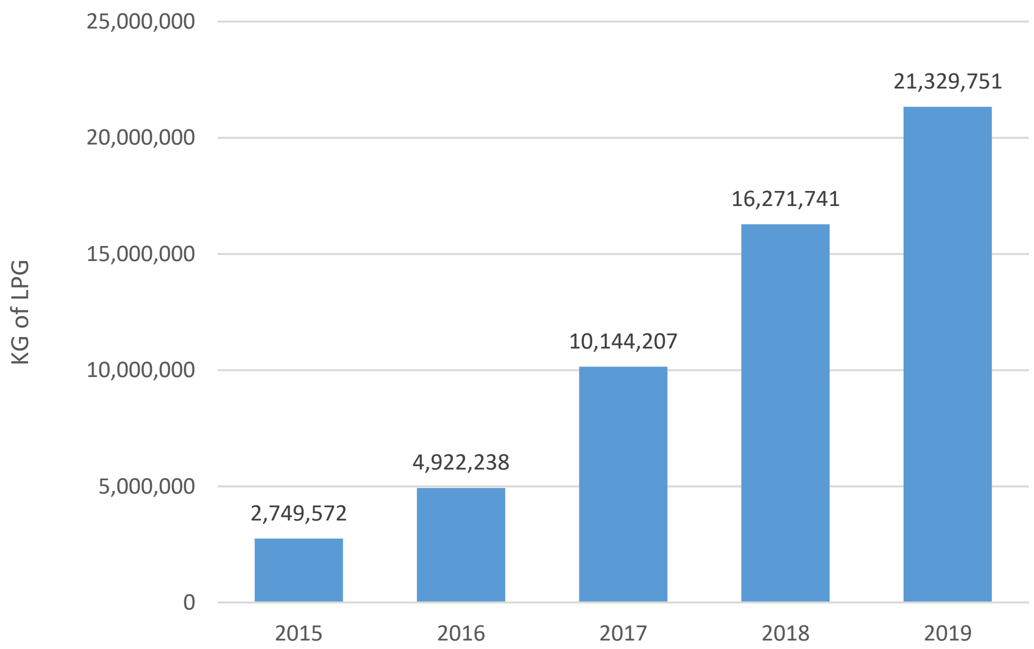
Figure 2 shows the share of Rwanda's LPG use compared to the East Africa region.

Figure 2. Rwanda share of EA LPG imports (2019)



Rwanda LPG consumption has grown rapidly in recent years, as shown in the following figure:

Figure 3. Rwanda LPG consumption 2015-2019



2020 consumption is estimated to be approximately 27,000 MT.

As of 2020, 5.6% of Rwanda's households used LPG for some or all of their cooking (CFET 2020), up from about 2.4% in 2016 (MTF, 2018). This LPG use largely displaces the use of biomass. Of the 5.6%, 2.1% used LPG exclusively, and the remainder used LPG at the primary fuel and other fuels such as biomass as a secondary fuel (CFET, 2020). The market for LPG is concentrated in Kigali so far.

2. Market Segments

The main market segments in Rwanda are

1. Households
    - Geographic segmentation: Kigali, other urban areas, rural areas
    - Socio-economic status (SES) segmentation
2. Public non-commercial institutions
    - Examples: schools, police/prisons, health facilities, refugee camps
3. Commercial and industrial
    - Commercial examples: Hotels and restaurants
    - Industrial examples: Africa Improved Foods, an agribusiness; tea and brick producers

Figure 4. Market segment shares by volume, 2020

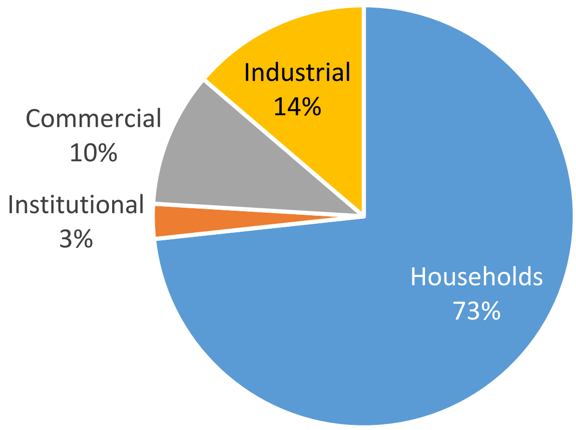


Figure 4 shows the current market breakdown by volume.

The household segment is projected to increase its share of the market to at least 80% by 2030. Based on the CFET survey responses, an estimated 19,200 MT of LPG was consumed in households in Rwanda in 2020[2].

Details on each segment are provided in Volume 2, Part XII, Chapter 26.

Key drivers of demand

National survey data and the relevant literature highlight several drivers of demand, including:

- **Ease of access.** The closer an LPG retail point to the consumer, the more the consumer is likely to adopt and use LPG. This is the strongest driver in evidence in the available Rwanda data. The effect is especially profound when cylinders are provided via home delivery.
- **Availability of fuel.** A history of shortages discourages the decision to adopt and rely upon LPG for cooking.
- **Demographic factors.** Socio-economic status, urbanization, and the age, gender and educational level of the head of household correlate with LPG uptake.

[2] The estimate of current household LPG demand (adoption percentage and fuel volume consumed) is based on a sample of about 5,000 households, with possible error or bias associated with self-reporting of the data.

- **Residency.** In Kigali, up to 85% of households living in high-rise buildings report LPG as a primary cooking energy source, per a 2015 survey. Charcoal use is higher among those living in dwellings with access to an open space. This driver is related to urbanization.
- **Up-front equipment costs.** The available data do not quantify this factor; however, global experience shows that mechanisms that reduce the up-front cost of becoming an LPG user can accelerate LPG adoption, especially when combined with education and sensitization efforts.
- **Cost of cooking.** Within the narrow pricing band in the national survey data, a very minor, but positive, relationship between LPG price and LPG adoption and use was evidenced. The data were too limited to allow quantification of how a significant change in the cost of cooking with LPG compared to other fuels would affect LPG adoption and use.
- **Appropriateness to cooking needs.** Factors such as the taste of cooked food, the ability to cook long-duration foods effectively, and the ability to use large-sized pots (e.g., to cook for extended families) are all determinants of sustained use of a fuel as well as fuel stacking behaviour. Data from the HAPIN randomised controlled trial (RCT) of LPG stove and fuel distribution and use for household cooking demonstrated that participant households in Rwanda (n=400) with access to unlimited LPG refills chose to meet 100% of their cooking requirements with LPG[3], indicating that some of the other possible barriers mentioned above, such as demography, residency and food taste, disappear from users' decision-making as LPG becomes more and more affordable.

Of these demand drivers, ease of access was by far the most strongly correlated with LPG adoption by households in the national survey data.

Key drivers of LPG sector growth

Various initiatives have contributed, and/or are expected to contribute, to the growth of the LPG market, including:

- Implementing and enforcing fully the BCRM in regulation to world standards;
- Ongoing home delivery initiatives by LPG retail outlets and LPG marketers;
- VAT exemptions / zero ratings of LPG and gas cylinders and accessories;
- GoR's plan to ban the use and supply of charcoal in Kigali City, which signals to the public and the industry to focus on LPG as the leading alternative cooking energy in future;

---

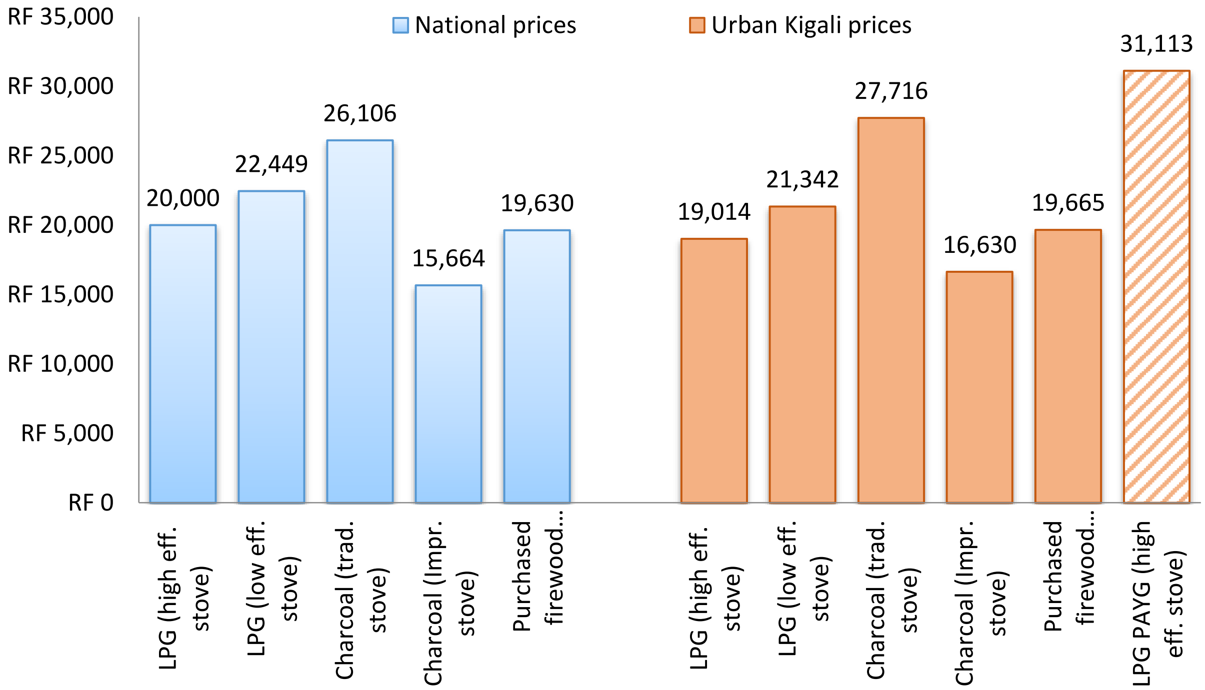
[3] Clasen et al., 2020. In addition to free LPG supply, the study also examined the costs and effects of extensive consumer education for participant households on how to cook traditional staple foods using LPG, These households also received a grill in order to ensure LPG could be used to meet all of their cooking needs. In combination, these elements made it possible for households to discontinue their use of biomass stoves for the full 18 months of the study.

- Announced potential funding from sources like the recently announced World Bank-funded Rwanda Energy Access and Quality Improvement Project (EAQIP) that could reduce the cost of consumer and/or industry investment in LPG equipment;
- GoR policy to establish strategic storage reserves by 2024 to mitigate any potential supply shocks caused, for example, by global or regional crises;
- The existence of this LPG Master Plan, to guide LPG companies, GoR, and investors and donors on the effective, safe and sustainable scale-up of LPG cylinders, infrastructure, distribution, and consumer adoption and use of LPG; and
- Access to capital (in particular, blended capital) for key LPG projects, business expansions, technical assistance, and consumer demand support, consistent with this Master Plan, on workable terms.

LPG affordability

The cost of daily cooking with different fuels/stove combinations for LPG, charcoal and firewood has been estimated using the average fuel prices for 2019-2020 (pre-Covid-19 pandemic). The use of this time period eliminates possible temporary distortions in the data caused by temporary Covid-19-related policies and/or supplier and consumer behavior changes. The following table presents the findings:

Figure 5. Monthly household price of cooking with LPG and other fuels/stoves (RwF)



Details regarding this comparison are provided in Volume 2, Chapter 21; see in particular Table 14 and Table 15.

Pay-as-you-go LPG

The effect of the relatively new pay-as-you-go (PAYG) business model, already successful in off grid electrification, has an unknown future with regard to LPG. Various new PAYG LPG companies have attracted some thousands of household customers in urban East Africa.

PAYG LPG's advantages and disadvantages from a consumer pricing perspective and an investment perspective are discussed in detail later in document. If PAYG LPG succeeds in Rwanda, it could be expected to help increase the portion of lower-income urban households that adopt and use LPG for a part of their cooking.

In the PAYG model (discussed in detail later in this document), the LPG Marketer (in the BCRM sense: a cylinder investor, LPG acquirer, and distribution network builder) installs a communicating smart-valve on the cylinder which allows the consumer to pay for and use small increments of LPG when and as needed. PAYG operates on a direct home-delivery distribution model.

No PAYG LPG company was reported to be active in Rwanda as of this writing. However, one company, BBOXX, an off grid electricity PAYG company active in Rwanda, piloted PAYG LPG in Kigali earlier in 2020. Information presented later in this document about PAYG LPG draws on the BBOXX experience in Rwanda and on the experience of currently active PAYG LPG firms in Kenya, which is the birthplace of African PAYG LPG, and in Tanzania. MeshPower Ltd, a competitor of BBOXX focused on the Rwanda market, has announced plans to pilot a PAYG LPG programme under the SHEAR research project of Colorado State University[4].

---

[4] MeshPower have not made mention of PAYG LPG plans on their own website, but this has been disclosed by the MeshPower CEO via this link: Richard Mori (www.invest-in-africa.co/contact-detail/richard-mori-0034J00000G8uyTQAR)

3. Market Structure and Trends

LPG companies in Rwanda are licensed to perform one or more roles in the supply chain. (It should be noted that this approach is not BCRM-compliant.) Accordingly, there are companies which invest in and own branded cylinders, import LPG, and own and operate filling plants; these are companies that own branded cylinders and do not operating filling plants, and there are companies that import LPG but have no cylinder or filling assets and perform no distribution function.

This diffusion of allowed responsibilities has safety and bankability implications which are discussed in depth in Volume 3.

The following table lists the companies and the supply chain positions they have taken. (The firms were not willing to disclose market share information for attribution.) Certain companies are affiliates of one another. For example, Safe Gas and Standard Gas are affiliates, with one acting as importer and the other as cylinder marketer. One Gas is an arm of AGOL, the dominant LPG importer in Mombasa.

Table 2. Licensed LPG companies and market roles

Company name	LPG cylinder brand owner	LPG filling plant ownership	Bulk LPG importer
Abbarci Petroleum Marketing Co. Ltd	Yes	Yes	Yes
BG Best Gas Ltd	Yes	No	No
Hashi Energy ('R) Ltd	Yes	Yes	Yes
Kigali Gas Traders Ltd	Yes	No	No
Kobil Petroleum Rwanda SARL	Yes	Yes	Yes
KV Group Gas Ltd	Yes	No	No
La Japanoise	Yes	No	No
Lake Petroleum Rwanda Ltd	Yes	Yes	Yes
Merez Petroleum Ltd	Yes	Yes	Yes
Metro Gas Ltd	Yes	No	No
Mogas Rwanda Ltd	Yes	No	No
Mount Meru Gas Rwanda Ltd	Yes	Yes	Yes
Noah Gas Ltd	Yes	No	No
One Gas Ltd	No	No	Yes
Oryx Oil Musosi Ltd	No	No	Yes
Roger Supply Ltd	Yes	No	No
Rwanda Oxygene	Yes	Yes	Yes
Safe Gas Rwanda Ltd	No	No	Yes
Societe Petroliere Ltd	Yes	Yes	Yes
Standard Gas Ltd	Yes	Yes	No
Sulfo Rwanda Industries Ltd	Yes	Yes	Yes
Yes Gas Ltd	Yes	No	No

Brand owners

18 marketers have their own cylinder brands. Of these, eight had no filling plants and relied on others for filling under outsourcing/hospitality agreements. (This is common in the early stages of market

development, and in countries where the filling and storage function has been organized as a common-user utility function.) Nine of the 18 have both filling plants and act as importers.

Filling plant operators

These are marketers who operate LPG cylinder filling plants. As stated above, nine of these also own LPG cylinder brands, and only one did not have any brand yet. It is expected that the single licenced operator without a brand will introduce its own brand once the plant, under construction at the time of writing this report, is ready.

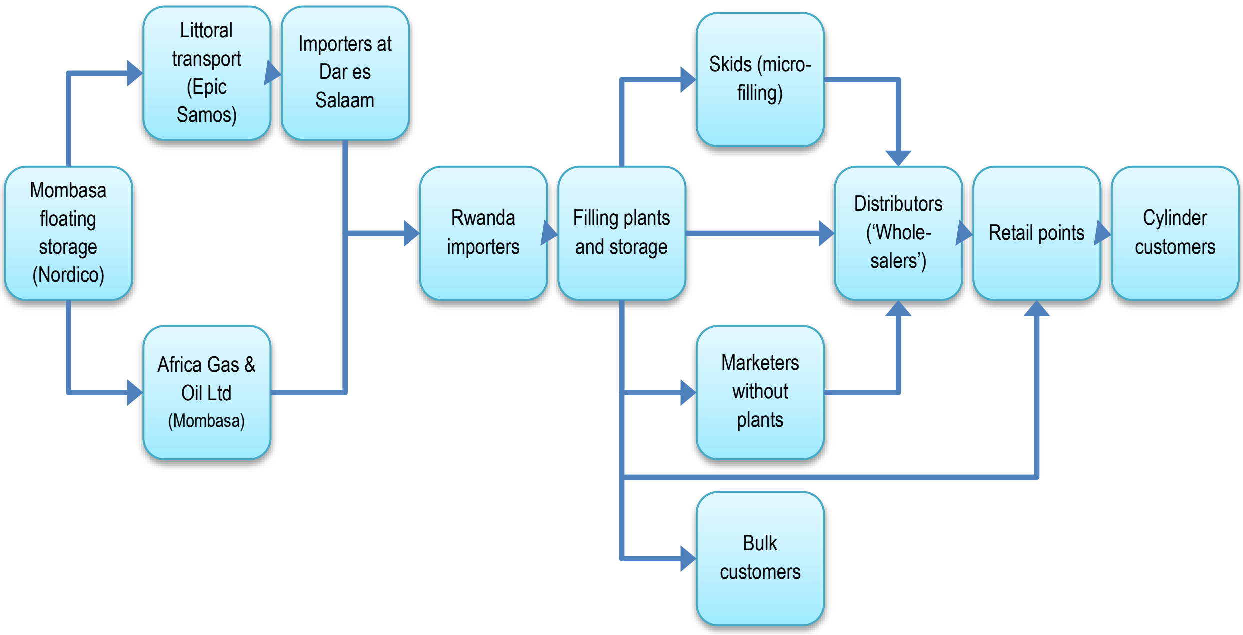
Importers

There are twelve LPG marketers licenced to import LPG into Rwanda. Nine of these are LPG cylinder brand owners and also own LPG filling plants. There are three licenced importers who do not play any other role in the value chain.

The LPG value chain

The value chain takes this overall form:

Figure 6. Current Rwanda LPG value chain diagram



Retail points are where households become new LPG customers and, afterward, where they exchange their empty cylinder for a filled cylinder (properly, of the same brand).

The active distribution models in Rwanda as of this writing are:

1. Distribution through the company's retail petrol stations. The petrol stations may be company-owned or franchised to independent operators. Cylinder distribution is primarily done via independent logistics companies ("Wholesalers" above), who pay a wholesale price to the marketer and who are paid a marked-up wholesale price by the retailer. This mode of distribution will tend to grow with, and at the rate of, the expansion of the automotive sector.

2. Distribution through independent multi-product retailers. For example, food and dry goods shops. Cylinder distribution is primarily done via the Wholesalers.

3. Direct distribution to independent retailers.

Increasingly, the larger marketers are disintermediating the Wholesalers in order to reduce costs and to increase their control over the cylinders as a defensive measure against cylinder piracy and cross-filling (in which case their cylinders cease to generate income, even while the brand owner remains liable for the cylinder’s safety).

Home delivery

An important force in Rwanda LPG distribution is home delivery, which has captured 27% of the market as of this writing. This is typically performed by independent motorbike operators and paid by the consumer. The effective distance to the retail point in home delivery becomes zero. The survey data indicate that, where it is present, home delivery significantly boosts LPG adoption and use.

Supply chain trends

In addition to supporting home delivery, leading marketers have started to develop in-house cylinder distribution capability to retail in order to reduce operating costs (treating distribution as a cost centre rather than a profit centre) and to increase control over their cylinders.

Additionally, certain marketers have begun disintermediating bulk transport from Kenya and Tanzania, also to reduce operating costs and maintain or improve control over the bulk LPG fuel.

As the market has grown, bad and unsafe industry practices have arisen among unscrupulous actors. These practices undermine public safety and the bankability and scalability of the sector. Most emerging LPG markets face these practices. Where they take root and expand, LPG safety inevitably declines, sector bankability falls, and the market stagnates and/or becomes ungovernable and dysfunctional. These are emerging in Rwanda as a result of certain aspects of the current regulatory environment and local entrepreneurial zeal. The practices noted in Rwanda include cylinder piracy, illegal cross-filling of cylinders (without safety and maintenance practices employed), and cylinder hoarding. These issues are discussed in detail and recommendations presented in Volume 3 from a regulatory perspective and Volume 5 from a business and financing perspective.

LPG importation

Rwanda imports its LPG from Kenya and Tanzania, which receive it by ocean from producing countries at coastal terminal and storage facilities. These import facilities are privately owned and operated. Each LPG company that imports LPG into Rwanda negotiates for supply prices with the importers in Kenya and/or Tanzania.

The imported LPG throughout East Africa is almost exclusively butane. (Commercial butane specifications provide for a limited presence of other natural gas liquids, such as propane and ethane, blended with the butane.)

This is important, because equipment specifications for propane are very different from those for butane. A propane-rated facility or cylinder equipment can safely handle butane or a propane-butane mix, but a butane-rated facility or cylinder equipment cannot safely handle LPG containing much propane.

A detailed discussion of the import routes and capacities and associated issues and trends is provided in Volume 2, Chapter 24.

Enabling environment

With rapid growth, adverse conditions have begun to arise for industry, which the regulatory environment has unintentionally permitted to arise and/or has been unable to suppress. These conditions create market dysfunctions that, if allowed to take hold and expand, will undermine both LPG safety and LPG sector bankability. Chief among these are fragmentation, diffused / overlapping roles and licensing, excess power in the distribution node of the supply chain, mini-filling, cylinder piracy, and illegal cylinder cross-filling.

The key to addressing these conditions is implementation and effective enforcement of a stronger form of the BCRM and associated safety specifications. BCRM defines the enabling environment (and constraints) for the LPG market and LPG industry. In its strong form, it has delivered worldwide on high safety, consumption growth, and sector bankability. In its weak form, or if not followed, the opposite results. In Rwanda, BCRM is partially but not sufficiently defined. However, this can be readily improved upon, as outlined in this document.

Before any major programme of strategic investments is undertaken, successful Government action regarding the strengthening of the enabling environment is an essential prerequisite.

A detailed discussion of BCRM, existing Rwanda LPG regulations and standards, and recommendations therefor are presented in Volume 3.

4. Cylinder and Infrastructure Assets

Cylinders

416,000 cylinders have been imported into Rwanda in the last five years, with a sharp increase in 2019, coinciding with revision of Rwanda regulations relating to LPG cylinder ownership rights. Sizes of 12-13kg and 6kg have been the most desired by users.

Figure 7. Annual Rwanda cylinder imports 2015-2019

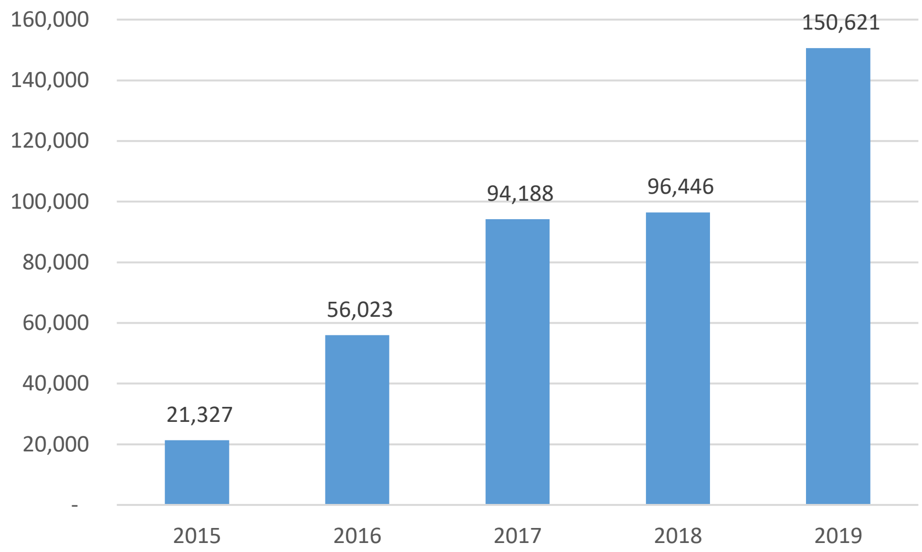
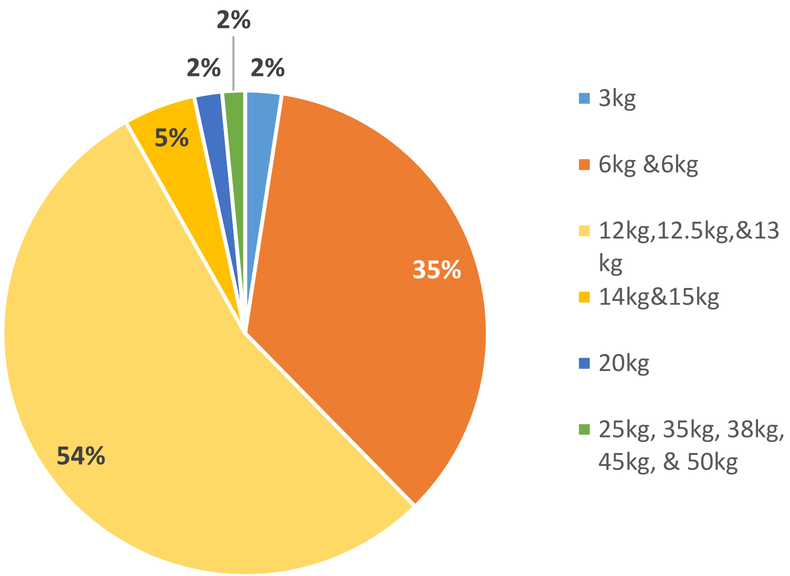


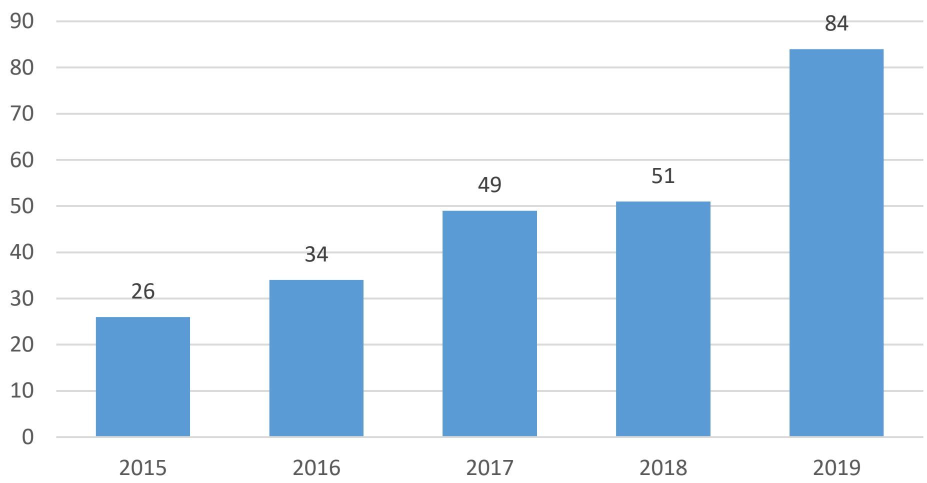
Figure 8. Cylinder import share by cylinder size 2015-2019



Bulk LPG tanks

Bulk tanks are imported both to support bottling (cylinder filling) and larger commercial, institutional and industrial users. The following chart shows the recent importation of LPG bulk tanks.

Figure 9. LPG bulk tank imports 2015-2019



Filling plants

Existing LPG filling plant locations and capacities

The following table shows the locations and storage capacities of Rwanda's LPG filling plants as of June 2020:

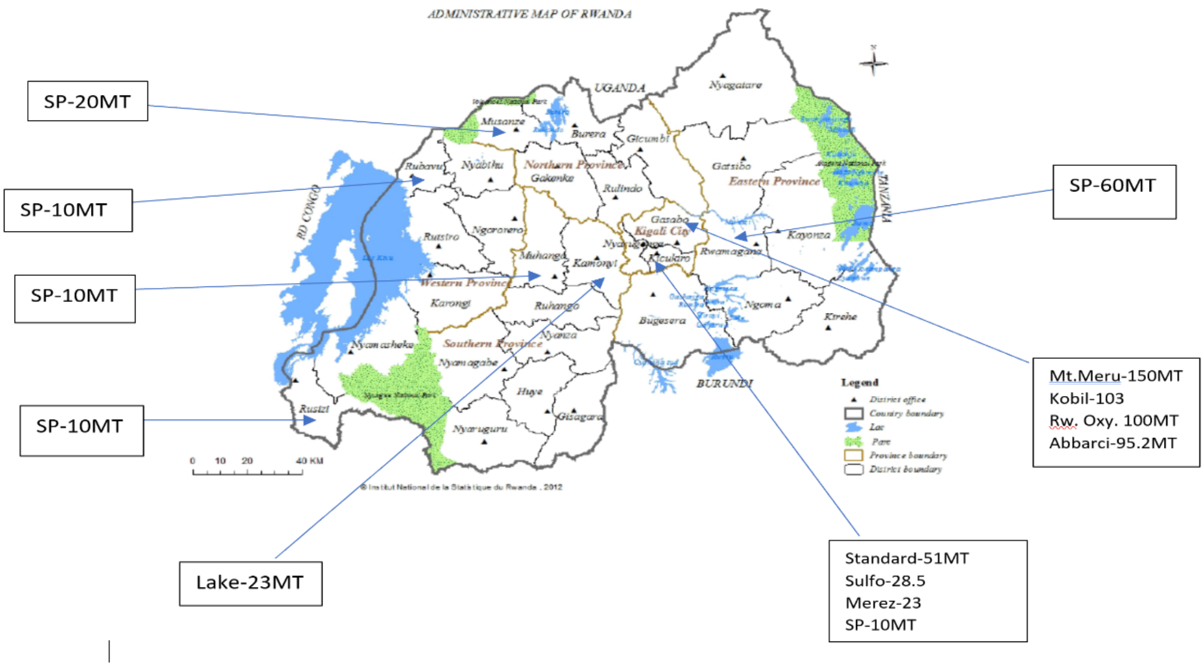
Table 3. Locations of LPG storage and filling plants, June 2020

District	LPG filling	Location	Capacity (MT)
Gasabo	Kobil Petroleum Rwanda	Gatsata	103
	Abbarci Petroleum Marketing Co.	Jabana	95.2
	Rwanda Oxygene	Ndera,-Mulindi	100
	Mount Meru Gas Rwanda	Kabuga II	150
Kicukiro	Sulfo Rwanda Industries	Gatenga -Magerwa	28.5
	Societe Petroliere	Giporoso	10
	Standard Gas	Kicukiro	51
	Merez Petroleum	Gahanga,	23
Kamonyi	Lake Petroleum Rwanda	Rugarika	23
Muhanga	Societe Petroliere	Nyamabuye	10
Rusizi	Societe Petroliere	Kamembe	10
Musanze	Societe Petroliere	Muhoza	20
Rwamagana	Societe Petroliere	Rwamagana -Town City	60
Rubavu	Societe Petroliere	Rubavu – Town City	10
Total			**693.7**

Source: RURA

The map below shows the dispersion (and concentration) of LPG storage and filling plants. 81% of the storage capacity is in Kigali. All but one of the filling plants outside Kigali are owned by a single marketer.

Figure 10. Map of existing filling plants



Available storage

RURA records indicate that LPG storage and its capacity utilization (as reflected in the rotation rate) have grown as follows:

Table 4. Bulk LPG storage and LPG imports, 2015-2019

Year	2015	2016	2017	2018	2019	2020E
Imported quantity (MT)	4,271	5,532	10,544	16,745	21,518	27,000
Available storage (MT)	144	183	298	383	487	693
Rotations/year	29.7	30.2	35.4	43.7	44.2	39.0
Rotations/month	2.47	2.52	2.95	3.64	3.68	3.25

Details on the national cylinder inventory, filling and storage infrastructure, and LPG transportation assets are presented in Volume 4.

5. LPG Cost Structure

The primary objectives of the price structure in any developing LPG market should be

- To prevent price abuses by the distribution system; and
- To balance fuel affordability for consumers with the financial returns required by investors.

Additional objectives can include whether prices vary by distance from LPG sources, or not, and whether the market will be a high-service or low-service market. High service, for example, could include home delivery—that is, in-home exchange of a filled LPG cylinder for an empty cylinder. High-service and low-service trade off possible modes of access and availability for the consumer (and stronger cylinder asset control for the supply chain participants) on the one hand against fuel affordability for the consumer on the other hand.

Ensuring sufficient unit margins also strengthens three key investment factors in LPG companies:

1. The sustainable growth rate (the maximum rate at which customers may be added without creating negative cashflow) of the company is higher;
2. The breakeven volume for a new company is lower, thus reducing the investment risk; and
3. The potential for generating required returns to investors and the capacity to service debt is increased.

Rwanda: Unregulated pricing model

Rwanda has unregulated LPG pricing[5], as shown in the table below.

Based on global LPG sector experience, there are six main choices of price system:

Table 5. Price structure modalities

LPG price system	Description	Example countries
Non-regulated	The market sets its own prices	**Rwanda**, Kenya, France, Italy, Germany
Regulated, fixed margins, International Parity Price (IPP)[6], no subsidy	The government regularly updates the price structure as the applicable International Parity Price changes (typically monthly)	India, Indonesia, much of Latin and South America, Belgium, Spain

5 An exception to this, in effect from May 2020, is a GoR-mandated end user price cap on LPG refills in Kigali, intended to prevent price-gauging during the Covid-19 crisis. As Saudi CP has begun to recover from its exceptional Covid-19 low, this cap has motivated LPG marketers to reengineer their activities within the supply chain in order to reduce their costs.

6 IPP is a regional index price adjusted for standard cost of transportation from the regional price hub

LPG price system	Description	Example countries
Regulated, fixed margins, actual sourced price, no subsidy	Maximum prices are revised regularly by each marketer as the international price is updated, according to the price formula (typically monthly)	Ghana, today
Regulated, fixed margins, common sourced price, no subsidy	The government regularly updates the price structure as the international price varies, per marketer	Kenya for petrol (not for LPG)
Regulated, fixed margins, fixed end-user price, IPP with variable subsidy	One permanent national end-user price remains in effect until the government chooses to revise the pricing formula	Morocco, Tunisia, Brazil, Argentina
Regulated, fixed margins, variable end-user price, fixed subsidy on IPP formula	The government regularly updates the price, which is discounted by a fixed subsidy amount, as the IPP changes	Dominican Republic (prior to removal of subsidy)

LPG pricing and margins in Rwanda are thus market-driven. Industry representatives indicate that 2-3 main marketers act as *de* facto price-setters for the market. LPG prices also rise with distance from Kigali, both to cover added transportation cost and to make up for lower population densities that, in turn, increase other operational costs. There is no dominant near-monopolist, but per RURA reporting, the AGOL affiliate One Gas exerted significant influence on the supply chain in 2020.

For purposes of analyses, it is assumed that the pricing structure in Rwanda will remain as it presently is. However, the effect of decreased prices from potential interventions is discussed in Volume 2.

A move to semi-regulated pricing, in which end-user prices and the margins at each supply chain node are capped and distance is adjusted for, would in principle (i) reduce or eliminate pricing excesses where they exist, (ii) allow pricing to be equalized nationally, by cross-subsidizing distance-based transportation costs, and (iii) provide increased stability of margins for LPG companies, for investment and bankability purposes[7].

Current LPG price build-up

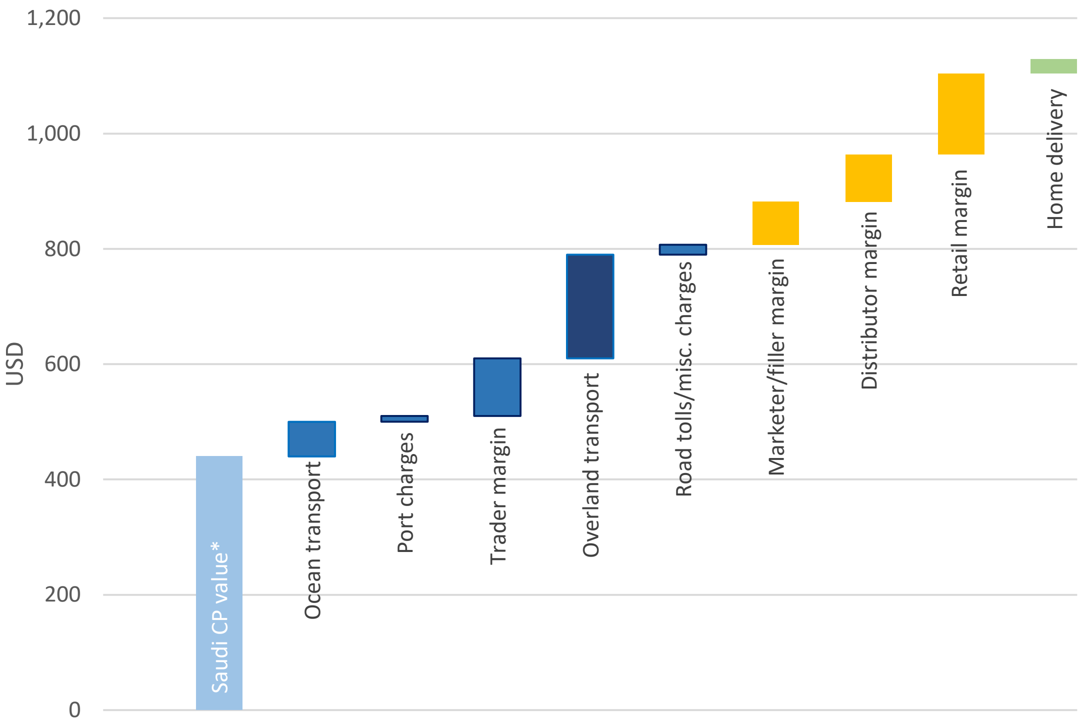
The determinants of the final consumer price are as follows:

1. Saudi Aramco CP (contract price) for butane, the international reference price for East Africa
2. Trader's premium
3. Landed cost at Mombasa or Dar es Salaam; Dar es Salaam quotes the Saudi CP for the current month, while Mombasa quotes the previous month's Saudi CP
4. Port charges
5. Transport charges from the port (Dar es Salaam or Mombasa-via-Uganda route to Rwanda)
6. Other transport related costs (road toll charges and other miscellaneous costs)
7. LPG marketer's margin
8. Distributor's (wholesaler's) margin, where applicable
9. Retailer's margin, where applicable
10. Home delivery charge, where applicable

[7] If future pricing regulations were to set maximum margins rather than fixed margins, the possibility of price wars is not eliminated.

These cost elements are shown in the figure below:

Figure 11. LPG Kigali price build-up
with Tanzania sourcing; Saudi CP is November 2020 butane value; in USD/MT



The Saudi CP value varies monthly and is expected on average to increase very gradually from 2021-2030. This value is beyond the control of the sector. The navy-colored bars (Ocean transport to Road tolls) tend to be stable over the long term, and can be reduced by supply chain innovation (e.g., use of rail transport when it becomes feasible), scale economies, and in particular vertical integration. The gold-colored bars (Marketer margin to Retail margin) are determined by the sector through competition, regulation (in the case where margins or prices are capped), the choice of distribution model, and the extent of vertical integration into distribution. Home delivery is presently paid by the consumer at his/her option, but could be paid by the distribution system as part of a national programme to encourage LPG adoption. Note: The GoR's Kigali end-user price cap of 1,084 RwF/kg (about US $1.11) sets the end-user price <u>below</u> what the distribution system would normally charge, based on the November 2020 Saudi CP. This regulatory pressure is motivating some marketers to insource transportation and to forward-integrate into distribution assets and operations where feasible.

The end-user price increases as one moves farther from Kigali. This is due to greater transport distances to these areas and, for rural areas especially, to the lower population density and lower cylinder rotation rate in such areas. Both of those factors increase the cost to serve those areas. 2020 pre-Covid data indicate a remoteness pricing effect for end-users as follows:

Average end-user price increase vs Kigali in other cities (USD/t)	+109
Average end-user price increase vs Kigali in rural areas (USD/t)	+435

III. Scenarios of LPG Demand Growth vs. NST-1

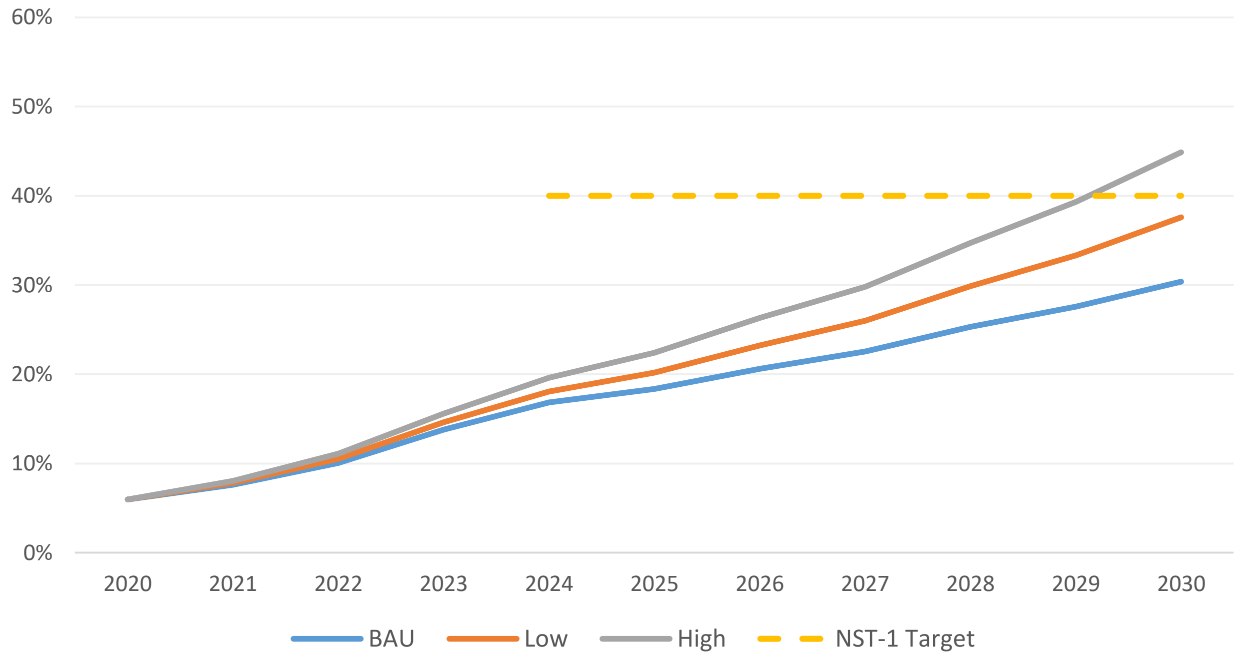
6. LPG Contribution Potential to NST-1 Target

The BAU scenario projects LPG penetration of 30% of households by 2030, significantly displacing use of biomass cooking fuels. This growth will be led by urban Kigali (about 86% projected penetration in 2030, up from 45% today), then the secondary cities (57%, up from 9%). Rural Rwanda will be a lesser contributor (under 4%, up from about 0.4%), although rural inclusion is morally important. Moreover, while the percent penetration of rural Rwanda by LPG may be small under the BAU projection, the associated volume of LPG is non-trivial, given the large portion of the Rwanda population that is expected to remain rural through 2030.

Public institutions, which can in principle be mandated to cook cleanly with LPG, could have the biggest near term impact toward reaching the NST-1 goal. But it is the household sector that will dominate national LPG use over the long term. Commercial institutions, such as hotels and restaurants, are an additionally important, if secondary, grouping.

With a well-crafted set of interventions to stimulate demand and support safe and accelerated supply chain expansion, the national penetration and use of LPG can get significantly larger: up to 22% by 2024 and 45% by 2030 in the High interventional scenario.

Figure 12. Market-driven demand projection scenarios, with and without interventions
LPG adoption as % of the population (residential and institutional)



Achieving the NST-1 biomass reduction goal with LPG

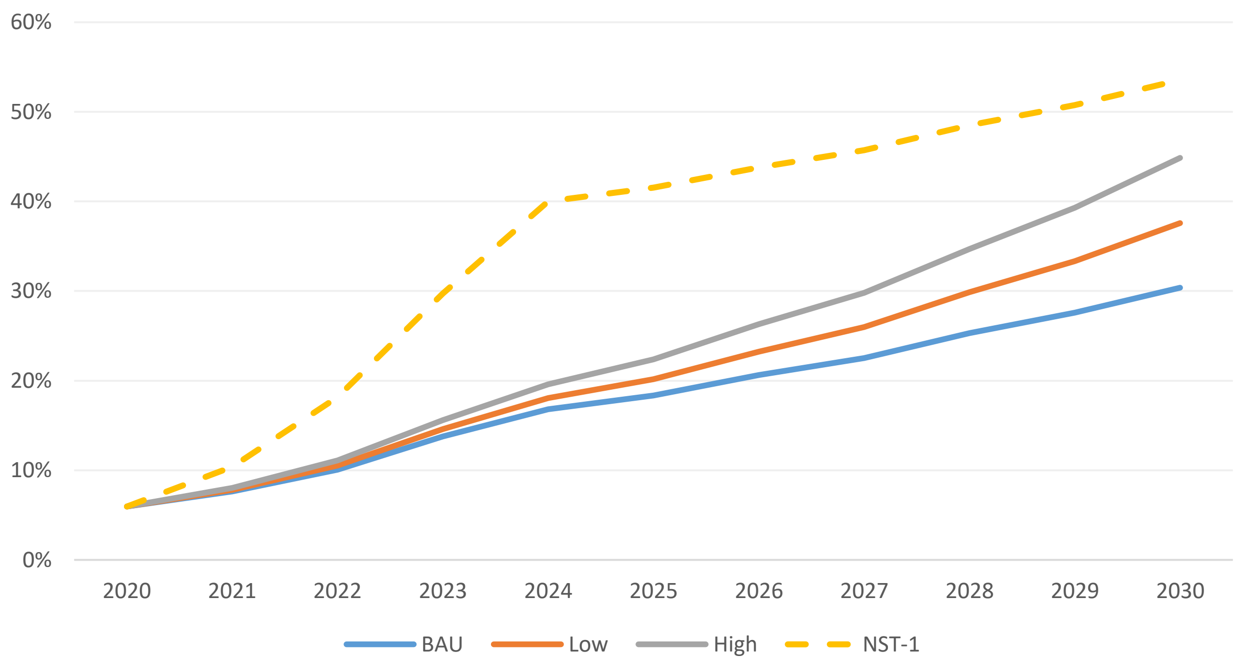
As shown in Figure 12 above, modeling indicates that interventional measures will increase LPG use significantly above the BAU case over the medium and long term but are likely to fall materially short of the NST-1 goal of 40% adoption of LPG by 2024.

The demand and supply scenario to achieve that goal (the "NST-1 Target" scenario) would require not only significant demand-side and supply-side interventions but also the effective use of mandates that require use of LPG and prohibitions not to use woodfuels for cooking in urban areas and amongst public institutions, and wherever else feasible. The NST-1 Target scenario would also require a major national mobilization of consumers to adopt and use, and of industry (together with the financial sector) to scale up to provide, LPG fuel and equipment between 2021 and 2024, including in rural areas. Achieving the NST-1 Target would require a near-total conversion of cooking in urban households and institutions to LPG, and a significant expansion of LPG use in rural Rwanda, within four years.

The Plan includes a roadmap of the build-out and investment that would be needed to achieve the NST-1 Target, if demand could be driven to the NST-1 level.

Figure 13 shows how demand might develop to 2024 and beyond were the NST-1 Target to be achieved through the foregoing measures.

Figure 13. Demand projection scenarios, including achievement of NST-1 Target
LPG adoption as % of the population (residential and institutional)



7. Market Growth Scenarios

The scenarios

This Plan presents projections of four scenarios of future demand, and how the supply chain should be developed and investment mobilized to serve the demand in each case. They are:

- **Business-as-usual** (BAU) scenario. In this scenario, existing demographic, market and industry trends are projected to continue unabated to 2024 and to 2030. This is necessarily hypothetical: much must go right for this scenario to come about, little must go wrong, and nothing about it is guaranteed. However, it presents the best computer-modeled statistical view of what could occur organically without any new, LPG-specific interventions. In this scenario, LPG use reaches 16.8% of the population in 2024 and 30.4% by 2030.

- **Intervention scenario, low case** (Low). This scenario adds to the BAU scenario the effects of policies and measures to encourage greater access to LPG (including via home delivery); to direct public institutions to transition to LPG use from charcoal and firewood; to implement and enforce fully the BCRM to world standards; and to promote LPG switching, especially among the urban and upper-SES segments. Of these actions, the data and modelling indicate that the strongest driver of LPG demand, by far, will be accessibility. The Low case models a lower bound of potential intervention results. In this scenario, LPG use reaches 19.6% of the population in 2024 and 37.6% by 2030,

- **Intervention scenario, high case** (High). This scenario assumes all interventions of the Low case plus aggressive distribution increases, such as a major emphasis on home delivery (which may include PAYG), and a comprehensive set of intensive demand stimulation measures, as outlined later in this document. The High case models an upper bound of potential intervention results. It therefore amplifies Low case effects and adds to them. In this scenario, LPG use reaches 22.4% of the population in 2024 and 44.9% by 2030.

- **NST-1 Target** (NST-1) scenario. In this scenario, 40% of the population, including institutions, is required to use LPG by 2024. To the incentivizing measures from the High case are added governmental requirements for exclusive use of LPG for cooking by households and institutions in at least urban settings and prohibitions on the supply and use of competing biomass fuels in those settings, and wherever else practical.

In all the scenarios, it is assumed that existing plans and policies to move public institutions to primary or exclusive LPG use in favor of biomass use for cooking will be accomplished within the next four years.

Because of limitations in the available data, it is not possible to quantify accurately the effects of individual measures, and the margin of error in the projections is significant. Therefore, they are indicative scenarios, indicating a range of what is probable, or at least possible, beyond the BAU projections. Follow-on studies and pilot programmes to assess the effectiveness of individual measures are presented in the Part X (Annexes to Volume 1), Chapter 20.

A detailed discussion of demand drivers and these scenarios of consumer and institutional demand is presented in Volume 2.

Time is of the essence

For the interventional and NST-1 Target scenarios, time is of the essence, due to the lead times to implement certain critical LPG projects and to arrange financing for them. Major actions relating to the expansion of the supply chain, if commenced in 2021, may have effect only in 2022 or 2023.

Helpfully, it is the consensus view of the local LPG industry that there is adequate spare capacity to double quickly its current throughput using its existing infrastructure, except that a large inventory of new LPG cylinders will be needed to create the new LPG customers. This spare infrastructure capacity is taken into account in the Plan.

Summary of LPG demand forecasting results

Forecasts of national LPG demand, with the target years of 2024 and 2030, was built up from projections of all the LPG market segments (households, public institutions, commercial and industrial users).

The household projections extrapolate historical and current trends evidenced between the 2016 (MTF) and 2020 (CFET) surveys, in RURA reports, in field data gathered by GLPGP, and in other data. Utilizing methodologies and modelling honed from experience in other LPG markets in Sub-Saharan Africa (SSA), three distinct, primary, quantitative drivers of household demand were identified and used for these projections:

- Changes in national demographics (population growth, increases in urbanization, changes in income/socio-economic profile);
- Expanded access to LPG, through increased retail outlet density and use of home delivery services, with consistently good safety achieved by sound implementation and effective enforcement of BCRM; and
- Potentially increased affordability of end-user costs of LPG fuel and cooking appliances.

Experience from other SSA and East African Community (EAC) countries has also shown than demand-side measures can have meaningful effects on LPG adoption and use among marginal populations. (See Chapter 17 regarding recommendations of such measures.) A "marginal population" in this context is one which would adopt LPG for cooking, if deemed safe, but only if certain accessibility and affordability barriers are also mitigated. The available data do not reveal the size of such marginal populations in Rwanda, and do not allow the effect of such measures in Rwanda to be quantitatively modeled. The foregoing quantitative drivers are thus performing two roles: first, as direct, quantitative drivers of demand growth for forecasting purposes, and second, as proxies for the aggregate effectiveness of a set of demand-supporting measures whose individual contributions to future demand cannot currently be quantified.

➲ In future, data should be gathered to allow modelling of the effects of such demand-side measures, and/or the prospective measures must be piloted and the pilots monitored and evaluated to discern their quantitative effects and their potential scalability.

The contributions of the drivers of demand were modelled in combination to create a demand forecast for the BAU scenario and for each of the interventional scenarios (Low, High, NST-1 Target) for the period 2021-2030:

- *Business-as-usual (BAU) scenario.* Assuming existing trends continue, in this scenario, LPG use reaches 16.8% of the total population (counting both household and institutional users) in 2024 and 30.4% by 2030.

- *Intervention scenario, low case (Low).* In this scenario, LPG use reaches 19.8% of the population in 2024 and 37.6% by 2030,

- *Intervention scenario, high case (High).* In this scenario, LPG use reaches 22.4% of the population in 2024 and 44.9% by 2030.

- *NST-1 Target scenario*. In this scenario, the urban household population and public institutions are mandated to use LPG by 2024. All other interventions serve to stimulate increased adoption and use in rural areas and by commercial institutions.

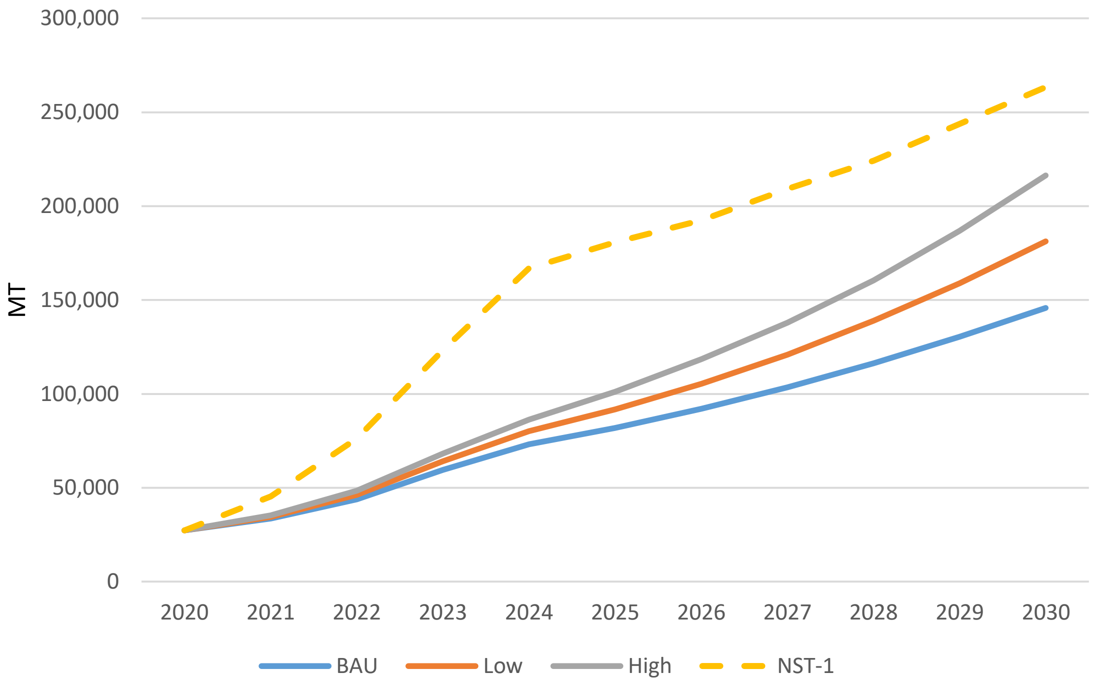
Because of limitations in the available data, it is not possible to quantify accurately the effects of individual measures, and the margin of error in the projections is potentially significant. Therefore, they are indicative scenarios, indicating a range of what is probable, or at least possible, beyond the BAU projections. Follow-on studies and pilot programs to assess the effectiveness of individual measures are presented in Part X (Annexes to Volume 1), Chapter 20.

The forecasts for non-commercial institutional demand were modelled based on an assumption of 100% LPG use by 2024 in all public institutions in alignment with current GoR policies, except for Rwanda prisons (projected as 60% long term use) and refugee camps (projected according to current trends and UNHCR projections for 2021). More detail is provided in Annex Chapter 78.

The forecast for commercial institutions (hotels and restaurants) and industrial demand was developed using existing levels of reported adoption, grown proportionately to GDP growth projections.

Figure 14 presents a summary of the forecasted LPG demand tonnage across all market segments, by scenario.

Figure 14. Projected LPG volumes by demand scenario *in MT* (residential, institutional and industrial)



Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BAU	27,297	33,551	43,784	59,520	73,086	81,935	92,069	103,481	116,248	130,379	145,770
Low	27,297	34,515	46,271	64,174	80,086	91,699	105,302	120,962	138,884	158,925	181,254
High	27,297	35,394	48,476	68,167	86,346	101,074	118,464	137,926	160,458	186,843	216,325
NST-1	27,297	45,385	76,307	123,350	166,872	180,770	192,496	209,247	224,164	243,884	263,431

An important finding is that the tonnage difference between scenarios is more prounounced than the penetration difference. This is because different categories of users use different amounts of LPG and adopt LPG at different rates under each scenario. The details are discussed in Volume 2.

Because Kigali would quickly saturate with LPG, LPG scale-up must also focus on other cities. Additional focus on rural areas would be necessary to grow demand to the desired 2024 level in the NST-1 Target case.

Whilst BAU projects a steady increase in LPG adoption in urban Rwanda, BAU projects no significant increase in LPG uptake in rural settings.

IV. Implementing the Branded Cylinder Recirculation Model (BCRM)

8. Conditions and Consequences of the BCRM LPG Market Model

Everywhere else in the world, when implemented in a self-consistent, well-enforced, and adequately financed way, BCRM eventually leads to widespread adoption of LPG with an acceptable level of safety (acceptable to the consumers, industry and governments in question).

BCRM is endorsed and promulgated by the World LPG Association, the global LPG industry organization.

Examples of major successes in LPG market development using BCRM include: Brazil (starting in 1979 following a near-collapse of the LPG market due to enforcement failure that led to thousands of monthly LPG fires and explosions), Morocco, Vietnam, Malaysia, India, Japan, Turkey and Senegal.

BCRM comprises a number of key principles, as follows.

- The LPG marketing company (Marketer) invests in, owns, inspects, maintains, and refills (away from populated areas) its own, branded cylinders and is responsible and liable for their safety. This function is specific to, and unique to, the Marketer. The Marketer is also exclusively licensed by the government to import and to market LPG. This linkage, between and among cylinder investment, cylinder refill income over the cylinder's life, liability for the cylinder's safety, licensing, the brand, and the acquisition of LPG, creates the needed incentives for LPG marketing companies to invest to expand their cylinder inventories in order to create new customers and to spend to maintain safety throughout the value chain.

  This key principle also serves to enable a self-reinforcing industry structure which is able to deliver adequate LPG safety at an affordable price to consumers while generating adequate financial returns to investors over the long term. Under the BCRM market structure, it becomes much more difficult for other parties (unlicensed marketers, wholesalers, and other legitimate or illegitimate parties) to steal and/or hoard cylinders, or to refill cylinders not belonging to them (thereby stealing the rightful refill income of the Marketer that made the cylinder investment). Where such black market or gray market activity is able to occur, private sector investment in cylinders and in safety inevitably decline, potentially leading to a destructive spiral of increasing market dysfunction in which bad actors increasingly drive out the good and consumers increasingly distrust LPG and LPG companies. This pattern has played out in many markets around the world where BCRM has been weakly implemented, or not at all. Once it takes hold, it is extremely difficult and takes many years to revese.

- The government must enforce the foregoing structure to ensure compliance by legitimate, authorized players and to create significant disincentive (through inspection, legal prosecution, significant penalties for conviction, and other means) for illegitimate players to coopt for their own ends the cylinders of legitimate players, thereby breaking the linkage.

- All cylinders in the market are branded cylinders.

- The consumer obtains his/her first cylinder from a Marketer's distribution channel in exchange for a deposit, which is typically set below the cost of the cylinder with a maximum percentage specified by law or regulation. The cylinder remains the property of the Marketer. When the consumer's LPG runs out, the consumer returns the empty cylinder to a refill point in the Marketer's distribution network to exchange it for a full cylinder, at the prevailing, posted price for a refill.

- Margins, if regulated, must be adequate to cover the costs of the operation of the supply chain and the chain of safety responsibility across all the nodes, and to allow for adequate debt service, returns to equity investors, and investment in growth.
- Safety standards, in particular regarding the condition of cylinders and handling and transport of LPG, must be defined clearly and well enforced.
- Allowing cylinders to cross between Marketers' branded distribution networks is prohibited, because it leads to diverting and hoarding (taking off the market) of competitors' brands of cylinder, thereby creating shortages as well as reducing sector bankability.

BCRM is enhanced with certain optional characteristics, including:

- Industry consolidation, leading to fewer but more capable and bankable players which lead the sector's growth and help perpetuate essential BCRM practices. The presence of an effective LPG trade association is also useful for the latter purpose.
- Transportation cost-equalisation to cause LPG prices paid by remote customers to be equal or almost equal to prices paid by centrally located customers.
- Pro-poor mechanisms, which may include micropayment and pay-as-you-go schemes, targeted subsidies, and the like.
- Consolidation of regulatory authority regarding the LPG ecosystem into a small number of agencies, or one LPG superagency. This facilitates business formation and expansion and facilitates effective enforcement of BCRM and its elements.
- Generating income for the LPG regulator(s) through levies on LPG volumes in the country rather than on renewal fees. This creates more certainty for investors, improving sector bankability and the prospects for growth.
- Sharing of major infrastructure for storage and filling. If such sharing is done, and done well, it focuses competition on acquiring and servicing customers, instead of on acquiring LPG.
- Sharing (pooling) of importation of LPG fuel. If such pooling is done, and done well, it can focus competition on acquiring and servicing customers, and can reduce the absolute cost of, or the volatility of, the LPG import price as the overall market increases in size.

9. Regulatory Recommendations

Reformed LPG value chain

The current LPG value chain and the value chain as it should be under BCRM are shown in these two figures:

Figure 15. Current Rwanda LPG value chain diagram

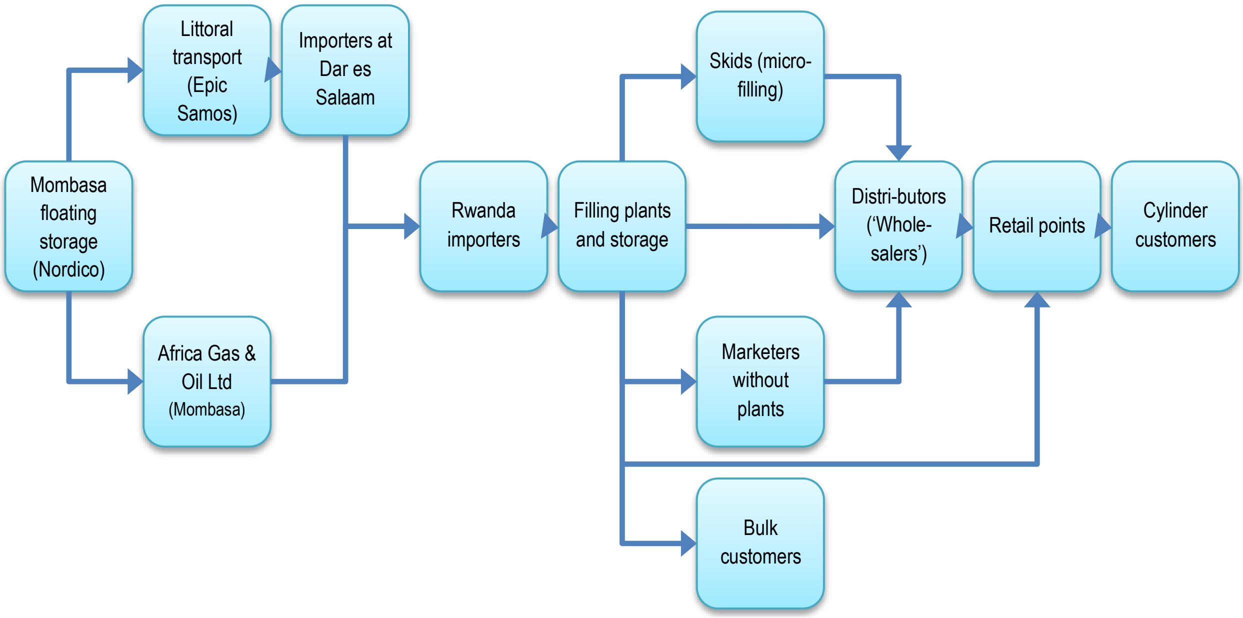
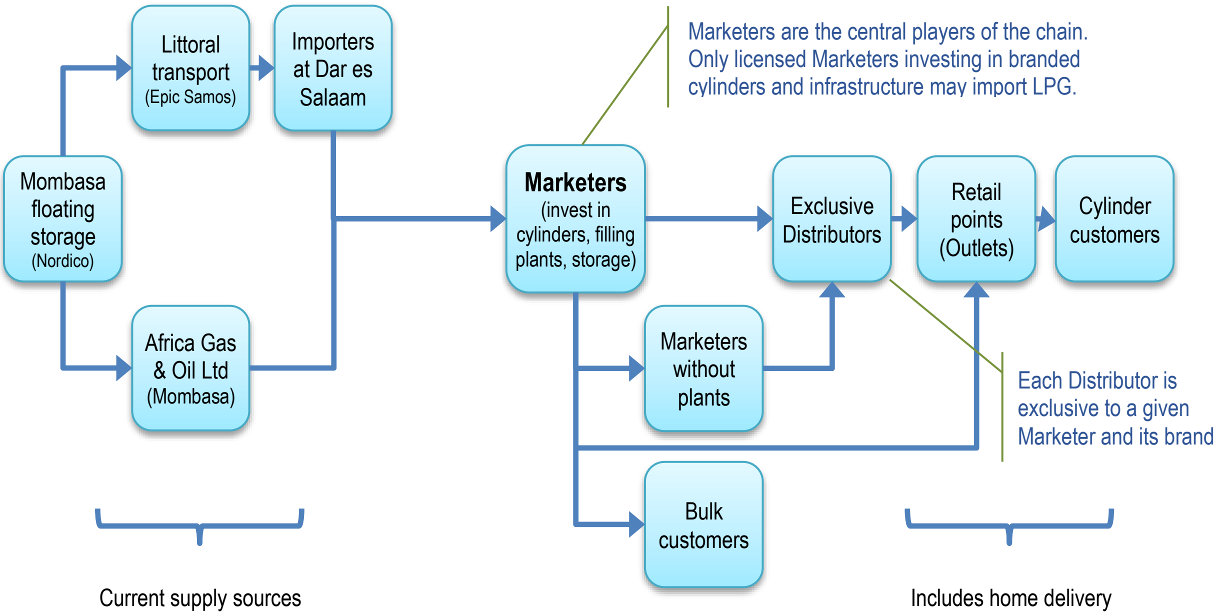


Figure 16. Rwanda BCRM-compliant LPG value chain diagram



BCRM requires the Marketer to be the central player, with clearly defined roles that it uniquely performs, and clearly defined relationships to and with the players in the other nodes. The Marketer is the sole type of player in the supply chain that is entitled to apply for, and receive, a license (see Volume 3 for details).

Essential regulatory framework documents

Analysis of international experience indicates that regulations be structured in three self-consistent documents:

1. The **LPG distribution regulations**
   - To define the distribution model (BCRM), and to assign the roles, tasks, rights, obligations and sanctions for licensing the Marketer, the Distributor, the Retailer, and the Refiller. The regulations will include the list of prohibited acts and the sanctions.
   - To set the conditions for obtaining licenses and permits, especially by setting the national LPG Master Plan as a framework for approving the business plan and the investment plan of applicants prior to granting them licenses and/or renewal of license, or granting them any other benefits[8].
   - To define the roles and responsibilities of ministerial entities.
2. An **LPG Safety Book** describing the specifications, standards and norms to be used for the construction, certification and repair of all LPG containers, facilities and operations related to filling, transport and maintenance of LPG cylinders. The LPG safety code shall be used as reference for the authorization, the construction, the operations and the safety management of all containers, installations and transportation of LPG.
3. The texts governing LPG consumer pricing and taxation.

This structure is particularly adaptable to include all forms of mutualization or sharing of logistics infrastructure investments in import and filling capacity, for example to create a shared national utility or quasi-utility for filling and storage operations.

Details on the foregoing are presented in Volume 3.

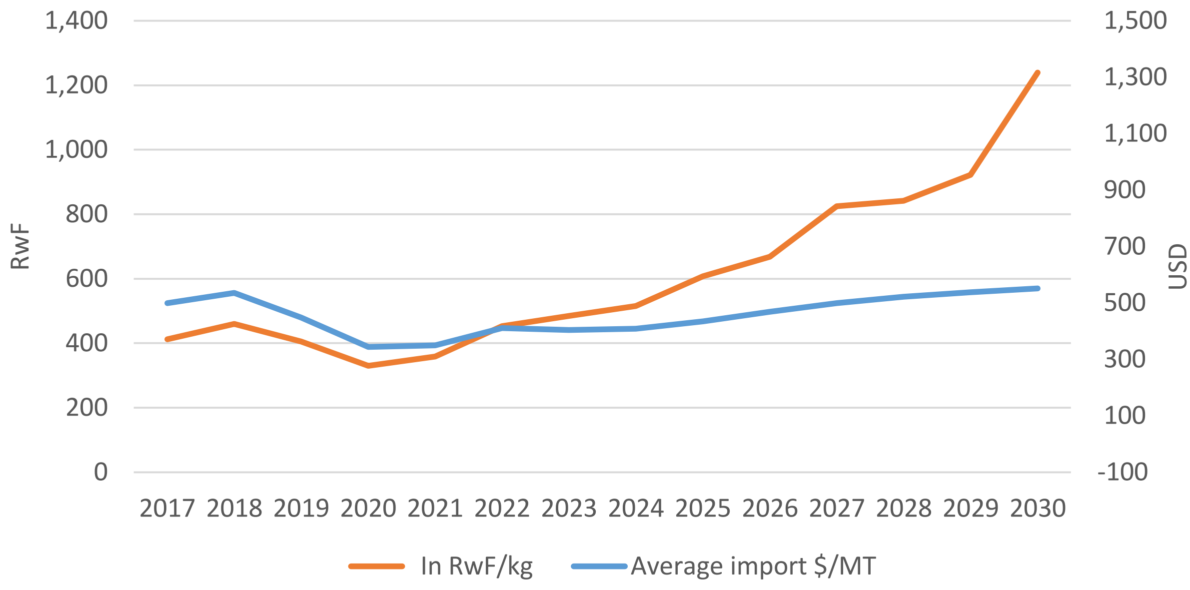
8 For example, an income tax holiday in connection with a major accelerated LPG investment programme or project.

V. Supply Security and Supply-Demand Balance Overview

There will be ample LPG supply to meet demand projections under all scenarios via importation from Tanzania and/or Kenya through 2030 and potentially 2040 without either shortfall or a major increase in the imported LPG price. While Rwanda cannot control the regional supply situation, which is dominated by its larger, maritime neighbors, it can exert influence and be prudent about procurement and logistics. Existing operators are already investing to increase their control over, and reduce their costs of, procurement of imported LPG.

In US dollar terms, LPG import costs are projected to be relatively stable to 2030 and beyond. However, Rwanda must protect against the effects of IMF[9]-projected RwF devaluation vs. the USD in the late 2020s, because imported LPG is priced in USD (for the relevant part of the delivered cost occuring outside Rwanda's borders), while Rwanda's consumers transact in RwF. A significant RwF devaluation could inflate nominal LPG end-user prices in RwF by as much as 70% by 2030, as shown in the figure below. (Any currency-driven increase would be offset in purchasing power parity terms by domestic price inflation, to the extent it occurs.)

Figure 17. Saudi CP Butane prices to 2030, in USD and RwF



Supply-demand balance details are presented in Volume 2, Part XIII.

[9] IMF Rwanda Macro Forecast, 2020

VI. Supply Chain Development Roadmap

10. Supply Chain Development and Investments

For each scenario of future demand, there is a corresponding need to invest step by step in, LPG cylinders, infrastructure, and distribution in each province to serve that demand. The asset value of these investments between 2021 and 2030 is US $191 million, US $223 million and US $278 million for the Low, High and NST-1 Target scenarios respectively, with a corresponding net financing need of $156 million, US $177 million and $214 million. Net financing is equal to the total investment minus the amount of money that new LPG consumers will pay as cylinder deposits to the Marketers that invest in the cylinders.

Table 6. Capital investment requirements for LPG sector scale-up 2021-2030

Category	**Investor**	**Capital requirement (mm USD)**		
Scenario		**Interventional Low**	**Interventional High**	**NST-1 Target**
Cylinders	Marketers[10]	$ 56.5	72.1	97.0
Cylinder cages	Retailers	1.9	2.4	3.1
Cylinder pallets	Marketers	7.3	8.5	9.6
Bottling plants and storage	Marketers	45.6	48.4	50.4
National strategic storage	GoR	49.5	52.9	72.3
Transportation assets	Marketers / Distributors	30.4	37.3	45.4
Total		**$ 191.2**	**222.6**	**277.8**

Investment tranches

For all scenarios, three financing tranches are recommended: 2021-24, 2025-28, 2029-30. Details of the investment and financing requirements for each tranche under each scenario are presented in Volume 5.

The needed investments could be accelerated or scaled back based on actual rates of LPG adoption and use by end-users, in order to meet the financial return requirements of investors.

Industrial-grade filling plant strategy

➲ To minimize costs through economies of scale and to maximize safety, it is recommended to create only larger, industrial-grade filling plants on a regional basis to serve the growth in the LPG market. Before a province has the volume to justify a filling plant of its own, it would operate a depot that is supplied from a neighboring province. Existing filling plants would continue to operate.

➲ Skid-based and containerized mini-plants, because of their high safety risk over time as well as their cost inefficiencies, should be phased out. The details of this strategy are elaborated in Volume 4.

10 Consumers contribute significantly to the total cylinder investment requirement by making cash deposits to access cylinders.

National strategic LPG storage

➲ Government policy specifies national strategic storage of petroleum products equal to 3 months' consumption. This policy should be modified in the case of LPG by offsetting intra-supply chain storage against the national reserve requirement. This can be done with minimum risk, because LPG's much longer supply chain in comparison to other petroleum products creates a significantly greater supply buffer for LPG.

Offsetting intra-supply chain storage against the national reserve requirement would avoid increasing the LPG end user price by 5%-8% (based on the scenario) to pay for an entirely separate 3-month national reserve storage. This strategy, called Integrated Strategic Storage (ISS), is reflected in the asset values presented above.

The following two tables show the total sector-wide investment requirements for the non-ISS strategy (NISS) and the ISS strategy, respectively. Over USD $60 million of costs in strategic storage development can be avoided for industry (and the consumer) and for GoR under the ISS strategy, by counting 50% of the supply chain's logistical and operational storage (in fililng plants, depots and filled cylinder inventory) toward the national strategic reserve objective.

Table 7. Total investment requirement to 2030 by scenario under strategic storage Option 1 (NISS)

INVESTMENT REQUIREMENT		BAU	Low	High	NST-1
CYLINDERS	NATIONAL	$41,453,116	$56,522,761	$73,111,264	$96,998,654
FILLING PLANTS	KIGALI	$9,839,500	$9,460,000	$9,918,400	$9,932,300
	SOUTHERN	$8,437,100	$8,750,400	$9,330,500	$9,870,600
	WESTERN	$8,832,100	$9,426,650	$9,652,300	$10,265,400
	NORTHERN	$8,646,600	$9,108,500	$9,889,200	$10,065,800
	EASTERN	$8,621,800	$8,904,400	$9,561,200	$10,262,600
	TOTAL	$44,377,100	$45,649,950	$48,351,600	$50,396,700
	Palletization in Filling plant	$5,101,000	$5,195,000	$5,790,000	$6,270,000
	Pallets in the logistic network	$1,575,147	$2,119,093	$2,699,805	$3,359,994
	TOTAL	$6,676,147	$7,314,093	$8,489,805	$9,629,994
STRATEGIC STORAGE	PRIVATE SECTOR PORTION	$15,075,000	$19,350,000	$22,125,000	$22,950,000
BULK PRIMARY TRANSPORT	NATIONAL	$21,295,981	$28,650,135	$36,501,357	$45,427,124
CYLINDER PRIMARY TRANSPORT	NATIONAL	$1,872,200	$1,702,000	$851,000	$0
CAGES	NATIONAL	$1,868,848	$1,889,600	$2,449,920	$3,082,560
	TOTALS	$132,618,392	$161,078,539	$191,879,946	$228,485,033
NATIONAL STRATEGIC STORAGE - GOR PORTION		$60,090,000	$67,878,000	$80,809,000	$99,892,000
COST OF THE LPG IN THE RESERVE (private sectoe+GOR)		$20,818,596	$26,323,857	$31,800,863	$37,136,704
430 $/T					
OPTION 1 GRAND TOTAL		$213,526,988	$255,280,396	$304,489,809	$365,513,736

Table 8. Total investment requirement to 2030 by scenario under strategic storage Option 2 (ISS)

INVESTMENT REQUIREMENT		BAU	Low	High	NST-1
CYLINDERS	**NATIONAL**	**$41,453,116**	**$56,522,761**	**$73,111,264**	**$96,998,654**
FILLING PLANTS	KIGALI	$9,839,500	$9,460,000	$9,918,400	$9,932,300
	SOUTHERN	$8,437,100	$8,750,400	$9,330,500	$9,870,600
	WESTERN	$8,832,100	$9,426,650	$9,652,300	$10,265,400
	NORTHERN	$8,646,600	$9,108,500	$9,889,200	$10,065,800
	EASTERN	$8,621,800	$8,904,400	$9,561,200	$10,262,600
	TOTAL	**$44,377,100**	**$45,649,950**	**$48,351,600**	**$50,396,700**
	Palettization in Filling plant	$5,101,000	$5,195,000	$5,790,000	$6,270,000
	Palets in the logistic network	$1,575,147	$2,119,093	$2,699,805	$3,359,994
	TOTAL	**$6,676,147**	**$7,314,093**	**$8,489,805**	**$9,629,994**
STRATEGIC STORAGE	**PRIVATE SECTOR PORTION**				
BULK PRIMARY TRANSPORT	**NATIONAL**	**$21,295,981**	**$28,650,135**	**$36,501,357**	**$45,427,124**
CYLINDER PRIMARY TRANSPORT	**NATIONAL**	**$1,872,200**	**$1,702,000**	**$851,000**	**$0**
CAGES	**NATIONAL**	**$1,868,848**	**$1,889,600**	**$2,449,920**	**$3,082,560**
	TOTALS	**$117,543,392**	**$141,728,539**	**$169,754,946**	**$205,535,033**
NATIONAL STRATEGIC STORAGE - GOR PORTION		**$42,488,000**	**$49,492,000**	**$52,890,000**	**$72,278,000**
COST OF THE LPG IN THE RESERVE (GOR)		**$12,165,689**	**$15,319,960**	**$17,028,244**	**$20,351,662**
OPTION 2 GRAND TOTAL		**$172,197,081**	**$206,540,499**	**$239,673,190**	**$298,164,695**

A leading LPG player made a proposal to the GoR for a strategic storage project. It is recommended that this project be adjusted to centralize the storage, build it out in three waves (2022, 2024, 2030), and adapt its scale to the ISS strategy. National storage would be sized to around 32 days, and intra-supply chain storage around 58 days. Further details are presented in Volume 4, Chapter 45.

Infrastructure deployment

New infrastructure would be deployed propotionate to the tonnage and end-user growth in each province. The following maps show the volumes that would be served in 2020, 2024 and 2030 for each, across scenarios:

Figure 18. Maps of LPG capacity requirements, 2020, 2024, 2030 by scenario

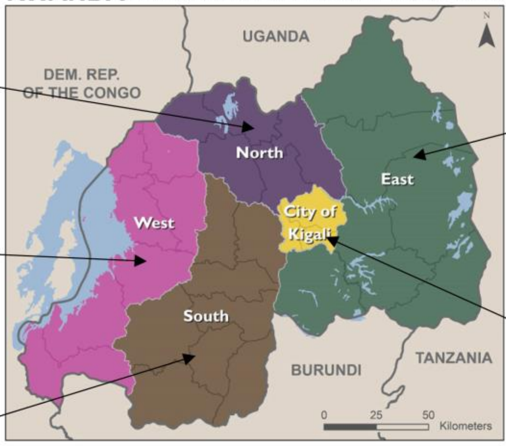
RWANDA ESTIMATED LPG CONSUMPTION IN 2020

RWANDA ESTIMATED LPG CONSUMPTION IN 2024

NORTHERN	2024
BAU +LI	11 395 T
BAU +HI	12 666 T
NST-1	28 381 T

WESTERN	2024
BAU +LI	12 773 T
BAU +HI	13 955T
NST-1	32 936 T

SOUTHERN	2024
BAU +LI	11 487 T
BAU +HI	12 384 T
NST-1	30 154 T



EASTERN	2024
BAU +LI	13 966 T
BAU +HI	14 848 T
NST-1	33 821 T

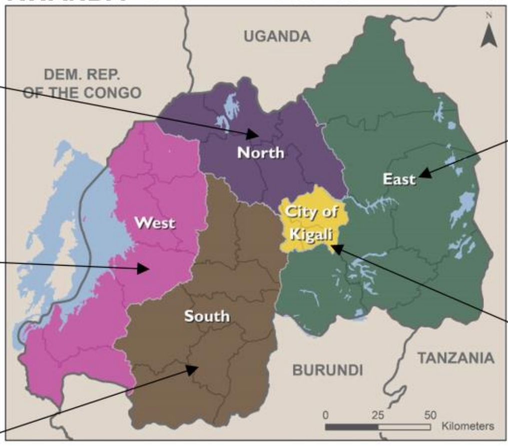
KIGALI	2024
BAU +LI	30 465 T
BAU +HI	32 493 T
NST-1	41 580 T

RWANDA ESTIMATED LPG CONSUMPTION IN 2030

NORTHERN	2030
BAU +LI	34 812 T
BAU +HI	42 072 T
NST-1	50 129T

WESTERN	2030
BAU +LI	36 594 T
BAU +HI	45 496 T
NST-1	57 010 T

SOUTHERN	2030
BAU +LI	31 004 T
BAU +HI	39 406 T
NST-1	51 213 T



EASTERN	2030
BAU +LI	33 854 T
BAU +HI	42 701 T
NST-1	55 743 T

KIGALI	2030
BAU +LI	44 991 T
BAU +HI	46 650 T
NST-1	49 342 T

The total yearly volumes are split in bulk and cylinders activities. Most of the cylinder volumes come from household consumption. The instutitional volumes are approximately 15% cylinder and 85% bulk.

The recommended locations of major new infrastructure are as follows:

Province	District	Town/ Area
Kigali City	Gasabo	Kabuga/Rusororo
		Jabana
	Kicukiro	Gahanga
Northern	Musanze	Musanze
Southern	Muhanga	Muhanga
Eastern	Kayonza	Kayonza
Western	Rusizi	Kamembe

Volume 4 provides the details of the recommended timing, location, sizing and costing of each type of asset (cylinders, infrastructure, transportation) for each scenario.

11. Procurement Strategy

Supply chain assets

Implementation of the Plan requires acquisition of cylinders, deployment of cylinders to consumers and cylinders and bulk tanks to institutional users, construction of filling plants and storage, acquisition of transportation assets, and purchase of LPG fuel. This Chapter summarizes key objectives and strategies for optimizing the outcomes of these activities. A more detailed discussion is presented in Volume 4.

The following table summarizes the key assets to be acquired or constructed:

Item	Quantity and Schedule	Modes of Aquisition
Cylinders 6kg, 12kg, 35kg	2.5 – 5 million new cylinders, based on scenario • 100,000-200,000 cylinders in Year 1, rising to 600,000-700,000 per year at the end of the programme	Primary: Importation from well-qualified manufacturers Secondary: Local manufacture from new-build factory/ies of 100 cyl./hr. capacity This is a private-sector choice
Filling plants and storage	5 industrial-grade plants and associated storage • Kigali in 2022, others regions 2024-2027 • For NST-1 Target, all 5 needed in 2022 National strategic storage (ISS) of 18,700 – 24,200 MT based on scenario • 9,400-13,800 MT in 2024 • 18,700-24,200 MT in 2030	New-build from well-qualified manufacturers
Bulk and cylinder trucks	Between 18-48 bulk trucks and 2=13 cylinder trucks per year, based on scenario and year	Importation or local purchase from qualified manufacturers

Details for each scenario are presented in Volume 4.

Insitutional procurement of LPG equipment and refills

Procurement applies to two elements of LPG service:

- Initial installation
- Regular refills

The following table summarizes the projected institutional requirement for cylinders and bulk tanks:

Table 9. Summary of LPG installation requirements for current institutions

Type of facility	**No. of units**
12kg cylinders	15,940
0.5 MT tanks	1,276
1 MT tanks	2,916
2 MT tanks	415
5 MT tanks	13

The cost of initial installation depends on the LPG volume of the institution. Usually, the Marketer can cover the cost of installation, provided the institution commits to buying LPG for a defined quantity and time period. Alternatively, an institution can invest in its own bulk tank and buy LPG from the lowest bidder on a spot basis. That is a commercial/budgetary decision for the institution.

Details on the quantities and sizes required for each type of institution are detailed in Volume 4.

Importing LPG

The best LPG price will be obtained through long-term take-or-pay contracting for supply on a defined schedule.

➲ It is recommended to pool acquisition of imported LPG under long-term contracts. This approach creates the following advantagess:

- Pooling of purchases improves the negotiation power of the buyers with the seller. By means of a take-or-pay contract, the buyers' committed volumes reduce the seller's risk, and the buyers may realize a reduction in the seller's premium (what the seller charges above the cost of the product itself).
- A stable supply schedule reduces the chance of the seller needing to employ an LPG vessel hired from the spot market at much higher cost (which would be passed on to the buyer), by creating a regular, defined delivery cycle that supports the use of time-chartered vessels.

The pool can be comprised of Rwandan LPG Marketers or, potentially to increase negotiating power further, Rwandan LPG Marketers together with a large Marketer or pool of Marketers in a neighboring country that imports LPG (i.e., Tanzania or Kenya). Details about potential approaches are given in Volume 4, Chapter 49.

The buyer-pool should commit to purchasing less than 100% of the expected volume needed, with the remainder to be acquired on a spot basis. This approach creates the following additional advantages:

- If there is a temporary oversupply or reduction in need, the buyers are not obligated to continue to purchase LPG at 100% of the projected level of need during that period.
- Buyers can take advantage of price arbitrages (time-based or source-based) via the spot market for quantities not subject to the long-term contract, without undermining the overall benefit from the contract, and without taking undue price or quantity risks, which are hedged by the contracted portion.
- If the contracted supplier(s) experience a temporary shortage or delay, the buyers are in good position to make up for it through their ongoing spot market purchasing.

Integrating backward into ocean port storage

As an option, a Rwanda-owned or shared/rented storage facility on an Indian Ocean port of 4,000 MT by 2024 could allow reception of pressurized vessels one, twice or three times par month under the control of Rwandan parties. The purpose of having such storage would be to increase the security of a portion of Rwanda's LPG supply. It would not necessarily create cost savings.

The yearly projected volumes for Rwanda—3,500-4,000 MT/month by 2024, 10,000-20,000 MT/month by 2030—will make this feasible. Such storage would not be needed to serve projected needs until 2027, allowing a long planning window. Which option to consider should be studied during Plan implementation. Details of the factors to be considered and the advantages and disadvantages of each option are presented in Volume 4, Chapter 49.

12. BioLPG Supply Development

Rwanda can achieve greater LPG supply diversification and hedge against import price increases by developing domestic bioLPG production within the next 5 years, utilizing municipal solid waste (MSW) from appropriately engineered landfills as the feedstock.

BioLPG's advantages are that it is renewable, not subject to RwF devaluation against the USD (as is imported LPG), is an economically better use of MSW gas than combined heat and power, and can be produced below the all-in cost of imported LPG.

The full supply chain build-out analysis and recommendation are presented for each scenario in Volume 4, Part XV. Details on the potential for bioLPG production are presented in Volume 2, Chapter 30.

A recent GLPGP report funded by UKAID Modern Energy Cooking Services (MECS) on bioLPG potential in SSA, including specifically in Rwanda, can be found here:

> *GLPGP (2020). Assessing Potential for BioLPG Production and Use within the Cooking Energy Sector in Africa.*
>
> https://mecs.org.uk/wp-content/uploads/2020/09/GLPGP-Potential-for-BioLPG-Production-and-Use-as-Clean-Cooking-Energy-in-Africa-2020.pdf

VII. Investment Plan and Financing Overview

13. Investment Cases

GLPGP was able to construct *pro forma* investment cases for LPG sector expansion using SSA and East Africa industry benchmarks and assumptions. It should be noted that the private sector LPG companies in Rwanda, when asked by the GoR to provide data for use in the Plan analyses, were not willing to disclose it.

The Plan therefore presents an exemplar *pro forma* LPG industry company as a model and guide for sector investment and its financing.

The financial analysis reveals the modes of operation and strategic choices by industry players that are most likely to be bankable.

These include

1. Vertical integration along the supply chain;
2. Achieving a minimum efficient scale (to justify ownership or co-ownership in a medium to large-scale filling plant with a rigorous cylinder safety and maintenance function);
3. Disintermediation of Distributors;
4. Utilizing the cost efficiencies resulting from these strategies to invest in
    - Retailing facilities with associated home delivery capability, for which the Marketer bears the home delivery cost, in order to maximize LPG adoption by households, and
    - Consumer marketing and education, to help stimulate demand.

Financial modelling indicates the expected financial rates of return would be in the approximate range of 10%-40%, based on the scenario, the approach taken to strategic storage sizing and cost sharing, and various operational choices that could be taken. The recommended set of choices and scenario produces a notional IRR to equity of 37%. Detailed financial analyses of these sets of choices is presented in Volume 5.

Investment case sensitivities

Key financial sensitivities include

- The rate of growth (as expected, higher growth rates result in lower financial returns);
- Foreign exchange effects (i.e., how potential RwF devaluation vs. the USD or Euro affects debt service and cost of product);
- Whether the PAYG model is used;
- Whether the company/project is vertically integrated;
- The extent of cylinder piracy and cross-filling (which strong BCRM is intended to suppress);
- The level of marketing spending;
- The amount of financial leverage;
- The cost of capital; and
- Whether cylinder acquisition is subsidized.

Investment considerations and "Industry Leader" firms

Volume 5 of the Plan examines the investment needs from a project and business financing perspective, including:

- The total investment and financing need for the sector under these three scenarios (Low, High, NST-1 Target);
- How the investment capital could be apportioned among those existing LPG companies in Rwanda that would, presumably, desire and use such financing to grow and to maintain market shares, consistent with the supply chain strategy set forth in Volume 4;
- The optimal structure, characteristics and operational choices for a generic LPG firm to be best positioned to lead the scale-up of the LPG sector (hereafter an "Industry Leader" firm);
- Whether, and under what conditions, such a firm is bankable;
- How that bankability and/or end-user prices are affected by key external factors such as national strategic storage investment requirements;
- How bankability and end-user prices are affected by firm configurations other than the Industry Leader design (e.g., PAYG, small Marketer without in-house filling capability, etc);
- The financing environment faced by Rwandan LPG companies;
- Structures and recommendations for how best to finance the sector and individual, qualified firms within it, to maximize bankability (including liquidity) while keeping LPG as affordable and accessible as possible to the public.

The concept of developing a small group of "Industry Leader" firms to lead the development of the LPG sector, attract the initial capital, and demonstrate the financial viability of the sector to funding sources in order that all firms would eventually benefit, is potentially important for Rwanda.

Achieving the projected results of any of the interventional scenarios will require a major national mobilization of consumers to adopt and use, and of industry (together with the financial sector) to scale up to provide, LPG fuel and equipment between 2021 and 2024, and beyond.

A few developing countries have successfully accomplished very-large-scale national LPG mobilizations of this kind within 3-5 year time horizons. But key factors in those countries were (a) the presence and leadership role of one, or a few, very large and powerful state-owned fuel utility company/ies capable of executing a national-scale programme, and (b) concerted political leadership and state coordination at the highest levels (president, vice president, prime minister).

For Rwanda, where no national champion LPG company exists today, and where a liberalized, private sector-led market is preferred, it is recommended to create the conditions for existing LPG companies to become champion-like and, thereby, to lead effectively the mobilization of industry and to assist the government in the mobilization of the public.

14. Supply-Chain Financing

The needed major LPG infrastructure and business expansions are potentially bankable. However, the needed capital does not appear to be sufficiently available at the local level. Therefore, international capital will be required to be mobilized.

If a significant portion of the needed capital is obtained in USD (or Euro), then, given the potential devaluation of the RwF, LPG companies and projects must raise prices over time in order to cover their costs of the USD/Euro-denominated capital, without harming their bankability, profitability and liquidity.

To induce private-sector, market-rate capital to flow, it will be critical to attract concessional capital from Rwanda's financial cooperation partners and the world development system to co-fund the LPG projects and business expansions set forth in this Plan. The involvement of concessional capital will motivate private-sector, market-rate capital sources to co-invest and co-lend, and will improve the risk and return profile of the sector as well. This mixing of concessional and market-rate capital is hereinafter referred to as "blended capital".

➲ GoR must therefore seek concessional capital up front from development finance institutions (DFIs) and other appropriate sources, to ensure that enough market-rate capital can be crowded in to finance the implementation of LPG sector's scale-up under the Plan.

Using blended capital not only improves access to capital but also reduces the cost of non-RfW capital, thereby improving industry liquidity and minimizing possible increases to consumer prices due to capital costs, if and as the RfW devalues. Maximizing the availability of RwF-denominated capital on reasonable terms is important.

Details regarding the structuring of blended capital financing are presented in Volume 5 Part XVII.

Risks and mitigation

Among the most significant investment risk considerations is the risk associated with cylinder investment. Because cylinders are a mobile asset, financing sources may be less willing to provide financing for their acquisition and, when doing so, may seek higher rates of return, shorter loan tenors or investment monetization periods, and/or greater debt security in order to offset the risk. This is important in Rwanda, where property rights in cylinders are not yet clearly defined in existing law or regulation; this can encourage black market activity as the market rapidly expands. Risk is discussed in detail in Chapter 58.

Main financing recommendations

In order to meet as much of the GoR's 2024 and 2030 LPG-related objectives as possible, as quickly as possible, actions must be promptly taken to:

- Prepare technical, business and financing plans for LPG sector expansion projects, firm by firm (plus NSS assets), and including cylinder procurements;
- Make certain the regulatory environment that will govern the sector over the life of the Plan and of the financing;
- Determine which LPG firms, via fair and transparent criteria and processes, should receive priority assistance and financing, to act as first-movers and leaders (that is, as the Industry Leaders) to drive LPG market expansion;

- Develop a queue of prioritized projects (supply side and demand side);
- Provide industry stakeholders with technical support to finalize detailed plans and enhance execution capability;
- Provide GoR (in particular, RURA) with technical support to build LPG-specific capacity;
- Create a Rwanda LPG Financing Mechanism (RLM) as an LPG-specific Non-Bank Financial Institution (NBFI) to aggregate transactions, LPG sector financing expertise (as from GLPGP and increasingly from Rwanda), and structure investments and lending to LPG sector entities and modalities in Rwanda;
- Establish BCRM to create the necessary supportive regulatory and fiscal conditions; and
- Start immediately to mobilize blended capital resources, comprising (i) quick funding (notionally around US $3mm) for technical assistance, pilot programs, demand support measures, training, and initial project preparations as described in Part X (Annexes to Volume 1) Chapter 20, and (ii) less-quick, large-quantum funding for project engineering, procurements, cylinder financing, and funding of new infrastructure and major business operational expansions.

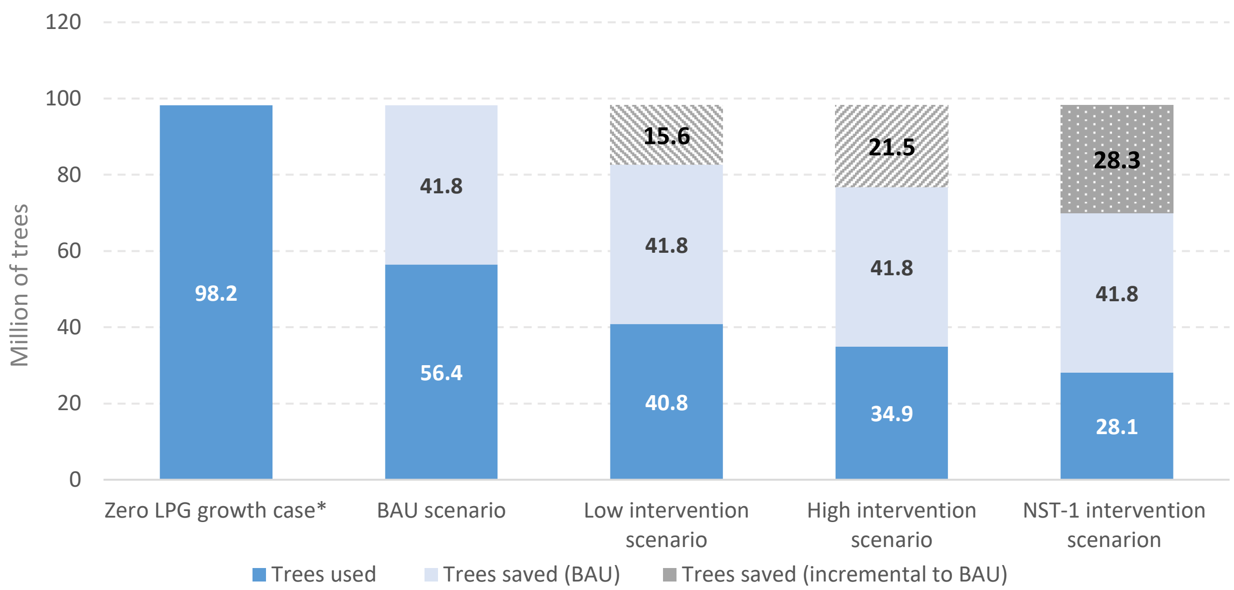
The full context and rationale for these recommendations is presented in Volume 5.

VIII. Impact Potential

15. Environmental, Climate, Social and Economic Impacts

If the projected LPG adoption and usage occur, there will be meaningful impacts on environment, forests, health, consumer economics, government income and the trade balance in each scenario. As an example, the figure below presents the potential savings in trees under each scenario:

Figure 19. Impact example: Trees saved during the 10th year (2030), by market growth scenario



**The Zero LPG growth case indicates the counterfactual: what happens if LPG use does not change from 2020.*

The main impacts are projected to be as follows:

Environmental:

- **Averted deforestation**: 243 – 354 million trees saved cumulatively between 2021 and 2030
- **Carbon dioxide equivalent (CO_2eq) emissions[11] averted:** 25.6 – 40.1 million MT of CO_2eq emissions averted cumulatively between 2021 and 2030
- **Black Carbon equivalent (BCeq) emissions[12] averted:** 14.9 – 25.8 million MT of BCeq emissions averted cumulatively between 2021 and 2030

11 CO_2eq emissions include carbon dioxide equivalent emissions from carbon dioxide, methane, and nitrous oxide. These were calculated using IPCC conform standards.

12 BCeq emissions includes black carbon equivalent emissions from black carbon, organic carbon, carbon monoxide, and total non-methane organic compounds.

- **The economic value of averted CO_2eq emissions in terms of carbon financing:** US $97 million – $ 152 million cumulatively between 2021 and 2030, using the 2020 prevailing price of carbon

Health:

- **Averted premature deaths:** between 2,600 and 7,700 deaths could be averted cumulatively between 2021 and 2030 due to LPG usage
- **Avoided Disability Adjusted Life Years (DALYs):** 135,700 – 403,700 DALYs between 2021 and 2030

Consumer economics:

- **Annual cost savings to a typical household from switching to LPG from charcoal or purchased firewood:** RwF 15,400 as of 2024 and RwF 35,200 as of 2030[13]

Tax revenues are projected to increase by RwF 1.7 billion – RwF 4.4 billion as of 2030[13], and the trade deficit by RwF 43 billion (US $44 million) – RwF 134 billion (US $138 million) as of 2030[13] due to increased LPG importation.

The details are presented in Volume 6.

[13] Based on an exchange rate of *US$ 1= RwF 975.00*

IX. Recommendations

16. Summary of Plan Recommendations

1. Implement BCRM

The highest priority is for GoR to implement BCRM and the corresponding regulatory roadmap documents. Of all the recommendations in this Plan, this is the most important.

2. Additional high-priority recommendations

The following are the most critical recommendations of the Plan, in priority order (after BCRM as priority one):

1. GOR should publicize the Plan to the private sector and require LPG players seeking new/renewed licenses and permits to align their projects and business strategies with the Plan, including an emphasis on home delivery of cylinders. Aligned players would thereby gain access to Plan implementation benefits, such as pooled LPG procurement participation, blended capital for cylinder and infrastructure financing, participation in demand-support programs, etc.

   In doing so, GOR should focus initially on the strongest Rwandan firms (i.e., Industry Leader companies), in order to create examples of success in attracting financing and executing on the Plan that would inure to the benefit of all other companies in due course. Financing of new cylinders is the most urgent priority.

2. Seek public sector concessional capital for implementing the Plan's projects, TA measures, and demand-side measures. The concessional capital will serve to crowd in private sector, market-rate capital that is otherwise likely to deny or delay investing in the LPG sector, especially for cylinders.

3. Set up the RLM (Rwanda LPG Financing Mechanism) to aggregate investment projects and mediate the flow of capital and expertise to them.

4. Develop, fund and execute the demand-side measures as outlined in the Plan (see the following Chapter). Direct public institutions to switch fully to LPG for cooking by 2024, wherever feasible.

5. Refine the national strategic storage project in accordance with the Plan recommendations.

6. Undertake key studies for long-term improvement to the national LPG ecosystem, including bioLPG studies, procurement pooling schemes and shared asset ownership schemes, and increased importation capability.

7. Encourage industry consolidation to increase the benefits from economies of scale and backward integration.

A complete list of Plan recommendations, including follow-on activities and technical assistance measures, is presented in Part X (Annexes to Volume 1) beginning on page 65.

17. Demand-Side Measures and Programmes

➲ A number of measures are recommended to encourage the development of demand, in order to improve the probability and speed of the realization of biomass reduction goals through LPG adoption and use, to improve inclusiveness of LPG access and affordability for commercially marginal populations, and to reduce the risks of the supply-side investments set forth in this Plan. Below is a matrix of such measures, showing how each is expected to affect the key parameters of the LPG ecosystem.

	Expected effect upon:				
Measure	Accessibility	Up front cost (equipment)	Cost to cook a meal	HH cashflow (transaction size)	Supplier bankability
Supply chain/distribution growth[14]	🟢	🟡	🟡/🟢	🟡	🟢
Home delivery requirement	🟢	🟡	🟡/🟢	🟡	○
Subsidy of equipment (e.g., RBF)	🟡	🟢	🟡	🟡	🟢
PAYG (with home delivery)	🟡/🟢	🟢	🔴	🟢	🔴
Smaller cylinders	🟡	🟡	🟡	🟡/🟢	🔴
Efficient multiburner LPG stoves	🟡	🟡/🔴	🟢	🟡/🟢	🟡
(Targeted) subsidy of fuel	🟡	🟡	🟢	🟢	○
Education (safety, costs, benefits, techniques, smart shopping)	🟡	🟡	🟢	🟡/🟢	🟢
Pro-LPG/anti-biomass mandates	○	🟡/🔴	○	○	🟢

Key: 🟢 Positive (beneficial) 🟡 Neutral/little to no effect 🔴 Negative ○ Not possible to predetermine

Discussion of the positive and negative effects of the measures

Supply chain/distribution growth under BCRM	Addition of cylinders and expansion of retail points / home delivery pursuant to this Plan creates access that allows major unmet demand to be served, and unlocks additional demand as consumer confidence in and knowledge about LPG increases. An effective expansion also increases bankability through economies of scale and improved stability, if BCRM is well enforced.
Home delivery requirement	Presently, home delivery is a retail option usually paid for by the consumer. At 27% estimated prevalence, it is popular, and the data show it is highly correlated with LPG use. This measure would mandate that home delivery be offered to the consumer, at least within urban areas, with the Marketer/distribution chain covering the cost out of its existing margins (that is, no extra cost to the consumer). This would significantly boost household demand; while it would lower slightly the unit margins of the Marketer, it

14 Under strong form BCRM

	would also accelerate revenue growth. (The net effect would need to be empirically determined and evaluated.)
Microfinance of equipment, fuel	Helps marginal-population consumers afford the up-front costs to switch to LPG and expands the market for LPG marketers and distributors. Requires good collaboration with the banking and MFI sector (e.g., Savings and Credit Co-operatives (Saccos)).
Subsidy of equipment (e.g., RBF)	Helps marginal-population consumers afford up-front costs to switch to LPG and expands the market for LPG marketers and distributors, as long as the consumer is then able to afford ongoing LPG refills. Such subsidy has the greatest impact on biomass reduction when directed to conventional users of LPG (especially with home delivery), vs. PAYG users, because more cylinders are deployable per dollar/RwF, and, data show, the conventional users use more LPG and less biomass than PAYG users.
PAYG (with home delivery)	Helps marginal-population consumers afford up-front costs and the need to save up in between refills. In consequence, the cost to cook a meal is significantly increased (40-60%). This contributes in turn to greater fuel-stacking. Much higher CapEx/ROA and labor costs vs. conventional LPG distribution make PAYG LPG companies less bankable that conventional LPG companies, all else being equal.
Smaller cylinders	Reduces the transaction size of a refill for the consumer, increases the number of purchases. Does not significantly affect up-front costs, because cylinder costs vary only slightly with cylinder size. Smaller cylinders are generally less safe and are effective for cooking only certain types of dishes. Industry bankability is reduced, because very small cylinders (e.g., 3kg) are incompatible with the filling plant equipment used for larger ones, thus requiring duplicate facilities and CapEx, and their higher refill frequency inflates transport and labor costs without increasing revenues.
Efficient multiburner LPG stoves	These allow cooking to be done with greater flame control and efficiency, resulting in significantly reduced cost to cook a meal. Allows for multiple dishes to be cooked at once, reducing fuel stacking. Multiburner stoves cost more than single-burner stoves and screw-on ring burners. Setting and publicizing LPG stove standards and best practices in stove choice and use by the public will support demand and maximize benefits from fuel switching to LPG from biomass for cooking.
(Targeted) subsidy of fuel	Reduces the cost to cook a meal. Requires effective targeting of beneficiaries and monitoring to ensure minimal leakage of subsidized fuel to unintended users or uses. (India has good lessons in this regard.) Can benefit industry by expanding the market, if the new users have high enough usage to cover service costs. If subsidy is provided to consumers by

	industry with government reimbursement, can make industry less bankable due to the risk of non- or delayed-reimbursement by the government.
Education (safety, costs, benefits, techniques, smart shopping)	Overcomes perceptual and knowledge barriers that limit consumer desire for, adoption of, and efficient and safe use of, LPG. Lowers cost to cook a meal. Education measures are particularly effective when (a) coming from government rather than industry, and (b) combined with other pro-consumer measures described above.
Pro-LPG/anti-biomass mandates	Pro-LPG mandates that are reasonably enforceable can (a) stimulate institutional use of LPG (with potential ripple effects on consumer perceptions) and (b) encourage LPG use as a national, patriotic, or social duty/opportunity for personal benefit and societal benefit. Anti-biomass mandates (e.g., prohibitions on logging, charcoal sales, etc.) have the effect of driving biomass users to alternatives such as LPG. This is supported by recent experience in Kenya, and paralleled by Indonesia's anti-kerosene, pro-LPG mandate and programme. If such mandates are evidenced to be supported and sustained for the long term, they increase LPG sector bankability by driving cooking demand to LPG and away from biomass. If not, they can make the sector seem higher risk—less bankable—because such incremental demand may evaporate.

Quantifying the measures' effectiveness and scalability in Rwanda

As mentioned in Volume 2, Part XII, the available data did not permit quantitative modelling of the disaggregated effect of each measure upon LPG demand. Therefore, in order to allocate resources and assign priorities effectively amongst the measures, it is necessary to perform follow-on studies and analysis and/or to carry out various pilot programs. Recommendations regarding such studies and pilot programs are made in Part X (Annexes to Volume 1), Chapter 20.

Combining measures into practical groupings

Combining measures and mechanisms can create synergies, if done wisely, and not overdone. Two examples are provided:

1. An LPG equipment subsidy ('Muturage Gas') programme that subsidizes consumer LPG equipment (stove, cylinder, accessories) for lower income/lower-SES households, to be piloted based on learnings from the sccuess and failures of other countries, and

2. An LPG equipment microfinance programme that spreads out the up-front costs of consumer LPG equipment and a series of cylinder refills over several months, to help lower income households more easily manage the costs of switching to LPG from biomass cooking, based on GLPGp experiences with successful programs in other countries.

Experience shows that it is important not to overload a single programme with too many elements. For example, consider the aforesaid example programs:

Programme element	"Muturage Gas" programme	LPG microfinance programme
Targeting of consumer	Lower-income / lower-SES with avowed desire to pay for LPG refills in future	Creditworthy lower-income/-SES
Geography	Peri-urban/rural where LPG companies operate	Peri-urban/rural where LPG companies operate
Consumer financial commitment	Subsidized cost of equipment; refills	Loan value of equipment and initial refills; interest; subsequent refills
Key organizational partners	Subsidy implementing agency (e.g., EDCL); LPG operator(s); LPG distributor(s); local leaders; programme staff; M&E	MFIs; bank(s); donor(s); LPG operator(s); LPG distributor(s); stove supplier(s); local leaders; programme staff and M&E (e.g., GLPGP)
Legal structures and documents	Legal decree as needed; fiscal budget authorization and allocation; consumer eligibility form; vouchers and voucher rules; operator undertakings/ concession agreement(s)	Master agreement among all partners; consumer registration form; loan agreement between consumer, MFI
Supply chain organization	By LPG operator as lead	By programme staff as lead
Sensitization	Education and demonstration programme carried out by programme staff	Education and sensitization programme carried out by programme and MFI staff
Core programme costs	Equipment subsidy; education/sensitization; programme management	Loan loss guarantees; loan capital (if needed, and to be repaid); education/sensitization; MFI training; programme management

As the above table shows, the significant differences in the targeting, structure, resources, costs and operations of the two programs indicate that they should be executed separately, and in non-overlapping areas, so that they do not compete with one another and do not set improper or confused expectations among the consumers or the programme partners.

These programs could potentially benefit from coordination with and financial support from the US $20 million World Bank Clean Cooking Fund (CCF) programme in Rwanda administered by RDB, which provides results-based funding to assist consumers to obtain clean cooking equipment and companies to supply it, including LPG stoves and accessories (but excluding the LPG cylinders).

Details of the design of these programs and CCF are presented in Volume 5, Part XVIII.

18. Sector Scale-up Timeline

Below is a planning timeline of key actions in Years 1-2 contributing to Plan implementation:

Table 10. Timing of key Master Plan implementation steps

Individual actions	Duration (months)	Could be done simultaneously
Master Plan detailed decision making	3 months	No
GoR incentive actions to support market development	6 months	Yes
GoR adaptation of LPG regulations	6 months	Yes
Commercial decision-making on filling plants, storage, cylinders	3 months	No
FEED[15] of filling plant and storage projects	3 months	No
Application for authorization and ESIA for storage and plants	4 months	No
RFQ project and tender	3 months	No
EPC[16] project; design, supply, construction and commissioning	18 months	No
Project implementation (rise in power)	3 months	No
Mobilization of cylinder and project funding	3-9 months	No
Time to supply cylinders, trucks, etc.	6 months	No
Cumulative durations:		
Filling plant (from planning through implementation)	24 months	
Cylinders and trucks (from planning through implementation)	6 months	

The following is a 10-year planning timeline for implementation of the Plan, for the recommended High case:

Table 11. High case technical and project implementation timeline

ITEMS: HIGH INTERVENTION SCENARIO	2021		2022		2023		2024		2025		2026		2027		2028		2029		2030	
Adoption of master plan	X																			
GoR implementation of BCRM		X	X																	
GoR interventional measures		X	X																	
Cylinder procurement		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Truck procurement		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
KIGALI filling plant/storage: decision-making through implementation		X	X	X																
SOUTHERN filling plant/storage: decision-making through implementation									X	X	X	X								
WESTERN filling plant/storage: decision-making through implementation			X	X	X	X														
NORTHERN filling plant/storage: decision-making through implementation			X	X	X	X														
EASTERN filling plant/storage: decision-making through implementation							X	X	X	X										

15 Front-end engineering design

16 Engineering, procurement and construction

X. Annexes to Volume 1

19. Table of Recommendations

Below, the key recommendations from throughout the Plan are assembled for ease of reference, grouped into categories, as shown in the table below.

Table 12. Summary of Plan recommendations

Deeper Understanding of Demand Factors	
Comprehensive consumer energy/LPG survey and focus groups	Data should be captured to deepen understanding of LPG demand drivers and barriers, and to allow quantitative modelling of the effects of demand-side measures that was not possible using existing study data sets and reports.
National fuels pricing study	Such a survey, combined with a consumer survey (per the next recommendation), would allow quantitative modelling and forecasting of how demand for each main cooking fuel in Rwanda is affected by prices—both absolute prices and relative prices. Such data do not exist today.
Promote efficient, multiburner LPG stoves	Promote efficient multiburner LPG stoves, through public communications / education and setting and publicizing standards. Such stoves, properly used, will reduce the cost to the consumer of cooking with LPG and will motivate use of LPG in place of biomass for a larger portion of the households' cooking tasks.
Demand Development	
Pilot an LPG equipment-subsidy programme for lower-SES consumers (e.g., "Muturage Gas")	A subsidy for equipment for qualifying households would remove one of the main cost barriers to LPG adoption. It should take into account learnings from such programs in other countries (successful and unsuccessful), as described in the Plan. A target size is 10,000 households. RBF has a potential role to play in such a project.
Pilot an LPG microfinance programme for lower-SES consumers (e.g., "Bottled Gas for Better Life")	An LPG microfinance pilot project (500HH) (role for RBF). GoR, GLPGP and RBD (in its CCF role) should collaborate on the design and launch of a pilot programme to assess its impactfulness and scalability. This pilot project should not overlap geographically with the LPG equipment subsidy programme. A target size is 500 households for a first phase. RBF has a potential role to play in such a project.
Evaluate a targeted subsidy of LPG fuel	This is a very significant decision to weigh, likely requiring a multi-stakeholder, multi-ministry process with expert consultations to consider. A specific plan would need to be developed for achieving the affordability objectives (and thereby increasing demand) without creating severe market-distorting side-effects. A prerequisite is deeper understanding of demand in order to enable careful, effective, evidence-based targeting and budgeting.
Ensure public institutions comply between 2021-2024 with policies for using up to 100% LPG for cooking	Public institutions can shift a much larger volume of fuel use from biomass to LPG than the household segment during the first years of the Plan, and should be prioritized accordingly.
Create, fund and execute a public communication/education campaign around LPG and its personal and national benefits	Sensitize and educate consumers regarding LPG safety, costs, benefits, cooking techniques, and smart shopping, to create consumer awareness of LPG and its benefits and public awareness of the national goals embodied in the Plan, and to create improved confidence in industry and among funders that supply-side projects will succeed.

Consider pro-LPG/anti-biomass mandates, where feasible	Pro-LPG/anti-biomass mandates should be pursued, where feasible (politically and practically), to accelerate the biomass-to-LPG transition in the country, and especially if the GoR desires to strive for the NST-1 growth scenario. Examples are: • Policy that most types of public institution transition to 100% LPG for cooking by 2024 • Policy banning charcoal in urban areas; policy banning logging
Continue zero-rating of VAT on LPG fuel, and apply the same to equipment	Expand VAT zero-rating from fuel only to fuel plus equipment, to stimulate additional LPG adoption and use.
Regulatory Environment and Licensing	
Fully implement BCRM per Plan recommendations	As set forth in Volume 3
Link all LPG licensing and permitting to the Plan	Ensure the Plan is followed by industry, by linking granting and renewal of licenses and permits to those projects and firms consistent with the Plan and following its recommendations.
Supply Chain Strategy	
Industrial-grade regional filling plants to displace skids, other small-scale plants	Transition away from small skid-based filling plants to large, structured, industrial-grade regional filling plants, well organized and staffed and equipped with all necessary safety equipment, truck transportation pallets, and safety management procedures. Position the filling plants to be as close as possible to the sales area but also as large as possible to minimize filling costs, management costs, maintenance staff and machine costs, and the safety staff and equipment costs. As a general rule, aim for a minimum filling plant size of at least 25KT/year filling capacity, to minimize filling cost and maximize safety level.
Use depots to serve areas whose demand is not yet large enough to justify a filling plant	When the consumption of the region is less than 10-15 KT/year, have a cylinder depot to serve the region, supplied by palletized trucks from the closest regional filling plant.
1 week of logistical storage at filling plants	Target one week of logistic storage for each filling plant, comprising 2-3 days as spare stock and 5 days as working stock. This high rate of rotation helps to optimize capital costs and keep low the cost of refilling.
Reconsider the national strategic storage reserve strategy to preserve its insurance value while significantly cutting its cost to GoR and to the private sector	Treat 50% of the LPG fuel already in the value chain, which is immediately to be used, as a contributor to the national reserve total. This would eliminate entirely the heavy cost burden on the private sector and cut significantly that cost burden on GoR, while ensuring 3+ months of fuel supply in the national supply chain at any point in time. (This is called "Option 2/Integrated Strategic Storage" in this Plan.) Place the national strategic storage at one central site near Kigali, where LPG consumption will be the greatest, instead of multiple storage sites, as more cost-effective. It could be structured in three expansion phases: 2022, 2024 and 2030.
Evaluate ownership or other GoR interest in a maritime LPG import terminal, for 2027	This will provide additional supply security for the long term and may partially mitigate importation cost volatility. 2027 is the first year in which this is economically justifiable, based on the growth scenarios in the Plan.
Evaluate asset co-ownership and/or importation pooling approaches	These approaches can improve economies of scale in CapEx and operations for Marketers in storage and filling, and negotiation power for importation of LPG into the country. The state could take a role or postion in each.
BioLPG	
BioLPG feasibility study	Pursue a detailed evaluation of the feasibility of a specific Rwanda MSW-to-bioLPG project starting in 2021 amongst the GoR, GLPGP and GTI (subject to funding availability), building on the recent pan-African GLPGP-MECS bioLPG

	feasibility study referenced in this Plan.
Distribution Modalities	
Require or incentivize home delivery by LMCs for all feasible areas	The optimal industry pathway to growth is evidenced, from the demand-side data, to be direct-to-consumer distribution with a home delivery component, wherever possible. The home delivery cost should be borne (directly or indirectly) by the Marketer, not the consumer.
Allow PAYG LPG operators to experiment in the market, subject to full BCRM compliance	The success or failure of PAYG in the market place (at scale) will be determined by whether the PAYG model, for LPG, appeals to a large enough group of consumers who would not otherwise buy LPG via conventional distribution. DFIs may wish to help PAYG LPG companies to carry out pilot programs to do so, noting that each US $1 of support for consumer equipment costs to a "conventional" LMC requires about US $8 to a PAYG company to achieve the same consumer penetration, per pro-forma modelling.
Investment Project Preparations	
Arrange for TA funding for expert advisory to industry for major procurements	Such procurements include: cylinder procurement, LPG bulk and cylinder trucks, pallets and cages
Arrange for TA funding for expert advisory to industry for project preparations	Such projects include the main filling plants, major regional depots, storage facilities.
Financing	
Direct and support the private sector to create bankable business and financial plans for investment, with appropriate expert advisory/TA	Such plans are essential to (i) attract and obtain funding, and (ii) ensure the private sector develops in alignment with the Plan. Such plans should focus on financing the High case, because it provides high LPG penetration by 2024 and 2030 without the pressure of significantly lowering equity rates of return and because it has less credit requirement, especially in the critical early years. The investment projects should be designed for maximum bankability, constrained by preserving the affordability of LPG for the public.
Prioritize cylinders	The most critical asset for expanding LPG adoption and use is the LPG cylinder. Because it is a procurement asset, not a construction asset, cylinder inventories can be rapidly built up and deployed to create new LPG consumers very quickly, if adequate financing is provided.
Mobilize blended capital	For maximum project bankability and lowest risk to grow LPG usage, concessional capital should be immediately mobilized to support approved projects (including cylinders), and to provide TA, with additional capital (including non-concessional capital) to be crowded-in based on the endorsements of the concessional capital providers. Engage with funding groups accustomed to working together to efficiently mobilize financial resources at scale. This includes, for example, DFIs such as AfDB, FMO, IFC, KfW, and OPIC (USDFC) for debt and/or equity capital sourcing; locally active financial institutions such as Development Bank of Rwanda, Bank of Kigali and Kenya Commercial Bank; and other risk mitigation sources such as SIDA and US EXIM.
Structure financing in tranches	Structure the financing needs into three tranches, commencing in 2021, 2025, and 2029, respectively, to allow exposure and risk to be staged for funders as well as industry. • Cylinders: Fund an initial revolver tranche to trigger immediate cylinder investments for the Plan. • Filling plants and pallets: Fund these fixed assets over 7 years or more (as modeled in this Plan). • Bulk and cylinder transport: Fund at 7 years or longer.

Structure an SPV and a Rwanda LPG Financing Mechanism (RLM)	Establish an RLM as an LPG-specific Non-Bank Financial Institution (NBFI) to aggregate transactions, LPG sector financing expertise (as from GLPGP[17] and increasingly from Rwanda), and structure investments and lending to LPG sector entities and modalities in Rwanda. The NBFI institution can also be funded or co-funded through an LPG special-purpose vehicle (LPG SPV) that would allow a variety of blended funding providers to participate in appropriately structured tranches.
Finance transactions in appropriate groupings	Finance the full set of operational assets together as much as possible, due to the synergistic effects between linked investments and the stronger collective collateral position from doing so, especially given the mobile nature of cylinder assets.
Investments should only be made with BCRM fully in place	Consider a major new investment only when it is clear that the regulatory environment has been fully upgraded according to BCRM, with corresponding enforcement capability.
Investments should only be made in alignment with the Plan	Consider a major new investment only when it is clear that the project directly supports the Plan objectives and complies with the Plan recommendations.
Focus on financing Industry Leader LPG firms first (and most)	Select Industry Leaders (as defined in this Plan) for financing priority so that they may lead the development of the sector and create evidence of success, at a high growth rate, that would induce additional financing to be made available to other, smaller firms, and would induce smaller, well-qualified firms to seek such financing as part of follow-on waves of sector growth.
Make enhancements to RBF	Regardless of whether RBF is used to support any other measures, the RBF programme design for the World Bank CCF in Rwanda should be amended to allow LPG cylinders to be included, with the LMC as the counterparty (i.e., the funds intermediary to the consumer) rather than a seller/manufacturer solely of the stoves.
Plan Implementation	
Publicize the Plan	The Plan will set a national direction and set of goals for industry, the public, the financial sector, donors/financing partners, and other stakeholders. Its information content will also assist stakeholders in decision-making about their project plans and activities.[18]
Establish formal M&E	Formalize and institutionalize the ISLE indicators in Rwanda as part of the efforts of GoR, industry, funding sources, and other stakeholders to monitor progress and to create a feedback mechanism to make adjustments to Plan execution and the investment programme over time.

17 GLPGP personnel have designed successful blended capital deployment mechanisms in sectors such as banking, SMEs and MSEs, healthcare, and agri-business in Africa and Latin America. To date, NBFIs for LPG have been proposed for several countries but none has been put into force as of this writing.

18 Subject to funding, GLPGP could partner GoR to conduct one or more Plan implementation workshops with stakeholders, subject also to Covid-19 conditions.

Capacity Building	
LPG capacity building for RURA	Mobilize TA funding for expert advisory to RURA to build its LPG capacity.[19]
Industry/SME capacity building	Mobilize TA funding for expert advisory to industry, via training programs and workshops, to build its management, planning, and execution capacity in connection with the Plan.[20]

Technical recommendations

The Plan also makes a number of technical recommendations. These have not been summarized here, because it requires the context of the Chapters in which they are made to appreciate their application and utility, and it is the text, tables and figures of the relevant Chapters which are intended for close scrutiny by technical experts.

19 GLPGP has done this in other SSA countries, e.g., DRC, where a GLPGP staff person (via United Nations funding) is embedded in the Ministry of Hydrocarbons.

20 GLPGP has done this in other SSA countries, e.g., Cameroon, where in addition to various training programs and audit programs, GLPGP has also (via AfDB funding) focused on empowering women entrepreneurs in the LPG distribution system.

20. Table of Recommended Follow-on Activities and Technical Assistance

The following table describes recommended follow-on programs and technical assistance for implementation of the Master Plan, including quantifying the impacts from, and validating the scalability potential of, a number of initiatives which it was beyond the scope of this Plan to investigate[21]. These are recommended to be funded via technical assistance grant funding, where feasible and where timely, otherwise from the GoR budget, to the extent feasible.

These recommendations would begin to be carried out, where desired by GoR, immediately following the formal public announcement of the national LPG Master Plan.

➲ The highest-priority recommendations, which are time-sensitive, have high strategic importance, and/or are on the critical path for Plan implementation, are highlighted in light blue.

Table 13. Follow-on activites for the Rwanda national LPG Master Plan

Activity	Purpose / Description	Recommended Organizations	2021	2022	2023	2024	After 2024	Notional Budget
Detailed consumer field survey	Quantify specific demand drivers and elasticity of demand to guide fiscal and pricing policies and to target the educational messages and campaign	GLPGP						$120,000
Consumer focus groups	Understand more deeply the consumer perceptions and barriers, to complement the consumer survey	GLPGP						$20,000
National fuels pricing study	Understand competing economics of LPG, CNG, electricity, charcoal/wood (with various stoves) and the effect on LPG consumption and biomass reduction	GLPGP, MININFRA, RURA, MINICOM						$30,000

21 These activities are typically included in the GLPGP Master Plan development process or the immediate follow-on implementation process, but were not undertaken to date due to limitations in the available time and funding and due to the Covid-19 pandemic.

Activity	Purpose / Description	Recommended Organizations	2021	2022	2023	2024	After 2024	Notional Budget
Microfinance pilot programme (500 households)	Prove and quantify how LPG equipment/fuel microloans increase LPG adoption, to demonstrate commercial viability for lenders/LMCs and to prepare for a larger follow-on programme	GLPGP, BRD, EDCL, FONERWA, selected Saccos/LPG operators						$70,000
Subsidy pilot programme (10,000 households)	Prove and quantify how targeted LPG equipment/fuel subsidies (if enacted nationally) increase LPG adoption, to demonstrate effectiveness and to prepare for a larger follow-on programme	GLPGP, MININFRA, RURA, REG, MINECOFIN, MINALOC						$550,000
National educational campaign	Stimulate LPG demand and overcome consumer perception barriers to LPG (for example, as done in India's PMUY programme targeting lower income households)	MINALOC, EDCL, GLPGP						$600,000
Monitoring & evaluation programme	Localization, launch and ongoing M&E, using ISLE framework	RURA, GLPGP, U. Liverpool						$120,000
Procurement assistance(a)	Maximize value from, and efficiency of, sector procurements	GLPGP						
Cylinders(a)								$17,000
LPG bulk trucks(a)								$17,000
Cages and pallets(a)								$11,000
Project technical preparation(b)	Ensure maximally efficient, safe and effective planning, development and execution of strategic projects	GLPGP						
Filling plant(b)								$192,000
Strategic storage(b)								$198,000
Marine terminal(b)								$348,000
Strategic storage roadmap process	Detailed planning of revisions to MINICOM-proposed strategic storage reserves requirement and how to achieve it, in consultation with stakehodlers, including industry and financing sources	MINECOFIN, MININFRA, RURA, GLPGP, private sector						$20,000
Pricing reform process/programme	Detailed multi-stakeholder process to agree on appropriate pricing interventions to ensure optimal balance between LPG affordability and industry profitability/bankability	MINCOM, MININFRA, RURA, GLPGP, private sector						$20,000
Regulation / license revision	Translation of regulatory/legal/standards recommendations into specific legislation, regulations, rules, standards, and industry licensing and permitting terms	MININFRA, RURA, GLPGP, GoR legal advisors						$60,000
LPG capacity building for RURA	Embedded resource in RURA to build up LPG capactiy and knowledge to oversee effectively a much larger sector	RURA, GLPGP						$120,000

Activity	Purpose / Description	Recommended Organizations	2021	2022	2023	2024	After 2024	Notional Budget
BioLPG from MSW scoping study	Detailed scoping study for a first bioLPG plant using Kigali-area municipal solid waste streams as feedstock	GLPGP, GTI, MININFRA, MINALOC, MoE						$200,000
Industry/SME capacity building	Training for local industry participants on LPG operational, business planning, management and safety best practices	GLPGP						$130,000
Detailed investment cases(a)(c)	Facilitate sector expansion and financing by assisting the private sector to create detailed, investment-grade business/investment plans, investment memoranda and presentations for business expansions and new projects aligned with the Master Plan, and to finalize optimal financing structures and modailities	Private sector, BRD, ESMAP, GLPGP						$104,000
Blended finance mobilization(a)(c)	Facilitate investments by introducing private sector players to relevant worldwide funding sources and assisting them to obtain optimal financing for Master Plan-aligned projects and business expansions	MINECOFIN, GLPGP, DFIs (e.g., KfW)						$62,000
Total(d)								**$3,009,000**

Notes:

(a)Budget sized to approx. 5 "Industry Leader" companies receiving such assistance; includes RFQ, tenders, manufacturer consultation, purchase assist, commissioning within each plant

(b)Budget is per project and includes pre-feasibility study, FEED, EPC RFQ, procurement and construction assistance, commissioning

(c)Budget and timeline assumes assistance provided for a first investment tranche only

(d)Does not count multiple projects of same type, e.g., 5+ filling plants

Rwanda National LPG Master Plan

Volume 2

Current LPG Market and Demand Potential

Contents

List of Tables

List of Figures

XI. LPG Market Details

21. Consumer Economics of Cooking Technologies and Fuels

Economics of LPG and other cooking fuels

LPG consumer prices

In the current distribution model for LPG throughout Rwanda (under the branded cylinder recirculation model), customers purchase LPG cylinders from retail shops and then get cylinder refills from both shops and petrol stations.

The retail price in Kigali City was estimated to be an average of 1,060 Rwf/kg based on the RURA report "C*ountrywide supply survey on liquefied petroleum gas"* which systematically collected LPG prices across the nationally territories in 2019 (n= 236 respondents among LPG retailers and petrol service stations). This is the most comprehensive LPG consumer prices dataset available for the country to date. However, the RURA report did not differentiate between LPG prices collected in urban vs rural areas but reported detailed prices by district and by type of shop (retailer vs. petrol station).

To calculate the LPG average end-users prices for urban and rural regions outside of Kigali, districts from the RURA report were classified as 'urban other' and 'rural' to provide a geographical stratification by average price (classification of districts was made the *National Urban Policies and City Profiles* report[22]). Districts with identified urban centres were then compared with information on the proportion of the urban population in each district from the 2012 census. A threshold of 6% or more of the population living in an urban area was used to define a district as 'other urban'.

Accordingly, the average LPG price for 'other urban' areas was calculated as 1,122 RwF/kg and for rural areas as 1,163 RwF/kg – both higher than Kigali city. These values (1,060 Rwf/kg in Kigali City, 1,122 Rwf/kg in other urban areas and 1,163 RwF/kg in rural areas) in 2019 formed the basis of all the scenarios' modelling.

Overall, the national average price of LPG was estimated as 1,115 RwF/kg (averaging local prices across geographies; see Table 14 below). This price was used for the cost-per-meal calculations presented in the *Household cooking economics* section.

Charcoal and firewood prices

To understand the end-user price for charchaol and firewood, data were summarised on self-reported 2020 fuel prices from immediately prior to the start of the Covid-19 pandemic in the CFET national survey.

For firewood, prices were calculated only for participants who exclusively purchased this fuel (n=27.2% of all firewood users). For both firewood and charcoal, price was calculated by dividing the self-reported amount of money spent on the fuel in the past 30 days with the self-reported amount (kg) of the fuel purchased in the same time period. While this data is not fully reliable given that the users do not receive receipts specifing the weight of the firewood or charchaol consumed, it was the best possible data available for national price estimates.

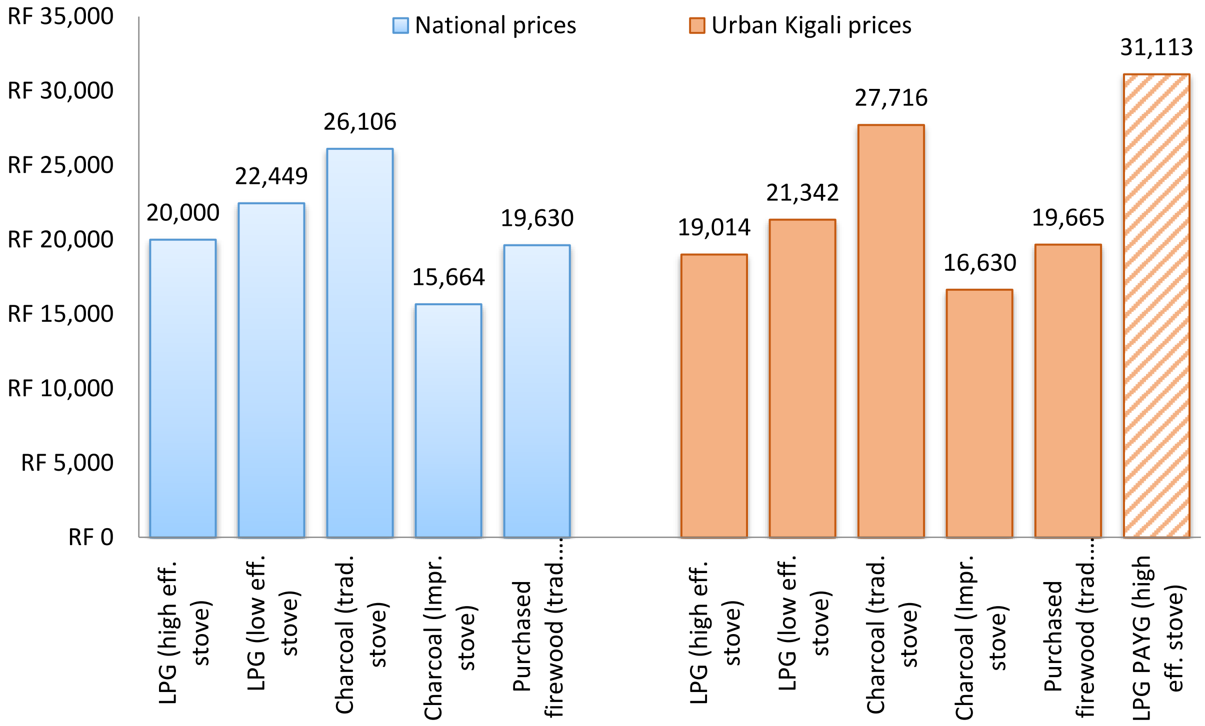
[22] http://www.centreforsustainablecities.ac.uk/research/rwanda-national-urban-policies-city-profiles-kigali-huye/

A summary of reported end-user prices of the three main fuels is presented in Table 14.

Cost of cooking

The cost of daily cooking with different fuels/stove combinations for LPG, charcoal and firewood was then estimated using the average fuel prices for 2019-2020 (pre-Covid-19 pandemic) (see Figure 20, Table 14 and Table 15). The use of this time period eliminates possible temporary distortions in the data caused by temporary Covid-19-related policies and/or supplier and consumer behavior changes.

Figure 20. Monthly household price of cooking with LPG and other fuels/stoves (RwF)



Note: The applied stove efficiencies are reported in Table 14. *Estimates based on field data from average household size of 3.5 members cooking exclusively with each given fuel. The fuel price data reflect prices from before the Covid-19 pandemic and the introduction of an LPG price cap and charcaol ban.*

The average LPG price/kg was based on the RURA report following the methodology described in the *LPG consumer prices* section above. The LPG PAYG prices reflect actual tariff charged to a small set of customers taking part in a pilot PAYG testing by a local Rwandan company in 2020[23]. The charcoal and firewood prices were taken as national averages from the CFET survey for lack of other reliable, official sources (see the *Charcoal and firewood prices* section above).

[23] Data provided by researchers at UCL London, as part of a study being funded by the UK Royal Academy of Engineering, UCL Engineering for International Department (EFID) Center, BBOXX and the Modern Energy Cooking Services (MECS) programme. Stove efficiency for the piloted stove is assumed equal to 55% efficiency to make the data comparable to other double LPG stoves not part of PAYG packages.

The calculation assumed that a typical Rwandan household of 3.5 members cooks a standard meal 2 times a day, requiring 15.16 MJ/day[24] of daily energy delivered to the pot. Global standard net calorific values for the different fuels and thermal efficiency values for typical African stove were used for the analysis (see Table 14). The CFET data indicated that the most-used stoves to burn charcoal are canamake (used by 30.2% of households), metal-clay (25.6%) and *rondereza* (21.2%). Information on actual stove durability in the field were not available in the survey data. For firewood, traditional stoves with low efficiencies (i.e., 15% stove thermal efficiency) were considered; according to data from the CFET survey, 69.4% of households reported using open fires for cooking, followed by open *rondereza* (7.9%) and round mud stoves (5.8%).

Table 14. Data for cooking costs

Fuel/stove combination	Net fuel calorific value (MJ/kg)	Average stove thermal efficiency (%)[25]	Average national fuel price (RwF/kg)	Average fuel price in Kigali (RwF/kg)	Average national fuel price ($/kg)	Average price in Kigali ($/kg)
LPG (high eff. stove)	46.1	55%	1,115	1,060	1.14	1.09
LPG (low eff. stove)	46.1	49%	1,115	1,060	1.14	1.09
Charcoal (trad. stove)	29.5	15%	254	270	0.26	0.28
Charcoal (Tier 1-2 impr. stove)	29.5	25%	254	270	0.26	0.28
Purchased firewood (trad. stove)	15.6	15%	101	101	0.10	0.10
PAYG LPG (high eff. stove)	46.1	55%	N/A	1,800	N/A	1.85

Sources: LPG prices from RURA, 2020. PAYG LPG prices from a commercial pilot programme conducted in Rwanda in 2020. Charcoal and firewood prices from CFET data, 2020. Estimates based on average household size of 3.5 members cooking exclusively with each given fuel. Currency conversion rate: US$ 1= RwF 975.00.

The relative prices of cooking a meal for each main fuel/stove combinations using the national average prices is shown in Table 15.

Depending on the efficiency of the stoves used, the cost to cook a meal using LPG (based on average national prices) is similar to the cost using charcoal in an unimproved stove and to purchased firewood. Charcoal used in improved stoves with an efficiency of 25% or more (varying with ISO Tier) appear to cost less per meal than LPG. However, thermal efficiencies for biomass stoves are influenced in practice by several factors, including correct (or incorrect) stove operation by the user and the quality and dryness of the fuel. As extensively reported in the literature, laboratory-based efficiencies, as stated by stove manufacturers, are

24 This energy consumption data is derived from Rwanda HAPIN trial median consumption data, based on 18 months of cooking with LPG. An individual cooking event is therefore estimated as requiring 7.58 MJ of energy.

25 Average stove thermal efficiencies for biomass stoves are taken from the literature (Obeng et al. 2017, Ekouedjen et al. 2020, and other studies). The stove thermal efficiencies do not reflect firewood burnt in open fires (the least efficient method, with thermal efficiency below 15%). The LPG stove efficiencies were derived from the Shen et.al. 2018 article separating single burner (less efficient) from double burner (more efficient) average stove efficiencies.

not transferrable to the field when used by households for everyday cooking, the moreso over time when the stove is not used or maintained correctly.

LPG becomes marginally less cost-competitive when used with a ring-top burner or low-quality stove, rather than a medium or high quality stove. With the use of screw on top camp valves, fuel inefficiencies also occur due to the inability to control the flame (i.e., the flame is always on maximum, whether or not that is appropriate for the pot or the food). In addition, the distance between the burner top and the pot bottom are also important features affecting the efficiency of the burner[26].

Table 15. Average costs of cooking a meal for LPG and other fuels, nationally

Fuel/stove combination	Cost of cooking a standard meal					
	Once (RwF)	Monthly (RwF)	Annual (RwF)	Once ($)	Monthly ($)	Annual ($)
LPG (high eff. stove)	333	20,000	240,001	0.342	20.5	246
LPG (low eff. stove)	374	22,449	269,389	0.384	23.0	276
Charcoal (trad. stove)	435	26,106	313,272	0.446	26.8	321
Charcoal (impr. stove)	261	15,664	187,963	0.268	16.1	193
Purchased firewood (trad. stove)	327	19,630	235,563	0.336	20.1	241

Note: Estimates based on average household size of 3.5 members cooking exclusively with each given fuel. Currency conversion rate: US$1= RwF 975.00.

The situation changes slightly when average fuel prices for urban Kigali are used (see Table 16). The average LPG price in urban Kigali is lower than in rural areas, while charcoal price is higher than in rural areas, so the relative price of cooking a meal using LPG burnt in double burner stoves becomes cheaper than using charcoal and firewood burnt in tradiional stoves in urban Kigali.

Table 16. Average costs of cooking a meal for LPG and other fuels, Kigali

Fuel/stove combination	Cost of cooking a standard meal					
	Once (RwF)	Monthly (RwF)	Annual (RwF)	Once ($)	Monthly ($)	Annual ($)
LPG (high effi stove)	317	19,013	228,162	0.325	19.5	234
LPG (low eff. stove)	356	21,341	256,101	0.365	21.9	263
Charcoal (trad. stove)	462	27,716	332,597	0.474	28.4	341
Charcoal (impr. stove)	277	16,630	199,558	0.284	17.1	205
Purchased firewood (trad. stove)	328	19,665	235,983	0.336	20.2	242

26 See Sutar et al. 2020.

Fuel/stove combination	Cost of cooking a standard meal					
	Once (RwF)	Monthly (RwF)	Annual (RwF)	Once ($)	Monthly ($)	Annual ($)
PAYG LPG (high eff. stove)	519	31,113	373,357	0.532	31.9	383

Note: Estimates based on field data from average household size of 3.5 members cooking exclusively with each given fuel. Currency conversion rate: US$1= RwF 975.00.

Equipment factors

The up front cost of cooking with LPG is often the main barrier to uptake among low- and middle-income households, given the higher costs (of the stove and the cylinder deposit) needed to adopt LPG compared to purchasing cheaply available charcoal and firewood stoves. Popular stove and equipment prices for all fuels are shown in Table 17. These prices were sourced using a field survey conducted with 89 fuel/stove retailers in September 2020 (see Annex Chapter 78). The costs of improved biomass cookstoves can vary greatly based on the material and manufacturing process.

Table 17. Prices of cooking equipment and estimated durability

	Up Front Payment (RwF)	Up Front Payment (US $)	Durability
LPG cylinder deposit (no gas)			
6kg	32,000	32.8	20 years[27]
12kg	66,500	68.2	20 years
15kg	75,000	76.9	20 years
LPG equipment accessories			
Regulator	5,000	5.1	5 years
Hose (per meter)	1,500	1.5	3 years
LPG stoves			
Camp (screw type) burner	3,500	3.6	1 year
1 burner stove	15,000	15.4	2-5 years
2 burner stove	35,000	35.9	5 years
3 burner stove	40,500	41.5	5 years
PAYG LPG package			
2 burner stove, full 12 kg cylinder, accessories	9,800	10.1	5 years
Charcoal stoves			
Traditional stove	1,500	1.5	1 year
Improved stove	10,000	10.2	1.5 years
Firewood			

27 LPG cylinder durability is assumed for 20 years as cylinders (of any size) are swapped every time a refill is made, with cylinders inspected and maintained or scrapped when needed by the cylinder-owning marketer, and therefore the consumer is immune from the lifespan of the cylinder and its lifetime does not affect these calculations.

	Up Front Payment (RwF)	Up Front Payment (US $)	Durability
Improved stove	15,000	15.2	1.5 years

Note: Prices reflect median values for the most popular cooking equipment identified in a retail survey conducted in 2020. The PAYG LPG pacakge reflects the median tariff applied during a 2020 pilot programme, with a downpayemt (sign-up fee) of RwF 13,500, from which the value of a built-in credit (2kg of free LPG) has been subtracted. Data on manufactured woodfuel stove prices was limited, because most firewood useres rely on three stone fires or mud stoves. Some outlets sold metal fuel-efficient/improved cookstoves distributed by NGOs for RwF 15,000; this amount was used for the calculations in Figure 22. For all stoves, durability can vary greatly depending on the quality of manufacture (usually reflected in the stove price), proper/improper operation of the stove, and proper/improper, regular/irregular/omitted maintenance. Charcaol stove durability can be higher (e.g., 3 years) for metal stoves properly operated and well maintained. The above case reflects Tier 1-2 stoves priced around US $10.2 on average. Currency conversion rate: US $1= RwF 975.00.

Figure 21. Examples of stoves available in the Rwandan market

Traditional charcoal stove

LPG screw on top burner

Double and triple LPG burners stoves

Fuel efficient mud stove

Improved firewood stove

Improved charcoal stove with fan

However, when the initial costs of equipment are considered in relation to the overall fuel expenditure in a year and durability of equipment, cooking with a high efficient double burner LPG stove become cost-competitive in many instances, with an annual cost of around RwF 250,000/year. This level of cooking expenditure is similar to purchased firewood burned in improved cookstoves and is cheaper than charcoal burnt in traditional stoves (see Figure 22). When urban Kigali fuel prices were to be applied, the cost-competitiveness of LPG is even greater. However, the cost advantage of cooking with LPG is reduced when the LPG is burnt using less efficient burners (e.g., screw-top burners).

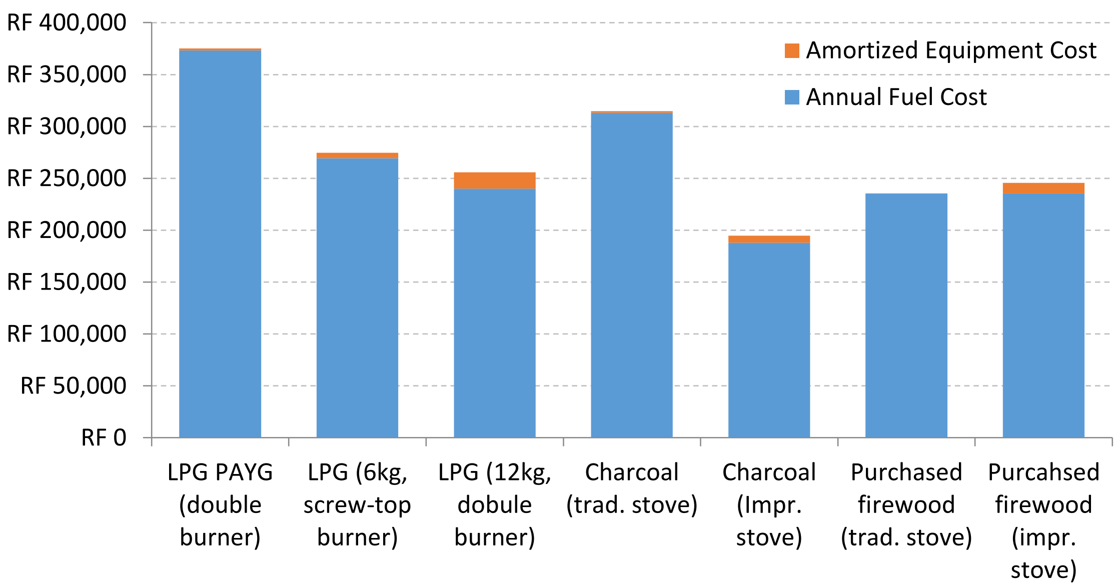
Screw-top burners do not use a regulator, which allows precise control over the intensity of the flame, and ensures that the flame does not quickly diminish in proportion to the LPG in the cylinder being used up.

Without a regulator, gas can easily be wasted when the cylinder is full, by generating more heat than is actually needed. This is especially the case when using LPG to cook slow foods that require lower heat, such as beans. When the flame becomes too low, it also means LPG may cook more slowly or without enough heat, causing consumers to switch to another fuel, or to return the cylinder before it is entirely used up to get a refill. All of these factors increase the cost of cooking with LPG, and are reflected in the lower effective efficiency level of burners that do not operate in conjunction with a regulator.

Finally, the end-user cost of PAYG LPG, as piloted in Rwanda, is uncompetitive with other fuels, and with conventionally sold LPG, when evaluated on a cost-per-meal, cost-per-kg, or cost-per-month basis. Despite this, some consumers in future may be interested in obtaining LPG at PAYG prices for a portion of their cooking tasks, since the up front cost under PAYG is (typically) reduced compared to conventionally sold LPG, and the refill transaction size can be as small as 1 kg rather than, for example, 6 kg or 12 kg. This positions PAYG LPG much more attractively on a day-to-day cash budget basis against fuels, like charcoal, which are routinely purchased in daily amounts by some households.

The extent to which Rwanda consumers will be willing to utilize LPG on a PAYG basis, against using charcoal or firewood with a traditional or improved stoves, remains to be seen. In Kenya, where PAYG LPG companies offer LPG at a more modest price premium per kg against conventional LPG due to competitive market pressures, the scale of PAYG use remains small: 10,000+ customers, against millions served by conventional LPG business models and technologies.

Figure 22. Annual cooking cost by fuel and stove, including equipment cost (RwF)



Cylinder choices

A consumer's LPG cylinder choice is determined by multiple factors such as availability in the market, affordability, ease of transport, ease of use, and longevity of use.

Because of the cost structure in cylinder manufacturing, there is only very modest difference in cost between smaller and larger residential cylinders. Therefore, the deposit paid for the cylinder by the consumer is not a major factor in the choice of cylinder.

The market has cylinders in assorted sizes as follows: 3kg, 6kg, 9kg, 12kg, 13kg, 15kg and 20kg intended for residential users, and various larger sizes intended for commercial and institutional settings. Figure 23 shows examples from the range of cylinders available in Rwanda (left) and a typical retail outlet in Kigali (right).

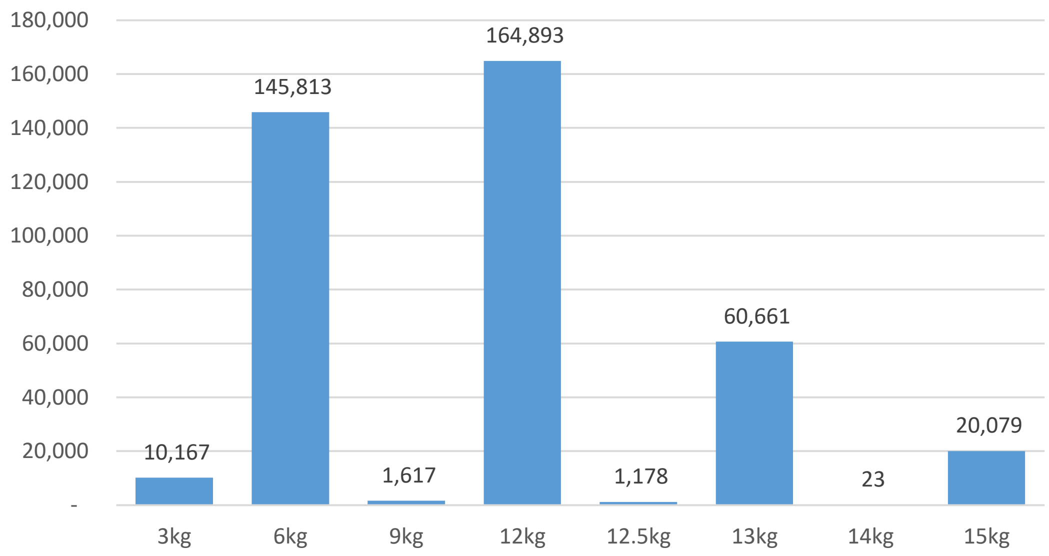
Figure 23. Examples of LPG cylinders in Rwanda and retail display

6kg,12kg,15kg, 20kg and 50kg cylinders (from SP)

Cylinder display in an LPG retail outlet

Data on imported cylinders between 2015-2019 indicates that the market preference is for the 12kg cylinder, closely followed by the 6kg, as shown in Figure 24 below.

Figure 24. Residential LPG cylinders imported 2015-2019



6kg cylinders

The 6kg cylinder is a good package for households using LPG for the first time, due to its ease of assembly and relative robustness. The first-time user requires only a screw type burner and a trivet stand, commonly referred to as a grill. Under the usual set-up, there is no need for a regulator, a hose-pipe or separate burner.

Refilling the cylinder is relatively affordable, and carrying the cylinder when filled is not cumbersome.

The disadvantages of this cylinder package are:

- The use only cooks one meal at a time, which is likely to encourage fuel stacking;
- Lack of a regulator means the gas comes out at its highest pressure, suited for dishes requiring high pressure, but wasteful for meals that need to simmer, such as beans;
- Lack of a regulator also means flame control is not easy, further compounded by the affixed burner, which has no minimum flame setting (pilot light).
- The cylinder valve has no safety relief, which creates a possible safety concern.

Upon prior arrangement with the cylinder importer, an LPG marketer can have the 6kg cylinder fitted with a standard valve that can take a regulator and be used with a double-burner stove connected by hose. This assembly is convenient but has not been promoted by the LPG marketing companies in Rwanda, because it tends to compete with the easily assembled 6kg. UNHCR has been supplying such a cylinder to refugees in Rwanda.

12kg cylinders

The 12kg cylinder requires a a regulator, a hose and a separate stove, usually with multiple burners. The ability to have two or four burners makes it appealing for families, because they can cook two or more dishes at the same time.

The presence of a regulator allows controlled flow of gas. Because the LPG cookstoves have a flame adjusting knob with maximum and minimum settings, the flame control with this cylinder is easy and precise. These two factors make the usage of LPG in the bigger cylinders considerably more efficient and economical. (This is seen in the comparative cost of cooking chart in Figure 22 above.

By design, most of the valves fitted in such cylinders also have a pressure relief valve. This releases LPG in case the cylinder is exposed to high temperatures that raise the internal pressure of the LPG. This makes the larger cylinders safer than the 6kg (and smaller) cylinders.

Users may also prefer that the LPG refills last longer with the 12kg size than with a smaller cylinder, allowing for better planning and (absent home delivery) fewer trips to a retail point. (Either way, it is a disadvantage if the LPG runs out before the household is ready to get or to request delivery of a replacement cylinder.) The available data do not quantify the presence or extent of this preference in Rwanda.

The disadvantages of 12kg against 6kg are the higher up front outlay for the complete user equipment package (including the fuel in the cylinder) and that a 12kg cylinder is heavier to carry to and from a retail point (absent home delivery). A filled 12kg cylinder made from steel weighs around 25kg.

3kg cylinders

The 3kg cylinder is similar to 6kg from the consumer's point of view. It requires a screw-type burner. 3kg cylinders are delicate compared to the larger ones. They cannot handle large pots or dishes that require vigourous stirring.

Table 18. Characteristics of different cylinder sizes

Requirements	3kg	6kg	12kg (and larger)
Assembly	Easy	Required regulator, hose pipe and a separate	Specialised, especially first time

Requirements	3kg	6kg	12kg (and larger)
Empty Weight	5kg	8kg	13kg
Filled Weight	8kg	14kg	25kg
Ability to carry	Easy	Easy	Not easy
Cost of Refill (RwF)	3252	6,504	13,008+
Type of burner	Single burner, mounted on cylinder	Single burner	Double or four-burner cookstove
Regulator	None	None	Yes
Hose	None	None	Yes
Current presence in Rwanda	1%	47%	52%

It might be assumed that the 3kg cylinder, due to its lower deposit cost and smaller refill transaction size, would be highly popular with consumers, but this is not the case. (This is consistent with the situation in the rest of East Africa, where the 3kg cylinder (see Figure 23) has failed to attract significant sales and is usually acquired by consumers for lighting, not for cooking.)

LPG filling plant operators prefer cylinder sizes that are possible to fill interchangeably on the same filling equipment in the plant. In this way, filling plants can spread their filling equipment costs over multiple sizes of cylinder and simplify their operations, scheduling, maintenance and training. 6kg and larger, as long as a standard valve type is used, can all be filled on the same equipment, but not 3kg cylinders. 3kg cylinders require separate filling equipment on a separate filling line. 3kg cylinders also incur higher logistics costs per tonne of LPG sold than larger cylinders do. For those reasons, industry tends to avoid investing in 3kg cylinders in any market where 6kg or larger cylinders have demonstrated strong consumer demand and acceptance.

22. Institutional Market Segments

Public institutions segment

This segment comprises non-commercial public sector institutions including (i) prisons, (ii) police stations with temporary detention centres, (iii) schools (day schools and boarding schools), (iv) healthcare facilities (including hospitals and health centres) and (v) military barracks. Catering institutions such as hotel and restaurants are treated as 'commercial' users of LPG and described in the following section.

Data on cooking fuels/energy sources information were available for a number of non-commercial institutions from the CFET survey (see Table 19) as well as from UNHCR for refugee camps.

Table 19. Annual cooking fuel consumption in selected institutions

Institution	Achieved sample	Firewood (Kg)	Briquettes (Kg)	Biogas (m^3)	LPG (Kg)	Electricity (KWh)
Prisons	12	2,212,600	11,542,560	140,832	30	
Police stations	31	1,764,456			163,860	
Military barracks	6	1,803,744			89,280	
Boarding schools	82	48,127,740			18,996	31,356

Source: CFET, 2020

Prisons/correctional facilities

The Rwanda Correctional Service (RCS) has 13 correctional facilities in the country[28], with an inmate population of around 70,000 in 2020. The facilities use a variety of fuel/energy sources including biogas. All 13 prisons have large onsite biodigesters installed[29], contributing to improved sanitation and reduction of cooking-related biomass use. According to the RCS information, biogas accounted for only about 40% of the cooking energy needs of prisons in 2020, with the remaining energy sources involving biomass fuels: briquettes, rice husks and sawdust (approximately 50%) and firewood (approximately 10%) (reconfirmed by CFET data). There is planning for this biomass reliance to be progressively phased out in favour of LPG.

Police detention centers and military barracks

Rwanda has 220 temporary detention centers with 8,000 monthly-detained individuals in 2020 (RCS communication). The maximum detention time is up to 72 hours (Rwanda Criminal Code, 2003). The CFET survey obtained data from about 14% (n=31) of these detention centers and reported current use of LPG of 163.8 MT. As per RCS data, 9,114 police officers already had access to LPG for cooking in the facilities in 2020[30].

28 See http://197.243.22.137/rcs/index.php?id=4

29 See https://cleanleap.com/rwanda-biogas-prisons-saves-millions-dollars

30 RCS communication

Information on military barracks and the domestic arrangements of populations living in the barracks is limited. According to 2016 data, the Rwanda defence force was estimated to be 33,000 individuals, all assumed to be residents of military barracks[31].

Schools

According to Ministry of Education data, in 2018 there were 3,225,699 day schools pupils from 3,210 nursery schools (226,706 pupils), 2,909 primary schools (2,503,705 pupils) and 1,416 general secondary schools (495,285 pupils) including boarding schools (163,038 pupils, accounting for 33% of all secondary schools) (MINEDUC, 2018).

The availability of school feeding programs in 2018 varied across school categories (MINEDUC, 2018). During this year, the proportion of nursery schools participating in a school feeding programme was 19.5% with 13.7% having a 'nutrition garden'. By comparison 13% of primary schools participated in school feeding programs representing 7.3% of all primary school students. The proportion of secondary schools with school feeding programmes was much higher with 68% participating representing two-thirds of all secondary school pupils.

Rwanda is now moving into adopting a universal school-feeding programme to ensure all school kids can receive at least one a meal/day in all day schools. It is expected that this target will be achieved in 2021. No official information is available on fuel/energy usage for different types of schools, except that 2.8% of secondary/boarding schools and under 0.4% of primary/nursery schools report having a biodigester installed.

Health care facilities

To date, Rwanda has a total of 20,399 bed facilities available across the national territories[32]. Of these, 9,064 are in the 48 national, provincial and district hospitals and 11,335 in the 500 health centres (Table 20). No official information is available on fuel/energy usage for these institutions.

Table 20. Rwanda healthcare facilities and bed capacity, 2020

Type of healthcare facility	Number	Beds	Average number of beds / facility
National referral hospitals	7	2,189	312.7
Provincial hospitals	4	682	170.5
District hospitals	37	6,193	167.4
Health centres	500	11,335	22.7

Refugee camps

As of 2019, the refugee population in Rwanda was 158,550 refugees. This is expected to grow to 163,553 by the end of 2020 based on the UNHCR *Rwanda Country Refugee Response Plan (2019-2020)'* projections[33]. New arrivals from Burundi are received in four reception facilities and those unable to live independently in urban settings are transferred to the Mahama camp, the newest and largest refugee

31 IISS (2016). The military Balance 2016. Routledge.

32 Ministry of Health, 2020

33 See https://reliefweb.int/sites/reliefweb.int/files/resources/69632.pdf

camp in the country, located in the Eastern Province[34]. Mahama was set up in 2015 and counted 58,575 refugee individuals (or 18,345 households) as of November 2020[35]. This makes Mahama the sixth largest urban settlement in Rwanda.

In October 2018, the Government of Rwanda (GoR) issued a directive to stop the distribution of firewood in the refugee camps, in order to transition to alternative clean cooking solutions and stop deforestation[36]. There was, therefore, an urgent need to scale up substantially the use of alternative sources of energy such as LPG, pellets and briquettes as the main source of cooking fuel provided by UNHCR in the camps. Targets were set under the energy and environment response to have 100% of camp-based refugee households with access to sustainable energy in 2020 (UNHCR *Rwanda Country Refugee Response Plan 2019-2020*). With the support of energy experts from UNHCR headquarters, the various alternative solutions available on the market in Rwanda were reviewed and a decision made to use a mix of briquette and pellet fuel solutions in the smaller camp populations and LPG in the largest refugee camp (Mahama).

As of July 2019, the population of the Mahama camp was receiving LPG for cooking, including the largest schools in the camp. A small LPG storage tank (1.2 MT) was installed in the camp. LPG cooking equipment (6 kg cylinder with screw-on top burner) is given in a sharing modality; only larger households (over 5 members) receive cylinders for their exclusive use. The amount of LPG provided by UNHCR and consumed by the refugee population in 2020 was estimated as 1,390 MT (including all reception centers that also started to use LPG). Any of the cooking energy needs unmet through LPG (given the current cap on the available amount per family) are met with biomass, particularly charcoal. The biomass fuel is used mainly for cooking foods of long durations, such as beans.

UNHCR reports that prior to the start of the LPG programme there were reports of young girls falling victim to sex- and gender-based violence (SGBV) and of deaths by drowning in the Akagera river occurring when the girls collected firewood outside the camp. Since the start of the LPG programme, there have been no reports of SGBV, nor any accidents or injuries connected to cooking fuel collection[37].

Refugees resident in other camps, who continue to rely firewood for their cooking energy needs, burn firewood in three-stone open fires and mud stoves. This exposes them to very high levels of household air pollution (HAP) (in addition to often fetching firewood illegally in camp surroundings)[38]. Based on data reported in the Practical Action 2020 study *Ensuring Refugee Camps in Rwanda have Access to Sustainable Energy, by Practical Action,* refugee women in the country spend more than three hours per day on cooking and related activities, of which 45 minutes per day is for collecting and preparing fuel.

Commercial institutions and industrial users

This segment includes commercial entities in the forms of restaurants, hotels and other industrial uses of LPG.

34 See https://www.unhcr.org/rw/14222-mahama-refugee-camp-is-taking-a-stepwithrefugees.html

35 UNHCR communication

36 UNHCR Global Compact on Refugees, 2020

37 UNHCR field report, 2019

38 Practical Action, 2020. Ensuring Refugee Camps in Rwanda have Access to Sustainable Energy

Hotels and restaurants

The CFET survey obtained fuel use information from 204 restaurants and 118 hotels across all provinces of Rwanda. According to the CFET information, charcoal met 49.7% of energy demand in the sampled hotels, followed by LPG (32.4%), firewood (16.7%) and electricity (1.2%). LPG use in the surveyed hotels totaled 1,337 MT. In restaurants, the predominant fuel used was also charcoal (69.3%), followed by firewood (18.5%), LPG (11.6%) and electricity (0.5%). LPG use in the surveyed restaurants totaled 1,359 MT.

Given that no further data were available regarding existing LPG consumption for this category of commercial institutions, the total measured consumption in the surveyed restaurants and hotels – 2,697 MT – was used the starting LPG volume for 2020 to model commercial-institution demand projections.

Industrial users

This segment is dominated today by a single company, today, Africa Improved Foods, which switched to the use of LPG in place of diesel for power generation at its facilities. Its LPG use is estimated as 3,600 MT for 2020.

Other industrial categories may also be good candidates for using LPG as a heat source in place of biomass, such as the tea industry and the brick-making industry[39]. Although data on companies in these sectors was not obtainable, they could be encouraged to explore the viability of switching to bulk LPG, using the procurement experience of industrial usage leaders like Africa Improved Foods as a guide.

39 Additional high-level information on industrial LPG applications has been gathered on a worldwide basis by the World LPG Association; see https://lpg-apps.org/index.php?mact=LPGApi,cntnt01,sector,0&cntnt01sector_id=1&cntnt01detailpage=general-applications&cntnt01returnid=17

23. Additional Demand Factors

In addition to the drivers of demand discussed in Volume 1 Part II, stakeholder consultation with local LPG licensed marketers and other stakeholders indicated several current and historical barriers that have hindered LPG market growth. Those commonly cited as important were as follows:

- Factors which increase the initial cost of LPG equipment for consumers, such as a historical 25% customs duty on imported LPG equipment;
- Consumer concerns about LPG being safe to use;
- Consumer misinformation about LPG, for example about its cost to cook a meal, its benefits, how to use it safely and efficiently, and its overall safety profile (noting that improved national LPG safety in actual fact, under well-implemented BCRM, will over time improve consumer perceptions of safety);
- Poor quality of imported LPG cookstoves, which contributes to a consumer viewpoint that LPG is unsafe and/or inefficient to cook with;
- Pricing power exerted by larger LPG companies (from the viewpoint of smaller LPG companies); and
- The role of certain staple foods, such as beans, in the Rwanda cusine. While the available Rwanda national survey data did not include household dietary information, data collected in a study led by researchers at UCL in 2020 (pre-Covid-19) indicate that PAYG LPG users in urban Kigali continued to cook beans on charcoal stoves instead of using LPG[40]. Similar findings are observed among refugees in Rwanda'a Mahama camp and in other countries' refugee camps who have a monthly quota of LPG assigned to meet all cooking needs. Pre-soaking of beans, which can greatly shorten cooking times and save energy, is not yet a common practice in Rwanda. Conversely, when Rwandan households do cook their beans using LPG, their LPG usage increases, displacing additional biomass fuel and increasing per-household/per-cylinder income to the LPG marketer.

Other LPG counterfactors

As part of GoR efforts to reduce the use of inefficient biomass-based cooking from 83% of households in 2017 to 42% by 2024, GOR will promote improved cooking solutions such as LPG, biogas, pellets, briquettes, and improved biomass cookstoves[41]. These other solutions may compete with LPG in some cases, as described below. The more successful these competing solutions are, the less LPG is likely to be adopted.

Improved cookstoves (ICS)

As part of programmes under the Biomass Energy Strategy, GoR will promote ICS by (a) supporting ICS producers to cope with market requirements, (b) setting up testing centres, (c) encouraging production of ICS through tax exemptions, (d) encouraging importation of ICS through reduced import duties, and (e) establishment of financial support and microfinance schemes as guarantees to, and/or in support of, consumer purchases of ICS. All these initiatives will tend to tilt the playing field against LPG adoption and use

---

40 Study funded by the Royal Academy of Engineering, BBOXX, UKAID MECS and UCL Engineering for International Development Centre

41 Biomass Energy Strategy 2019-2030

where they compete for the same consumers, unless the same sorts of programmes are also developed for LPG.

Compressed natural gas (CNG)

GoR is pursuring the possibility of using methane in the form of CNG from Lake Kivu in the medium term as a cooking fuel[41]. Gasmeth Energy Ltd, per agreement with GoR, is progressing a project to extract methane gas from Lake Kivu and process it into compressed natural gas (CNG)[42].

CNG can in principle substitute for LPG in appliances, with a flow adjustment to adapt the fuel-air mix.

However, there are two main reasons that CNG would not be expected to displace LPG for cylinder-based applications. These stem from the different physical and chemical properties of the two fuels:

Table 21. CNG and LPG properties compared

Properties	**CNG – Methane**	**LPG – Butane**
Chemical formula	CH_4	C_4H_{10}
Energy content	9MJ/L	28MJ/L
Storage pressure	20-25 MPa	0.115-0.230 MPa
Air:gas combustion ratio	10:1	31:1
Operating pressure	1.1 kPa	2.7 kPa
Relative empty cylinder weight	1	3x
State at room temperature	Gas	Liquid or Gas

Source: WLPGA

The outcome of these differences of properties is that LPG stores much more energy per unit volume than CNG and requires significantly less storage matter (steel) per unit of volume. LPG has triple the energy density and requires only one third of the container weight. These factors make CNG uneconomic to distribute to households compared to LPG, all else in the household being equal.

42 Sources: African Energy, Issue 386, 14 February 2019; Reuters, 5th February 2019

24. LPG Importation Routes

Dar es Salaam, Tanzania

Tanzania has rapidly expanded the LPG receiving terminals in the last two years. Reports indicate a total receiving capacity of 17,000 MT, with those operational shown in Table 22 below.

Table 22. Operational LPG receiving facilities in Dar es Salaam, 2019

S/N	Name	Physical Location	Capacity (MT)
1.	Taifa Gas	Kigamboni, Dar es Salaam	7,450
2.	Oryx Gas Tanzania Limited	Kigamboni, Dar es Salaam	3,100
3.	Manjis Gas Supply Limited	Kigamboni, Dar es Salaam	2,900
4.	Lake Gas Limited	Chumbageni, Tanga	1,050
5.	Lake Gas Limited	Kigamboni, Dar es Salaam	750
6.	Oilcom Tanzania Limited	Kurasini, Dar es Salaam	500
	Total		**15,750**

Note: The following recent changes have occurred in the import storage at Dar es Salaam and are reflected above: Taifa Gas: two facilities of 50 MT and 23 MT (total 73 MT) are no longer operational; Oryx Gas: one facility of 1,250 MT is no longer operational; Cam Gas: one facility of 100 MT is no longer operational; Manjis: added 200 MT storage.

In Tanzania, the berthing facilities are at Dar es Salaam Port, Tanga Port and Mtwara Port.

The Dar es Salaam port consists of:

- Single Point Mooring (SPM), capacity of 150,000 DWT (deadweight tonnage) used for offloading diesel and crude oil;
- Kurasini Oil Jetty 1 (KOJ-1) capacity of 45,000 DWT for petrol and Jet A-1 offloading;
- Kurasini Oil Jetty 2 (KOJ-2) for offloading LPG and vegetable oil, can handle a maximum capacity of 38,000 DWT

Tanga's berthing facility can handle a maximum capacity of 5,000 DWT including LPG, and Mtwara berthing facilities are capable of handling a maximum capacity of 40,000 DWT.

As of 2020, LPG imports in Tanzania can only be received at KOJ-2 and Tanga.

For Tanzania, the *Mid And Downstream Petroleum Sub Sector Performance Review Report For Year 2019* indicates the total operational LPG import storage in Dar es Salaam is 15,750 MT. Tanzania operates a Bulk Procurement System (BPS) to ensure best possible pricing of imported LPG. Its requirements include that all LPG imports be through the BPS, but this is not yet fully the case. The Tanzania Ministry of Energy is working with stakeholders on how best to implement full importation of LPG through the BPS.

As of December 2019, there are five companies with LPG import facilities in Dar es Salaam. These are Taifa Gas (formerly Mihan Gas), whose storage capacity is largest, followed by Oryx Gas, the Tanzania market leader by volume. Oryx Gas has sisters companies operating in Rwanda and other East African countries. Lake Gas Ltd, part of the Lake Petroleum Group, owns an import terminal and storage facility located in Tanga and is active in Rwanda.

Mombasa, Kenya

Kenya has two LPG import terminals: the Shimanzi Oil Terminal (SOT) and the Africa Gas and Oil Ltd (AGOL) Terminal. SOT is an older terminal. Its LPG infrastructure was developed in the 1990s when demand for LPG first exceeded the local production from Kenya Petroleum Refineries Ltd (KPRL). SOT is owned by the Kenya Ports Authority (KPA), and has LPG pipelines connecting four major marketers (as well as KPRL) with a combined storage capacity of 2,500 MT. See Table 23 for the summary of LPG import terminals in East Africa (Mombasa, Dar es Salaam and Tanga).

Due to the small storage capacity connected to SOT, the importers who use the facility to import LPG usually supply only their own needs and are unable to offer competitive prices to the export market.

The newer facility, AGOL, is privately owned import storage with a storage capacity of 20,500 MT, and is currently expanding by an extra 10,000 MT.

This situation has given AGOL a dominant position at the starting point of the East African LPG supply chain. (LPG shipped to Dar es Salaam is trans-shipped first at Mombasa.)

AGOL's trading arm, One Gas, is the main bulk supplier from Mombasa, supplying Kenyan LPG marketers as well as LPG marketers in neighbouring countries, including Rwanda. RURA records indicate that One Gas, licenced in 2020, is already the leading importer in Rwanda. One Gas offers the Rwanda market a delivered price quoted in local currency. For instance, the September 2020 price was quoted at RwF642,000/ MT. At the exchange rate of US $1=RwF 975, this indicates a mark-up of US $303MT above the September 2020 Saudi CP of $358/MT[43], for a landed price of $661/ MT. (See Table 25 for the indicative price build-up of Rwandan LPG.)

One Gas Ltd utilized an affiliated company, Mackenzie Maritime EA Ltd[44] for the bulk LPG transport to Rwanda.

Table 23. Summary of LPG import terminals on the East Africa coast, 2019

Import terminal	Capacity in MT	Remarks
Shimanzi Oil Terminal (SOT)[45]	2,620 MT	Storage shared by 4 companies
AGOL -Miritini	20,000 MT	Expanding to 30,000 MT
Dar es Salaam	15,750 MT	Some facilities not operational
Total available import storage	38,370 MT	11 rotations in 2019

43 Saudi CP has been at a historical low in 2020 due to the effects of Covid-19 on global and regional LPG trade.

44 See https://www.mackenzie.co.ke/about-us

45 SOT is connected to storage tanks owned by major marketers in Kenya: Vivo-520 MT, Hashi-410 MT, Oilibya-200 MT and Total 240 MT as well as to the now defunct Kenya Petroleum Refineries Ltd, which has a total capacity of 1,250 MT. *Source:* GLPGP (2019), National Feasibility Assessment: LPG for Clean Cooking in Kenya. New York: The Global LPG Partnership.

Once the 10,000 MT AGOL expansion is completed, the total import storage on the East Africa Coast will be 48,370 MT. At the 2019 level of demand, the rotation rate, a key efficiency measure, will decrease from 11 rotations per year to 9 rotations.

Kenya Ports Authority (KPA) is currently constructing a new import terminal for oil products, Kipevu Oil Terminal (KOT), which will include an LPG pipeline. The LPG pipeline will be a 1.2m undersea pipeline with a common user manifold in the mainland, located in KPC land and with access to the railway line. KPC has had plans to build an LPG import and storage terminal in order to enable the Kenya government to manage LPG imports in the same manner that other petroleum products are imported, i.e., via its Open Tender System (OTS). OTS is designed to minimize import prices of petroleum products. It is expected that the new KOT pipeline will be accessible to all marketers that are able to connect to the common user manifold and store the imported LPG.

So far, KOT is the only public facility anticipated to be ready in the near term to serve the regional market, but it will require either private sector or state-owned KPC to develop the needed storage capacity to receive and store the imported LPG.

As of September 2020, LPG importers in Rwanda do not have formal contracts with Kenya and Tanzania suppliers. Instead, they buy on spot, attempting to secure the lowest price available, taking into account differences in transport costs between the two countries. The LPG pricing in the region is built up from the Saudi CP butane price, with Mombasa pricing based on the current month’s price while Dar prices are based on the previous month’s price (CP- 1 month).

The government of Rwanda is reported to own land in Mombasa which might be used for storing imported LPG. The location of the land has not been provided.

➲ It would be important to evaluate the feasibility and net benefit of having a Rwanda-owned (or leased/rented) LPG tank connected to KOT, as well as certain other approached as presented below. Some Rwandan marketers indicate they would consider operating the Government storage facility pursuant to an appropriate agreement. Prioritizing the KOT evaluation is justified because KOT is the only public facility anticipated to be ready for development in the near term.

Among the potential advantages of this are achieving a better price (based on Saudi CP) through disintermediation and through a larger combined volume; greater opportunity to take advantage of spot market prices when they fall; avoidance of some or all local TVA and customs duties.

Additional options which could be studied, beyond the scope of the present Plan, could be

- Utilize Rwanda-owned floating storage, as AGOL presently does in Mombasa, connected to an on-shore buffer tank to load LPG bulk trucks;
- Rent part of the volume in an existing ocean import facility from a Kenyan or Tanzanian importer that has overcapacity (if one actually exists) and could benefit from Rwanda’s added volumes to help negotiate for better import pricing;
- Construct new shared storage with an existing operator interested to expand and capable of benefitting in its price negotiations from Rwanda’s added volumes;

- Construct a wholly-owned new, complete, independent ocean storage facility and assume operational responsibility of this storage.

The number of questions that must be considered before any one option can be determined as the best option is significant, and should be part of the feasibility evaluation.

Preference for Tanzania route

Rwandan LPG marketers with their own bulk trucks stated a preference to obtain LPG from Dar es Salaam. In addition to the longer distance, and the need to cross two countries, the bulk LPG transport in Kenya has many non-tariff barriers. The two most often cited are:

- Regulatory requirements, including a requirement for GPS tracking for bulk LPG trucks; and
- Multiple weighbridges that delay the trucks.

Evolving import strategies of LPG marketers

Leading Rwanda LPG marketers are making efforts to integrate into bulk transport to reduce their cost structure, as compared to purchasing services from independent trucking companies. A typical structure is for the marketer to have a product business entity and a bulk logistics entity under common ownership and/or common control.

Risks cited in association with LPG importation

Supply reliability

Interruptions in supply have occurred, if very rarely. In 2011, an LPG ship was hijacked off the East African coast. Due to the then-limited LPG storage available at the coast, the delay of this ship created product shortages that affected domestic consumers and manufacturers. In the decade since, coastal and inland storage in Kenya and Tanzania has increased significantly, and the impact of such an event today would be expected to have no or very limited effect.

Road logistics issues and considerations

Today and for the foreseeable future, imported LPG will come to Rwanda by road. There are plans to have LPG rail wagons, but these remain remote considerations. Road travel has inherent risks of delay due to mechanical and weather issues, and (particularly on the Kenya route) regulatory compliance issues for both the truck and the driver.

Border crossing can also face political and governmental risk under certain conditions. For example, in May 2020, LPG deliveries attempting to cross the border between Tanzania and Rwanda experienced unprecedented delays due to differences in the two countries' approaches to the COVID-19 pandemic.

Natural calamities, such as the wash-out of the bridge at Rusumo in March 2020[46], can also delay deliveries.

Specific to the Kenya route, weighbridges in Kenya and Uganda add to transport time, increasing the cost

46 See https://rba.co.rw/post/Over-50-Rwandan-trucks-are-stuck-following-a-bridge-collapse-in-Tanzania

structure for such imports.

Also specific to Kenya, non-tariff barriers are an increasing reason cited by some Rwanda LPG marketers to prefer the Tanzania import route. The newest LPG regulations in Kenya, the Petroleum (Liquefied Petroleum Gas) Regulations of 2019, referred to as Legal Notice 100 of 2019, were enacted to implement measures to crack down on illegal LPG market activity, such as cylinder piracy and illegal cross-filling of cylinders. These new regulations affect not only Kenyans but also non-Kenyans. Every driver of an LPG truck, as well as each truck that transports LPG, must be licenced in order to do so within Kenya.

➲ It is recommended for RURA to have negotiations with EPRA, Kenya's regulator, so that RURA-licenced vehicles are allowed to transport LPG within Kenya with a waiver of the aforementioned Kenyan regulations, provided that the LPG in question will not be sold or used in Kenya.

Thus, although technically a Rwandan company can import LPG from Tanga in Tanzania and pass through Kenya, cross-border barriers specific to Kenya make it a less attractive option. (The Kenyan LPG importer One Gas Ltd, which started operations in Rwanda in 2020, was largely able to overcome these barriers.)

Another non-tariff barrier is different side-of-the-road rules: Rwanda drives on the right side, while the rest of East Africa drives on the left. For very experienced drivers, this is not much of a problem, but it does have a safety implication, because drivers of any level of experience must switch from driving on the left to driving on the right when crossing into Rwanda. Obviously, the placement of the vehicle's driver controls remains fixed.

Table 24. Return distances from Kigali to LPG storage terminals at the EA Coast

Route	**Distance (one way)**	**Non-stop (time required)**
Kigali-Dar (KOJ)	1,459 km	25 hours
Kigali-Tanga (Lake)	1,353 km	25 hours
Kigali-Miritini (AGOL)	1,635 km	28 hours

Maintaining strategic flexibility in importation options

Because some of the important conditions from Kenya and from Tanzania could change in future, it is important to maintain optionality; one route should always be maintained as a backup or complement to the other. This benefits both negotiation by buyers with the maritime importers and optimizing of import costs and supply reliability amongst the options.

25. Price Structure Detail

The following table summarizes the cost build-up from importation to the consumer.

Table 25. LPG cost build-up
in USD per MT; values approximate due to local spot-market negotiation of transfer prices

Pricing elements	**From Tanzania (USD)**	**From Kenya (USD)**
Base import price index (changes monthly)	Saudi CP	Saudi CP M-1
Saudi CP value (e.g., November 2020) (USD)	440	380
Ocean transport (may be marked up by trader) (USD)	60	60
Port Charges (charged in local currency)	10	10
Petroleum Development Levy (Kenya) (charged in KSh)		4
Railway Development Levy (in KSh)		6.6
International trader's margin (quoted USD, paid TSh or KSh)	100	100
Transport to Rwanda (if Kenya/Tanzania firm, paid in USD; if in-house, in RwF)[47]	180	180
Road Tolls – Kenya (in KSh) and Uganda (Ush)		14
Road Tolls – Tanzania (in TSh)	7	
Miscellaneous charges (KSh, USh, TSh)	10	10
Subtotal: Landed cost to Rwanda importer	*807*	*765*
Margin between landed cost and wholesale price (in RwF)	75	117
Margin between wholesaler and retailer (in RwF)	82	82
Margin between retailer and consumer (in RwF)	140	140
Total: End-user price (in Kigali) (in RwF)	**1,104**	**1,104**
Kigali regulatory price cap (since May 2020) (in RwF)	*1,084*	*1,084*
Home delivery charge (in RwF)	~25	~25
Average end-user price increase vs Kigali in other cities	+109	+109
Average end-user price increase vs Kigali in rural areas	+435	+435

Source: https://3mgas.vn/news/saudi-aramco-lpg-prices-per-metric-tonne-mt-n148.html

47 Prices with independent road logistics providers are negotiated case by case, with standard prices usually reset from time to time based on internal pricing and foreign exchange formulae.


Charcoal for sale
Photo credit: GLPGP

XII. Scenarios of LPG Demand

26. Market Segments

Household segment

Baseline LPG consumption for household cooking in Rwanda in 2020

Rwanda had a population of over 12.6 million in 2020. The adoption of LPG for cooking has increased nationally from 2.4% in 2016 (MTF, 2018) to 5.6% in 2020 (CFET, 2020) (Figure 25). In the City of Kigali alone, the consumption increased from 7.4% in 2016, to 45.1% in 2020 (Figure 26).

As presented in Figure 25, firewood remains the dominant cooking fuel in Rwanda, particularly in rural areas where 91.1% of households rely on it for cooking. Of the firewood users, one-third of households reported gathering firewood for free.

Charcoal is the predominant fuel used in urban areas, both in Kigali (76.9% of Kigali households) and in other urban areas (44.5% of other urban households). The majority of LPG use is in urban Kigali, where 45.1% of the households use LPG, representing 76.2% of total national household LPG consumption.

Figure 25. Rwandan household cooking fuel use in 2020
(CFET data)

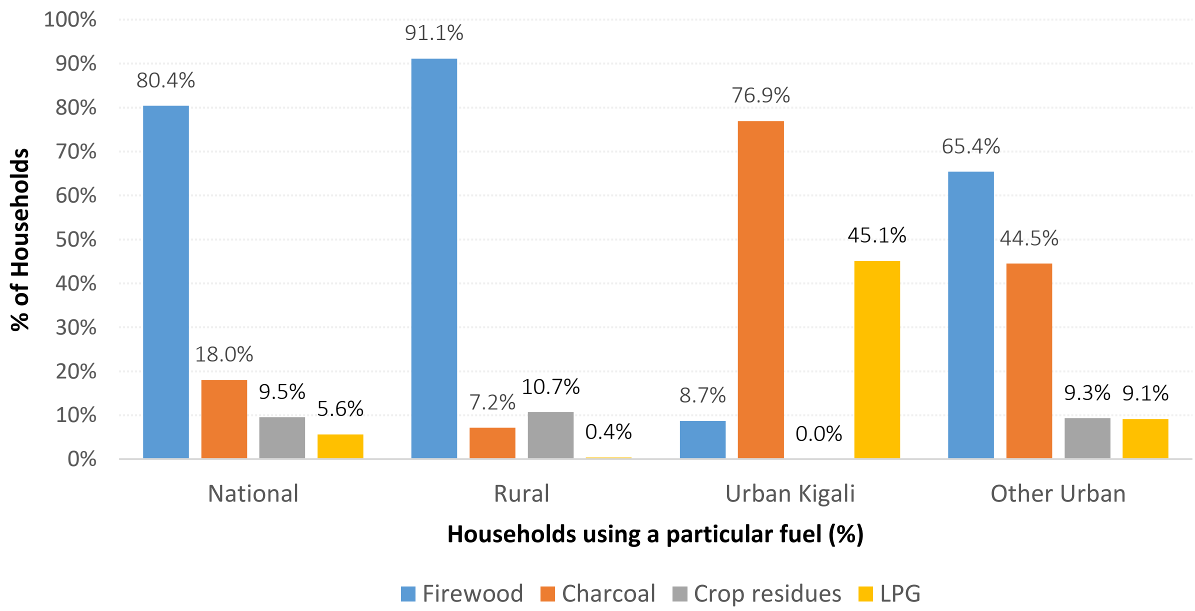
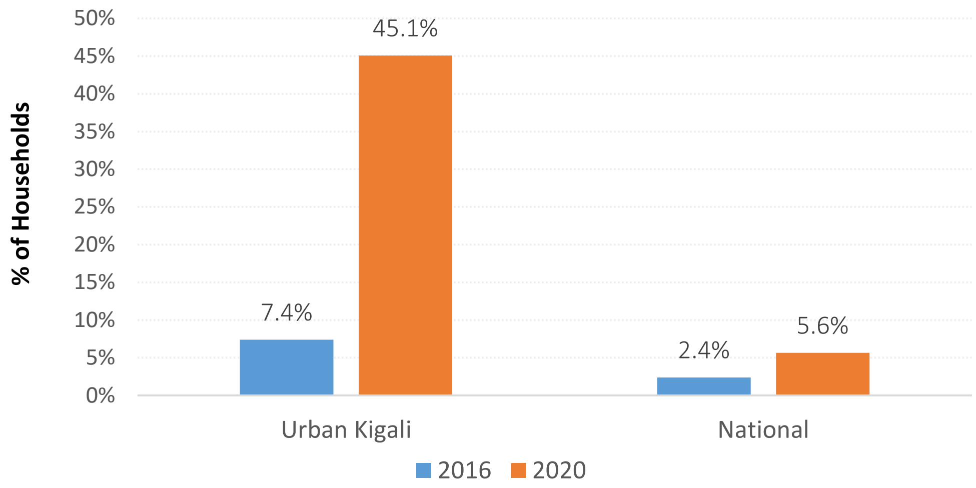


Figure 26. Percentage of households cooking with LPG in 2016 and 2020 in urban Kigali and nationally



Note: *The 2016 percentage represent households that use LPG as the primary fuel (MTF data), while the 2020 percentage includes households with any use of LPG (CFET data).*

Based on the CFET survey responses, an estimated 19,200 MT of LPG was consumed in households in Rwanda in 2020[48]. The LPG per capita consumption among existing LPG users in 2020 was calculated based on responses to survey questions on the amount of LPG used in the past month. This amount (in kilograms) was divided by the reported household size (number of people resident in the household). The average amount of LPG used in those households reporting 'mixed' use of LPG was a median of 28.8 kg per capita. Average consumption in households reporting 'exclusive' use was a median of 48 kg per capita. When both 'mixed' and 'exclusive users' are taken together, the median consumption was 36 kg per capita/year.

For the modelling projections, a more conservative estimate was used, 28.8 kg per capita/year for 'mixed' users, to account for (i) exclusive users being predominantly from the most affluent socioeconomic groups (classified as fourth *ubudehe*[49] category for analysis), and (ii) the potential that cooking would be for a larger number of people than the reported household size (e.g. household staff), leading to an overestimation if basing estimates on 'exclusive' LPG consumption (or an average of the two). In addition for some households it is possible that food cooked with LPG might be sold commercially, which again could result in an overestimation of household LPG use per capita. The conservative estimate of 28.8 kg per capita/year is therefore likely to be closer to actual consumption across all LPG users and also reflective of cooking local Rwandan cusine, (including dishes with a long cooking duration such as beans, which are typically cooked with biomass fuels).

Estimated baseline LPG household consumption according to the different geographical areas is shown in Table 26. Average consumption was highest within urban Kigali for both mixed and exclusive LPG users, followed by other urban areas, with very low consumption in rural areas.

---

48 The estimate of current household LPG demand (adoption percentage and fuel volume consumed) is based on a sample of about 5,000 households, with possible error or bias associated with self-reporting of the data.

49 Rwanda households are currently classified into four *ubudehe* categories according to their socio-economic status. See Annex Chapter 78 for further definition.

Table 26. Summary of baseline household LPG consumption in Rwanda in 2020

Components of baseline LPG consumption	**2020**
Total residential LPG consumed by households	19,200 MT
Urban Kigali	14,100 MT
Other urban areas	3,950 MT
Rural areas	1,150 MT
Share of households consuming LPG	
As mixed users	3.5%
As exclusive users	2.1%
Total	5.6%
Median annual LPG consumption per capita for *households that use LPG*	28.8 kg
Annual LPG consumption per capita for *all households (including non-users)*	2.4 kg

Institutions

Public institutions segment

This segment comprises non-commercial public sector institutions including (i) prisons, (ii) police stations with temporary detention centres, (iii) schools (day schools and boarding schools), (iv) healthcare facilities (including hospitals and health centres) and (v) military barracks. Catering institutions such as hotel and restaurants are treated as 'commercial' users of LPG and described in the following section.

Data on cooking fuels/energy sources information were available for a number of non-commercial institutions from the CFET survey (see Table 27) as well as from UNHCR for refugee camps.

Table 27. Annual cooking fuel consumption in selected institutions

Institution	**Achieved sample**	**Firewood (Kg)**	**Briquettes (Kg)**	**Biogas (m^3)**	**LPG (Kg)**	**Electricity (KWh)**
Prisons	12	2,212,600	11,542,560	140,832	30	
Police stations	31	1,764,456			163,860	
Military barracks	6	1,803,744			89,280	
Boarding schools	82	48,127,740			18,996	31,356

Source: CFET, 2020

Health care facilities

To date, Rwanda has a total of 20,399 bed facilities available across the national territories[50]. Of these, 9,064 are in the 48 national, provincial and district hospitals and 11,335 in the 500 health centres (Table 28). No official information is available on fuel/energy usage for these institutions.

50 Ministry of Health, 2020

Table 28. Rwanda healthcare facilities and bed capacity, 2020

Type of healthcare facility	Number	Beds	Average number of beds / facility
National referral hospitals	7	2,189	312.7
Provincial hospitals	4	682	170.5
District hospitals	37	6,193	167.4
Health centres	500	11,335	22.7

Commercial institutions and industrial users

This segment includes commercial entities in the forms of restaurants, hotels and other industrial uses of LPG.

Hotels and restaurants

The CFET survey obtained fuel use information from 204 restaurants and 118 hotels across all provinces of Rwanda. According to the CFET information, charcoal met 49.7% of energy demand in the sampled hotels, followed by LPG (32.4%), firewood (16.7%) and electricity (1.2%). LPG use in the surveyed hotels totaled 1,337 MT. In restaurants, the predominant fuel used was also charcoal (69.3%), followed by firewood (18.5%), LPG (11.6%) and electricity (0.5%). LPG use in the surveyed restaurants totaled 1,359 MT.

Given that no further data were available regarding existing LPG consumption for this category of commercial institutions, the total measured consumption in the surveyed restaurants and hotels – 2,697 MT – was used the starting LPG volume for 2020 to model commercial-institution demand projections.

Other segments

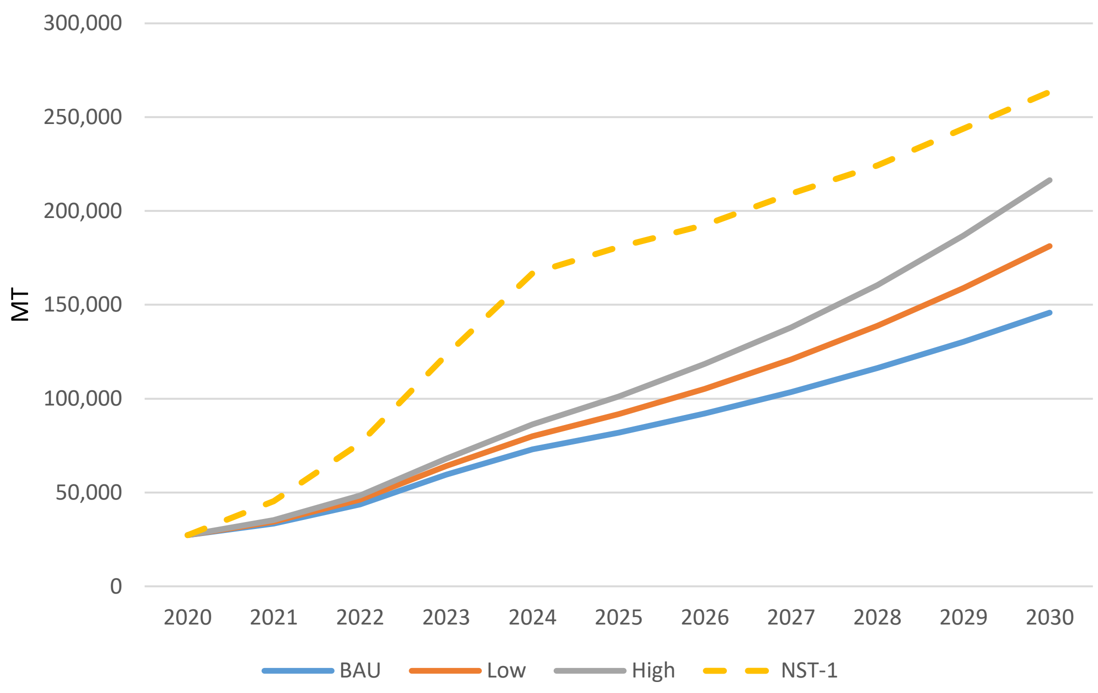
Additional segments including refugee camps and industrial LPG users are discussed in detail in the next Chapter.

27. Demand Forecast Details by Market Segment

Overall demand projections

Figure 27 presents a summary of the forecasted LPG tonnage across all market segments.

Figure 27. Projected LPG volumes by demand scenario
in MT (residential and institutional)

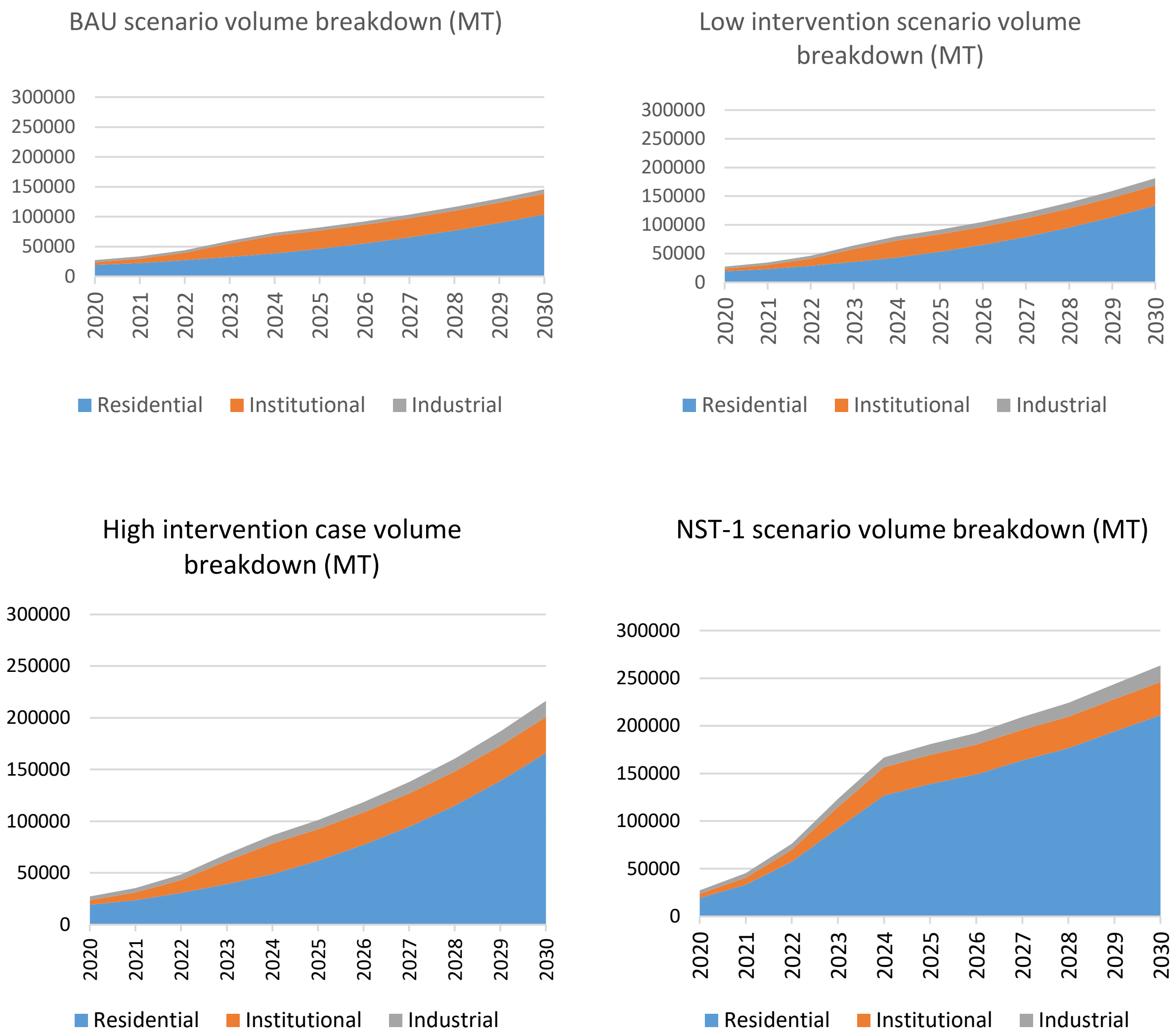


Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BAU	27,297	33,551	43,784	59,520	73,086	81,935	92,069	103,481	116,248	130,379	145,770
Low	27,297	34,515	46,271	64,174	80,086	91,699	105,302	120,962	138,884	158,925	181,254
High	27,297	35,394	48,476	68,167	86,346	101,074	118,464	137,926	160,458	186,843	216,325
NST-1	27,297	45,385	76,307	123,350	166,872	180,770	192,496	209,247	224,164	243,884	263,431

The modelling indicates that reaching the NST-1 Target requires a very high level of intervention, including LPG use requirements and biomass fuel prohibitions. Because Kigali would quickly saturate with LPG, a focus not only on other cities but also rural areas would be necessary to grow demand to the desired 2024 level in the NST-1 Target case. Whilst BAU will result in a steady increase in LPG adoption in urban contexts, BAU shows no significant increase in uptake in rural settings, and national adoption will fall short of the 40% NST-1 goal.

Figure 28 illustrates variations in each market segment across the different scenarios.

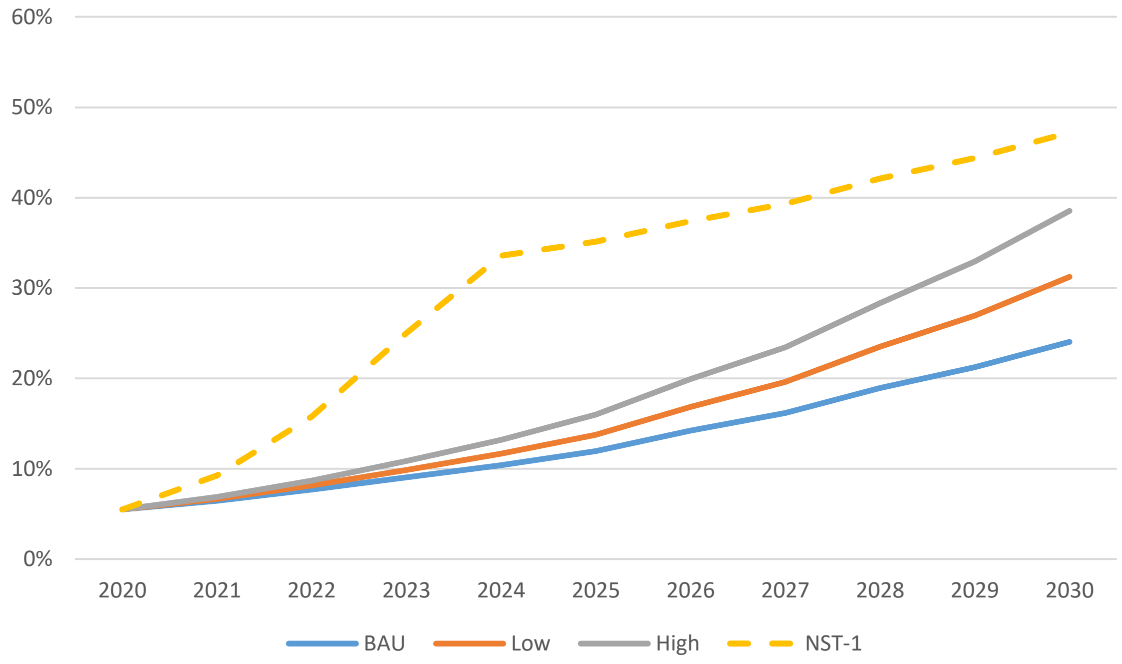
Figure 28. Projected LPG volumes by market segment, by scenario



Household LPG demand

The following chart shows the projected residential penetration of LPG by scenario:

Figure 29. Projected residential LPG penetration by scenario



Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BAU	5.6%	6.5%	7.7%	9.0%	10.4%	12.0%	14.2%	16.2%	18.9%	21.2%	24.0%
Low	5.6%	6.7%	8.2%	9.8%	11.7%	13.8%	16.8%	19.6%	23.5%	27.0%	31.2%
High	5.6%	6.9%	8.7%	10.8%	13.2%	16.0%	19.9%	23.4%	28.3%	32.9%	38.5%
NST-1	5.6%	9.2%	15.8%	25.0%	33.6%	35.1%	37.4%	39.3%	42.1%	44.4%	47.2%

The following sections detail the individual scenario results for this segment, and the assumptions used to produce the scenarios. Each of the household demand projections was calibrated to avoid double counting of school children eating one meal (or more) per day in school for nine months a year (see Annex Chapter 78 for details). This results in slight reductions of the estimated annual LPG per capita consumption, from 28.8 kg/capita/year in 2020 to 27.2 kg/capita/year in 2021 and progressive reductions in each following year.

Business as usual (BAU) scenario

The BAU household demand scenario extrapolates historical growth trends of LPG use from 2016 to 2030, with an assumption that no geography (i.e., Kigali) can saturate above about 95% LPG in practice. The growth is an extrapolation of 2020 data-based trends in evidence between the available survey data for 2016 (MTF) and 2020 (CFET), and as reported in other GoR studies and reports. Specifically, the observed LPG increase from 2.4% in 2016 to 5.6% in 2020 was decomposed and attributed separately to changes in LPG price, distance from LPG point of sale, urbanization, socioeconomic factors (*ubudehe* categories) and time-series trends. Modelling based on these attribution factors was carried out to 2030 under varying assumptions for the remaining factors. These assumptions are described in more detail below for each demand scenario.

The projected households using LPG under the BAU scenario are estimated to grow from 5.6% in 2020 to 10.4% in 2024 and then 24.0% by 2030, as shown in the following table:

Table 29. BAU projected LPG household demand growth

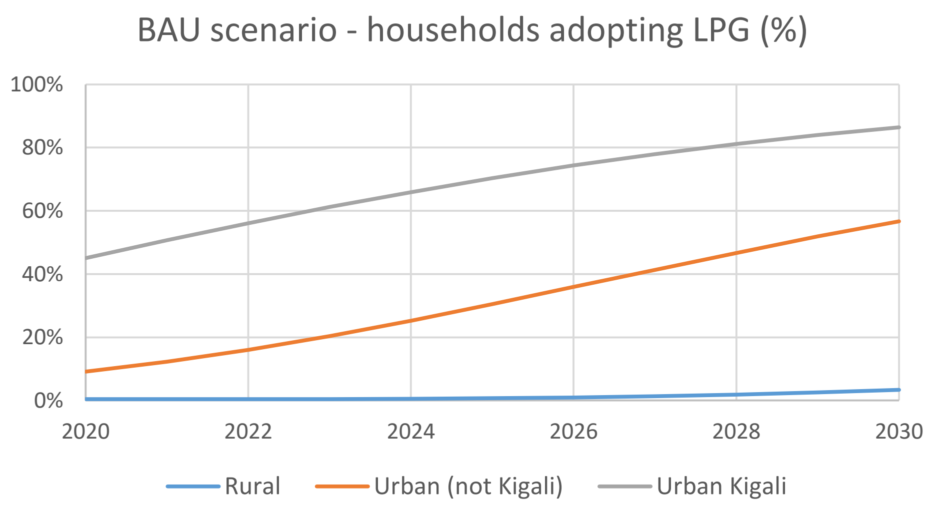
Year	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
LPG volume (MT)	19,245	22,308	27,154	32,670	**38,525**	46,212	55,138	65,299	76,762	89,545	**103,528**
LPG users (%)	5.6%	6.5%	7.7%	9.0%	**10.4%**	11.9%	14.2%	16.2%	18.9%	21.2%	**24.0%**

Note: Includes exclusive and mixed LPG users

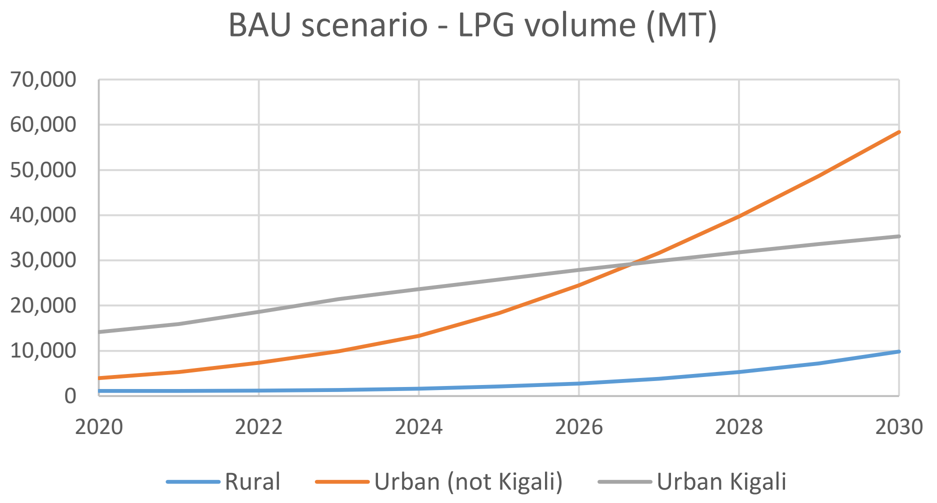
The greatest growth is projected to occur in urban areas, with 65.9% of the households in Kigali city projected to be using LPG in 2024, increasing to 86.4% in 2030, and 25.2% households in other urban areas projected to be using LPG in 2024, increasing to 56.7% in 2030 (see Figure 30-A). By comparison, rural areas are projected to have very limited growth with only 0.6% of the households estimated to be using LPG in 2024, and 3.4% in 2030.

Figure 30. BAU projected residential demand by geographic segment

A) Projected proportion of households adopting LPG, by geography



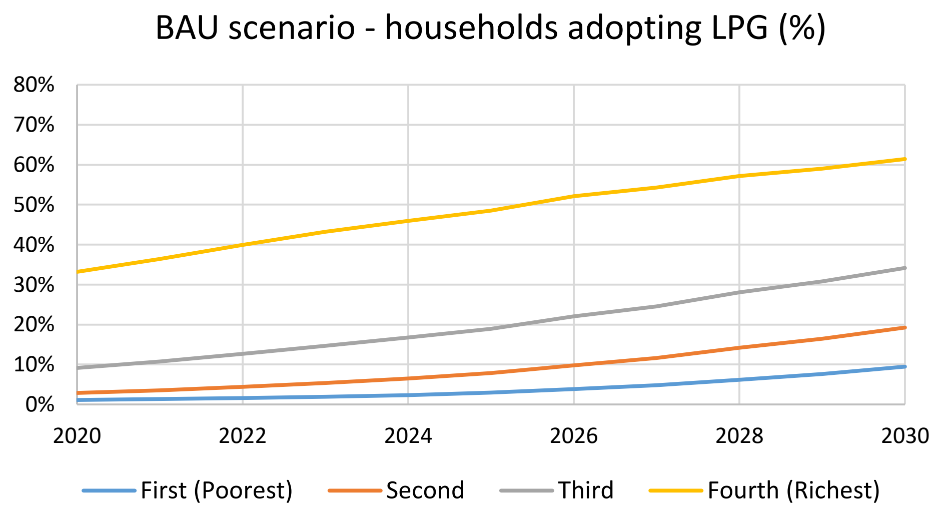
B) Projected volumes (MT) of LPG used by households, by geography



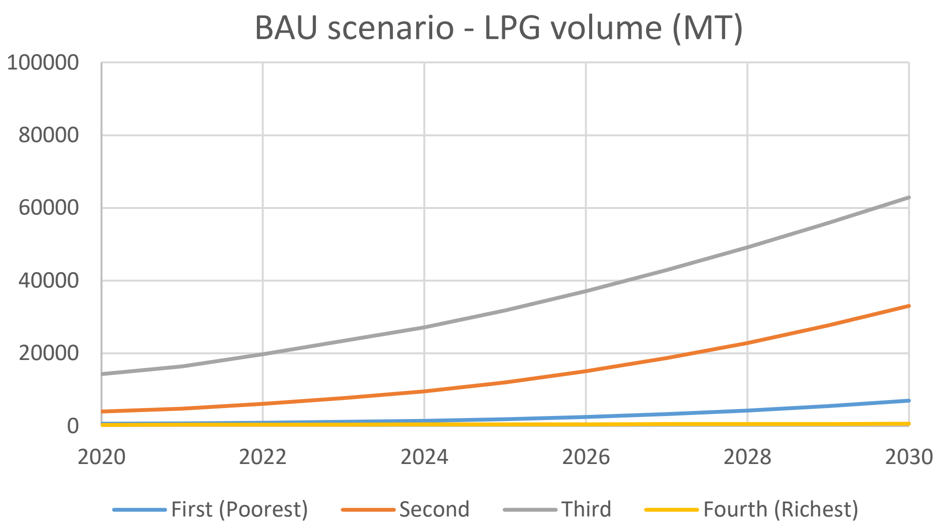
Under the BAU scenario, the total volume of LPG consumed by households is projected to increase from 19,245 MT in 2020 to 103,528 MT nationally in 2030 (Table 29 above). Following the trends in adoption, the largest increases in consumption are projected to occur in urban settings (outside Kigali city), with growth from 3,952 MT in 2020 to 58,425 MT in 2030 (reflecting both increases in adoption and rates of urbanisation). The volumes for Kigali city are projected to increase from 14,145 MT in 2020 to 35,310 MT in 2030 (see Figure 30-B).

Figure 31. BAU projected residential demand by socio-economic status (SES)

A) Projected proportion of households adopting LPG, by SES



B) Projected volumes (MT) of LPG used by households, by SES



The demand projections stratified by the four *ubudehe* categories under the BAU scenario is shown in Figure 31. As might be expected, the percentage of LPG-using households is highest in the highest SES category (the fourth *ubudehe* category), growing from 33.2% in 2020 to 46% in 2024 and 61.4% in 2030. This is followed by the third *ubudehe* category, with 9.1% of the households using LPG in 2020, 16.7% in 2024 and 34.1% in 2030. A similar shape of growth curves is observed in the second *ubudehe* cateogory (with the growth predicted from 2.9% LPG using households in 2020 to 6.5% in 2024 and 19.2% in 2030). Finally, the uptake of LPG among households in the poorest *ubudehe* category is predicted to grow from 1.2% in 2020 to 2.4% in 2024 and 9.5% in 2030.

Regarding the total demand volume projected in each of the SES categories, the relative contribution of each category is different. Whilst the percentage of LPG using households is highest in the top *ubudehe* category, it is the smallest number of households in absolute terms, because only a small percentage of Rwandan households fall into this SES category. The total volume of LPG use is lowest in the fourth SES category. In 2020, only 0.3% of households are in the fourth category, translating into 316 MT of LPG used. This is projected to grow to 437 MT in 2024 and 616 MT in 2030. Because the highest absolute number of LPG households come from the third *ubudehe* category, the thrid category contributes the most LPG volume, rising from 14,269 MT in 2020 to 27,125 MT in 2024 and 62,867 MT in 2030. The increase in volume used by the households in the second *ubudehe* category follows a similar trajectory, with a projected increase from 4,011 MT in 2020 to 9,528 MT in 2024 and 33,071 MT in 2030. Finally, the poorest category is projected to grow in usage from 649 MT in 2020 to 1,435 MT in 2024 and 6,975 MT in 2030, contributing to the total LPG usage more than the highest SES category due to the higher absolute number of households.

Assumptions used in the BAU scenario

1. *Urbanization*: The urbanisation rate will reach 25% by 2024 and 35% by 2030.

2. *Population*: Population growth will follow the median projection from National Institute of Statistics Rwanda (NIRS) (projected to be 15.7 million in 2030)[51].
3. *Average household size*: household size for urban and rural areas will follow the projection from NIRS (projected to be 3.2 household members in 2030 for both urban and rural areas).
4. *Changes in income/socio-economic profile*: An improvement in the socioeconomic conditions of the population is projected from the 2016 and 2020 survey data to follow a linear trend in logit scale.
5. *Average LPG household consumption*: As described above, this is estimated for 2020 based on the median value (from 'mixed' users) of 28.8kg per capita per year (CFET).
6. *LPG consumer price*: Based on RURA LPG price data collected in 2019[52] and IMF-based projections of future RwF-USD exchange rates, the average LPG price in Kigali City in RwF is estimated to increase from 1,060 RwF/Kg in 2020 to 1,834 RwF/Kg in 2030. The price in other urban areas is estimated to increase from 1,166 RWF/Kg in 2020 to 2,017 RwF/Kg by 2030. Finally, in rural areas, the average LPG price is estimated to increase from 1,484 RfF/Kg in 2020 to 2,567 RwF/Kg in 2030. (See Annex Chapter 78 for a full description of the methodology.)
7. *Consumer distance from LPG point of sale:* Mean distance for an LPG consumer to access an LPG point of sale is estimated to decrease in Kigali from 632m in 2020 to 569m in 2030 and in other urban areas from 940m to 846m. Mean distance in rural areas is estimated to remain the same in 2030 as in 2020 (3.1km). Currently, 27.4% of households using LPG in 2020 use home delivery services to receive the refills (29.4% in urban Kigali). For these customers, the distance is treated as zero (see Annex Chapter 78).

Low-case intervention scenario

The 'Low case' intervention demand scenario projects increases in LPG adoption by households in line with national trends (see *Business as usual (BAU) scenario*, assumptions 1-5, above) with the addition of increased accessibility of LPG via increased use of home delivery services and reduced distances needed to travel to the nearest LPG retail point[53]. Specific assumptions are as follows:

- *Consumer distance from LPG point of sale:* Mean distance for an LPG consumer to access an LPG point of sale is estimated to decrease in Kigali from 632m in 2020 to 390m in 2030 and in other urban areas from 940m to 529m. Mean distance to LPG point of sale in rural areas is estimated to decrease from 3.1km in 2020 to 2.4km in 2030. It is estimated that the number of households using home delivery services will increase to 50% in all areas, urban and rural. Detailed information on the assumptions and correlations is provided in Annex Chapter 78.

---

51 See: http://statistics.gov.rw/publication/rphc4-atlas

52 RURA, 2019. Countrywide supply survey on Liquefied Petroleum Gas.

53 It should be noted that accessibility may be a proxy variable for other factors that are correlated or causative but are not present in the survey data. For this reason, interventions other than those purely focused on accessibility may have important effects on LPG demand and usage, but they cannot be distinctly quantified based on the available data.

The projected demand for LPG use under the Low interventional scenario is, necessarily, greater than the BAU scenario, with a projected increase in the proportion of households using LPG from 5.6% in 2020 to 11.7% in 2024 and 31.2% in 2030 (see Table 30). This increase is still not sufficient to meet the government target of 40% in 2024. Projected adoption is highest in urban areas, reaching 94% in urban Kigali and 75% in other urban areas by 2030 (see Figure 32-A). Adoption in rural areas is projected to remain low at 6.6% of households using LPG in 2030.

Table 30. Low intervention projected rediential LPG demand growth

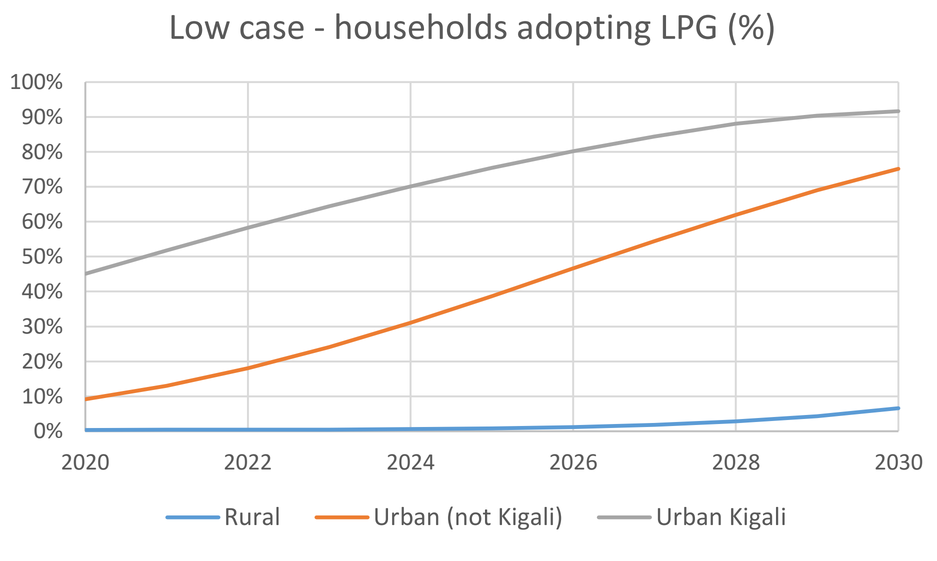
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
LPG volume (MT)	19,245	22,970	28,780	35,610	43,160	53,260	65,240	79,190	95,280	113,400	133,700
LPG users (%)	5.6%	6.7%	8.2%	9.8%	**11.7%**	13.8%	16.8%	19.6%	23.5%	27.0%	**31.2%**

Includes exclusive and mixed LPG users

Reflecting projected LPG penetration under Low-case assumptions, projected increases in LPG volumes follow similar patterns geographically. Nationally, consumption is projected to increase to 43,160 MT in 2024 and to 133,700 MT in 2030 (see Table 30), with the largest increases in consumption projected to be in urban Kigali and 'other urban' areas, reaching 37,460 MT and 77,410 MT respectively, in 2030 (Figure 32-B).

Figure 32. Low intervention projected residential demand by geographic segment

A) Projected proportion of households adopting LPG according to geography



B) Projected volumes (MT) of LPG used by households according to geography

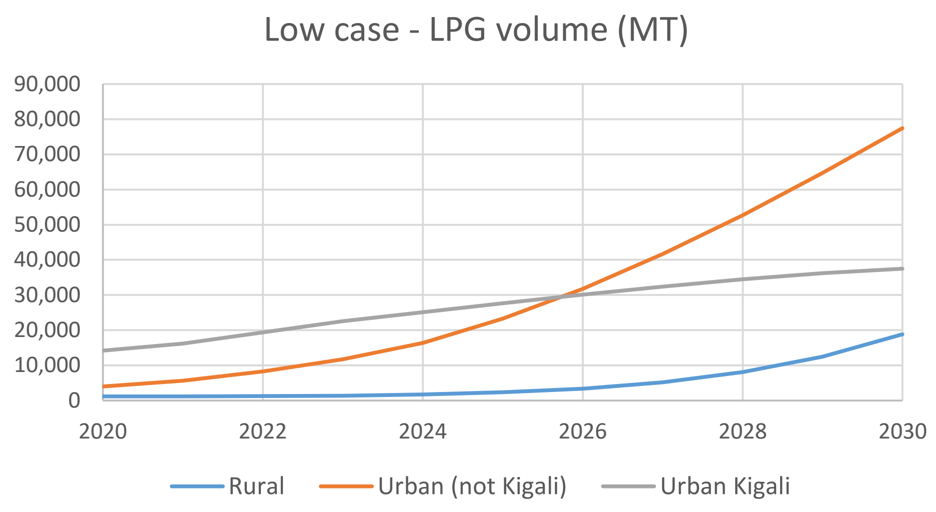
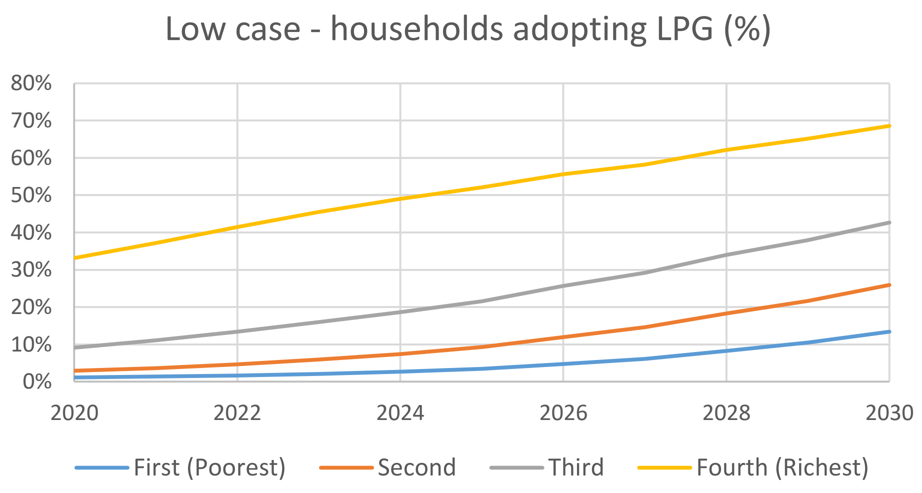
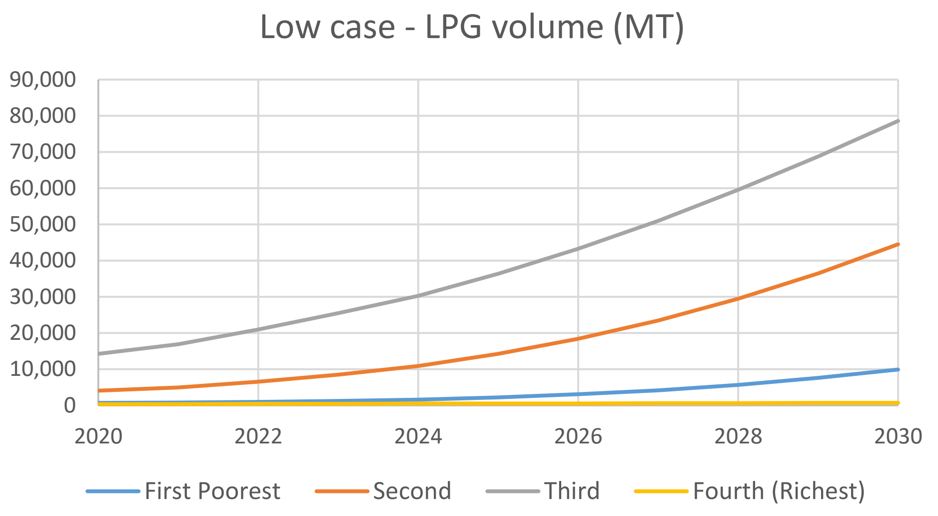


Figure 33. Low intervention projected residential demand by socio-economic status (SES)

A) Projected proportion of households adopting LPG, by SES



B) Projected volumes (MT) of LPG used by households, by SES



Projections of LPG use by each of the socio-economic (SES) category in the Low Intervention scenario are presented in Figure 33. The percentage of LPG using households in the fourth *ubudehe* category is projected to grow from 33.2% in 2020 to 49% in 2024 and 68.6% in 2030. For the third *ubudehe* category, the growth is projected from 9.1% of the households using LPG in 2020, increasing to 18.6% in 2024 and 42.7% in 2030. For the second *ubudehe* cateogory, the growth is predicted from 2.9% LPG using households in 2020, to 7.4% in 2024 and 25.9% in 2030. Lastly, the percentage of LPG using households in the poorest *ubudehe* category is predicted to grow from 1.2% in 2020, to 2.6% in 2024 and 13.4% in 2030.

Similarly to the projections under the BAU scenario, relative contributions of total LPG volumes depend on the absolute number of households in each of the categores, so the highest *ubudehe* category contributes the lowest tonnage of LPG used. It is projected to grow from 316 MT in 2020, to 466 MT in 2024, and to 687 MT in 2030. The highest contributor is again the third *ubudehe* category, projected to grow from 14,269 MT in 2020, to 30,230 MT in 2024 and 78,602 MT in 2030. The growth of LPG volumes in the second *ubudehe* category is projected to go from 4,011 MT in 2020, to 10,862 MT in 2024, and 44,543 MT in 2030. The households in the lowest *ubudehe* category are projcted to increase their LPG use from 649 MT in 2020, to 1604 MT in 2024 and 9,877 MT in 2030.

High case intervention scenario

The High case intervention projects increased LPG adoption following the same assumptions used in the Low case, with a higher level of LPG home delivery and decreased distance from consumer to LPG outlet, as detailed below:

Consumer distance from LPG point of sale: Mean distance for an LPG consumer to access an LPG point of sale is estimated to decrease by 25%, resulting in a decrease from 632m in 2020 to 163m in Kigali and from 940m to 221m in other urban areas by 2030. Mean distance in rural areas is assumed to decrease from 3.1km in 2020 to 988m in 2030. In addition, the percentage of households using home delivery services is estimated to increase to 75% in all urban areas, and to 50% in all rural areas. Detailed information on the assumptions and correlations is provided in Annex Chapter 78.The total proportion of households using LPG is expected to increase from 5.6% in 2020 to 13.2% in 2024, and to 38.5% in 2030 (see Table 31).

Table 31. High intervention projected LPG residential demand growth

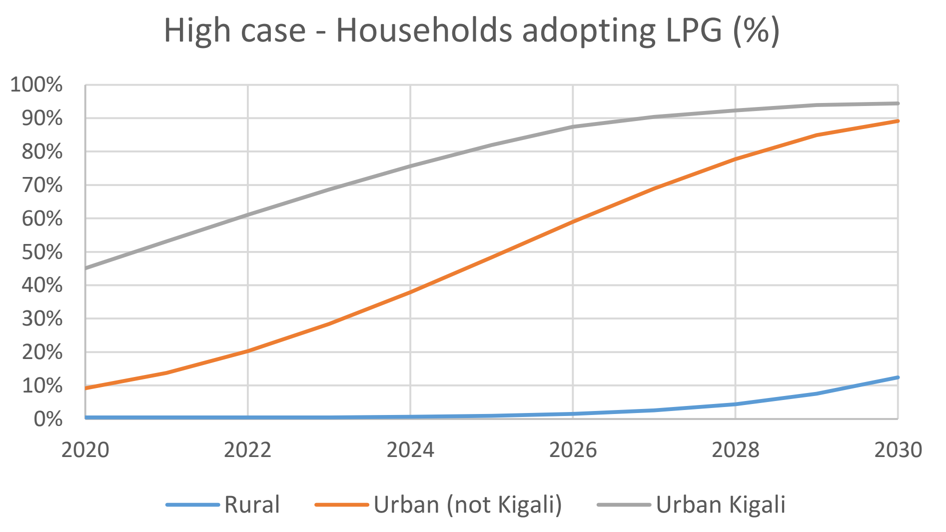
Year	2020	2021	2022	2023	**2024**	2025	2026	2027	2028	2029	**2030**
LPG Volume (MT)	19,245	23,740	30,740	39,200	**48,840**	61,790	77,260	94,690	115,000	139,000	**166,000**
LPG users (%)	5.6%	6.9%	8.7%	10.8%	**13.2%**	16.0%	19.9%	23.4%	28.3%	32.9%	**38.5%**

Includes exclusive and mixed LPG users

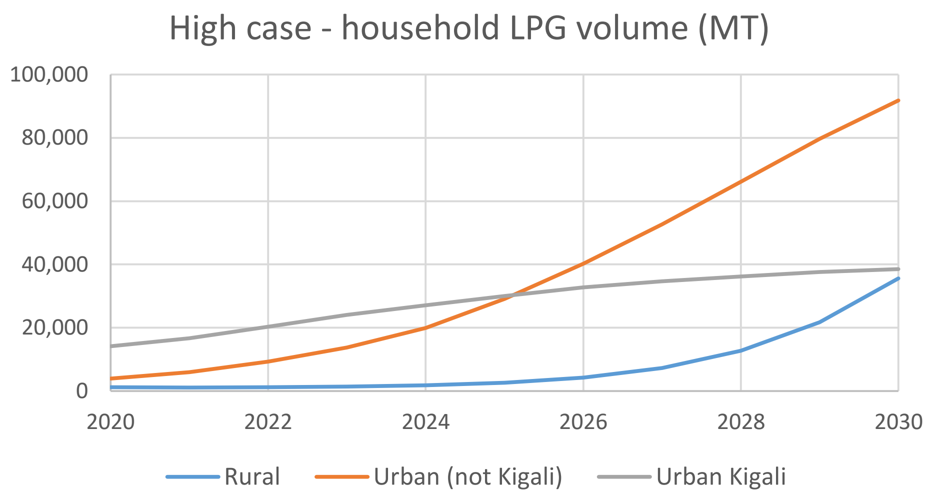
As in the Low case scenario, the increase is driven primarily by urban areas. However, in this scenario the increase is slightly higher in rural areas over time, driving higher national adoption levels (Table 31).

Figure 34. High intervention projected residential demand by geographic segment

A) Projected proportion of households adopting LPG according to geography



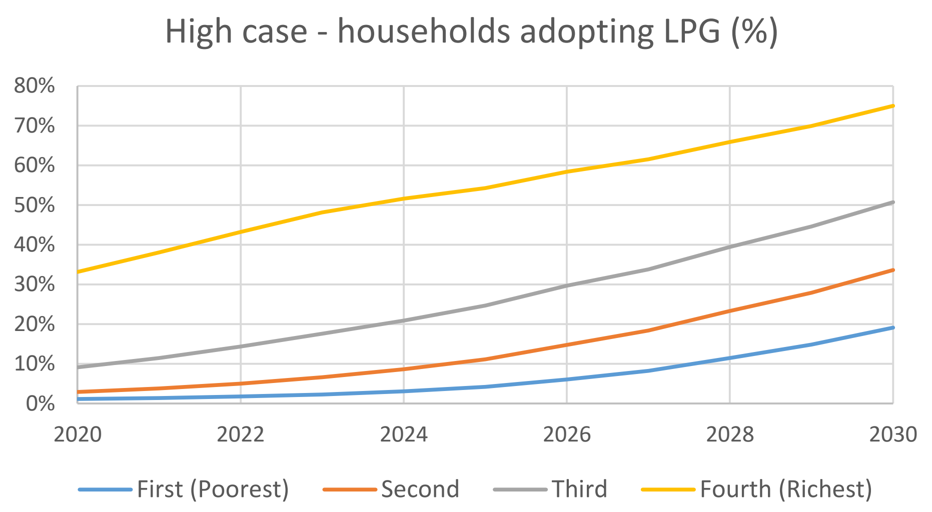
B) Projected volumes (MT) of LPG used by households, by geography



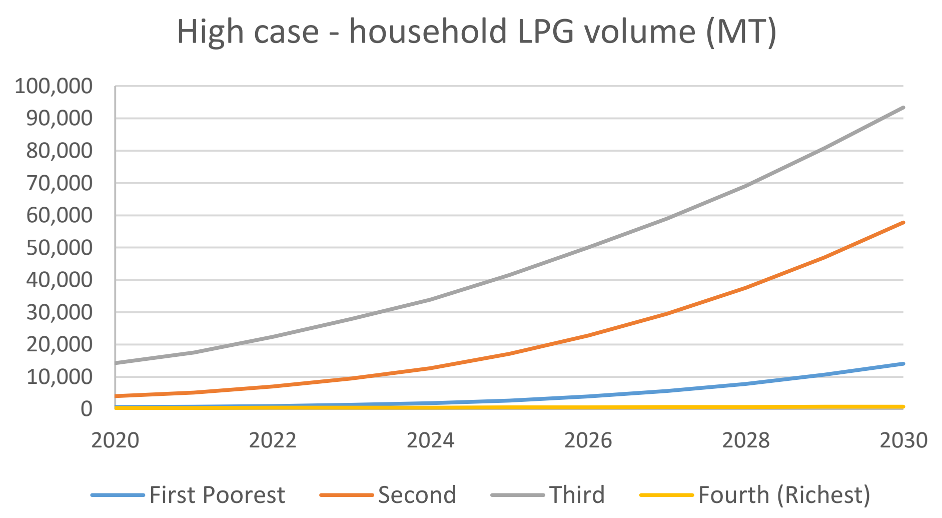
The High-case scenario projects that, in 2024, 75.6% of urban Kigali households will be using LPG, 38% of the households in other uban area, and 0.62% of rural households. In 2030, penetration is projected to increase to 94.4% in urban Kigali, 89.2% in other urban areas, and 12.4% in rural areas (Figure 34-A). Total LPG volumes are projected to increase nationally to 48,880 MT in 2024 and 166,000 MT in 2030. The largest increase in consuption is estimated for 'urban areas (not Kigali)' reaching 19,940 MT in 2024 and then 91,860 MT in 2030. The LPG volume in Kigali City are projected to reach 27,090 MT in 2024 and 38,560 MT in 2030. Rural areas will also see a significant increase from MT 1,800 MT in 2024 to 35,560 MT in 2030 (Figure 34-B).

Figure 35. High intervention projected residential demand by socio-economic status (SES)

A) Projected proportion of households adopting LPG, by SES



B) Projected volumes (MT) of LPG used by households, by SES



The SES curves are similar to the BAU and Low intervention scenarios, except wth accelerated adoption in all four SES categories (Figure 35). The percentage of LPG using households in the fourth *ubudehe* category is projected to grow from 33.2% in 2020 to 51.6% in 2024 and 75% in 2030. For the third *ubudehe* category, growth is projected from 9.1% of households using LPG in 2020 to 20.9% in 2024 and 50.7% in 2030. For the second *ubudehe* cateogory, growth is projected from 2.9% of households using LPG in 2020 to 8.6% in 2024 and 33.6% in 2030. Finally, the percentage of LPG using households in the poorest *ubudehe* category is projected to grow from 1.2% in 2020 to 3% in 2024 and 19.1% in 2030. In terms of LPG volumes, demand is projected to increase from 316 MT in 2020 to 490 MT in

2024 and to 750 MT in 2030 for the fourth (richest) category. The highest contributor to increased LPG volume demand is again the third *ubudehe* category, projected to grow from 14,270 MT in 2020, to 33,890 MT in 2024 and 93,410 MT in 2030. The growth of LPG volumes in the second *ubudehe* category is projected to go from 4,010 MT in 2020 to 12,610 MT in 2024 and 57,780 MT in 2030. The households in the first (lowest) *ubudehe* category are projcted to increase their LPG use from 649 MT in 2020 to 1,850 MT in 2024 and 14,050 MT in 2030.

NST-1 Target scenario

As previously mentioned, the NST-1 Target scenario differs from the others by not extrapolating or accelerating existing trends and growth drivers between 2021 and 2024. Rather, the NST-1 Target case assumes hypothetically that between 2021 and 2024, LPG demand is scaled up by whatever means necessary to reflect 40% of the population (household and institutional) using LPG by 2024. (A corresponding scenario of supply chain development and investment is then created in Volume 4 to show what is required to be accomplished to serve that level of demand.) After 2024, growth generally follows the BAU trajectory, except that it tapers off in urban Kigali and other urban areas as they become saturated with LPG in the late 2020s.

Table 32 shows the details.

Table 32. NST-1 Target scenario projected LPG household demand growth

Year	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
LPG volume (MT)	19,245	33,240	57,440	92,500	**126,900**	139,000	148,970	163,700	176,600	194,100	**211,300**
LPG users (%)	6.0%	10.4%	18.2%	29.7%	**40.0%**	41.5%	43.8%	45.7%	48.5%	50.8%	**53.6%**

Includes exclusive and mixed LPG users

Institutional LPG demand

As documented in official sources (e.g., RURA 2020[54]), schools, refugee camps, prisons, etc., and commercial institutions such as hotels and restaurants have begun tp shift gradually from the use of biomass for cooking to LPG, often using large cylinders or small bulk tanks. This shift is partially due to GoR directives and sensitization programs whose aim is to reduce use of biomass for institutional cooking.

Assumptions used in the institutional forecast

Demand from institutions is modelled to grow at the same rate in all four demand scenarios, on the assumption that they will increase LPG use to the maximum practical level no later than 2024 as a matter of policy (for public institutions) and economic self-interest (commercial).

[54] RURA 2020, Annual Report 2019-2020

Current LPG usage in 2020 for each institutional category was estimated based on sources described in the section titled *Institutions* in Chapter 26 (see page 101). The yearly projections of LPG demand up to 2024 and 2030 are modelled based on an assumption of 100% LPG use from 2024 onwards in all institutions, except for (i) prisons, (ii) temporary detention centers/police stations and (iii) refugee camps, as detailed below.

Prisons. As reported in Chapter 26, biogas accounts for approximately 40% of cooking energy requirements in all prison facilities in 2020, with biomass fuels including briquettes and firewood making up the rest. Based on communication with the Rwanda Correctional Service (RCS) authorities, LPG demand in prisons is projected assuming continued biogas use at the 40% level, with the remaining 60% being met through LPG starting as of 2024. Incremental annual increases in LPG use are projected between 2021 and 2024 in order to ramp up to the 60% target (see Table 33).

Police stations. Data provided by RCS indicats that 9,114 police officers had access to LPG for cooking at their police facilities in 2020. This population datum was used to calculate the corresponding LPG volumes consumed in 2020 using the average LPG kg per capita. Regarding the temporary detainees who are fed at the police stations (an average of 8,000 persons per month, detained for 1-3 days each), calculations were made on the assumption that detainees remain in custody an average of 1.5 days (out of the maximum three days allowed by Rwandan law), and that they are provided two meals per day. Considering that the average amount of energy to feed a family of 3.5 members in Rwanda is 15.16 MJ for two meals day (based on Rwanda HAPIN data), the amount of LPG needed to feed a detainee was estimated as 0.047 kg of LPG per meal[55]. This amount was used to estimate the annual LPG volume projections for the temporary detainees.

Table 33. Prison and police satation populations with LPG-cooked meals, 2020-2030

Year	Total detainees	Total detainees fed via LPG	Detainee population feed via LPG (%)$	Police staff and temporary custody population	Total institutional population fed with LPG*	Institutional population using LPG (%)
2020	70,000	49	0.1%	17,114	9,114	53%
2021	71,628	4,598	6%	17,512	12,330	70%
2022	73,257	13,794	19%	17,910	13,829	77%
2023	74,945	32,186	43%	18,323	15,888	87%
2024	76,633	45,980	60%	18,736	18,736	100%
2025	78,321	46,992	60%	19,148	19,148	100%
2026	80,009	48,005	60%	19,561	19,561	100%
2027	81,697	49,018	60%	19,974	19,974	100%
2028	83,414	50,048	60%	20,393	20,393	100%
2029	85,131	51,078	60%	20,813	20,813	100%
2030	86,848	52,109	60%	21,233	21,233	100%

Note: Institutional population growth follows the national population growth proportionally. The 60% of LPG use takes into account biogas already used in all prisons, accounting for 40% of the prisons' present and expected energy needs.

55 The amount of energy used for cooking for an average family of 3.5 members (15.16 MJ/day) was converted into kg of LPG using the LPG calorific value of 46.1 MJ/kg. This corresponds to 0.33 kg of LPG/day. The amount of LPG needed for one single cooking event was calculated as half of the daily kg amount (i.e. 0.164 kg) and divided by 3.5 to obtain the estimate of LPG needed to cook one meal for one person (0.047 kg or 470 g).

Refugee camps. The 2020 LPG volumes for the refugee population of Rwanda are based on information provided by UNHCR for the Mahama camp and reception centers as detailed in the *Refugee camps* section of Chapter 22 (see page 87). Their 2020 usage corresponds to approximately 1,392 MT of LPG. This LPG consumption is projected to grow to 1,743 MT in 2021, taking into account that (i) more school pupils in Mahama will be fed in schools with LPG as of 2021 (increasing from 29,600 students as of 2020 to 71,459 refugee and host community students in 2021), and (ii) LPG will be provided to a second camp, Mugombaw (Northern Province) starting in 2021. The Mugombaw camp is home to 10,890 refugees (2,271 households) (see Table 34). It is estimated that 259 MT of LPG may be distributed among the resident refugees based on the per capita LPG consumption rates from the Mahama camp (about 23.8 kg/capita/year).

Table 34. Refugee camp populations in 2020 disaggregated by household size

Facility	Household size (number of persons)				Total households
	1 - 3	4 - 5	6 - 7	>7	
Mahama Camp	11,103	3,727	2,291	1,211	18,332
Mugombwa Camp	774	618	504	375	2,271

Although the number of individuals residing in refugee camps is likely to fluctuate, no changes were assumed to the refugee camp population using LPG, nor to the associated LPG volumes, over time, nor any interruption to future LPG supply by UNHCR and its partner LPG suppliers. This anticipates that UNHCR and its donors will continue current levels of LPG provision and/or that market-based in-camp LPG distribution may be promoted over time via the establishment of a Global LPG Fund for refugees as announced in the UNHCR 2019 Global Report[56]. The projected 2021 LPG consumption volumes are therefore held constant each year to 2030.

Table 35. Public institution populations with LPG-cooked meals, 2020-2030

	Health care facilities			Military barracks		
Year	Total patient population	Total institutional population fed via LPG	Institutional population fed via LPG (%)	Total defence force population	Population fed via LPG	Institutional population fed via LPG (%)
2020	20,399	1,273	6%	33,000	4376	13%
2021	20,874	2,233	11%	33,000	7676	23%
2022	21,348	6,700	31%	33,000	14276	43%
2023	21,840	15,632	72%	33,000	27476	83%
2024	22,332	22,332	100%	33,000	33000	100%
2025	22,824	22,824	100%	33,000	33000	100%
2026	23,316	23,316	100%	33,000	33000	100%
2027	23,808	23,808	100%	33,000	33000	100%
2028	24,308	24,308	100%	33,000	33000	100%
2029	24,808	24,808	100%	33,000	33000	100%
2030	25,309	25,309	100%	33,000	33000	100%

56 See https://www.unhcr.org/dach/wp-content/uploads/sites/27/2020/06/UNHCR_global_report2019.pdf (page 235)

,

	Nursery schools			Primary schools		
Year	Total nursery school pupils	Pupils in nurseries fed via LPG	Pupils in nurseries fed via LPG (%)	Total primary school pupil population	Pupils in primary schools fed via LPG	Pupils in primary schools fed via LPG (%)
2020	236,705	2,698	1%	2,614,133	2,698	0.1%
2021	242,211	25,913	11%	2,674,945	25,913	11%
2022	247,718	77,740	31%	2,735,757	77,740	31%
2023	253,426	181,393	72%	2,798,793	181,393	72%
2024	259,134	259,134	100%	2,861,829	2,861,829	100%
2025	264,841	264,841	100%	2,924,866	2,924,866	100%
2026	270,549	270,549	100%	2,987,902	2,987,902	100%
2027	276,257	276,257	100%	3,050,938	3,050,938	100%
2028	282,063	282,063	100%	3,115,063	3,115,063	100%
2029	287,870	287,870	100%	3,179,188	3,179,188	100%
2030	293,676	293,676	100%	3,243,314	3,243,314	100%

	Secondary schools			Boarding schools		
Year	Total secondary schools pupil population	Pupils in secondary schools fed using LPG	Pupils in secondary schools fed using LPG (%)	Total boarding school pupil population	Pupils in boarding schools fed using LPG	Pupils in boarding schools fed using LPG (%)[$]
2020	517,130	5,894	1%	162,646	1,242	1%
2021	529,160	56,613	11%	166,429	11,925	7%
2022	541,190	169,839	31%	170,213	33,292	20%
2023	553,660	396,291	72%	174,135	76,026	44%
2024	566,129	566,129	100%	178,057	106,834	60%
2025	578,599	578,599	100%	181,979	109,187	60%
2026	591,069	591,069	100%	185,901	111,541	60%
2027	603,539	603,539	100%	189,,823	113,894	60%
2028	616,224	616,224	100%	193,813	116,288	60%
2029	628,910	628,910	100%	197,802	118,681	60%
2030	641,595	641,595	100%	201,792	121,075	60%

Note: Police station population consists of police staff and temporary detainees. Population in defence services assumed constant over time given the service is voluntary. Boarding schools assumed to meet 40% of daily cooking energy needs with biogas over time.

Assumptions for non-commercial institutions

For institutions where data on LPG consumption was not available for 2020 (i.e., prisons, healthcare facilities and day schools), minimal levels of LPG usage were assumed in 2020. For boarding schools, these were estimated based on the proportional growth of LPG adoption reported in boarding schools between 2020 and 2021 (where initial LPG volumes were estimated as 19 MT in 2020 with a projected increase of 10.4% for 2021).

Institutional demand curves for LPG were modelled assuming an increase to 100% LPG usage in 2024, except for (a) a 40% biogas/60% LPG split in prisons and boarding schools and (b) constant consumption in refugee camps. For all the institutions projected to reach 100% LPG use in 2024, the LPG demand levels between 2021 and 2023 were set to 10%, 30% and 70% of the 2024 projected maximum volumes, reaching 100% in 2024, in order to reflect a conservative four-year ramp up period of both consumption and supply. In those institutions where LPG use in 2020 is already higher than 10% of the 2024 estimate (e.g., military barrakcs, boarding schools), projections were set as 10%, 30% and 70% of the 2024 projected volumes and added to the initial 2020 reported volumes.

100% LPG usage in a given institution may require that the institution secure an appropriate;y sized LPG procurement budget. Should institutions—especially smaller, rural ones—not obtain sufficient funding for LPG, they might continue to rely on contributed firewood or charcoal.

For all institutions, the projected 2024 LPG volumes are calculated based on the population size estimated to be served meals cooked with LPG multiplied by the estimated kg per capita that would apply to each institution type (Table 36).

Table 36. LPG per capita usage estimates by institution type

Institution	LPG consumption (kg/capita/year)	Basis of estimate
Prisons	20.4	Assumes number of meals and diet similar to police stations
Police stations	20.4	Based on official study done at a police training station with meals including beans and maize
Health Facilities	20.4	Assumes number of meals and diet similar to police stations
Nursery Schools	5.4	Assumes one meal per day over 5 days a week, for 9 months a year
Primary Schools	5.4	Assumes one meal per day over 5 days a week, for 9 months a year
Secondary Schools	5.4	Assumes one meal per day over 5 days a week, for 9 months a year
Boarding Schools	15.3	Assumes two meals per day and light breakfast over 7 days a week, for 9 months a year
Refugee camps	23.8	Based on data from the Mahama camp in Rwanda. Assumes most cooking needs are meet but likely insufficient for daily/frequent cooking of beans.
Military Barracks	20.4	Assumes number of meals and diet similar to police stations

First, the population in 2020 in each given institution is projected to grow in line with the overall increase of the total Rwandan population, keeping the 2020 proportion of the population for each institution constant. This approach applies to all institutions except for military and refugee camp populations, where constant population are assumed. Secondly, LPG volume per capita is calculated for each institution in 2020, and that volume is multiplied by the projected population in each institution in 2024 to estimate the volume associated with maximum LPG use for that institution. From 2024 to 2030, the increase in demand is modelled as a function of increased institutional population (in line with Rwanda's overall population growth).

Assumptions for commercial institutions

Commercial institutions (hotel and restaurants) accounted for 2,697 MT of LPG consumed in 2020 (CFET). LPG demand was projected to grow conservatively in this segment, according to GDP growth. The year-on-year GDP growth rates applied to the LPG volume projections are reported in Table 37. These were derived from the International Monetary Fund (IMF) 2020 Rwanda Country report, released in April 2020[57].

Table 37. Rwanda real GDP growth projections, 2021-2030

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GDP growth	8.1%	8.2%	8.0%	7.5%	7.5%	7.5%	7.4%	7.3%	7.2%	7.2%

Institutional LPG demand results

Table 38 summarises LPG demand by type of non-commercial and commercial institution to 2030, based on the respective assumptions and growth rates set forth above. These projected volumes are used in all four scenarios.

Table 38. Breakdown of projected institutional LPG demand volumes, 2020-2030
in MT

Type	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Prisons	1	94	281	657	938	959	979	1,000	1,021	1,042	1,063
Police stations	186	235	330	516	656	670	685	699	714	729	743
Health facilities	5	46	137	319	456	466	476	486	496	506	516
Nursery schools	15	140	420	980	1,399	1,430	1,461	1,492	1,523	1,554	1,586
Primary schools	16	1,545	4,636	10,818	15,454	15,794	16,135	16,475	16,821	17,168	17,514
Secondary schools	32	306	917	2,140	3,057	3,124	3,192	3,259	3,328	3,396	3,465
Boarding schools	19	182	509	1,163	1,635	1,671	1,707	1,743	1,779	1,816	1,852
Military barracks	89	145	291	561	673	673	673	673	673	673	673
Refugee camps	1,392	1,743	1,743	1,743	1,743	1,743	1,743	1,743	1,743	1,743	1,743
Hotels and restaurants	2,697	2,915	3,155	3,407	3,662	3,937	4,232	4,546	4,877	5,229	5,605
Total	**4,451**	**7,352**	**12,419**	**22,302**	**29,673**	**30,467**	**31,282**	**32,115**	**32,975**	**33,855**	**34,760**

57 MF Country Report 20/115 – Rwanda

Industrial segment assumptions and results

Industrial LPG volumes were projected to grow in relation to a scenario-specific weighting of overall LPG market growth and GDP growth. The corresponding volumes under each scenario are summarised in Table 39.

Table 39. Projected industrial LPG demand, 2020-2030
in MT

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BAU	3,600	3,892	4,211	4,548	4,889	5,255	5,649	6,067	6,510	6,979	7,482
GDP growth		*8.1%*	*8.2%*	*8.0%*	*7.5%*	*7.5%*	*7.5%*	*7.4%*	*7.3%*	*7.2%*	*7.2%*
Low case	3,600	4,199	5,073	6,262	7,251	7,973	8,779	9,662	10,626	11,670	12,794
Avg of GDP, mkt growth		*16.6%*	*20.8%*	*23.5%*	*15.8%*	*10.0%*	*10.1%*	*10.1%*	*10.0%*	*9.8%*	*9.6%*
High case	3,600	4,307	5,320	6,664	7,835	8,815	9,923	11,125	12,460	13,957	15,584
Avg of GDP, mkt growth		*19.6%*	*23.5%*	*25.3%*	*17.6%*	*12.5%*	*12.6%*	*12.1%*	*12.0%*	*12.0%*	*11.7%*
NST-1 case	3,600	4,789	6,446	8,542	10,293	11,262	12,254	13,404	14,580	15,940	17,364
Avg of GDP, mkt growth		*33.0%*	*34.6%*	*32.5%*	*20.5%*	*9.4%*	*8.8%*	*9.4%*	*8.8%*	*9.3%*	*8.9%*

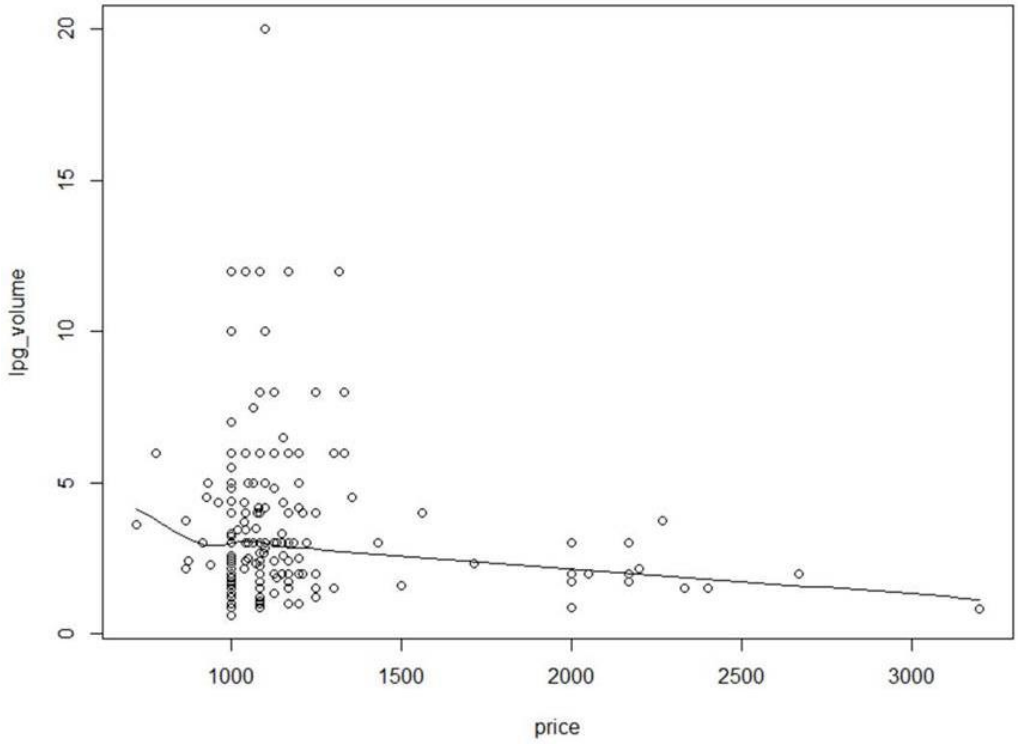
28. Household Demand Sensitivity

Effect of LPG price on household demand

Demand modelling also assessed the potential demand-dampening effect of LPG fuel price increases over time. Prices were drawn from the CFET 2020 survey and from RURA data to estimate the prevailing average fuel prices in Kigali, other urban areas, and rural areas.

Overall, a very minimal correlation between LPG price and usage was found from the available data. To the extent there is any correlation, a 1% increase in price reduces demand by 0.33% (inelastic) on the national level, and 0.43% in urban areas (See Figure 36). While it is expected that price changes may lead to some usage changes, we were not able to quantify such change given the overall paucity of data from LPG using households in Rwanda reflected in the CFET dataset. In the early stage of LPG market development in the country, where the majority of the population is rural with limited or no access to LPG fuel, expanding access to cylinders and LPG equipment is the main driver of demand according to the modelling. Fluctuations in price will impact LPG uptake only once accessible and reliable supply is established.

Figure 36. Probability of LPG consumption based on refill price per kg



Whilst it was not possible to model the effects of price increases for alternative cooking fuels on LPG demand, it is expected that higher relative LPG prices may negatively impact demand for LPG. Similarly, higher prices for purchased fuel alternative such us firewood and charcoal, should promote greater adoption of LPG should supply constraints been overcome. Finally, it is expected that any future price increases in imported LPG (for example predicted due to depreciation of the RwF against the US dollar over time) may potentially be offset by a rise in Rwandan incomes, especially as the country moves towards increased urbanization, and/or by general domestic price inflation.

While the price elasticity analysis shows that demand is not sensitive to fuel price at the current stage of LPG market development in Rwanda, it is probable that significant changes in LPG fuel prices will impact LPG use after accessible and reliable supply is established on a wide scale.

In addition, international experience from other countries in SSA and from South-East Asia suggests that purchase of start-up LPG cooking equipment is an important barrier of uptake, and it is reasonable to assume this could also be the case for Rwanda.

Distance from retail point

The scenarios of projected LPG adoption and use by 2030 indicate that the demand is highly sensitive to acessibility of LPG. From the models, a threshold distance of 2km emerges as indicative of a rapid drop-off in use: if the LPG outlet is further than 2km away from the household, the usage is very low. When closer than 2km, LPG adoption increases rapidly with decreases in distance. The modelled threshold of 2km may be slightly different in the real world due to uncertainty in the model caused by the small number of LPG users in rural areas presently, but the reverse association between LPG use and distance nonetheless persists. Detailed information on the related assumptions and correlations is provided in Annex Chapter 78.

Other factors potentially influencing household demand

There are several potential drivers of demand that were not included discretely in the quantitative modeling due to limitations of the available datasets. For example, there were no available data on LPG cylinders in households, such as the cylinder size and frequency of refill, which could produce reliable correlations and predictions.

It was not possible to model the effect of variations in up-front costs on becoming an LPG user, as only cookstove prices were recorded in the CFET survey, and these were reported historically as of the time of purchase, making it impossible to estimate current equivalent prices. Furthermore, the CFET survey suggested that the highest LPG stove price was associated with highest LPG usage, which may represent a characteristic of early adopters who are predominantly from the high socioeconomic statuses and not necessarily representative of the general population. Finally, there were no available data on perceptual factors, such as risk perception (safety), that could further influence LPG adoption.

Methodological limitations

There were several methodological limitations associated with the household demand projection models. The BAU projection trends were modelled using two data points for LPG use and socio-economic variables (MTF 2018, and CFET 2020), and one data point for the LPG accessibility estimate (distance from point of sale; CFET 2020). The older available national data sets (EICV) did not include variables that could be harmonised with the more recent nationally representative surveys.

A second data issue is that questions related to LPG use, such as prices paid and distances to retail outlets, were asked only of existing LPG users. Estimates for these variables for non-LPG using households were made based on modelling assumptions.

Finally, the projections for rural areas are based on data from a very small number of users in those areas (there were only two LPG-using households in 2016 and 19 in 2020 in the survey data), so the uncertainty of the predictive models with respect to rural areas is large.

XIII. Supply-Demand Balance, Sourcing and Price Effects

29. Regional LPG Availability to 2040

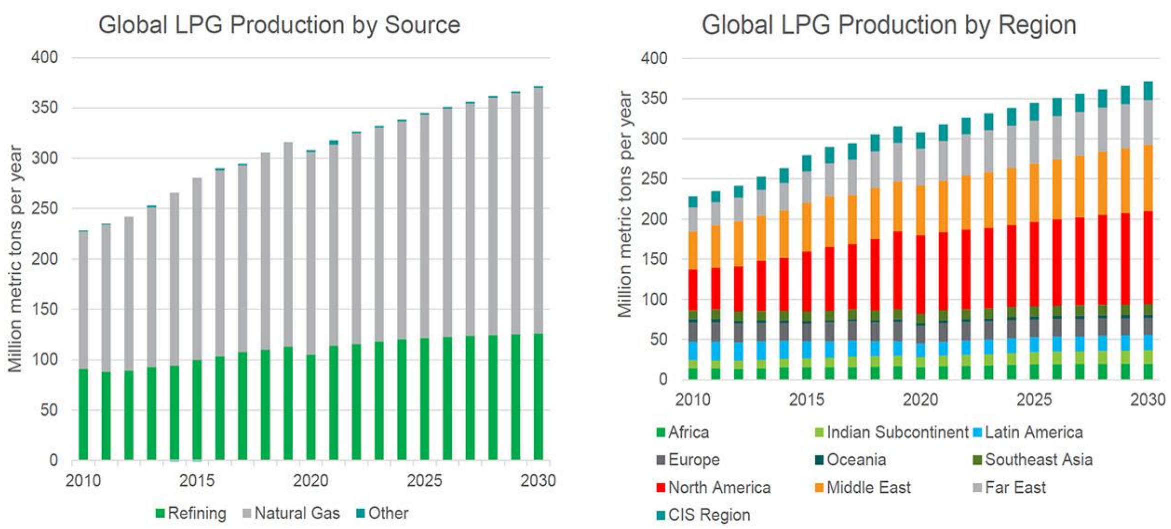
An analysis was performed of global and regional supply and shipping trends relevant to East Africa, indicating that more international LPG will be available to Rwanda, under any scenario of future demand, until at least 2040, with only gradual increase in the relevant international import reference price, Saudi CP—butane.

Supply factors

LPG production is expected to remain in absolute surplus to at least 2030, based on projections of known production and extrapolation of demand and consumption trends.

The following figure shows the production trends. Because LPG is a by-product of oil refining and oil and natural gas processing (plus some recent renewable LPG production), it is produced whether or not there is demand for it, and this production is proportional to primary oil and natural gas production needed to satisfy global demand for major petroleum products.

Figure 37. Global LPG production projections to 2030
Source: IHSM



Exported production is fungible on international markets; ocean trade routes evolve to match demand with supply. The surplus is ultimately cleared by the petrochemical industry as the buyer of last resort. Petrochemicals currently clear about 30% of global LPG production, creating a very substantial buffer in case of a tightening of the market.

As demand develops in East Africa, trade routes will adjust accordingly.

Rwanda's larger neighbors will continue to dominate regional import conditions. Growth in Rwanda's demand will not shift regional conditions under any of the demand scenarios discussed in this document.

As Kenyan maritime import capacity is increased, and larger vessels (including VLGCs) can be discharged there, supply options will increase and ocean transport costs will fall.

The following map presents the adjustment and arbitrage factors; the inset chart demonstrates the petrochemical market clearing function.

Figure 38. Global LPG supply factors and market clearing mechanism
Source: IHSM

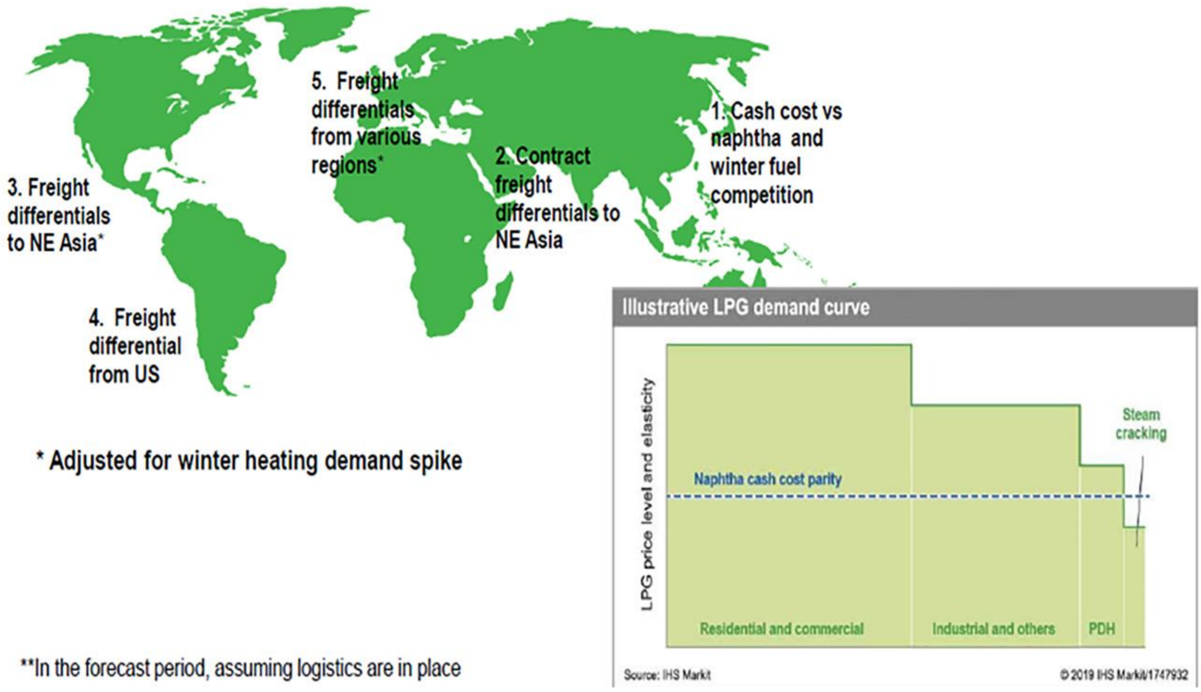


Figure 39 shows the relative size and composition of the global, African, and East African markets.

Figure 39. Size and composition of global, African and East African LPG markets
Source: IHSM

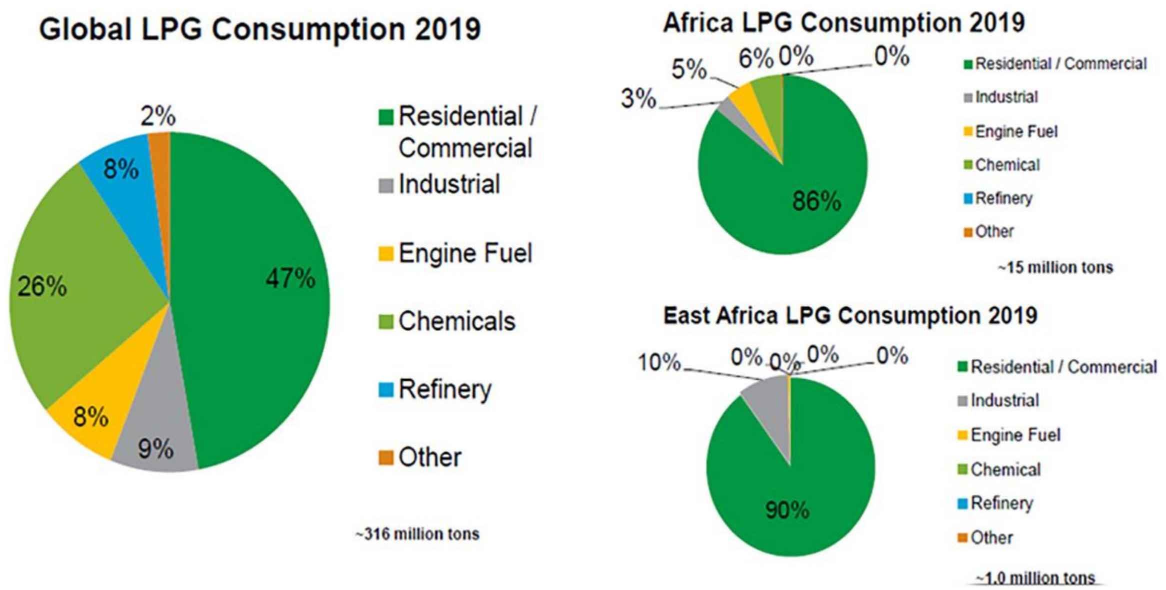
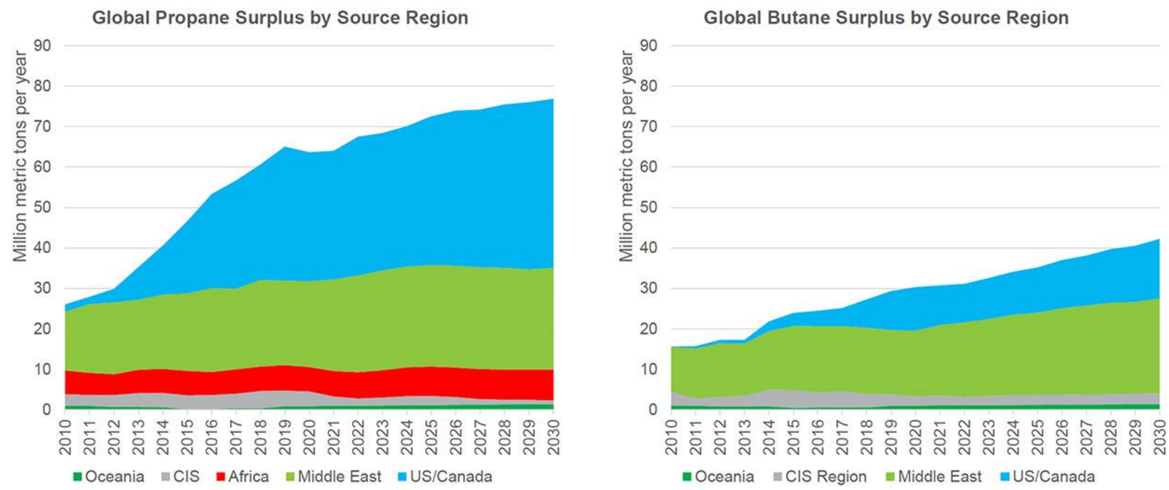


Figure 40 shows the trends in production surplus from the main potential suppliers to East Africa. Historically, Middle East supply has dominated the region (in large part due to lower ocean transport costs vs. North America, and in part on the shipping choices applicable to the two regions); this is projected to continue for the foreseeable future. The current level of butane surplus (around 20 million tpa) represents 20X the current East African LPG demand and is projected to double by 2030.

Figure 40. Primary sources of LPG surplus relevant to East Africa, to 2030

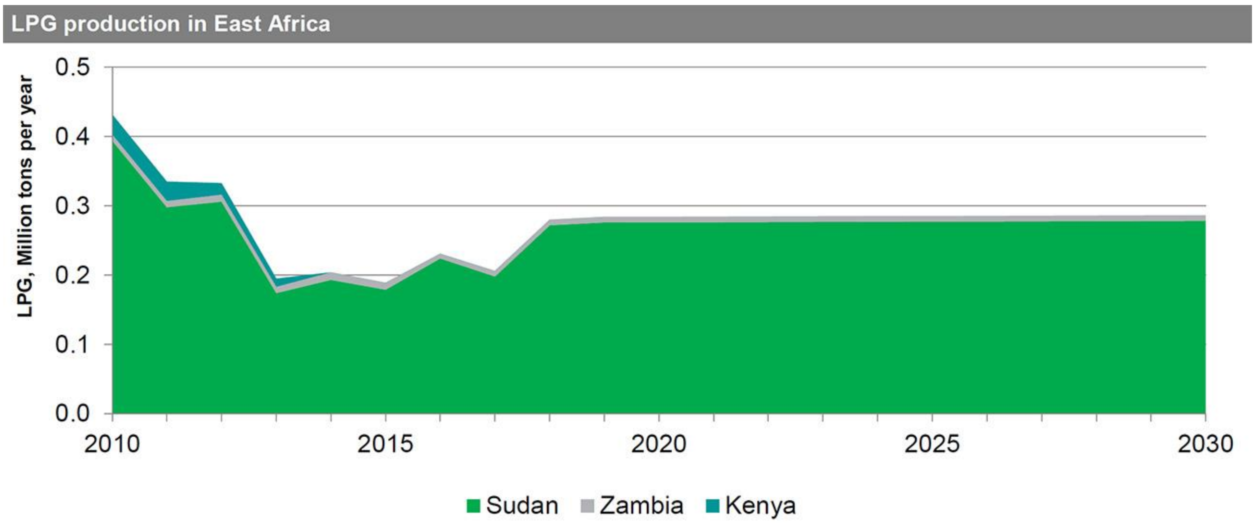
Source: IHSM



Production in the greater eastern Africa region is expected to remain flat, and not a contributor to Rwanda LPG imports.

Figure 41. Regional LPG production forecast to 2030

Source: IHSM



Ocean terminals

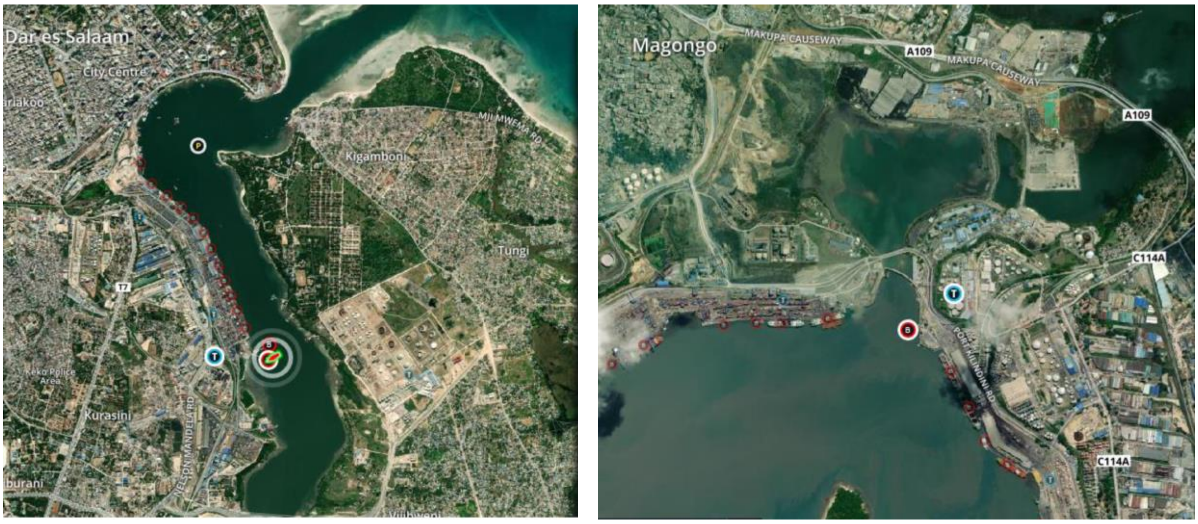
The Kenya and Tanzania ocean terminals described in Chapters 24 and 29 have ample capacity to handle East African (and thus Rwandan) LPG import needs. Images of these facilities are shown in the following figure:

Figure 42. East African LPG import facility satellite images

Source: IHSM

KOT facility, Dar es Salaam

Shimanzi facility, Mombassa



Price factors

Cost of product

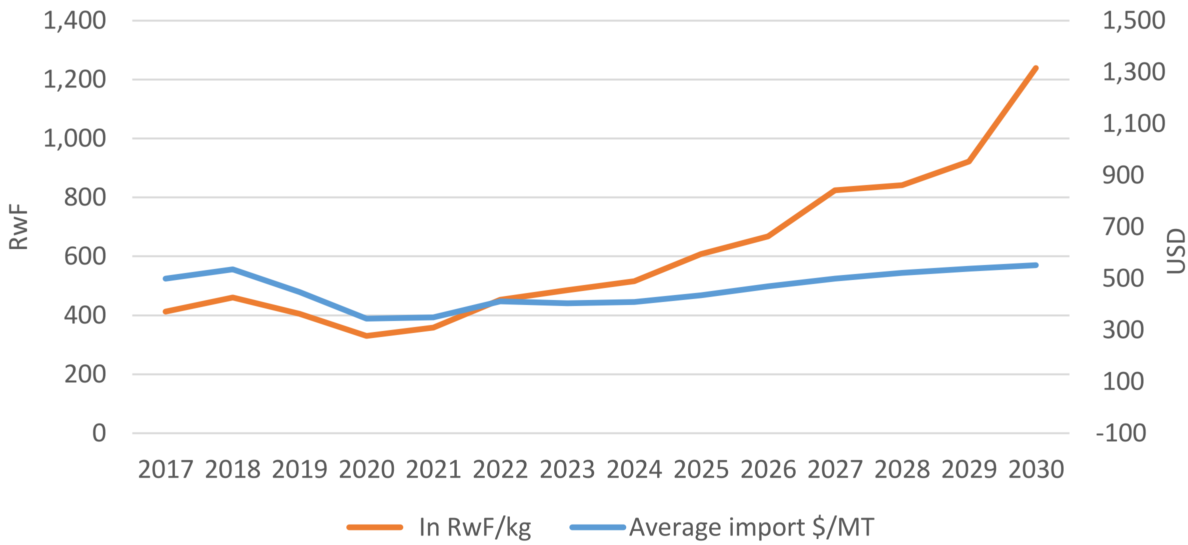
Covid-19 has temporarily depressed LPG export and import pricing globally; normal market conditions are expected to return by 2022.

Arbitrage and substitutes to LPG will constrain LPG pricing globally for the near, medium and long term.

The following figure shows the projected Saudi CP butane price in USD, and converted to RwF.

Figure 43. Saudi CP butane prices to 2030, in USD and RwF

Source: IHSM (USD); IMF (exchange rates)



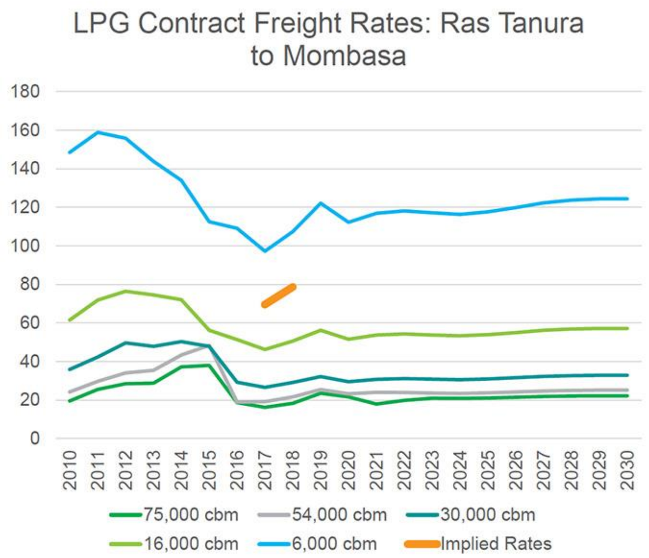
This portends significant price stability for the end-user price of LPG in Rwanda, if (a) the supply chain operates at current levels of cost efficiency (or better) to 2030, (b) projected devaluation of the RwF vs. USD in later years is moderated or mitigated and/or there is offsetting domestic price inflation that counteracts RfW-USD movement.

It should be noted that the effect of RwF devaluation on the cost of LPG imported to Rwanda, and on the Rwanda end-user LPG price, has been taken into account in the demand scenarios summarized in Volume 1 and presented in detail in Volume 2.

Cost of ocean transport

The cost of ocean transport from the Middle East to East Africa is projected to remain stable to 2030 (Figure 44, top curve). There is a significant opportunity to reduce landed LPG cost in East Africa via the eventual expansion of maritime port capabilities and import capacities in Kenya (and Tanzania) to handle larger-sized LPG vessels as the East African market grows. The lower price points provided larger vessels are shown in the lower curves in Figure 44. As the figure shows, savings of at least US $60 per tonne (about RwF 59,000) are feasible when it becomes possible to accept and fully offload larger-sized LPG vessels.

Figure 44. Projected ocean LPG transport costs by vessel size to 2030
Source: IHSM



Cost values in USD/t.

1 cbm of butane represents approximately 0.573 t

30. BioLPG Potential in Rwanda

Pursuant to a grant from UKAID through its Modern Energy Cooking Services (MECS) programme, GLPGP, in partnership with the Gas Technology Institute (USA) and the University of Surrey (UK), carried out a feasibility study regarding bioLPG production in Africa[58].

BioLPG is LPG produced from renewable resources.

It can be produced as biopropane and/or biobutane, based on the tuning of the bioLPG plant technology. BioLPG is chemically the same as fossil-sourced LPG.

The objectives of the study were (a) to be the key initial reference point for understanding the feasibility of producing LPG from renewable feedstocks in Africa before 2030; and (b) having found potential feasibility during the course of the study, to provide a short list of recommended pilot projects for support, whose successful implementation could then serve as a template for large scale replication of similar projects across Africa.

The study found that bioLPG could be produced feasibly in Rwanda at a very affordable end-user price and at meaningful scale by utilizing municipal solid wastes (MSW) from properly engineered landfills as feedstock.

Such bioLPG production would give Rwanda local control over an important source of LPG supply, denominated in RfW, and immune from international fuel supply-chain risks.

The study also determined that the use of MSW to produce bioLPG in Rwanda was likely to be a higher and better use of landfill gas (biogas) than for uses in generating heat and power, or for other commercial end-uses.

The prospect of large quantities of economically feasible LPG production from renewable feedstocks such as MSW is highly attractive, as it would augment the existing societal advantages stemming from use of LPG by substantially mitigating concerns about increased use of fossil-origin LPG. It would also contribute to the development of a green, circular energy economy in Rwanda.

Provision of bioLPG to supplement or replace fossil-fuel sourced LPG would also enable the highly attractive economic efficiency of continued use and further expansion of the considerable investments in supply-side LPG infrastructure and demand-side household LPG equipment outlined in this Plan.

Recommended Rwanda bioLPG production route

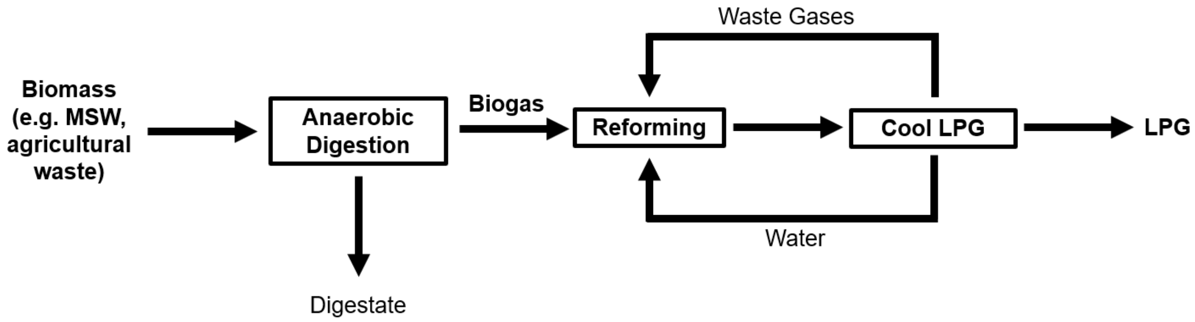
CoolLPG, a GTI-developed process which uses a methanol-mediated route to produce LPG directly from biogas-derived syngas, represents the optimal technical route to bioLPG production in Rwanda, according to the GLPGP-MECS study. The approach is similar to an integrated methanol synthesis route but produces a mixture of mostly propane and butane for fuel rather than separated olefins for use as a chemical feedstock. The CoolLPG process can be used to produce propane and butane mixtures. This

---

[58] GLPGP (2020). *Assessing Potential for BioLPG Production and Use within the Cooking Energy Sector in Africa*. See https://mecs.org.uk/wp-content/uploads/2020/09/GLPGP-Potential-for-BioLPG-Production-and-Use-as-Clean-Cooking-Energy-in-Africa-2020.pdf

technology is still in the development phase but is expected to be rapidly highly scalable based on the extensive existing knowledge and industrial experience of reforming, methanol synthesis and conversion processes. Furthermore, the process is self-contained and able to run entirely on biogas without separation of CO_2 or extensive existing infrastructure in place. Because it is one of the only routes specifically targeting propane and butane, this is a highly promising technology for LPG production within the context of the present Plan.

Figure 45. CoolLPG route to bioLPG



Rwandan advantages for bioLPG production

The study considered the starting conditions in Rwanda for feasibility of bioLPG production, summarized as follows:

Current status of biogas production

Rwanda launched a National Domestic Biogas Programme in 2006 (supported by SNV Netherlands Development Organisation), with targets for the installation of 15,000 household-scale anaerobic digestion (AD) plants (up to 10 m^3 capacity). Aims of the project include reducing dependence on traditional cooking fuel, reducing energy expenditure, and improving air quality in the home. Over the duration of the project, targets had to be revised and, as of 2012, only 2,600 units had been installed. The failings of the project were similar to those in other African countries (Landi et al., 2013; Bedi et al., 2015). Rwanda has had more success in implementing biogas systems in institutions such as prisons and schools, developed as a means of managing human waste and providing clean fuel for cooking (Munyehirwe and Kabanda, 2008). In 2008, 36 digesters had been installed in institutions, with capacities up to 1,250 m^3 in larger facilities. Information about large scale biogas facilities associated with the management of residues and wastes from agro-processing has not been found; however, this may be integrated into future planning for the agricultural industry.

Assessment of feedstocks

The availability of agro-processing residues from sugarcane, cassava and beer brewing were investigated as feedstock for the application of AD technology at large scales. Urban wastes such as MSW and wastewater were also reviewed.

Urban wastes

Sanitation systems in the city of Kigali currently only cover 700 households (Rwanda National Sanitation Plan, 2016). However, the city is in the process of developing a centralised sewerage system. Waste which is collected from septic tanks is currently dumped in lagoons at the Nduba landfill site, which creates considerable health and safety issues and is under threat of flooding in poor weather conditions.

The site at Nduba is an open dumpsite and is poorly managed despite the ambitions of the Rwandan government (Alice et al., 2017). It is used to manage both liquid and solid waste. Currently, there is no engineering in place to allow for energy recovery, despite efforts to engage with contractors to manage the waste. The site receives between 400 and 800 tonnes of MSW per day, which represents a collection rate of approximately 25-40% of the MSW generated in Kigali.

Agricultural feedstocks

According to the FAO, the total land area is 24, 670 km^2, with an agricultural area of 18,117 km^2 and forested area of 4,800 km^2. The Rwandan landscape is relatively diverse and is considered a tropical temperate climate with an average temperature of 16-20^oC and average rainfall intensity of 1,156 mm/annum. It is renowned for its mountainous landscape, at an altitude of between 915 and 4,486 m, and supports a variety of crops, following two distinct growing seasons. Coffee and tea are the main crops grown for export; bananas, sweet potatoes and cassava are the main crops, producing over 1 million tonnes in 2018 (FAOSTAT). Sugarcane, sorghum and rice are also grown in the country as well as a wide diversity of horticultural fruit and vegetable crops. However, value chains for crops are poorly developed, with very little processing of crops other than brewing, sugarcane and cassava processing, and relatively small amounts of ground nut oil for local use. Due to a lack of storage and processing capacity, much food is wasted due to spoilage, and considerable attention is being paid to the development of agro-processing in the country.

A report by the Rwanda Ministry of Trade and Industry (MINICOM, 2014) highlights that, despite GDP being largely driven by agriculture, the industry suffers from poverty, low productivity, inadequate infrastructure and poorly integrated markets, with little value added by downstream processing. Most of the population (83.4%) rely on subsistence agriculture, and the country faces several challenges associated with its topography and pressure on land availability. The agro-processing sector was identified in Rwanda's Vision 2020 report as an industrial sector for targeted development, to contribute to the transformation of Rwanda to a middle income country by 2030. The development of the agricultural industry is supported by the Industrial Master Plan for the Agro-processing Sector, which identifies improved productivity at the field level and upgrading of the agro-processing sector as areas for improvement; however, further investigation would be required to assess residue availability and current disposal practices.

Feesdstock conclusion

The MSW route is the more appropriate path to follow. It appears that the management of waste in Kigali is in urgent need of upgrading and could offer a strategic development opportunity for bioLPG production. Rwanda has had its own local success in the development of community-scale AD to manage waste in institutions such as prisons, hospitals and schools. The College of Science and

Technology (formerly the Kigali Institute of Science and Technology) have been instrumental in developing these systems, suggesting a degree of in-house capability for future partnerships.

Favorable policy environment for bioLPG development from MSW

Within the waste management sector, the Government has indicated a strong commitment to move away from the "collect and dump" approach and adopt an environmentally sustainable approach. Over the years, the Government has made a substantial improvement in its waste collection service. In Kigali, between 2012 and 2015, the number of households with access to solid waste collection service increased from 44% to 90%. The Government also recognises the generation of electric power from landfill gas collection at the landfill site as an opportunity to utilise waste methane. The Rwandan (Updated) NDC (2020) sets out a plan for the extraction and utilisation of landfill gas for power generation in urban areas. It also outlines an intent to develop energy recovery options other than landfill gas to increase access to electricity and reduce dependency on traditional biomass energy.

Waste management is guided by principles that centre around environmental protection, sustainability, sanitation and health. Efforts in this area are supported and regulated by a set of policies and decrees. The backbone of all waste management activities in the country is the Organic Law Determining the Modalities of Protection, Conservation, and Promotion of the Environment in Rwanda (2005). The Law on Environment (2018) outlines the rules and regulations, including sanctions and fines for unauthorised activities. The Law also creates environmental protection committees at district, sector and cell levels. The Solid Waste Collection and Transportation Act (2014) categorises waste collection companies and regulates the mode and frequency of waste collection. Regulations of Solid Waste Recycling (2015) provides standards for a recycling site and recycling facility permitting process. Finally, Guidelines on Practical Tools in Solid Waste Management (2010) sets out a detailed technical guideline on landfill and compost operations.

BioLPG price competitiveness

Based on a high level economic analysis, it was estimated that bioLPG could be produced in the Kigali area at a wholesale price of approximately USD $800-850/t (but denominated in RwF), based on an initial plant scale of 10,000 tpa.

Derisking steps

As a business and risk-mitigation strategy, the bioLPG plant would seek to have long term take-or-pay sales contracts for its output with multiple LPG Marketers in the country (and with oil-and-gas marketers with respect to the gasoline co-produced via the IH^2 process.) These marketers would benefit in numerous ways, including (1) high stability of LPG supply volumes from the plant, (2) price stability over time, (3) no need for foreign currency (directly or indirectly) to import LPG, (4) possible access to carbon finance from providing renewable LPG to consumers for cooking to displace high-emitting fuels, (5) marketing advantages from being a provider of "green" LPG, and (6) possible governmental support that encourages provision and consumption of renewable LPG in place of high-emitting and/or forest-degrading fuels such as charcoal, firewood and kerosene (and fossil LPG).

Plant financial analysis

1. The output of an initial commercial-scale plant was assumed to be 10,000 tpa of bioLPG.
2. The capital expenditure for an AD + CoolLPG route at 10,000 tpa bioLPG output was estimated at US $26.3 million (US $10.5 million for the AD portion and US $15.8 million for the CoolLPG portion). This costing was based on the Chemical Engineering Plant Cost Index ("CEPCI") in 2019 USD.
3. The MSW input tonnage needed to generate 10,000 tpa of bioLPG output via AD + CoolLPG would be 270,301 tpa (a ratio of about 1:27).
4. It is highly beneficial for the bioLPG plant, from an investment perspective, to be in position to receive a gate fee (notionally, US $10/t) from the relevant governmental authority to use/clean up the waste.
5. A capitalization mix of 35% bank/commercial debt, 40% concessional debt and 25% equity was assumed, with an approximately 12% blended cost of capital (including equity).
6. The plant cost is depreciated over 10 years, starting in the third year, as it is assumed that it will take two years to build the plant. 40% of the construction cost is expended in the first year, 60% in the second.

The IRR of the free cashflows from such a plant, including a terminal value estimate, is modeled in the range of 45%, based on the wholesale pricing of its output at US$ 850/t and assuming the availability of the aforesaid MSW gate fee.

Conclusion

The GLPGP-MECS study indicates that bioLPG could be produces in Rwanda within a few years to supplement or complement imported fossil LPG.

➲ Whilst is beyond the scope of the Plan work to evaluate in detail the feasibility of a specific Rwanda MSW-to-bioLPG project, this is recommended to be pursued, starting with a scoping study in 2021 amongst the GoR, GLPGP and GTI (subject to funding availability).

Rwanda National LPG Master Plan

Volume 3

Regulatory and Standards Recommendations

Contents

List of Tables

List of Figures

XIV. Regulatory and Standards Review and Recommendations

This Part is intended to guide the GoR regarding LPG distribution regulations, by assessing the current set of regulations regarding the LPG sector and recommending improvements, from the importation of LPG cylinders to the final delivery of refilled LPG cylinders to the public in a safe and sustainable way, ensuring constant safety for the public and at the lowest feasible cost.

This part of the Plan does not present actual regulatory language. Rather, it serves as a base document to guide the drafting of regulation enhancements for the Government to consider, adapt where necessary, adopt, enact and enforce.

Note: Because the Chapters within this Volume are in themselves a comprehensive and detailed set of recommendations, the recommendation attention symbol (➲) is not used here.

31. Models of National LPG Systems

Globally there are two main models for organizing residential LPG markets: the Consumer-Controlled Cylinder Model (CCCM) and the Branded Cylinder Recirculation Model (BCRM). Today, the latter dominates the world and, when well implemented and rigorously enforced, strongly correlates with a safe, robust, bankable LPG sector and widespread LPG use by the population.

Where not well implemented or poorly enforced, markets exhibit dysfunctions. These dysfunctions correlate with poor safety, limited or no bankability (other than friends-and-family capital), limited LPG adoption with slow or no long-term growth, and declining levels of investment.

BCRM emerged in conjunction with the invention of the centralized filling plant in the 1960s, which enabled a much improved safety profile for LPG in cylinders provided the LPG marketer owned, controlled, benefitted financially from, and was held liable for, cylinder investment and cylinder safety.

CCCM is a legacy model that nonetheless survives in a few countries. It is the conceptual antithesis of BCRM.

CCCM is used together with BCRM in the United States and Canada. CCCM is also used for a small portion of the LPG market of Germany. In modern times, it has been tried, or has been devolved into, in some developing countries. Aspects of CCCM invaded the BRCM model in Brazil in the 1970s and resulted in a major increase in accidents and fatalities that shook public confidence in LPG and risked market implosion, until BCRM was properly reconstituted and enforced through concerted joint government-industry action. CCCM has been attempted in Haiti without success. It is the dominant model in Nigeria, which has suffered decades of boom-bust investment cycles in LPG with negligible growth in LPG use per capita, despite being a major LPG producing country and one of Africa's wealthier countries. Nigeria recently announced plans to transition to BCRM for the long term.

BCRM can be implemented rigorously ("strong form") or loosely ("weak form").

In all developing countries which have succeeded in achieving meaningful levels of residential LPG use per capita, strong-form BCRM has been the model.

32. Objectives of an LPG Regulatory Framework

LPG can be dangerous to handle and use without the application of known, trusted safety rules. This is of great importance in a country that has, or plans to have, a very large number of LPG cylinders scattered in millions of households. LPG distribution actors must follow essential safety rules and meet essential responsibilities in order that accidents and fatalities are avoided. The global LPG industry has developed best practice regulations, regulatory frameworks, safety rules and standards with a demonstrated track record of success in the countries which have employed them fully and enforced them well, usually via a working partnership between the regulator and the industry.

The regulatory framework for LPG distribution is intended to define safety rules applicable to, and the consistent assigned role of, each actor in the LPG value chain, in order that responsibilities are clearly established for all parties at all times: from the importation of LPG cylinders to the final, safe delivery of refilled LPG cylinders for the public and the lowest feasible cost.

These safety rules and role responsibilities, when effectively impleented and enforced, provide investors with a secure operating framework for operations and investments and consumers with the security of knowing that the cylinder distribution chain has a consistently strong safety profile.

Risks posed by LPG are easy to control by all actors respecting effective safety rules

LPG is gaseous at normal temperature and pressure, but becomes a liquid upon compression, as in a cylinder or tank[59]. LPG ignites very easily and burns with minimal emissions. The danger arises from leaks of LPG, whether in liquid or gas form, which can cause a fire and, rarely, an explosion in an enclosed space. The most grave danger comes from a container filled with LPG heated by a fire fueled by a leak that evolves into an explosion of expanding boiling LPG steam (called a BLEVE[60]). A BLEVE can create a shock and fire wave over a radius ranging from 100m to 500m, resulting in physical damage, injury and death. LPG presents this risk that other liquid hydrocarbons do not pose. Safety rules must therefore be set separately for LPG.

The needed safety rules to prevent fires and BLEVEs are well known

To reduce the risks associated with the use and handling of LPG, all containers storing LPG in liquid form (cylinders, stationary tanks, tankers, specialized vessels and pipelines) must remain watertight and present no leakage. Any potential source of hazard must comply with a series of conditions of construction standards and operating standards, safety distances, filling procedures, and pre- and post-testing procedures, to ensure that the container is permanently and safely sealed.

Cylinders must be exchanged, empty for full, so that empty cylinders are checked in a properly equipped, staffed, and supervised filling facility before reuse. Storage and filling facilities must be equipped with leak detection and fire-fighting systems. Staff must be properly trained and monitored at all times.

59 Required storage pressure for LPG is about 1 bar for butane, about 7 bars for propane.

60 BLEVE is an acronym of boiling liquid expanding vapour explosion.

The details are presented later in this Chapter.

Translating BCRM into tasks and responsibilities for safety

BCRM, described in the next Chapter, is the globally proven model for organizing the distribution of LPG cylinders and ensuring that safety chain of responsibilities works.[61,62]

The absence of definition of a responsibility chain in cylinder re-filling, maintenance and distribution operations has been shown, in a number of countries, to result in the development of uncontrollable, dangerous cylinders, resulting in the disengagement of the public toward LPG and the cessation of cylinder investment by industry.

Chain failures occur when the cylinder ownership is not defined or is no longer respected by the competing operators, who then fail to comply with essential safety practices (no leak control, no valve change, under or over-filling), causing accidents without any consequence to themselves.

The BCRM describes which tasks, rights, and obligations are assigned to which actors (i.e., via licensing*)*.

Under BCRM, the safety chain is underpinned by the essential premise of swapping empty cylinders against refilled ones, with the empty ones recirculated to the responsible filling plant for safety checks prior to refill and return into the distribution network. The model requires the assignment to the cylinder investor of brand ownership and a guarantee of control over the cylinder and its recirculation. With this, the cylinder investor also assumes liability for the safety of the cylinder, and for any accident caused by a safety failure.

For the responsibility to work, the central role therefore belongs to the Marketer, which is the entity that:

- Invests in a large number of its own-branded cylinders;
- Develops its distribution network from exclusive distributors, retail points, home delivery systems and/or "smart valves"[63];
- Is responsible for the refilling and maintenance of its cylinders, either in self-owned or shared-ownership filling plants; and
- Is responsible for sourcing the supply of bulk LPG for its cylinders.

Each of the above assigned responsibilities must be assigned only to Marketers, through permits set in the regulation:

- Permit to import and purchase LPG cylinders;

---

61 The BCRM is described in the book composed by industry professionals, which can be downloaded here: https://www.wlpga.org/wp-content/uploads/2015/09/wlpga-guidelines-for-the-development-of-sustainable-lp-gas-markets.pdf

62 All well-developed LPG markets have strictly applied this model.

63 Innovative system allowing consumers to buy the amount of gas via mobile money based on their financial capabilities, instead of buying a whole cylinder refill at once.

- Permit to construct and operate owned or shared filling plants and bulk depots;
- Permit to import LPG for its filling plants;
- Permit to appoint exclusive distributors and transport LPG in cylinders; and
- Permit to contract transportation of LPG in bulk.

33. Conditions and Consequences of the BCRM LPG Market Model

Everywhere else in the world, if implemented in a self-consistent, well-enforced, and adequately financed way, BCRM eventually leads to widespread adoption of LPG with an acceptable level of safety (acceptable to the consumers, industry and governments in question).

BCRM is endorsed and promulgated by the World LPG Association, the global LPG industry organization.

Examples of major successes in LPG market development using BCRM include: Brazil (starting in 1979 following a near-collapse of the LPG market due to enforcement failure that led to thousands of monthly LPG fires and explosions), Morocco, Vietnam, Malaysia, India, Japan, Turkey and Senegal.

BCRM comprises a number of key principles, as follows.

- The LPG marketing company (Marketer) invests in, owns, inspects, maintains, and refills (away from populated areas) its own, branded cylinders and is responsible and liable for their safety. This function is specific to, and unique to, the Marketer. The Marketer is also exclusively authorized by the government to import and to market LPG. This linkage, between and among cylinder investment, cylinder refill income over the cylinder's life, liability for the cylinder's safety, licensing and permitting, the brand, and the acquisition of LPG, creates the needed incentives for LPG marketing companies to invest to expand their cylinder inventories in order to create new customers and to spend to maintain safety throughout the value chain.

  This key principle also serves to enable a self-reinforcing industry structure which is able to deliver adequate LPG safety at an affordable price to consumers while generating adequate financial returns to investors over the long term. Under the BCRM market structure, it becomes much more difficult for other parties (unlicensed marketers, wholesalers, and other legitimate or illegitimate parties) to steal and/or hoard cylinders, or to refill cylinders not belonging to them (thereby stealing the rightful refill income of the Marketer that made the cylinder investment). Where such black market or gray market activity is able to occur, private sector investment in cylinders and in safety inevitably decline, potentially leading to a destructive spiral of increasing market dysfunction in which bad actors increasingly drive out the good and consumers increasingly distrust LPG and LPG companies. This pattern has played out in many markets around the world where BCRM has been weakly implemented, or not at all. Once it takes hold, it is extremely difficult and takes many years to revese.

- The government must enforce the foregoing structure to ensure compliance by legitimate, licensed Marketers (and all other legitimate players) and to create significant disincentive (through inspection, legal prosecution, significant penalties for conviction, and other means) for illegitimate players to coopt for their own ends the cylinders of legitimate players, thereby breaking the linkage.

- All cylinders in the market are branded cylinders.

- The consumer obtains his/her first cylinder from a Marketer's distribution channel in exchange for a deposit, which is typically set below the cost of the cylinder with a maximum percentage specified by law or regulation. The cylinder remains the property of the Marketer. When the consumer's LPG runs out, the consumer returns the empty cylinder to a retail point in the Marketer's distribution network to exchange it for a full cylinder, at the prevailing, posted price for a refill.

- Margins, if regulated, must be adequate to cover the costs of the operation of the supply chain and the chain of safety responsibility across all the nodes, and to allow for adequate debt service, returns to equity investors, and investment in growth.
- Safety standards, in particular regarding the condition of cylinders and handling and transport of LPG, must be defined clearly and well enforced.
- Allowing cylinders to cross between Marketers' branded distribution networks is prohibited, because it leads to diverting and hoarding (taking off the market) of competing brands of cylinder, thereby creating shortages as well as reducing sector bankability.

BCRM is enhanced with certain optional characteristics, including:

- Industry consolidation, leading to fewer but more capable and bankable players which lead the sector's growth and help perpetuate essential BCRM practices. The presence of an effective LPG trade association is also useful for the latter purpose.
- Transportation cost-equalization to cause LPG prices paid by remote customers to be approximately equal to prices paid by centrally located customers.
- Pro-poor mechanisms, which may include micropayment and pay-as-you-go schemes, targeted subsidies, and the like.
- Consolidation of regulatory authority regarding the LPG ecosystem into a small number of agencies, or one LPG superagency. This facilitates business formation and expansion and facilitates effective enforcement of BCRM and its elements.
- Generating income for the LPG regulator(s) through levies on LPG volumes in the country rather than on renewal fees. This creates more certainty for investors, improving sector bankability and the prospects for growth.
- Sharing of major infrastructure for storage and filling. If this is done, and done well, it focuses competition on acquiring and servicing customers, instead of on acquiring LPG.
- Sharing (pooling) of importation of LPG fuel. If this is done, and done well, it focuses competition on acquiring and servicing customers and can reduce the absolute cost of, or the volatility of, the LPG import price as the overall market increases in size.

34. Recommended Regulatory Framework

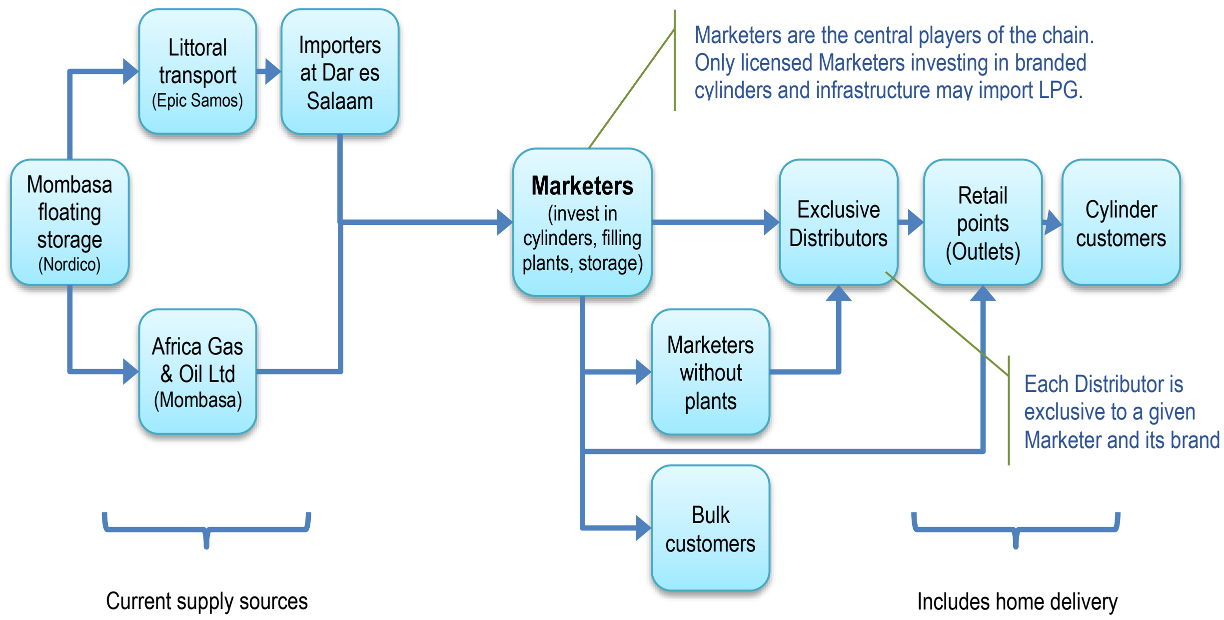
Note: Because this Chapter and the following Chapters within this Part are in themselves a comprehensive and detailed set of recommendations, the recommendation attention symbol (➲) is not used here.

Reformed LPG value chain

The current LPG value chain in Rwanda is shown in Figure 6 on page 25.

BCRM requires the Marketer to be the central player, as described in the prior Chapter, with clearly defined roles that it uniquely performs, and clearly defined relationships to and with the players in the other nodes. Under BCRM, the value chain in Rwanda would transition to the following:

Figure 46. Recommended Rwanda BCRM-compliant LPG value chain



Essential regulatory framework doucments

Based on international empirical experience, the regulation is proposed to be structured with the following three documents that must remain permanently self-consistent:

4. **LPG distribution regulations**
   - To define the distribution model (BCRM), and to assign the roles, tasks, rights, obligations and sanctions for licensing the Marketer, the Distributor, the Retailer, and the Refiller. The regulations will include the list of prohibited acts and the sanctions.
   - To set the conditions for obtaining licenses and permits, especially by setting the national LPG Master Plan as a framework for approving the business plan and the

investment plan of applicants prior to granting them licenses and/or renewal of license, or granting them any other benefits[64].

- To define the roles and responsibilities of ministerial entities.

5. An **LPG Safety Book** describing the specifications, standards and norms to be used for the construction, certification and repair of all LPG containers, facilities and operations related to filling, transport and maintenance of LPG cylinders. The LPG safety code shall be used as reference for the authorization, the construction, the operations and the safety management of all containers, installations and transportation of LPG.

6. The texts governing LPG consumer pricing and taxation.

This structure is particularly adaptable to include all forms of mutualization or sharing of logistics infrastructure investments in import and filling capacity, for example to create a shared national utility or quasi-utility for filling and storage operations.

[64] For example, an income tax holiday in connection with a major accelerated LPG investment programme or project.

35. Structuring of the LPG Distribution Regulations

This Chapter is intended to describe why the LPG sector must be regulated, and the reasons of how it must be regulated.

Safety rules for the transfer, storage and use of LPG

LPG is a mixture of mainly propane (chemical formula: C_3H_8) and butane (chemical formula: C_4H_{10}). (In this document, LPG will be used as a generic term to signify propane or butane.) Rwanda and the rest of East Africa are primarily butane markets.

Under normal temperature and pressure, both butane and propane are in gaseous form. They turn into liquid form when compressed to a certain pressure (about 1 bar for butane, about 7 bars for propane, varying with temperature).

All containers storing LPG in liquid form (cylinders, stationary tanks, truck tanks, specialized vessels and pipelines) must respect a series of conditions of construction, safety distances, tightness of the container, and control of permanent tightness to avoid gas leaks.

The leaks of LPG in liquid form or in gaseous form create the danger of fire and/or explosion if ignited in a closed space. The LPG-ignited fire underneath an LPG container (cylinder or tank) can evolve into a boiling liquid expanding vapor explosion (BLEVE), which is the most critical danger, resulting in physical damage, injuries and, in all likelihood, fatalities.

To ensure permanent safety when manipulating filled containers, all measures must be taken to ensure there is no leakage, to monitor any leakage occurring, and to be equipped with firefighting equipment and procedures to suppress any fire and counter any possibility of explosion and BLEVE.

A critical point in the safety management lifecycle is the process of refilling the LPG cylinder. International norms have set how the refilling must be conducted in order to minimize the safety risk for the end-user and the public. The central point of these norms is that the refilling must be conducted in an industrial-grade facility, and never in the presence of the end-user. This obliges the distribution system to swap any empty cylinder for a refilled cylinder on the consumer's behalf.

The safety rationale comes from the necessity:

1. To control the cylinder before refilling, with the possibility to carry out all needed maintenance on the cylinder before it is refilled (change of valve, periodic certification pressure test, body, collar and foot repair in a dedicated facility, repainting, washing, retesting the tare-weight of the cylinder);
2. To refill the cylinder by weight using its tare weight, and not by volume;
3. To ensure the refill does not exceed 85% of the water capacity of the cylinder;
4. To ensure the refilled cylinder does not show any leaks;
5. To drain the cylinder in case of excess refill or a leak;
6. To fix the leaking cylinder; and
7. to scrap the deficient cylinder for not being compliant any more. This causes dangerous cylinders to be removed from the market. Thus, the cylinder cannot be owned by the end-user; the refiller cannot scrap a cylinder it does not own, and the consumer does not have the

capability on his/her own to ensure the needed battery cylinder safety checks and compliance with each refill.

The regulation must set forth all safety measures regarding the safety compliance status of all LPG containers, depot-filling facilities, transportation means, and appliances and accessories used in the storage, transfer and use of LPG.

The regulation must also implement an efficient tracking system, so that it is clear where the responsibility lies in any operational failures of refilling and distribution that put the population at risk and/or generate damage, injuries or fatalities.

The Branded Cylinder Recirculation Model (BCRM)

The BCRM is the empirical response for safety from developed LPG markets worldwide, in order to fulfil all the safety rules mentioned in the previous section. The BCRM is a comprehensive set of rules of legal responsibilities originated from the necessity to identify those accountable/responsible for failures, claims, accidents, injuries, and fatalities.

At a high level, BCRM is defined by these embedded rules:

a) Empty cylinders must be swapped for refiled ones

Any empty cylinder is swapped with another refilled one in a commercial place, at home or from a delivery truck, and the empty cylinder is returned to the filling facility by the distribution system (trucks) to go through the required controls before and after refilling, prior to its return to the distribution network for sale.

b) The cylinder investor owns the cylinder and the cylinder brand

The name of the refiller matches the brand name of the cylinder, allowing identification of who is accountable/responsible in case of claim or accident. A model in which the cylinder is refilled in front of the end-user (like in a service station) breaks the "re-circulating" part of the BCRM, and does not allow the cylinder to be fully checked, repaired, rejected and removed from circulation if dangerous, before refilling, or to be fixed when overfilling results in cylinder leaking. It is critical that the refilling be done using a well calibrated scale and tare-weight; the latter must have been controlled by the refiller prior to refilling.

c) The identification of those accountable/responsible

Every cylinder must be identified by the brand name and colour of the Marketer and the marks of the refiller.

d) Safety responsibility and liability is attached to the ownership of the cylinder

The branded LPG marketer (Marketer) is held responsible for the safety of the cylinder because, and only because, the Marketer is the owner of the cylinder. There is a logical continuity of enforcing the cylinder ownership this way: the party with the responsibility for the asset is the party with legal control of the asset, especially where safety is concerned.

Having ownership of the cylinder (and its lifetime profit potential) incentivizes the Marketer to invest in a large quantity of cylinders under its brand name and to accept responsibility for the safety of the cylinder, by enforcing its ownership rights in the cylinder and the cylinder brand name, and by investing in the safety of the cylinder.

In particular, cylinder interchangeability[65] and cylinder cross-filling must be prohibited.

The non-respect of the ownership of the cylinder, such as by interchanging/swapping and/or by cross-filling cylinders of different brands, is a break of the BCRM and its safety chain, eventually leading to stoppage of new investment in cylinders and thus the further development of the LPG market, all of which being detrimental to the end-user.

e) Access to the cylinder by the end-user

The end-user accesses the use of a new cylinder through a refundable deposit. This ensures that the entity that introduced the new cylinder into the market keeps track of it, and of its customer. It also gives the customer the economic freedom to change brands, by returning his/her cylinder to the company that owns it, recovering his/her deposit, and using the returned deposit to obtain a different brand of cylinder provided by a different Marketer.

f) The deposit system

The refundable deposit is the legal way for the company owning the cylinder to "lend" that cylinder for future swaps of cylinders (empty/refilled) in a safe and legally enforceable way, in order to ensure that the cylinder recirculates back to the Marketer that owns it. The cylinder is required to be swapped with one of the same brand, in order to reduce the change of cylinder cross-filling, competitive hoarding, and piracy.

g) The link between safety responsibility and cylinder investment

The linkage between (a) the investment in a new cylinder and branding it, (b) having it recirculate to an industrial-grade filling facility for safety procedures with each refill, via the swap of empty cylinder for full cylinder of the same brand, (c) the lifetime of profit from that cylinder inuring to the benefit of the party that invested in it and branded it, and (d) the responsibility and liability for the cylinder's safety, is the core of BCRM. This ensures that the incentives to invest in cylinders and the accountability for safety are mutually reinforcing, to the benefit of all LPG stakeholders.

This description of the BCRM as the "re-circulation of the cylinder from the filling plant to the end-user" via retail outlets and back to the filling plant is the one proven model worldwide for safe and sustainable development of the LPG market.

The cylinder and the Marketer form the core of the LPG infrastructure and supply chain. Without safe cylinders, there can be no meaningful LPG market or consumption.

LPG distribution participants and their roles and relationships

The cylinder will be handled by a series of participants involved in its distribution. (See Volume 1, Chapter 3, for a description of Rwanda's current chain, which is not BCRM-compliant.) The Marketers

65 The prohibition of the cylinder interchangeability and cross-filling will be part of the rights and obligations in the chapter in the regulations concerning licensing

have the role to set and execute a distribution strategy for refilled cylinders. The essential practices, entrenched in developed markets, describe how the cylinders are transported and where/how the refills get to the end-user.

The refilled cylinders are transported from the filling plant:

a) To retail outlets where the end-user goes to collect the swapped refills by trucks; retailers are usually private independent operators, but sometimes belong to the Marketer. This form of distribution enables the Marketer to gain visibility in its territory of distribution, requires a highly dense network of outlets capable of gaining new end-users, and allows the Marketer to keep distribution cost low as long as the density of outlets (and customers) is high. The Marketer shares a part of the margin with the retailer.

b) Directly to end-users at home, delivering the refills and swapping them with the empty cylinders from the truck, either

   - Arranged via a telephone call or a mobile app; or
   - On truck milk-run route, usually weekly.

   This form of distribution allows the Marketer to retain the retailer margin for itself, but it tends to grow the distribution network more slowly than using exclusive independent distributors as in case (a) above.

c) Through the technology of a smart-metered cylinder (and smart-valved cylinder in connection with the PAYG business model), with the smart-equipped cylinder swapped only by employees of the Marketer. This technology necessitates a higher end-user prices per kg, because the Marketer must go to the end-user's home to make the swap and must invest in the smart meter or (for PAYG) smart valve, which is a major capital cost—substantially greater than the cost of the cylinder itself.

The cylinder distribution trucks can belong to two types of participants:

- Trucks of the Marketer driven by employees of the Marketer. (The Marketer contracts the retail outlets).
- Trucks of a Distributor contracted by the Marketer to represent the brand of the Marketer and to act on behalf of the Marketer in a specified distribution area. The employees driving the truck and making the deliveries are of the Distributor. (The Distributor contracts the retail outlets, on behalf of the Marketer.)

The Marketer can combine all these forms of distribution in order to cover its territory according to its sales and cost objectives.

Therefore, the participants in the BCRM are identified according to their contracts, as follows:

- The Marketer
- The Marketer's exclusive Distributors (Distributors[66])
- The Retailers
- The LPG transporting company

[66] Rwanda has a variant of this, calling this group of intermediaries "Wholesalers"

For consistency in rolling out the BCRM, the rights of the Marketer to solely import LPG and cylinders, store LPG in bulk, construct Filling Plants and refill cylinders should be given after application for, and receipt of, the respective permit and fulfilment of the respective conditions attached thereto.

Competition rules are therefore applied between Marketers and between outlets. The Marketer's Distributors supply refilled cylinders with the mandate from the Marketer to ensure the Marketer's cylinders return only to the Marketer's designated filling plant for refill. The Distributor ensures the daily dispatch to the dense network of outlets it has developed in the name of the Marketer.

It is the responsibility of the Marketer to decide if it will mandate its Distributors for the distribution of the refills; if the Marketer wishes instead to distribute using its own drivers and trucks; or a combination[67] of both.

It is also the responsibility of the Marketer to develop its "home delivery service"[68] with its own drivers and trucks, through the Distributors, or a combination of both.

Table 40. Key tasks and task allocations in LPG distribution

		LPG Marketer	**Bulk transport company**	**Marketer's Distributor**	**Retailer**
T1	Investment in the Marketer's brand cylinders	X			
T2	Development of the branded distribution network of the cylinder's recirculation	X			
T3	• Ownership and operation of Filling Plant(s) for refilling, maintenance of cylinders including removal of dangerous cylinders • Set agreement of sub-contracting refilling with other Marketer(s) owning Filling plants. • Can set joint venture in common filling and common depot facility and import terminal	Only			
T4	Set agreement with LPG producers/refiners and/or traders for the sourcing/importation of Bulk LPG	Only			
T5	Transport of Bulk LPG from source point (terminal-refinery) to Filling Plant	May have its own bulk trucks	Only contracted by Marketer		
T6	Contract exclusive Distributors who transport refilled cylinders for the account of the Marketer	Only			
T7	Contract outlets who resell refills by swapping cylinders for the account of the Distributors. The outlet can also develop home delivery.	Less common		Usual case	

[67] Quite common in Latin America

[68] In some countries, the Marketer has developed a dedicated app for home delivery

		LPG Marketer	Bulk transport company	Marketer's Distributor	Retailer
T8	Transport and sell refilled cylinders to outlets close to the end-users, and collect the empty cylinder back to the Filling Plant	Less common		Usual case	
T9	Sell refills to end-user and collect the empty cylinders - collect deposit for cylinder acquisition	Less common		Common in some countries	Usual case
T10	Bulk end-user: contract – installation – delivery	Only			
T10	Home smart metering	Only			

The structure of the LPG distribution regulations

Regulating LPG distribution consists of assembling various regulations related to:

1. The safety of the LPG containers, of the LPG installations and means of transportation, and the safety rules applying to all operations; and
2. The safety responsibility of the licensed participants who will invest in LPG equipment and operate and handle the equipment—especially cylinders—under defined safety rules.

Eventually, the price regime that determines the end-user price and the margin available to the operators could also be regulated. Additionally, further regulations to favour the conversion to LPG and discontinue the use of biomass fuel could also be enacted, as suggested in the discussion of demand scenarios in Volume 1, Part XII.

An important additional chapter in the regulations is the text organizing the monitoring and supervision of the LPG sector by the authorities (that is, by one or more regulatory agencies), with respect to licensing, the permitting, issuing certificates to operate, investigation of accidents and investigation of competitors' practices.

These different parts can be segmented as follows:

1. The organisation of the LPG distribution system according to the BCRM.

   This includes the definition of the roles and responsibilities assigned to the selected participants in cylinder distribution, the LPG Safety Book, the conditions, rights, and obligations applying to the Marketer, the Distributor and the Retailer as part of their licensing, and the different permits necessary to enable investment in and operation of LPG distribution.

   It includes governmental enforcement, supervision and monitoring of the entire set of regulations, consistent with the application of BCRM.

2. The safety rules.

   (a) The safety standards and norms regarding LPG, the containers, and the equipment for the use and handling of LPG; and

   (b) The safety standards and rules regarding the design, the construction, and the operations of the LPG installations, from bulk depots to filling plants to means of transportation.

3. The LPG price regime. This sets (or influences) the end-user price and all the price and margin elements for the market participants.

The LPG distribution regulations

The LPG distribution regulations set the objectives and the principles of the distribution of LPG in the country. The LPG regulations should be collected into a single text. Key principles and elements are:

1. The objectives are control of the application of the safety rules and the nationwide development of the use of LPG (especially for clean cooking), expressed with a targeted penetration rate (consistent with NST-1 and its successor policies).

2. LPG being a potentially dangerous product, the development of its use shall be according to the national LPG master plan (Master Plan) as approved by the authorities, including the following distribution principles.

3. To fulfil the previous points 1. and 2., the central role in the market and the supply chain will be assigned to the Marketers, which must invest in cylinders, in the build-out of their own in-house and/or contracted distribution network, and in filling plants. The setting of the BCRM rules in regulations will designate the Marketers as responsible for the safety of the cylinders and the LPG installations, for good refilling practices, for cylinder maintenance, and for the safe transportation of the cylinders in the distribution network.

4. The Marketer's assigned role:

    - Investing in branded cylinders (the Marketer owns its cylinders);
    - Registering its brand and monitoring compliance and maintenance of all the cylinders of its brand;
    - Creation of its distribution network: deciding on the marketing strategy / business model (direct deliveries, contracted Distributors, own retail outlets, smart meters, etc.);
    - Investing in filling plants and cylinders' maintenance units;
    - Investing in supply infrastructure (bulk import terminal, intermediate cylinder depots);
    - Implementing the cylinder deposit and refund regime within its distribution network;
    - Contracting bulk supply from producers (refineries, bioLPG plants, gas processing plants) or international traders, or from other Marketers;
    - Contracting bulk transportation to supply filling plants and bulk consumers.

    IMPORTANT: By not assigning the central role to the Marketer and dividing these assignments between separate independent entities, the regulation cannot ensure consistent investment in cylinders and distribution under conditions of fair competition. Assigning the right to import or to refill to entities not investing in cylinders creates conditions ripe for unfair competition and undermines the consistency and strength of the safety chain. If all these assignments are not *conditioned on the investment in cylinders, effective market development will not take place, and the compliance with the safety rules will disappear over time.*

5. The following changes can occur over the life of the companies, and the regulation should make provisions and procedures for the registration or the approval of these changes:
    a) Purchase, sale, or merger of an existing LPG business, including the owned cylinders, between Marketers;
    b) Co-investment by Marketers in shared filling plant(s) facility, storage, or import terminal;
    c) Sale or importation of used cylinders;
    d) Supply pooling agreement between a group of competitors; and
    e) Hospitality agreement for filling and/or for bulk storage between competitors.
6. The Marketers will apply to obtain respective permits to import LPG cylinders and bulk LPG, and to construct and operate bulk depots, filling plants and cylinder depots. The administrative process of application for obtaining the permits will be defined in a decree.
7. Several obligations and sanctions will apply to Marketers failing to respect the regulation and comply with all the safety rules.
8. The rules of the BCRM shall be embedded in the regulation to ensure the consistency of the responsibility for the safety chain and supply chain and to set the common competition rules between Marketers.
9. To ensure performance of the responsibilities attached to safety in the distribution chain, the following events should be prohibited, monitored, and sanctioned:

    a) "Cylinder interchangeability":

    A Marketer's cylinders are taken over by a competitor or its appointed Distributors, usually induced by a competition regarding the ownership of the cylinders.

    b) "Cylinder deviation":

    A Marketer's cylinders are transported by an unauthorized entity into a location not under its control and without its permission; if the cylinders are also not returned to the Marketer, it is called "cylinder hoarding".

    c) "Cross-filling":

    A Marketer's cylinders are refilled by another Marketer or entity without its permission.

    d) "Cylinder smuggling":

    A Marketer's cylinders are exported without its permission.

    e) "Cylinder theft" (also called "piracy"):

    A Marketer's cylinders are "re-branded and painted" to those of another Marketer.

<u>IMPORTANT</u>: If these practices are permitted, then the chain of responsibility is broken. In case of an accident, injury or fatality, it becomes impossible to hold anyone accountable. Any failure to regulate these practices rigorously can greatly harm the public as well as the development of the LPG market.

10. The regulations should establish all the legal "rules of the road" concerning safety standards, safety norms and safety rules for the construction and use of the LPG containers, means of transportation, and the installations of LPG. These rules will be the documents of reference to establish compliance in all the permits and controls.
11. The regulations will refer to application texts (such as decrees and legal notices) for the steps in applying for a license as a Marketer, for the Marketer to obtain the required permits (importation, filling, etc.), and when the final certificate of operation applies. The regulations would establish which authority will approve or co-approve the specific documents, including the modalities of revision.

The LPG Safety Book

The LPG Safety Book is a compilation of technical features and norms that must be respected and used to provide the required level of safety when constructing, operating and distributing containers of LPG, and to enable the authorities to approve all permits and certifications of compliance.

The LPG Safety Book will have a number of chapters, as set forth below.

CYLINDER: The safety rules and specification of the LPG cylinder:

1. Authorized sizes of cylinders, and the application process for introduction of a new size of cylinder or container
2. Norm of the maximum safety filling ratio of containers with LPG
3. Rules and specifications concerning the design, construction, marking and protection of the cylinder
4. Description of the mandatory manufacturer file attached to every procurement of cylinders
5. Administrative process of controlling the procurement and the reception of new cylinders
6. Administrative process to register a cylinder brand name and cylinder colour
7. Safety Rules applying prior to and after the refilling
8. Rules for cylinder certification and cylinder pressure test
9. Periodicity of the pressure test
10. Rules for rejection of cylinders found to be unsafe, faulty or non-compliant
11. Life duration of the cylinders depending if they are transported with pallets or not
12. Rules for how to render defective a damaged gas cylinder and dispose of a gas cylinder that must be scrapped

This chapter of the LPG Safety Book has a direct impact on the procurement cost of the cylinder and the cost of maintenance and depreciation for the Marketer.

The safety ratio has an impact on the water capacity, dimensions, and price of the containers (tanks and cylinders), in the safety procedures to refill cylinders.

BULK TANKS: The safety rules regarding the equipment used for bulk tanks of LPG:

1. Tanks: construction and accessories
2. Piping and safety valves: construction and accessories

The regulation includes: the safety rules of operations, periodic certification

It shall conform to the requirements of RS EAS 900 series and EAS 924-3

This chapter of the LPG Safety Book has a direct impact on the procurement cost of the cylinder and the cost of maintenance and depreciation for the Marketer.

FILLING PLANTS: The safety rules for the design, construction, operation, and safety of LPG depots with LPG liquid transfer: bulk depots, import terminal, filling plants:

Some of the points to be regulated in this chapter include:

1. Safety distances of the elements of the installation, depending on the storage technology (pressurized aerial tanks, mounded tanks, refrigerated tank)[69]
2. Bulk LPG storage
3. LPG pump system (pumps, compressors)
4. Bulk LPG transfer stations: tank trucks and rail tanks
5. LPG piping
6. Filling plant/hall
7. LPG piping equipment
8. Gas and fire detection
9. Emergency shutdown system
10. Firefighting
11. Emergency plan
12. Inspection, testing and maintenance of safety equipment
13. Access, fence, and traffic
14. Control and limitation of ignition sources and prevention of explosion hazards
15. Safety management system
16. Safety management system control, audits, and management reviews

Regulation of LPG installations at the consumer premises:

In relation to the stored LPG quantity, the safety rules applying to such depots, including:

1. The situation of the depot and the safety distances (inside/outside buildings, proximity of hydrocarbon products, proximity of the public …)
2. The zoning generated by LPG ("ATEX" zone)
3. Safety means and precautions to be taken (fencing, lighting, firefighting …)

The requirement on Safe installation and equipment to be used.

Safety rules regarding the LPG cylinder depots:

In relation to the stored LPG quantity, this part would cover:

1. The situation of the depot (inside/outside buildings, proximity of hydrocarbon products, proximity of the public, etc.)
2. The zoning generated by LPG ("ATEX" zone)

69 A risk assessment survey shall be performed in connection with permit application to construct such a facility, which defines risk scenarios based on the installation design (in accordance with the design template in the LPG Safety Book), technology used, and LPG tonnage stored. The authories must set the limits of acceptance for the safety distances required for permit approval.

3. Safety means and precautions to be taken (fencing, lighting, firefighting, etc.)

Safety norms and specifications of accessories:

1. Cylinder valve: design and testing
2. Smart meter device
3. Gas stoves
4. Regulators
5. Hoses
6. LPG detectors
7. Burners / LPG grill

Regulation of the LPG transportation by truck and river barge:

1. The vehicles (bulk and cylinders trucks)
2. The drivers (licences and certifications)
3. The delivery procedures
4. The on-board computing
5. The “safe to load” procedure in filling plants

36. Guide for the LPG Distribution Regulations

The LPG distribution regulations concern licensing, permits, rights, obligations, prohibitions, and sanctions. **These regulations, including all of the aforesaid elements, should be collected into a single text.**

Definitions and interpretations

1. The LPG Marketer (**Marketer**) means the licensed company entitled to develop the LPG distribution chain through the different activities required for a continuous supply of LPG in safe cylinders of its own brand name: importation of LPG, cylinders and tanks; construction and operation of bulk depots and filling plants; construction and operation of cylinder depots; distribution of refilled cylinders to contracted Distributors or through its own mean of marketing; contract its own means of bulk and cylinder transportation; and agreement on mutual hospitality or joint venture on a common logistics facility such as an import terminal, bulk depots and filling plant.
2. The LPG Filling Plant (**Filling Plant**) means the industrial facility where empty cylinders are taken for testing and, if determined to be safe, for refilling with LPG prior to return to users.
3. The cylinder Distributors (**Distributors**) are LPG distributing companies appointed by Marketers through a Distributorship agreement describing the rules and conditions of access to cylinders and refills, to distribute refills and branded cylinders on behalf of the Marketer. The Distributors will necessarily have their own cylinder warehouses, trucks, and distributing staff. The distribution of refills consists in either directly supplying end-users or supplying Outlets and collecting the empty cylinders and returning them back to the Marketer's filling plant.
4. The LPG outlets (**Outlets**) mean stores or shops selling assorted cylinder refills to customers. Outlets can be specialized in LPG, for the sole purpose of selling assorted LPG and accessories, or selling LPG equipment together with other products.
5. The Cylinder deposit (**Deposit**) means the amount paid by the consumer to the owner of the LPG cylinder to secure the right to use the cylinder and then swap that cylinder, when empty, for a refilled cylinder of the same brand.
6. The **Regulator**[70] means the governmental authority/ies with primary responsibility for the LPG sector and its regulations. GoR should make a determination about which governmental bodies will have which responsibilities, pursuant to existing legal precedent and current policy. (Specific recommendations are set forth hereafter.) What is important is that there is consistency and effective coordination among the assigned agencies and Ministries for the enforcement of BCRM, the LPG Safety Book, etc.

The national LPG Master Plan

The national LPG Master Plan (this document) contains the LPG development directions desired by the Government. It describes where investments in cylinders and filling capacity should be made, in

70 In general, this is RURA. Exceptions are noted throughout the text of this Volume.

order to optimize the cost of LPG distribution and its impact on the consumer price. It is a document of reference to guide the Government for delivering Marketer licences.

1. Any license and/or permit to invest and develop LPG distribution activity must be conducted according to the Master Plan and built in accordance with the stipulated technical specifications.
2. The Master Plan shall frame the development of the LPG distribution, the permitting and licensing of Marketers and projects such as LPG producing plants, LPG filling plants, and LPG import terminal facilities for marine importation. The authorities shall inspect and supervise the implementation of the approved Master Plan.
3. The ministry in charge of the LPG sector shall be responsible for preparing the Master Plan and the necessary revisions for the development of the LPG sector. The Master Plan shall be referred to in order that Marketers, Distributors, Outlets, Filling Plants, and cylinder warehouses develop consistently their respective business plans, in accordance with the Master Plan, for the benefit of the public. All permits and licenses shall be delivered so that the business plan presented by the applicant complies with the Master Plan. Inspection of compliance of the business plan according to the Master Plan will be carried out by the authorities.

<u>Example of implementation provisions</u>

1. This Decree shall take its full force and effect as of ____________.
2. Regulations on LPG distribution previously promulgated by Ministries and/or the Regulator, which are now inconsistent with the provisions of this Decree, shall be repealed.
3. LPG business establishments of Marketers, which are currently in operation but fail to satisfy all the conditions as stipulated in this Decree, shall be permitted to continue operating until __________. As of that date, they shall be required to comply with the conditions stipulated in this Decree.
4. Relevant Ministries and agencies shall be responsible for directing the examination, monitoring and supervision of the implementation by Marketers having LPG business activity.
5. Ministers, Relevant Directors, heads of agencies attached to the Government, and the leaders of provinces shall be responsible for implementation of this Decree.

The LPG permanent stock

1. Every licensed Marketer must maintain and report a permanent stock of LPG, in bulk and/or in refilled cylinders, corresponding to at least 15 days of sales of its distribution network. This minimum level can be revised periodically.
2. A Marketer's Distributors must keep at all times a permanent stock of at least 3 days of sales.

The LPG Marketer: rights and obligations

1. The Marketer is the owner of the LPG cylinders and responsible for safety compliance, the refilling conditions, and the maintenance of its cylinders. The Marketer is entitled to purchase

LPG cylinders from domestic manufacturers or by import pursuant to an issued permit to import.

2. The Marketer can purchase LPG cylinders from other Marketers under a legal transfer agreement, under the condition that all cylinders so purchased must have the complete set of documents provided by the manufacturer, and the report of the pressure test of the cylinders. The transfer of cylinder brand and colour must be registered with the authorities.
3. The Marketer is the sole entity to have the right and obligation to refill its own branded LPG cylinders, in its own Filling Plants, and/or in written hospitality agreements with other licensed Marketers.
4. The Marketer is responsible for ensuring that all its cylinders, when refilled, are compliant with the safety rules and procedures listed in the LPG Regulations before being made available for use by the end-users.
5. The Marketer is authorized to sub-contract the filling of its cylinders with other licensed Marketers through a hospitality filling agreement, attaching to the agreement the Marketer's valid license, and the files of the cylinder owned by the requesting Marketer, the certificate of registration, the brand name and the colour.
6. The Marketer must discard and scrap from the Filling Plant any LPG cylinders which do not comply with the safety rules of the present LPG Regulations.
7. The Marketer shall never transport in its trucks cylinders that are not its property. Such cylinders shall never enter the Marketer's Filling Plant under any circumstances.
8. The Marketer shall comply at all times with all the conditions stipulated in the present LPG Regulations and related decrees, as well with all applicable relevant laws in the country.
9. The Marketer ensures at all times it will abide by the rules of the weights and measures bureau regarding the quantity of LPG in its cylinders prior to their release for use by the public and the metrological requirements set by RSB.
10. The Marketer ensures at all times the refilled cylinder is complying with existing applicable safety rules prior to being released for use by the public.
11. Before selling or delivering to customers according to a contract, the cylinder refills must satisfy all the conditions stipulated in the LPG Safety Book of this Decree; to be responsible for the volume and quality of the LPG already sold and delivered to the customers.
12. Marketers, being the owners of Filling Plants, shall be responsible for installing sufficient personal protective equipment and carrying insurance for the officials and employees working at the station, as provided for by applicable laws.
13. The Marketer legally owning and operating a Filling Plant shall never be permitted to stock cylinders of other Marketers that have not signed any LPG filling hospitality contract with the Marketer.
14. The Marketer shall follow the applicable procedure for introducing new LPG cylinders in the market and get the safety technical inspection report, the compliance certificate, and the cylinders' registration for use, prior to being commercialised in the market.

15. The Marketer must have and keep, during the useful life of the cylinders, the complete technical and safety dossier[71] of construction of the cylinders provided by the manufacturer.
16. If the Marketer sells out, merges, or terminates its LPG business, all cylinders must be reclaimed with the complete dossier of construction and be attached to the business sale and transfer agreement with the buying Marketer. After purchase, the buying Marketer shall register the acquired cylinders and brand name in its own license at the supervising Ministry, including the number and names of the Distributors and Outlets listed in the transfer agreement.
17. As owner of LPG cylinders, the Marketer is entitled to collect a cylinder security deposit through an LPG CYLINDER SECURITY DEPOSIT NOTE, uniformly applied in the distribution system and end-users under its management authority. The Marketer shall make public the conditions set forth for refund of the deposit in case the cylinder is returned to the Marketer, directly and/or through its Distributors. No Marketer can claim the reimbursement of the deposit notes attached to the cylinders, under any circumstances.
18. All refilled cylinders circulating in the market shall mention the Filling Plant where the cylinder has been refilled, either using a coloured valve cap and/or a label attached to the valve.
19. The licensed Marketer is entitled to import or co-import bulk LPG with other Marketers provided a permit to import has been issued.

<u>Responsibilities of the Marketers:</u>

The Marketer has the following responsibilities:

1. Develop its LPG business in accordance with the Master Plan approved by MININFRA so as to organize the LPG distribution system network composed of LPG warehouses, Distributors, cylinder refills, Outlets, a direct delivery system optionally including smart-metered cylinders, in a dense way in various localities nationwide.
2. Carry out the distribution of cylinder refills in the market via its distribution network system, composed of Outlets or direct delivery trucks of the Marketer or contracted Distributors, or smart-metered cylinders with consumers. The Marketer undertakes the development and the supervision of the Outlets directly or through its Distributors.
3. Not create scarcity of LPG and cylinder refills in its entire network. To that extent, the Marketer is responsible for respective provisions regarding the permanent LPG stock, as defined in the LPG Regulations.
4. Report monthly the detailed sales per Filling Plant, per Distributors per size of cylinders.
5. Report every quarter the number and the names of authorised Distributors and Outlets.
6. Report annually the balance of its cylinder assets: the previous balance, the number of new cylinders, the number of cylinders scrapped, the number of cylinders having passed the periodical pressure test, and the number of replaced valves.

[71] This dossier file is described in the LPG Safety Book

7. Supervise the activity of its Distributors and Outlets.
8. Be responsible for the quantity and quality of LPG sold through its distribution network.
9. Ensure permanent safety procedures on the LPG cylinders, LPG quality, maintenance, and replacement of LPG cylinders which no longer comply.
10. Comply with provisions of the laws and regulations on registration of brand names and colours.
11. Ensure good and efficient distribution of its cylinders and refills.
12. Comply with the present regulation of LPG distribution, and any other laws applying in the country.
13. Never cause an insufficient LPG supply in the distribution network under its management, avoiding commercial fraud and ensuring stabilization of domestic consumption.
14. Inform of any increase or decrease of selling price of LPG in all modes to the Regulator and Ministry responsible for pricing policy.
15. Show the brand name and logo within its distribution network.
16. Procure liability insurance coverage of a minimum of US $5 million, covering all types of damages and injuries to customers.
17. Ensure permanent removal from the market and destruction of non-complying LPG cylinders as per the LPG Safety Book.
18. Provide safety guidelines to customers on the use of LPG.
19. Ensure the safety norms compliance of the accessories sold at Outlets, such as gas stoves, LPG regulators and connecting pipe.
20. Be responsible to refund security deposits of LPG cylinders to customers when they no longer use cylinders.

The Marketer’s Distributors: rights and obligations

1. Sign an exclusive Distributorship agreement with the Marketer.
2. Select and sign contracts of supply of refills and cylinders with Outlets in the name of the Marketer.
3. Do not manipulate, transport or sell cylinders of another Marketer.
4. Do not accept interchangeability of cylinders of different brands.
5. Provide sufficient LPG and cylinder refills to satisfy consumption demand in the distribution network of the Marketer.
6. Ensure working stock of cylinders in its warehouse of at least 3 days of sales.
7. Sell the refills at the price set forth by the Marketer.
8. Comply with the rules of the competition law and do not collude with other Distributors to increase the selling price or take any other act which cheats the end-user.

9. Comply with the country rules of accounting and taxes, especially to issue invoices, vouchers of LPG business operations.
10. Cannot purchase nor sell LPG outside the Marketer.
11. Cannot store, circulate, or consume assorted LPG and cylinder refills of other LPG trading entities without signing a contract; upon the liquidation of the Distributorship agreement, the Distributor shall be required to return to the Marketer all the LPG cylinders which have been deposited with it, including documents of the cylinders.
12. Hang signboards and logos of the Marketer with which the Distributors has signed an exclusive contract; such signboards must contain clear and sufficient content as required by law.
13. Properly comply with the applicable regulations on LPG.
14. Select and sign contracts with end-users and with retail outlets selling to the public under the commercial and safety conditions stipulated in the LPG Regulations.
15. Ensure a permanent supply of refills and cylinders for acquisition against payment of the deposit, supplied by its Marketer, in application with Marketer's price policy and/or the country price regime as stipulated in the correspondent decree. Every registered Outlet must make public the selling price of the cylinder refills and the cylinder deposit.
16. Inspect and supervise the compliance of the Outlets contracted by the Distributors, and report the results to the Marketer.

The Outlets (retailers of cylinder refills): rights and obligations

1. Sign refill supply contracts with no more than three Marketers or Marketer's Distributors.
2. Do not purchase nor sell LPG without having clear origin available in the marketplace, or which is inconsistent with the contract.
3. Keep all invoices and vouchers updated as per the rules of accounting and taxes in the country.
4. Hang only signboards and logos of the Marketer of the supply contract; such signboards must contain clear and sufficient content as required by regulation, including the number of the Business Registration Certificate of the Outlet's owner.
5. Post the selling price of the refills as set forth by the Marketer and/or the Distributors and sell at the posted price.
6. Allow Marketer's representative to inspect and control the stock of refills and cylinders and the sales report of the Outlet.
7. Not to sell cylinders and refills from Marketers without signing a contract with the Distributors or the Marketer.
8. Not to sell refilled cylinders from other Marketers.

Provisions for sharing common LPG facilities and infrastructure

Conditions applicable to the sharing, the lease, and/or the hospitality arrangements of LPG storage, LPG Filling Plants and import terminal.

1. The Business Registration Certificate of the LPG facility (depot, terminal, jetty, Filling Plant) owned by the licensed Marketer, to be leased or with hospitality arrangement
2. The lease or hospitality arrangement between Marketers
3. Only Marketers can be approved for such agreements, and evidence of the origin of the LPG must always be provided
4. There must be a valid certificate of qualification of the facility.

Conditions for transportation of LPG

All companies of transportation of LPG in bulk or in cylinders, including the Marketer must always provide the following documents:

1. Evidence of the Business Registration Certificate for LPG transportation services
2. Evidence of the License to Transport Dangerous Goods
3. Evidence of the Certificate of Testing of Measurement/Gauging Equipment and Safety
4. Evidence of the Certificate of safety compliance of the LPG equipment (tanks, relieve valves, accessories)
5. Evidence from the drivers of the company of a certificate of training for LPG trucks
6. Evidence of registration of every truck with the Regulator
7. Insurance coverage for LPG transportation from a reputable insurance company

<u>Rights and obligations of owners and users of LPG transportation vehicles</u>

1. A transportation company can only contract transportation service of LPG with the Marketers and Marketer's Distributors.
2. A transportation company and/or a Marketer cannot transport, purchase, or sell smuggled LPG or LPG of unknown origin, LPG not meeting the LPG norm, LPG cylinders not approved by the Marketer or from another Marketer, or purchase, sell and transport any cylinders and refills from other Marketers.
3. For safety reasons, cylinders, empty or refilled, must be transported in metallic pallets, as defined in the LPG Safety Book.
4. All conditions and provisions of all relevant laws and regulations on safety of dangerous goods transportation must be complied with, with contracted liability and damage waiver insurance for the transportation of LPG.
5. Inspection and control of all transporting vehicles by the designated authorities must be allowed.

Inspection and audit of LPG distribution activities

1. The Regulator (RURA), in collaboration with RSB and MINICOM, is responsible to organize and conduct the inspection of the measurement of the quantity refilled in the different Filling Plants, at any time without prior notice, under the Weight and Measures rules.

2. The Regulator is entitled to run an inspection, audit and control of the activity of Marketers, to ensure compliance with all the applicable laws and regulations and to ensure compliance with their approved business plans. This can be supported by an independent LPG industry association (hereafter, LPG Association) or a well-qualified inspection company such as SGS or Bureau Veritas.
3. The Regulator is also entitled to apply sanctions as set forth in the regulations to any Marketers and individuals which fail to comply with the provisions on quantity of refilling, quality of LPG and any other acts of fraud causing prejudice for the public, unfair competition, non-respect of the ownership regulation, and provoking instability in the market. This can be supported by a committee to include RSM, MINICOM, RICA, and the LPG Association.
4. Distributors and Outlets are exposed to inspection and control for fulfilment of the safety rules and the LPG Regulations. This would be carried out under RURA, in collaboration with RSB/MINALOC.
5. RURA in collaboration with the RSB Metrology Departent is responsible to set out the rules for monitoring the level of accuracy of the quantity of refills and to recommend the Marketer to record in a specific document all the periodic tests of accuracy of all the scales in use in its Filling Plants.

Actions prohibited in LPG distribution

The following actions are prohibited and are deemed a breach of the Marketer's license and the Distributorship agreement:

1. To refill a cylinder from mobile Filling Plants or truck tanks or in service-stations
2. To refill any LPG cylinders or other equipment from any truck tanks
3. To refill disposable "mini-cylinders" which are not permitted to be further refilled
4. To refill any cylinders belonging to another Marketer, except with written consent through hospitality arrangements
5. To illegally hold, purchase, sell or exchange cylinders that are not under a Marketer's ownership and belonging to other Marketers, except under a filling hospitality agreement and under the temporary written instruction of the government to ask a Marketer to take care of the cylinders of a declared failing Marketer and not leave the end-users without supply
6. To refill noncomplying cylinders
7. To refill cylinders that have not been tested after the periodic pressure test or all cylinders that are supposed to be removed from the market and scrapped
8. To sell refills at a price above the authorised price
9. To sell refills with weight below the stated/marked full weight of the cylinder
10. To refuse to sell to outlets and to end-users with the intention to create scarcity
11. To collude with other Marketers, Distributors and/or retailers to increase the refill selling price and the cylinder security deposit

12. To imitate registered brand names, trademarks, logo, and colours of cylinders circulating in the market and belonging to licensed Marketers
13. To import second-hand/used cylinders and accessories for LPG, like regulators and burners
14. To put into circulation LPG cylinders and accessories using LPG not respecting the specifications and safety standards defined in the LPG Safety Book
15. To refill cylinders at any LPG outlets and premises that do not have a valid Certificate of Qualification for a LPG Filling Plant
16. To repair cylinders with the intention to steal and change the brand name and the Marketer's name marked on the cylinder
17. To repair LPG cylinders at any manufacturing premises which have not been issued an Operation Permit
18. To repair cylinders of Marketers without any repair contracts signed with the licensed Marketers
19. To repair cylinders without complying with all the safety rules and standards defined in the LPG Safety Book
20. To let cylinders with similar serial numbers be in circulation in the market, without adjusting the serial number
21. To transport cylinders without pallets
22. To distribute, transport and sell refilled cylinders without seals

Breaches of Licenses

Applying to Marketers and/or Distributors:

1. To refill, distribute and transport cylinders not complying with the safety rules and that are required to have been removed from the market
2. To refill cylinders directly from truck tanks
3. To refill any cylinders belonging to another Marketer, except with written consent through hospitality arrangements
4. To illegally hold, purchase, sell or exchange cylinders that are not under a Marketer's ownership and belonging to other Marketers, except under a filling hospitality agreement and under the temporary written instruction of the government to ask a Marketer to take care of the cylinders of a declared failing Marketer and not leave the end-users without supply
5. To underfill cylinders and to sell underfilled refills, below the limit fixed by the weights and measures bureau's applicable rules
6. To purchase LPG from, or sell LPG to, any Marketer having a Filling Plant without a valid certificate of qualification

7. To lease out storage, import terminal, Filling Plant, LPG, or means of transportation to any Marketer not having a valid license and permits as defined in the LPG Regulations, and not complying with the LPG Safety Book
8. To sell any improperly sealed refills, any refills sealed without the mandatory labels defined in the LPG Safety Book, or unsealed refills
9. To operate LPG distribution without, or after expiration of, the following certificates:
    - Certificate of Qualification for Outlet
    - Certificate of Qualification for Filling Plant
    - Certificate of Qualification for Marketer
10. To not carry out the mandatory periodic pressure test of the cylinders, and to not record the different tested cylinders
11. To refill cylinders that are no longer fulfilling the safety norm and standards and should have been removed from circulation in the market
12. To not respect the country labour and social security regulations concerning the employees working for the Marketer or Distributors
13. To not contract the mandatory liability insurance of a minimum of US $5 million equivalent covering the LPG activity
14. To not refund cylinder security deposits when customers return the cylinders to the Marketer or Distributors
15. To operate leased facilities not complying with the LPG Regulations
16. To not comply with the applicable provisions on transportation of flammable and explosive goods, as defined in the LPG Safety Book
17. To allow any transportation vehicles without coverage of the mandatory vehicle insurance
18. To transport, purchase and sell LPG without documented origin and procurement invoice

Applying to retail Outlets

1. To not comply with the LPG Regulations
2. To operate without obtaining the Certificate of Qualification for retail refills
3. To not comply with the provisions on safety and firefighting rules of the LPG Safety Book
4. To decant refilled cylinders in empty cylinders, to adulterate the seal of refills, and to adulterate the trademarks of a cylinder
5. To not respect the conditions of the contract with a Distributor or Marketer
6. To purchase and sell refills without documents or invoice of origin
7. To illegally hold, retain, purchase, and sell any cylinders and refills of Marketers without the permission of those Marketers

Settlement of violations

1. When a Marketer violates provisions of this Decree and LPG Regulations, depending on the seriousness and repetition of the violation, it shall be subject to administrative sanctions or to penal (criminal) prosecution as provided for by law.
2. Any Marketer committing any violation of any requirement specified in *Actions prohibited in LPG distribution* and *Breaches of Licenses* above shall be sanctioned with a penalty of US $1,000 equivalent for each violation. The penalty will be recorded at the Regulator.
3. Any Marketer committing any violation of any requirement specified in *Breaches of Licenses* can face a suspension of its License, for a limited period of time, and the payment of a cash penalty defined by the court based on the recommendations of the Regulator and/or the legal defence of a Marketer.
4. In the case of violation of clauses 4 and 5 of article *Actions prohibited in LPG distribution* and clauses 3 and 4 of *Breaches of Licenses*, the Marketer at fault must return all LPG cylinders not belonging to it to the entitled owner, at the cost of the Marketer at fault.
5. When such violations are repeatedly committed, revocation of the Licence, the permits, and all Certificates of Qualification of Filling Plants shall occur for a definite or indefinite term, including termination of operations; where it is considered as a serious violation, it shall be subject to penal (criminal) prosecution.
6. When employees of Marketers, Distributors, and transportation companies, or civil servants violate the provisions of the LPG Regulations when performing their duties, they shall be, depending on the seriousness of such violation, subject to administrative sanctions or penal (criminal) prosecution as defined by the Regulations.

Responsibilities of the relevant Ministries and agencies

In addition to the responsibilities specifically set forth in articles and clauses mentioned above, relevant Ministries shall bear the following responsibilities:

<u>MININFRA, as the Ministry responsible for Energy/Petroleum:</u>

1. To revise and promulgate laws relevant to LPG and the application of relevant Decrees, supported by RURA and the LPG Association.
2. To audit the Regulator's processes for delivery, renewal and denial of the different licenses, permits and certificates.

<u>RURA, as the lead Regulator of the LPG sector:</u>

1. To promulgate, revise, implement and enforce the LPG Regulations (including any Decree) and the LPG Safety Book, with appropriate coordination with MININFRA and collaboration from the LPG Association.
2. To monitor and report monthly the number of circulating cylinders, the quantity of LPG sold per type of container, the number of Filling Plants and their capacities, the number of bulk LPG trucks, the number of pallets, the number of Distributors and outlets, the importation capacities, and the origin of the imported LPG. The Regulator will also check consistency of the

sales volume declared by each Marketer with its own number of owned cylinders. REG would perform the analysis of the sales data obtained by RURA.

3. To process applications, to deliver, renew and revoke licences, permits and certificates as per the processes stipulated in the LPG Regulations and Decree. This activity would be subject to oversight from MININFRA and carried out with support from MINICOM and MINALOC.
4. To coordinate with other Ministries and agencies, notably RICA, MINALOC and the police, inspection of the activity of the Marketers, Distributors, retailers, and transportation companies and the extent of their compliance with the LPG Regulations and rules.
5. To lead and coordinate with relevant stakeholders the promulgation of the LPG Safety Book. This would be supported as necessary by RSB, MINALOC, MINICOM and the LPG Association.
6. To lead and coordinate with relevant Ministries and agencies the application of LPG safety rules and standards on all means of transportation and vehicles. This would be supported by the Police (Fire and Rescue).
7. To organize professional training and education on LPG measurement and quality to staff and employees working at LPG business establishments nationwide. This would be supported as appropriate by REG, RSB and MINALOC.
8. To lead and coordinate with the Ministry in charge of price supervision for inspecting and monitoring the Marketers in respect of their LPG selling prices, and their price of security deposits, including the setting of depreciation rules for every type of asset, including cylinders. This would be coordinated with MINECOFIN and supported by the LPG Association.
9. To organize training on the safety rules and firefighting to staff and employees working at the LPG depots, Filling Plants and cylinder depots, and to issue a Certificate of Qualification for Firefighting. This would be supported by the Police (Fire and Rescue).
10. To organize safety training and certification of the drivers of LPG trucks. The certificate of compliance of the safety training for drivers of LPG trucks must be carried by each driver and presented upon demand. RURA can decide to delegate some of the training or inspection to designated skilled and qualified organisations. This would be supported as appropriate by MINALOC and the Police.
11. To lead and coordinate with relevant Ministries and branches in organizing the inspection and supervision of LPG facilities and LPG distribution companies in respect of their compliance with the provisions of the law, accuracy of refill, safety and firefighting, commercial fraud fighting, and ownership of the cylinders.
12. To organize the transparency of the regulation, prices, and changes on a dedicated website[72], where claims can be registered and answered.
13. To strictly apply sanctions upon any breaches of the conditions set out in the LPG Regulations, in appropriate coordination with the justice system, especially the following acts:
    a) Filling Plants possessing and refilling LPG cylinders not under their ownership (except for written contractual lease of refilling service);

72 For example, El Salvador has organized with success such a website: https://www.edrhym.gob.sv/drhm/

b) LPG cylinders and refills failing to meet all conditions for circulation in the market in accordance with the current LPG Regulations, and that are still in circulation in the market;
c) LPG cylinders that have not been registered, tested, and checked for safety rules compliance, that are circulating in the market;
d) Any reform or adulteration of LPG cylinders, like replacing sealing, cutting handles, rubbing logos, changing the brand names, changing the serial numbers of the cylinders, welding additional metal, changing the top valves, and imitation of trademarks and the brand name;
e) Any cylinder with brand and colours that have not been registered;
f) Collusion of market participants provoking an artificial increase of the refill price.

REG:

1. With EDCL, to lead and coordinate with relevant stakeholders any programme of training and education on LPG distribution to employees of Marketers, Distributors, retailers and transporting companies nationwide. This would be coordinated with and supported by RURA, MINALOC, MINEDUC, and the Police (Fire and Rescue).

RSB:

1. To lead and coordinate with relevant Ministries and agencies in managing the quality of produced LPG, imported LPG, LPG circulating in the market, in issuing a Certificate of Qualification for LPG production and processing to plants. This can be supported by a well-qualified inspection company such as SGS or Bureau Veritas.
2. To lead and coordinate with relevant Ministries and agencies in setting up, amending, supplementing and perfecting the system of standards, technical specifications on LPG quality; to stipulate the maximum number of usable years in respect of each type of LPG cylinder from its production date in its history. This would be coordinated with RURA and supported by the LPG Association, and supervised as appropriate by MININFRA.

Decree on the norm of the quality of LPG

LPG is a mixture mainly composed of propane and butane plus a series of other hydrocarbons in small quantities, such as olefins and aromatics, depending on the process of production: refinery, gas processing plant, or bioLPG plant.

The LPG norm is required to

- Define the quality of the imported or refined LPG;
- Define the allowed blend of butane/propane; and
- Check and control conformity to the norm at reception of the imported LPG.

The Norm has a direct impact on:

- The pressure test of the containers and the cost of the containers
- The cost of procurement and the selling price of the LPG, either locally produced (gas processing plant, bioLPG plant, refinery) or imported

- The quality of the pollutants emitted during combustion of the LPG

Main characteristics in the specification of LPG, that will be used to define the norm:

- The maximum % of butane or propane
- The maximum % of olefins, of butadiene, etc.
- The maximum vapor pressure at 15°C (190 kPa for butane, 750 kPa for propane)
- The density at 15°C (0.584 for pure butane, 0.508 for pure propane)
- The maximum sulphur content
- The maximum corrosion
- The maximum water content and moisture

The Norm of LPG should be RS 140, and take into consideration existing international norms. The French norm of commercial butane NF M 40-001, for commercial propane NF M 40-002, the ASTM D1835, and the ISO 9162-2013 can be used as reference.

Hereafter, as an example, is an extract of the GPA 2140 specification of the Gas Processors Association of the USA, commonly used by traders.

Figure 47. GPA 2140 specification for LPG

GPA LIQUEFIED PETROLEUM GAS SPECIFICATIONS

	Product Designation				
Product Characteristics	**Commercial Propane**	**Commercial Butane**	**Commercial B-P Mixtures**	**Propane HD-5**	**Test Methods**
Composition	Predominantly propane and/or propylene	Predominantly butanes and/or butylenes	Predominantly mixtures of butanes and/or butylenes with propane and/or propylene	not less than 90 liquid volume percent propane; not more than 5 liquid volume percent propylene	ASTM D-2163-91
Vapor pressure at 100°F, psig, max at 37.8°C, kPa, max	208 1434	70 483	208 1434	208 1434	ASTM D-1267-95
Volatile residue: temperature at 95% evaporation, deg. F, max. deg. C, max *or* butane and heavier, liquid volume percent max pentane and heavier, liquid volume percent max	 -37 -38.3 2.5 –	 36 2.2 – 2.0	 36 2.2 – 2.0	 -37 -38.3 2.5 –	 ASTM D-1837-94 ASTM D-2163-91 ASTM D-2163-91
Residual matter: residue on evaporation of 100 ml, max oil stain observation	 0.05 ml pass (1)	 – –	 – –	 0.05 ml pass (1)	 ASTM D-2158-92 ASTM D-2158-92
Corrosion, copper strip, max	No. 1	No. 1	No. 1	No. 1	ASTM D-1838-91 (Note A)
Total sulfur, ppmw	185	140	140	123	ASTM D-2784-92 (Note B)
Moisture content	pass	–	–	pass	GPA Propane Dryness Test (Cobalt Bromide) or D-2713-91
Free water content	–	none	none	–	–

(1) An acceptable product shall not yield a persistent oil ring when 0.3 ml of solvent residue mixture is added to a filter paper in 0.1 increments and examined in daylight after 2 minutes as described in ASTM D-2158.
NOTE A: This method may not accurately determine the corrosivity of the liquefied petroleum gas if the sample contains corrosion inhibitors or other chemicals which diminish the corrosivity of the sample to the copper strip. Therefore, the addition of such compounds for the sole purpose of biasing the test is prohibited.
NOTE B: Be advised that the total sulfur limits in these specifications do include sulfur compounds used for stenching purposes.

Licensing process for LPG Marketers (application and renewal)

The application process:

1. The applicant submits the application file, as defined hereunder, to the licensing committee (Licensing Committee), which is chaired by the Regulator and comprises a representative of MININFRA, a representative of MINICOM, a representative of the Ministry of Environment, and a representative of the Fire Department.
2. The Licensing Committee will report on the application file for approval, renewal, modification or rejection to the Regulator and the respective three Ministers and the director of the Fire Department.
3. The Regulator will issue the license co-signed by the other three ministers and the director of the Fire Department.
4. The Marketer license will have a duration of 10 years before renewal is required.
5. The Licensing Committee will roll out a compliance audit two years after the licence date.
6. The Marketer will indicate the date of the start of operation. If the operation has not started within the two-year period after the date of the license, the Marketer must reapply.

Application file and conditions to obtain and/or renew the LPG Marketer license:

Applicants must satisfy all of the following conditions to receive the Marketer license to distribute LPG. The application must be submitted with the following documents:

1. The Business Registration Certificate, under which the import and export of LPG has been registered.
2. The certificate of registration of the brand name(s) and the colour(s) of the cylinders intended to be marketed by the applicant.
3. The certificate of validation of the business plan and project presented by the applicant to the designated authorities, showing consistency with the Master Plan including the annual investment in cylinders, and the magnitude and coverage of the LPG distribution network. The business plan must include the staff organization and their proven skills and knowledge in conducting safely the operations of such LPG activities.
4. The invoices of acquisition of, or the approved business plan with the commitment to purchase, at least 300,000 LPG cylinders of size between 6kg to 15kg. These LPG cylinders must have the registration certificate of compliance to the regulation delivered by the authorities and must be branded and coloured to the registered brand and colour of the Marketer.
5. The certificate of insurance covering any damages for an amount of minimum USD 5 million equivalent from a reputable insurance company.
6. The certificate of qualification and commissioning of at least one owned or co-owned Filling Plant, as defined in the LPG Regulations, or the lease agreement to operate such certified Filling Plant belonging to another entity, or the hospitality agreement with a licensed Marketer having a Filling Plant, with the certificate of qualification and commissioning.

7. The description of the existing distribution system or the description of the programmed distribution system in the business plan for the license application, including: the list or number of Distributors with the attached Outlets, the number of directly supplied Outlets, the number of smart meter customers, the tonnage and/or number of home delivery customers, and the number of intermediate cylinder warehouses.
8. The bulk supply agreement with a trader or another Marketer.
9. The bulk transportation agreement with a transportation company with certified trucks and drivers.

Process for LPG Marketer permitting

Conditions to apply for the registration of the brand name and colour of cylinders

Marketers to apply with the following documents:

1. Letter of application, with mention of the brand name, the logo, and the colour reference (in Pantone or RAL or equivalent) of the cylinder attached to the brand name. Marketers can apply for several brand names and several colours.
2. The license of Marketer and the Company Registration Certificate.
3. The copy of the approved business plan complying with the Master Plan.
4. The brand name and the colour cannot be accepted if they create confusion in the mind of the public. End-users must be able to clearly distinguish one Marketer’s brand name and the colour from another’s.
5. The registration of the brand name must follow the intellectual property laws of the country.

Conditions applicable to deliver a permit to import and/or export LPG

Marketers to apply with the following documents:

1. Letter of application, indicating the type of product, the norm and the tonnage intended to import for itself and on behalf of other Marketers, with the request letters attached to the application letter, and/or the tonnage to export with the name of the country and the names of the Marketers in the destination country.
2. The license of the Marketer and the Company Registration Certificate.
3. The copy of the approved business plan complying with the Master Plan.
4. The evidence of the access to a jetty connected to an authorised import depot or equivalent inland facility. The facilities can be the property of the Marketer or co-owned with other Marketers as per a joint venture contract or be leased with a lease contract of minimum one year for an import facility authorised to receive bulk LPG (by vessels if by water, by bulk trucks or rail if by land). Importation through the offload of a vessel into LPG trucks is not allowed unless specific temporary written authorisation has been delivered by the Regulator with co-signature from the Minister of Energy/Petroleum.
5. Only importing Marketers can apply for the permit to export the surplus of imported LPG.

Conditions applicable to deliver a permit to import and/or export LPG cylinders

Marketers to apply with the following documents:

1. Letter of application, indicating the type, the Marketer specification and the number of cylinders to be imported, the origin, the name of the manufacturer and the evidence of the records of the manufacturer.
2. The license of the Marketer and the Company Registration Certificate.
3. The copy of the approved business plan complying with the Master Plan and the number of cylinders already owned by the Marketer.
4. In the case of export, the application letter must detail the number of cylinders, brand name, size and colour, the country of destination, the purchase order from the Marketer of the country of destination, and the point where the cylinders will cross the border and will be inspected by the customs. A transportation truck can only cross the border with cylinders with the permit of export signed by the selling Marketer, the purchase order of the buying Marketer, and the permit to export.

Distributors: conditions applicable to operate as Distributors

The following documents are required for the application:

1. The Business Registration Certificate, for the activity of Distributors of LPG.
2. The certificate of property or lease of each warehouse to store up to 2,000 cylinders and/or refills, constructed in accordance with the current safety rules of the LPG Law.
3. The Fire Department certificate of compliance with the safety rules for each warehouse.
4. The Distributorship agreement with the Marketer.
5. A certified copy of the certificate of completion of a professional training course issued in favour of each employee working for the Distributors.
6. Within seven working days from the date of receipt of the complete and valid application file, the Regulator shall consider, evaluate and, if appropriate, issue the Certificate of Qualification for LPG Distributors. This Certificate shall be effective for a term of five years from the issuing date; upon expiration, the Distributors shall be required to complete procedures of renewal.

Conditions applicable to deliver a permit of construction or modification of an LPG Depot and/or a Filling Plant

Marketers applying for such a permit shall provide the following documents:

1. The Business Registration Certificate, with the approved business plan mentioning the project.
2. The location of the Filling Plant, which must be in accordance with the Master Plan and the project presentation, the drawings, and the construction budget. The construction of the Filling Plant must comply with all provisions of the Law on Construction, the LPG Regulations, the LPG Safety Book and the provisions of all other relevant laws and regulations on construction of LPG works.

3. The Filling Plant, filling equipment, pipeline system, tanks and accessories must comply with regulations on safety as required by the current national technical specifications.
4. Machinery, equipment subject to strict requirements on labour safety, and labour hygiene of the station have been inspected and registered as so required.
5. The Filling Plant must have a surrounding fence, ensuring aeration, and must comply with requirements on safety distances as stipulated in the LPG Safety Book.
6. The Certificate of Qualification of Firefighting and Safety Management delivered by the designated safety agency and the Fire Department.
7. The list of safety and operations procedures of the Filling Plant.

Issuance of the certificate of compliance for Filling Plants (new or modernised)

RSB, with the explicit concurrence of the Regulator, shall be responsible for issuing the Certificate of Qualification of a new or modernised Filling Plant. The application for the certificate of compliance shall include the following documents:

1. Letter of request for issuance of Certificate of Qualification for LPG Filling Plant.
2. Copy of the Business Registration Certificate, and the business plan in which the project has been approved.
3. The construction permit accompanied with the project file and drawings approved by the Regulator.
4. All the drawings of the final construction including information about the equipment installed, tanks, filling facility, pumps, compressors, safety and firefighting devices, discharging racks of the bulk trucks, maintenance workshops, LPG pipeline system, electricity system, and safety control to stop refilling in case of danger. The drawings must specify the capacity of the LPG tanks, the manufacturer file, and the minimum safety distances as stipulated in the LPG Safety Book.
5. Results of the inspection of machinery, equipment subject to strict requirements on labour safety of the Filling Plant.
6. Results of the inspection with respect to each piece of equipment and measurement examining tool in the station: weight scale, bulk measuring device, pressure meter and other equipment, and devices.
7. Certificate of compliance of firefighting.
8. Certificate of compliance with the safety rules of construction and operation.
9. Procedures for refilling LPG, procedures for operation of machinery, equipment in the station, error handling procedures and safety regulations.
10. Certificate of completion of a professional training course issued in favour of each employee working in the LPG Filling Plant.
11. Within ten working days from the date of receipt of the complete and valid dossier as stipulated in the present decree, RSB shall consider, evaluate and, if appropriate and with the concurrence of the Regulator, issue the Certificate of Qualification for LPG Filling.

12. The Certificate of Qualification for LPG Filling shall be effective for a term of ten years from the issuing date; upon expiration, the Marketer must apply for renewal of the Certificate of Qualification. If the renewal of the Certificate is not obtained, the Filling Plant shall stop operating, and can only resume operations after renewal of the Certificate.

37. Guide for the LPG Safety Book

The objective of the LPG Safety Book is to gather in one place all the safety rules, standards, and norms applicable to the construction of the LPG containers, LPG accessories (valves, pumps, compressors, pipes, etc.) and the installations and depots (with or without liquid transfer) for refilling of cylinders or for end-user consumption. The Safety Book includes all the safety rules applying to the operations, maintenance, and certification tests for all of these items, as well as the rules for the safe management of the installations.

Logically, it would be composed of a different chapter related to each item. For efficiency of defining such safety rules, it is recommended to use as reference existing international norms, as will be proposed in this Plan Chapter.

Regulating the LPG cylinder and the valve

Dimensioning a cylinder: the water capacity and the kg content

The size and dimension of a cylinder is calculated from the water capacity, applying the maximum filling ratio to the kg content of the cylinder. The filling ratio is a safety factor for the dimensioning of the cylinder. The dimension of the cylinder (diameter and height are defined according to the constraints of the Filling Plant and according to the calculation of the resistance of the body of the cylinder through the thickness of the plate). These elements are necessary for the construction by the manufacturer. This calculation is part of the Marketer's specification for procurement of cylinders.

It is recommended to calculate the size, the dimension, and the resistance of the cylinder for commercial propane, even if the current norm is commercial butane. The difference in price is minor, but that way it allows flexibility in the future change of the LPG norm, from butane to more propane without having to change all the cylinders. It also enables reduced risk for the end-user in case of change of the LPG blend[73].

Example of calculation of the water capacity for a cylinder of 9 kg:

- The content of the cylinder: 9 kg
- The assumed product: commercial propane, with density at 50°C of 0.43
- The maximum filling ratio is: 85%
- The water capacity of such 9kg cylinder will be: 9.0 / 0.43 / 0.85 = 24.62 litre

[73] Reference the LPG situation in Niger, that changed the % of propane from 20% to 60% overnight when the refinery started producing LPG without segregation between butane and propane, while the cylinders were designed for butane with a maximum 20% propane content. (The pressure of propane is about seven times higher than butane.) Existing LPG equipment that was not propane-capable was unable to handle the new mix.

To be regulated: the allowed size of the cylinders in the country

The LPG regulation of the country can set the allowed sizes of cylinders, related to price structure. Many countries only allow the following sizes: 3 kg – 6 kg – 12 or 13 kg and 35 or 45 kg. (In some countries, 5 kg, 9 or 10 kg, and 15 kg are also regulated sizes.) These sizes are very often related to the price structure. In many countries an application for introduction of new sizes by a Marketer is allowed.

To be regulated: the maximum filling ratio for cylinders (85%)

This ratio is an important safety factor because it helps calculate the conditions of construction of the cylinder and the maximum level of filling in the Filling Plant. This is due to the high variability of density of the LPG in its liquid phase, which provokes a high-volume expansion in the container, inducing more pressure on the body. For safety reasons, the filling ratio must be defined as a limiter of expansion of volume in the cylinder and enforced to ensure a safe use of the cylinder. During and after refilling at the Filling Plant, the operator will apply the filling ratio to the water capacity of the cylinder. An overfilling can result, damaging the body of the cylinder and result in leakage, which is extremely dangerous for the end-user. The RID/ADR P200-3c can be used as reference.

In most of the countries in the world, and in Africa, the filling ratio set by the authorities of 85% is necessary to calculate the water capacity in liters for a given size of cylinder content in kg. The present LPG Safety Book must define this filling ratio.

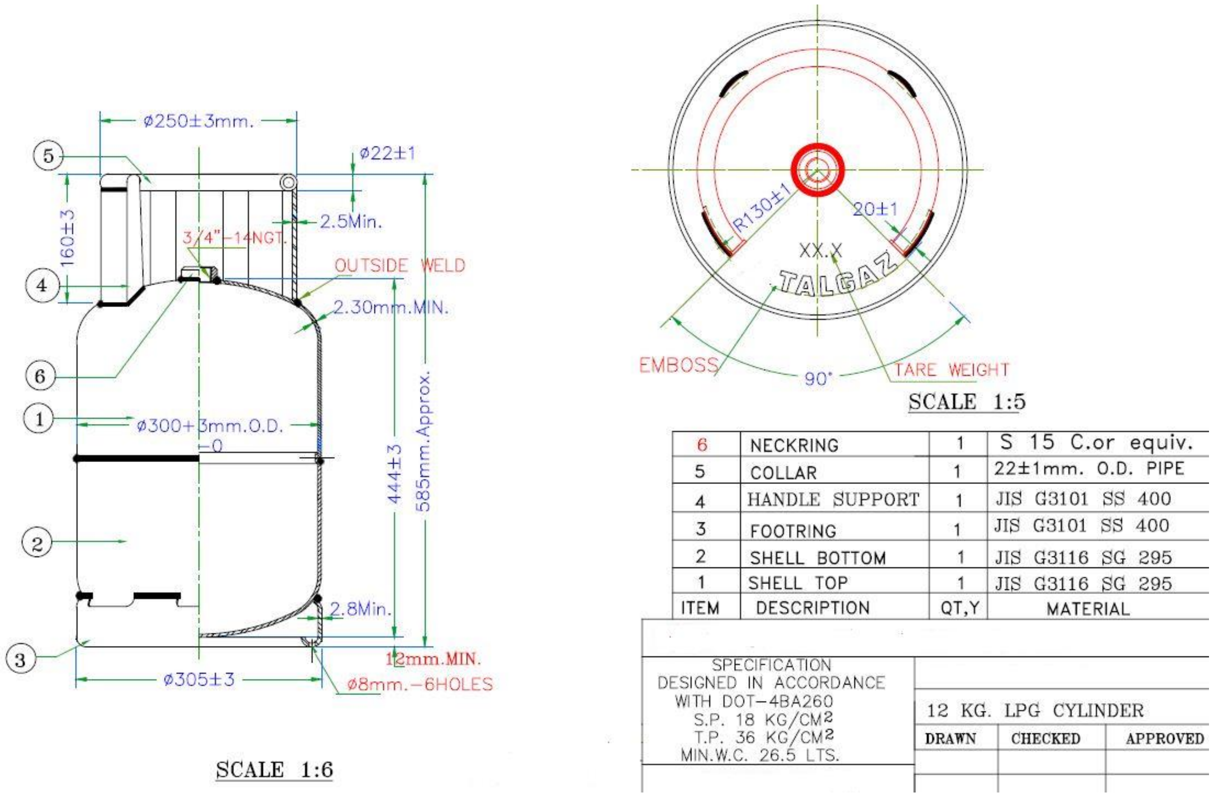
To be regulated: The Marketer's cylinder specifications for procurement

Every Marketer will have to submit the specification of the cylinder for procurement to the manufacturer and to RURA and RSB for the application of the permit to import.

The Marketer's specification must include the following points:

- Kg content of the cylinder
- Calculation for commercial propane
- Water filling capacity and maximum filling ratio
- Diameter and height of the body
- Technology used for the construction: classical steel, light steel, steel with casing, or composite (carbon fibres with polypropylene matrix). It is recommended to avoid the use of aluminium.
- The norm of construction set by the LPG Regulations
- Form of the collar, neck ring and foot ring
- The coating and protection of the cylinder
- Type of shroud and valve intended to be mounted
- The markings

Figure 48. Example of a mechanical drawing of a cylinder for construction



To be regulated: the allowed norms for the construction of the cylinder according to the specifications

The recommended norms to be used for the construction will be defined in the LPG Safety Book, as compulsory for the acceptance of cylinders to be used by the public. The most common norm for steel welded cylinders is the EN 1442 "Transportable refillable welded steel cylinders for LPG". The ISO version is the 22991 and ISO 4706. These norms include all the criteria for welding, heat treatment, testing, hydraulic testing, burst mechanical testing, etc.

The following norms should be included in the cylinder specification:

- The norm for steel of the body: EN 10120 (the P265NB is usual in the industry)
- The norm for inspection: RS ISO 10464; ISO 2859 is the norm the manufacturer has to apply for construction quality control
- For the coating: the norm for blasting is ISO 850-1, for Zinc spraying ISO 2063

The norms for composite cylinders shall adhere to the requirements of RS ISO 11119.

To be regulated: The permanent markings on the cylinder

<u>Embossed on the body</u>: the brand name of the Marketer

<u>Engraved on the collar ring (as per RS ISO 13769):</u>

- The name of the Marketer
- The name of the Manufacturer

- The norm of construction
- The year of construction
- The cylinder serial number
- The water capacity in litres
- The Kg content of the type of LPG
- The pressure test in bars

Painted on the body:

- The sum of kg content and the kg of tare weight
- The next year for periodic inspection

To be regulated: The documents submitted by the manufacturer to the Marketer for any batch of cylinders

The file of the construction of every batch of cylinders must include the following documents. Every file must be kept by the Marketer during the lifetime of the cylinders.

- The design and manufacturing drawings, as well as diagrams of the components
- The conformity certificate of the steel used for the body
- The results of destructive or non-destructive tests required by ISO 22991
- The hydraulic test conformity certificate for every cylinder
- The inspection certificates for ends, neck ring and filler metal

To be regulated: the test pressure

The test pressure is the pressure used for testing periodically the resistance and the tightness of the cylinders. This pressure must be set by the regulator.

To be regulated: the pressure test shall be 30 bar for all cylinders, because the cylinders are designed for commercial propane content, even if the content is commercial butane. Reference to the RID/ADR[74] P200-3c can be made.

To be regulated: The periodic pressure test interval of the cylinder

The cylinder, being a pressure vessel, must be retested and inspected periodically per RS ISO 13769; with the recommendation to take into account EN- ADR P200 §9 (b) due to its very high safety profile.

The periodic pressure test interval shall be:

- Every ten years for cylinders transported with pallets in the trucks
- Every five years for cylinders transported without pallets in the trucks

The cylinder must show on the body when the last periodic pressure has been done, or the year/month of the next pressure test, so any control can be made by the end-user, the distribution chain and the operator in the Filling Plant.

[74] https://www.unece.org/trans/danger/publi/unrec/rev21/21files_e.html

To be regulated: the procedure of filling of cylinders

The filling of the cylinder is a very sensitive operation, because of the liquid transfer operation requiring the control of the safety of the Filling Plant and also because it affects directly the safety of the cylinder, due to the pressure of the LPG.

The conditions required by the RID/ADR P200 concerning the filling of cylinders makes it compulsory that the filling be realised in a dedicated industrial facility, with skilled personnel and with the entire knowledge of the technical features of the cylinders. (The Marketer who has purchased the cylinders is the only one to know precisely the features of the cylinders.)

Thus, refilling cylinders cannot be left to anyone to do, and cross-filling or refilling in a service station do not respect these recommendations.

The RID/ADR reference for filling is the P200-4, reported hereunder:

> The filling of pressure receptacles shall be carried out by qualified staff using appropriate equipment and procedures.
>
> The procedures should include checks of:
>
> - The conformity of receptacles and accessories with these regulations
> - Their compatibility with the product to be transported
> - The absence of damage which might affect safety
> - Compliance with the degree or pressure of filling, as appropriate
> - Marks and identification
>
> These requirements are deemed to be met if the following standards are applied:
>
> - ISO 10691 Procedures for checking before, during and after filling: Refillable welded steel cylinders for LPG
> - ISO 24431:2016 Inspection at time of filling: Seamless, welded, and composite cylinders for compressed and liquefied gases (excluding acetylene)

The norm EN 13952 can also be used for the procedures for filling a cylinder.

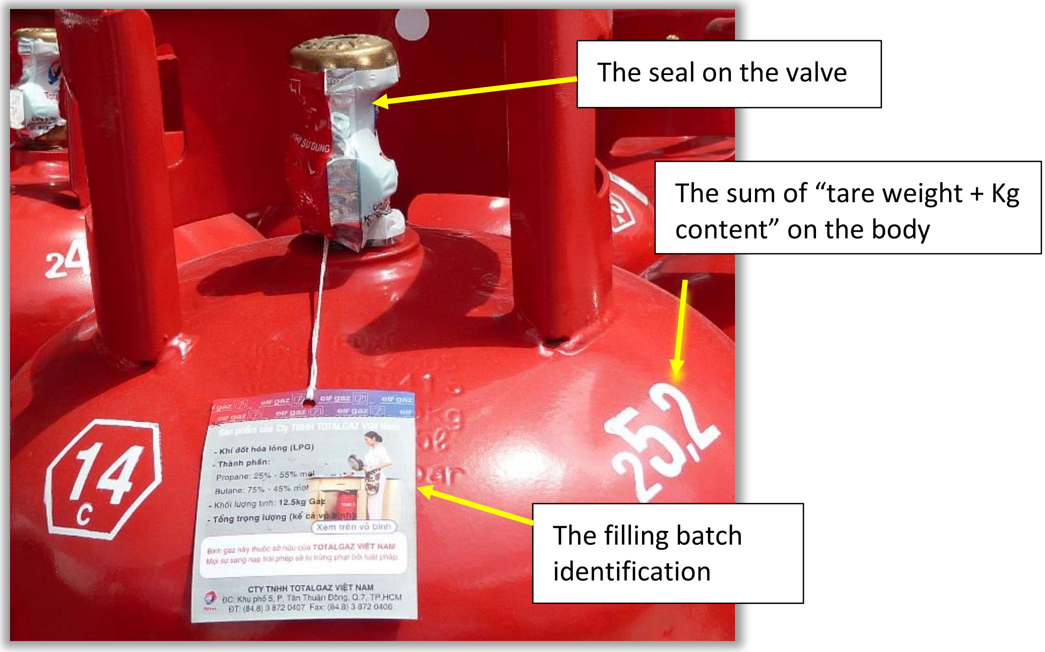
Procedures of acceptance of the cylinder before and after refilling

The cylinder must be inspected before and after refilling. The ISO 10691 is a norm giving the procedures to be followed. Another equivalent norm (EN 1439) can also be used.

Filling only with scales: tolerance and use of the tare weight

- By using a scale: the filling of cylinders can only be done by weighing with a scale, because the LPG density is highly variable with temperature. The filling cannot be done by volume dispenser (litre) to ensure the correct quantity of the kg content of the cylinder. This is also why a refill is always set in kg of LPG and never in litres.

- The tare weight: to ensure the refilling doesn't exceed the maximum filling ratio, which value is embedded in the kg content, the procedure consists in ensuring the refill will stop when the scale measures the total weight of the empty cylinder (tare weight) + kg content of the cylinder. To simplify the work for the operator, to avoid summing the two values at each refilling, a good practice of the industry consists in marking the body with the sum of tare weight + kg content. Note that the tare weight is in the marking list of the cylinder.
- The tolerance on the refilled quantity by a scale (scale accuracy) must be defined by the Weights and Measures bureau.



In summary, the refilling steps at the Filling Plant are:

- Ensuring the cylinder is the property of the Marketer
- Visual inspection of the cylinder and valve for acceptance:
  conformity with the norms and standards, good condition of the valve, absence of damageable corrosion and damageable deformation of the body (criteria of norms to be recommended)
- Periodic pressure test interval not expired
- Readability of the tare weight
  (otherwise, cylinder must be vacuumed and weighed for tare weight)
- Filling with a scale using the tare weight + kg content
- Weight control after filling
  In case of excess, the cylinder must be vacuumed and refilled again.
- Leak test on the body and the valve. In case of leaks, the cylinder must be vacuumed before deciding if the valve is to be changed or the cylinder to be scrapped and replaced.
- Seal of the valve and identification of the filling batch

Lifetime of the cylinder

There are no norms or international regulations which define the lifetime of the cylinder, but for safety reasons it should be a maximum of 40 years.

To be regulated: the pallet for cylinder handling and transportation

The manual handling and transportation of LPG cylinders is a risk factor for their safety and integrity, for the public during transportation, and for the employees of the Filling Plant and the delivery location. Discharging cylinders stacked on a truck in a bulky way affects the integrity of the cylinder and generates risk for the employees discharging the cylinders.

The industry has designed the pallet (of 35 cylinders of 12kg), that can be handled with a forklift, and the pallets can be stacked up to 5 levels, optimizing the use of the land.

It is recommended to introduce the obligation of the transportation with pallet for better operations (charging/discharging time saving and better staff safety, more accurate inventory counting, and less maintenance of the cylinders), and less transportation risk.

There is no international norm on pallets to be used as a reference. Usually the manufacturers know how to design cylinder pallets.

Figure 49. LPG cylinder transport pallet and palleted trucks

To be regulated: the valve and the regulator

The valve is the part that allows the LPG to be consumed. Several types of valves have been designed by manufacturers and used by Marketers.

Regulating the valves sometimes leads the authorities to standardize the type of valve in the market. Experience shows that because not all valves are of the same quality (relative to safety for the end-user), Marketers can use the valves to differentiate their product from that of competitors.

Markets with freedom of selection of valves leads to higher quality of the cylinder.

There are 4 types of valves:

<u>Hand wheeled valves, with and without embedded relief valves</u>

This type of valve requires a regulator to be screwed on. They are the safest of all the valves but require some skills to fix the regulator on the valve.

These valves are mandatory in some countries (USA, Canada), and preferred by the end-users for better control in case of a gas leak.

- *Regulator*

<u>Quick-on valves</u>

This type of valve is less safe compared to the hand-wheeled valve, for the loss of control in the case of a leak, and for generating gas leaks due to sand and dust in the seals connecting with the regulator, although it is considered easier to install on the top of the cylinder. The valve is designed for a specific regulator to be clipped on it.



Bayonet valves

The bayonet valve is like a quick-on valve, but the regulator is more tightly mounted on the valve. This valve is usually of long-life duration, and more expensive.

Camping gas valve

This valve is not as strong over its life as the previous ones. This type of valve does not require a regulator, so it is recommended only with butane, not propane, to avoid the consequence of a bad use. This valve is usually used with the 6 kg in Africa.

One of the main faults of this valve is the fragility of the internal small seals leading to a gas leaks even when not in use.

All these valves are designed according to the following international norms:

- EN 15202: Essential operational dimensions of LPG cylinder valve connections and associated equipment
- EN 13152/ISO 14245: Valves for gas cylinders specifications and testing of LPG cylinder valves; self-closing valves
- EN 13153/ISO 15995: Valves for gas cylinders specifications and testing of LPG cylinder valves; manually operated valves
- EN 14912: Inspection and maintenance of LPG cylinder valves at the time of periodic inspection of cylinders

The tanks and the equipment for storing bulk LPG

These assets must follow construction rules and safety standards from the LPG Safety Book.

The LPG tanks

The tanks or pressure vessels containing LPG must follow the design and manufacturing for propane, as set by the regulation and the calculation codes such as

- ASME
- CODAP
- BS 1500
- ADMERKBLAT
- EU Directive 2014/68 (ex EN97/23)

The tank equipment is detailed in the next section, on Filling Plants.

The service pressure and service temperature must be imposed by regulation.

Piping

The piping includes tubes, pipes or a set of pipes, casings, plumbing accessories, expansion joints, hoses or, if necessary, other pressure-resistant components such as valves, faucets, etc.

Piping and these accessories must comply with international norms such as

- EU Directive 2014/68
- NFPA54
- ASME B31.2
- API 5L

Filling Plants

Regulation of the design, construction, operation, and safety of LPG depots with liquid transfer: bulk depots, import terminal, Filling Plants

In this draft regulation of LPG activities, attention must be paid to liquid gas transfer because a liquid leak causes a very large gas cloud -- one liter of liquid LPG turns into 250 liters of gaseous LPG. In addition, the transfer implements connections (connections to trucks, cylinders) and rotating machines such as pumps or compressors.

The guiding principle of regulation on the design, construction and operation of LPG transfer deposits is safety, based on the essential principles of:

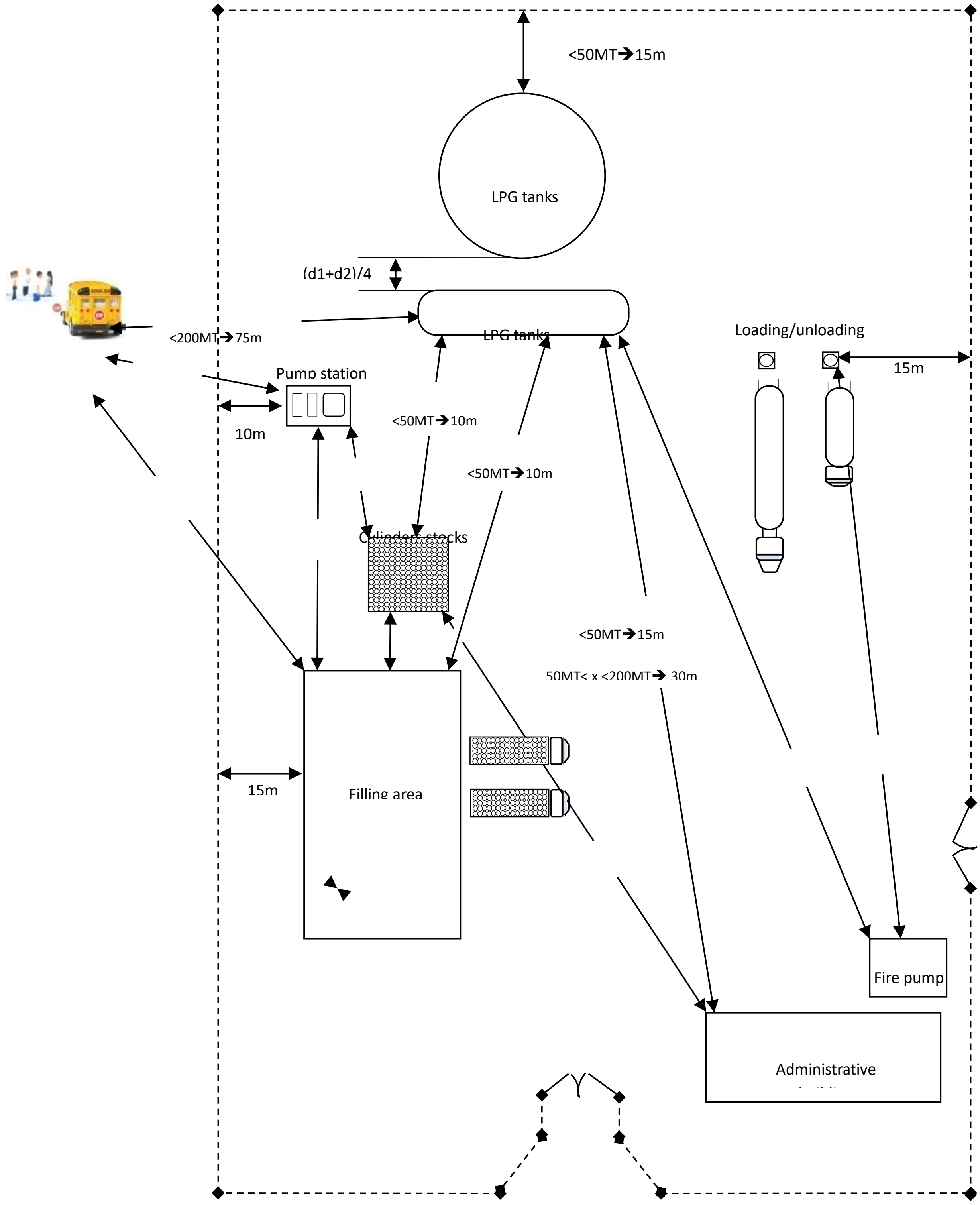
a) Safeguarding people and property
   - Safety distances adapted to environmental and urban planning impacts
   - Limit risk based on storage size
b) Avoiding any risk of explosion and ignition by limiting gas leaks
   - Automatic valves of closures and instrumentation
   - Gas detection equipment
c) Avoiding fires in areas where the risk of gas leakage is possible
   - Adapted electrical equipment (ATEX)
   - Grounding
   - Safety distances
   - Flame detection
d) Avoiding domino effects
   - Security distances and site configuration in its environment
e) In case of fire, putting in place firefighting means sized for the magnitude of the risks to overcome in case of fire leading to a BLEVE, in connection of the LPG storage quantity and the nature of the surroundings in the risk zones

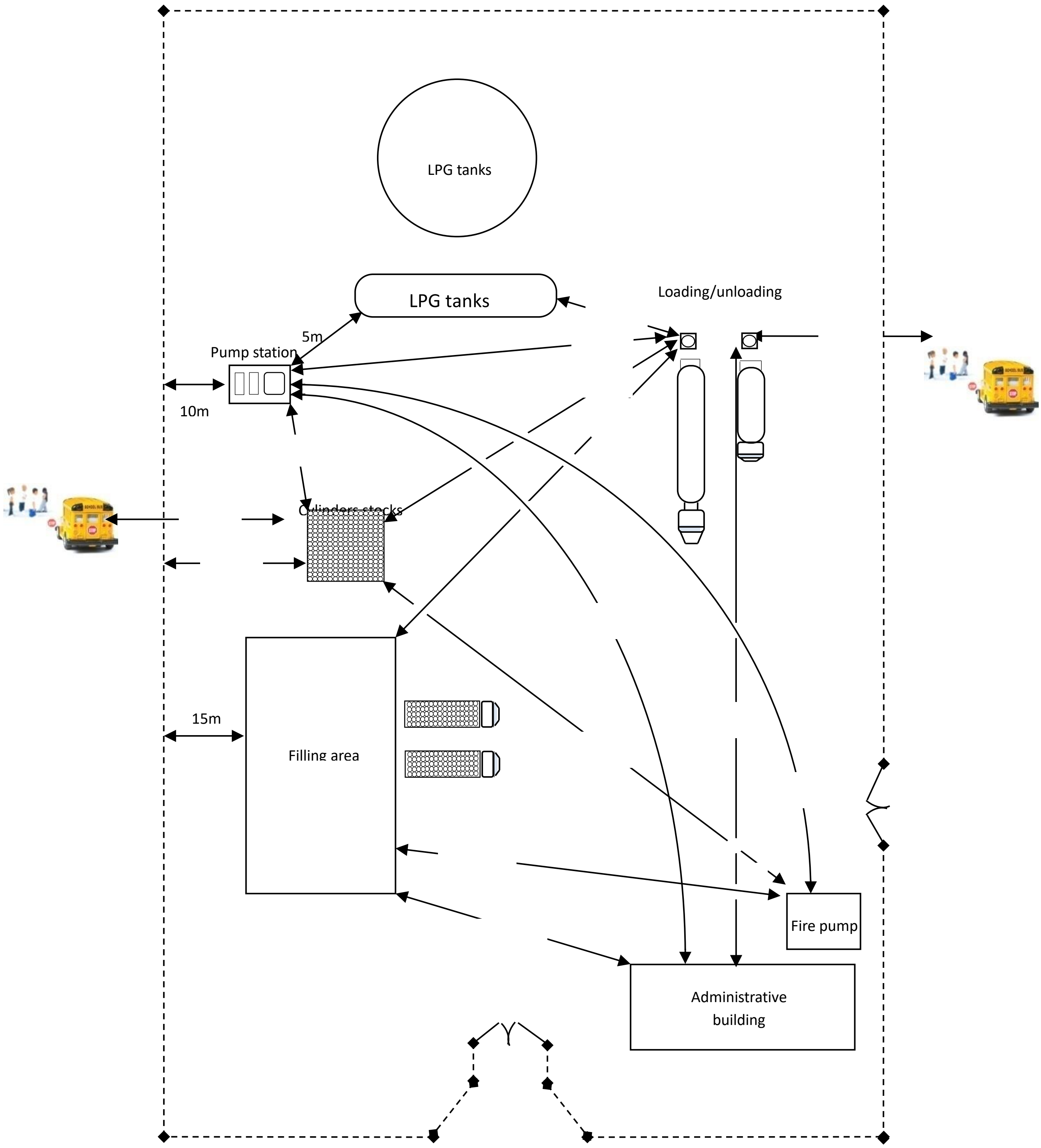
This chapter of the LPG Safety Book shall be aligned with the requirements of RS EAS 900 series, should take into account EAS 924-3 (noting it is an incomplete rule set), and should include the following rules:

<u>Safety distances of the elements of the installation</u>

The safety distances vary according to the technology of the storage tank: aerial pressurized tank, mounded pressurized tank, or refrigerated tank (see example diagrams on next pages)

Figure 50. Examples of LPG tank safety distances diagrams

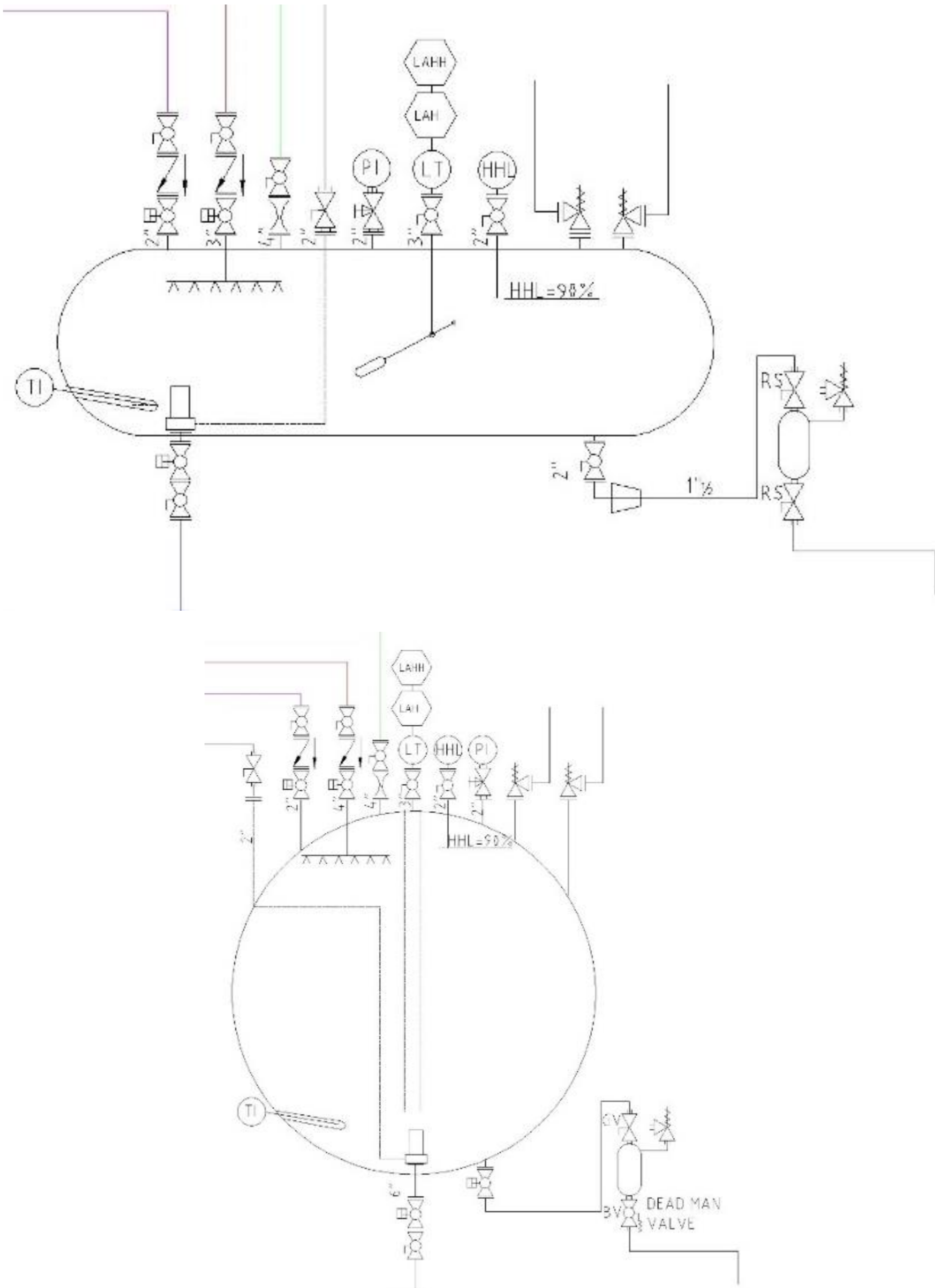



LPG tanks
LPG tanks
Loading/unloading
5m
Pump station
10m
Cylinders stocks
15m
Filling area
Fire pump
Administrative building

Bulk LPG storage

- Type of technologies (aerial or mounded)
- Design of the tanks
- Cut-off devices
- Pressure relief valves
- Automatic level management
- LPG tank draining
- Pressure – temperature measurements
- Access to tanks

Figure 51. Example drawings of bulk storage tanks



LPG pump system (pumps, compressors)

- ATEX proof
- Liquid recirculation

Bulk LPG transfer stations

- Tank trucks and rail tank carriers (layout, safety equipment and procedures)
- Unloading of ships (layout, safety equipment and procedures)

LPG Piping

- LPG piping
- Thermal relief valves
- Pipelines
- Flexible hoses
- Earthing

Equipment of the LPG piping

- Valves and motor valves
- Hydraulic valves
- LPG drainage (excluding tank)

Filling Plant/Hall (layout, safety equipment)

This chapter of the LPG Safety Book will be detailed with comprehensive safety rules and information.

Truck Loading/Unloading Bay – Equipment and procedures

- Layout
- Earthing
- Flexible hoses — loading/unloading arm
- Automatic closing valves

Rail Tank Carrier Loading/Unloading Bay – Equipment and procedures

- Layout
- Earthing
- Flexible hoses — loading/unloading arm
- Automatic closing valves

Gas and Fire Detection

- Emergency stop button
- Gas detection fire detection
- Table of detection required

Emergency Shutdown System

- Triggering shutdown - site shutdown - alarm
- Activity stops - maintain safety functions
- Starting firefighting units

Fire Fighting

- Thermal protection of installations
- Passive protection
- Protection by cooling with water

- To be regulated: the water flow rate in liter/m^2/minute and the duration of the water spray
- Extinguishers, number, and type
- Water tank (sizing the water capacity for firefighting)

Electricity
- Atex zoning (explosion hazard zone) and equipment
- Armoured cable
- Normative reference
- Lighting zone
- Lightning protection

Installation and premises emergency plan

Inspection, testing and maintenance of safety equipment
- Monitoring pressure equipment
- Controls and monitoring of hoses in operation
- Control of safety equipment

Access, fence, and traffic
- Access gate, fence, and barriers
- Trucks circulation and parking - lift trucks

Control and limitation of ignition sources and prevention of explosion hazards
- Drain traps
- Power grid

Safety management system
- Prevention policy for major accidents
- Organization, training
- Identification and assessment of major accident risks
- Process control, operational control
- Management of emergency situations and of experience feedback

Safety management system control, audits, and management reviews
- Safety management system control and reviews
- Site safety audits

LPG bulk installations at consumer locations

LPG could be used in tanks to supply gas in gaseous phase at customer (e.g., commercial) premises. In this configuration, there is no transfer of product, so the risk associated with this task is lower than storage with transfer. Nevertheless, some rules must be defined related to

- The distance and layout
- The storage and its accessories
- The piping
- The equipment
- The firefighting
- The electricity
- The access, fence, and traffic
- The safety management

These rules must be defined according to the LPG storage capacity of the installation. The threshold can be according to the rules of the permit application.

- Up to 5T of LPG
- Up to 15T of LPG
- Up to 35T of LPG
- Up to 50T of LPG
- Above 50T of LPG

These rules shall be per EAS 900-2:2018.

The LPG cylinder depot

LPG cylinder depots are usually operated by either the Marketer or Distributors.

These depots need to be regulated to comply with safety rules regarding the quantity of stored LPG in the cylinder depot.

This regulation is attached to the delivery of the permit for the Distributors licence.

Specific features must be regulated:

- The distance to
  - Property limits
  - Deposit of combustible material
  - Buildings receiving public
  - Opening of administrative or technical buildings
- Maximum height of the cylinder storage
- Condition to store in closed building
- Soil conditions, fence
- Fire extinguishers or nearby fire hydrant

- Marking, safety directive and signage

These rules must be adapted to the size of the storage: for example, less than 5T, less than 15T, less than 35T, and up to 50T.

LPG transportation by truck, rail tank carrier or river barges

Trucks must comply with the ADR rules and the Rwanda regulations for vehicles transporting goods, and shall also be aligned with EAS 924-4. Additional features must be regulated to address the transportation of LPG as a hazardous good.

Bulk trucks

Regulations are required regarding the tractor and semi-trailer.

<u>Tractor</u>

- Propulsion engine
- Security order
- Braking system
- Electrical equipment
- Fire extinguishers
- Various equipment
- Additional requirements for the LPG tractor

<u>Tanker semi-trailer</u>

- Braking system
- Electrical equipment
- Various equipment
- Additional requirement for the LPG semi-trailer

<u>Tank</u>

- Capacity
- Construction
- Holes
- Mounting the tank on the moving train
- Nozzle equipment
- Pipes
- Additional requirement for the LPG semi-trailer

<u>Bodywork and accessories</u>

- Anti-projection system
- Road code signage
- Dangerous goods signage
- Additional requirement for the LPG semi-trailer

<u>Safety</u>

Cylinder trucks

Regulation are required regarding the truck features.

<u>Chassis-cab</u>

- Propulsion engine
- Braking systems
- Suspensions
- Electrical equipment
- Fire extinguishers
- Diving equipment

<u>Bodyworks and accessories</u>

- Tray
- Docking system
- Chests
- Step
- Anti-projection systems
- Floor mat
- Road signage code
- Dangerous goods signage
- Tyres

<u>Vehicle technical commissioning</u>

- Controls
- Folders

Domestic LPG cylinder accessories

The following accessories for cylinders must comply with Rwandan and international norms, which would become mandatory:

- Regulators connecting the gas stove to cylinder:

  RS 134:2012, ISO 23551-2:2006 norms, NF M88-778

- Flexible hoses:

  ISO 2928:2003 norms

- Clip-on hoses: XP-D36-110

- Gas cooking stove:

  EN 30-1, EN30-2, ISO 21364 norms

- Smart metering / smart valve device for PAYG

  These devices allow the consumer to unlock small amounts of gas for a small incremental mobile payment

  Reference can be made to the Kenyan DKNWA 2019

38. LPG Pricing and Taxation

Below, are the six different types of price regimes encountered in many countries. (See also Table 5 on page 31 of Volume 1.) The adoption of a specific price regime is an important decision, for which the following criteria will have to be considered from the Government's perspective:

1. Liberalized pricing; in this case, an assumption is made that competitive forces will "self-regulate" the market price;
2. Controlling the risk of price abuses by industry; capping the retail price or the supply chain margins;
3. Equalization of the transportation cost of bulk LPG to the Filling Plants so that no Filling Plant pays more for bulk transportation than any other, regardless of its distance from the import terminal (or other supply point); in effect, this subsidizes prices in more remote parts of the country (where volumes are lower) by increasing the price slightly in the areas where transport costs are lower (and volumes are much higher);
4. Publication of the end-user price(s) to improve consumer awareness and knowledge;
5. Introduction of a general price subsidy (not recommended);
6. Introduction of a targeted price subsidy system.

Depending on the objectives, one of the six pricing modes can be selected, with or without amendments.

A. <u>No price regulation, prices are liberalized</u>

   Every Marketer sets its own price policy and publishes its own price updates; the competitive market forces define the end-user price(s); there is no possibility of transport or other subsidy due to the absence of a mechanism to calculate and implement it case by case.

   Example countries following this approach: France, Germany, Guinea, Italy, Kenya, Liberia, Nigeria, Sierra Leone, and Uganda.

   Comment: Unit margins in these markets tend to be high, end-user prices are high, and price abuses are common, especially in markets where end-users have limited access to information for checking competitors' prices.

A. <u>Variable monthly maximum prices calculated by the Government for the entire sector, through a price structure with an import parity price formula and capped margins</u>

   The end-user price is regulated and calculated by summing the LPG import parity plus all the different fixed margins for terminal cost, the LPG permanent stock, the bulk transportation, the refilling, the maintenance of cylinders, the investment in cylinders and distribution networks, the Distributors and the retailers. (See Volume 1, Chapter 25 for the Rwanda LPG cost structure from November 2020.) The final end-user price can vary according to the final distance between the Filling Plant and the outlets. The margins are fixed in the decree, and the pricing is revised and published monthly by the Government (noting that the import reference price, Saudi CP, changes monthly). The Government can easily pool the importation needs of the Marketers to improve negotiating power. The equalization of the bulk transportation cost to the Filling Plant, for geographic uniformity of the Filling Plant landed cost to help lower prices for rural users, is possible. Some countries add an equalization of the cylinder final transportation cost as well, to make the end-user price the same all over the country. This type of price structure is the one needed for introducing fuel subsidies (whether general or targeted).

Examples: Belgium, India, Indonesia, Latin America (95%), Malaysia, Senegal, South Africa, Spain, Tanzania, and Vietnam.

Comment: This price structure is very often associated with the successful development of LPG markets in their early and growth stages. At the early stage of LPG market development, the Government uses this price regime to ensure proper control of prices for the benefit of the public until the market is well saturated with active cylinders, and then usually the price is deregulated. This system allows the Government to limit price abuses and to moderate or standardize the end-user price in the country (equalization of transportation cost), but it requires a good understanding of the level of unit margins, so that the Marketers are always able to cover the cost of market development, operations and safety. This system is also required to implement a "targeted subsidy price", a system by which the government reimburses the subsidy directly to certain categories of lower-income end-users, without involving the Marketer. The most simple and economical implementation was done by El Salvador in 2012.

B. Prices are entirely regulated via a price structure updated monthly, having an import parity price formula, capped margins, and a reimbursed fixed subsidy (the end-user price varies)

This price structure is like the previous one, with the introduction of a monthly fixed price subsidy, making a variable subsidized end-user price.

Two options are seen: the subsidy applies to the importation cost, or at the Filling Plant on the ex-Filling Plant refill price. A monthly report is required from the Marketers to claim and get reimbursement of the price subsidy applicable to each.

Examples: Dominican Republic, before removal of its LPG subsidy.

Comments: This price system allows the government to control the annual budget for the subsidy and keeps the end-user conscious that the prices vary regularly. The government can easily reduce and remove the subsidy.

C. Prices are entirely regulated via a price structure, updated monthly, having an Import parity price formula, capped unit margins, and a variable subsidy (the end-user price is fixed)

This price structure is like the previous one, with the introduction of a monthly variable price subsidy, making a fixed and stable subsidized end-user price during a period of time.

Example countries: Burkina Faso, Cabo Verde, Cameroon, Cote d'Ivoire, Gabon, Morocco and Tunisia.

Comments: This system does not help the government to control its budget for subsidy. It creates the appearance of stable LPG prices in the mind of the population, and creates difficulties for the government to phase out the subsidy scheme in future.

D. Variable monthly end-user price per Marketer with capped margins applied on top of the Marketer's actual supply cost

This price structure combines the freedom for the Marketer of calculating the end-user price from its actual own cost of importation with the fixed items composing the end-user price defined by the government: unit margins for the refilling, the transportation, the cylinder maintenance, the investment in cylinders, etc. The Marketers must publish monthly their maximum price list per location, and the publication is passed in the web site of the government.

Example country: Ghana.

Comments: The government seeks to control the unit margins along the supply chain.

E. Variable monthly end-user price with capped margins applied on top of the average actual supply cost of the last importation, which is pooled for the entire sector by the government

This price structure is like the previous one, except that the government averages the actual importation cost of LPG and makes it the same for every Marketer.

Example countries: Kenya for gasoline, Vietnam.

Comments: The government seeks to control the cost of imported LPG. This price system favors those marketers capable of negotiating a cheaper import price. It can lead to unfair competition. There is no record of sustained success, except to favor a national LPG company or one single import monpolist.

Considerations on taxation of the LPG sector

The practice in developed markets on the LPG taxation regime:

1. Import duty tax on LPG: limited to at most 1%, but above 0%, for purposes of monitoring importation;
2. Import duty tax on cylinders and accessories, like regulators, gas stoves: limited to 1% for importation monitoring purposes;
3. Import duty tax on Filling Plant equipment: not applied;
4. Import duty tax on the trucks: the general applicable regime;
5. VAT on the LPG price: usually removed, including on the transportation costs, to favour a lower price for the public; and
6. VAT on the cylinder deposit: not applied.

Table 41. Characteristics of LPG price regime options

	LPG Price System	LPG CiF price	Unit Margins: refilling/marketer/ distribuor/retail	transportation cost	end user price	Subsidy	updates	equalization of the transportation cost for uniformizing and equalizing the end-user price in remote areas	countries of reference
S1	No Regulation	not published	every marketer's price policy	embedded in the marketer's price policy	competition forces define the end-user price	NO	Marketer's decision	not possible	Kenya, France, Italy, Germany, Nigeria, Guinea, Uganda
S2	Official price structure, entirely regulated with a formula updated monthly	Import parity formula applying to all marketers - Government can easily pool the importation	regulated and capped	added on top and applies per district	capped, published, monthly end-user price per district	NO	usually monthly - margins revised with Govrnment decision	possible for bulk and for cylinder transportation	India, Indonesia, much of Latin America, Belgium, Spain, South Africa, tanzania
S3	Official price structure, entirely regulated with a formula applied monthly. Variable subsidy is introduced either on the Marketer price or on the refilling price	Import parity formula applying to all marketers	regulated and capped	added on top and applies per district	Fix subsidised constant end-user price - per district	FIXED	Government decision	possible for bulk and for cylinder transportation	Dominican Republic in the past
S4	Official price structure, entirely regulated with a formula updated monthly. Fixed subsidy is introduced either at the Marketer price or at the refilling price	Import parity formula applying to all marketers	regulated and capped	added on top and applies per district	Variable subsidized end-user price, per district	VARIABLE	Government decision	possible for bulk and for cylinder transportation	Cote dIvoire - Mali - Burkina Faso - Cameroon - Gabon - Cabo verde - Morocco - Tunisia
S5	Official capped margins applying on every Marketer's actual CiF price, published monthly	per marketer published CiF price	regulated and capped	added on top and applies per district	per marketer maximum monthly end-user price, per district (published with Govt)	NO	every importation occurs	not possible	Ghana
S6	Official price structure with capped margins applying on average of the import CiF price or pooled import price	average of the actual CiF/stock price of all the importers (or pooled by the government)	regulated and capped	added on top and applies per district	capped published end-user price per district	NO	every importation occurs	not possible	Vietnam - Kenya for petrol

Price-structure recommendations for Rwanda

The service model is linked to the level of margins

A critical issue in setting or capping unit margins through regulation is the service model intended for the country. Margin choice implies service level. With high unit margins for the marketing/filling/distribution part of the supply chain, services such as home delivery (paid for by industry) become viable. Indeed, home delivery with bicycles and motorbikes already exists, serving approximately 27% of present urban LPG users (paid by the consumer). High unit margins, per industry norms, would be in the range US $200-400 per tonne.

With low unit margins, in a range of US $50-100 per tonne, only a basic service level is viable for industry, and the focus of the supply chain participants is, of commercial necessity, on increasing volume, both in order to cover fixed costs (including any debt service) and, with additional volume, to generate financial returns to owners and investors.

In the case of the prevailing average described above, the total of Marketer, Distributor and Retailer margins is approximately US $300/tonne, making a service-intensive model possible to the extent that (i) Marketers and their distribution networks are willing to spend their margins on services in favor of delivering greater returns to investors, and (ii) the level and the economic impact of diversion and theft of their cylinders is tolerably low. (Rwanda's Marketers were unwilling or unable to disclose the financial consequences to them of such black-market activities.)

It is also recommended that the GoR study the pricing reforms contemplated and recommended in the other Clean Cooking for Africa countries with respect to models, issues, and implications of the structuring and allocation of margins within an effective regulated price scheme.

Ultimately, if any price regulations or reforms are enacted, the Government must determine the amount of the transport equalization levy per tonne and to what extent it is applied to reduce distance differentials toward zero. The data shown above are notional and indicative in this respect.

The price formula would be updated as tenders are executed to reflect the most-current import price.

Cylinder deposits and deposit reform

The amount of the cylinder deposit collected by the distribution chain from a new consumer in Rwanda is also subject to market forces. Historically, these forces have been arrayed in favor of the Marketer over the consumer. In general, LPG Marketers in Rwanda have followed a practice of charging the consumer 5% above the cylinder acquisition cost.

One marketer experimented with discounting the cylinder deposit but found that its distributors kept the extra cylinder deposit amount for themselves.

It is a widespread practice throughout SSA (and worldwide) that the cylinder deposit that can be charged to a consumer is capped by national law or regulation. In highly developed LPG markets such as Morocco's, competitive forces have driven down the average cylinder deposit to about 20-25% of the cost of a cylinder. In Cameroon, as another example, the maximum under law is 80%.

➲ It is recommended that the GoR consider instituting such a cylinder deposit cap together with the other reforms contemplated for LPG pricing.

The deposit entitles the consumer to possess a cylinder of a certain brand, and to have his/her cylinder (typically a different one with each refill) refilled, inspected and maintained for safety by the LPG marketing company. When the deposit is capped by law or regulation, the consumer is insulated from wholesale and retail price mark-ups as well as from the full acquisition cost of the cylinder itself. The up-front cost to become an LPG user is reduced in direct proportion to the deposit cap.

The consumer may recover his/her deposit by giving up the cylinder to the appropriate LPG marketer's retailer or distributor.

Encouraging cylinder deposit reform via financing

A second lever for encouraging deposit fees to be charged at below 100% of cylinder costs is for concessional financing sources (for example, an extension of the results-based financing on offer from the World Bank) to develop a highly attractive cylinder financing package and structure, which is made available to willing and qualified firms that agree to price their cylinder deposit fees meaningfully below 100%.

Moving to a regulated pricing structure

➲ In a developing LPG market at the early stage, such as Rwanda, it is important the Marketers (and investors) have a stable vision of the unit margins to be earned (even if moderate), rather than face income instability from unpredictable price competition. It is also beneficial to create confidence among the end-users by setting published uniform prices, as much as possible. The only simple way is to use the system of variable monthly maximum prices, calculated by the Government for the sector, via a price structure with an import parity price formula and capped margins (option B above). This should be combined with transport cost equalization (cross-subsidy) between Kigali and secondary cities in which, in principle, a Filling Plant has been approved.

Table 42 presents a notional structure for this approach.

Table 42. Notional Rwanda regulated LPG price structure
Dar es Salaam example

Nr	Elements	Description	Example in $/MT	Example in RwF for 12kg
1	Average FOB Saudi CP price M and M-1 – Dar es Salaam in $/t	Average of the FOB Butane CP of the current month and the previous month (published by Platts Gaswire) [*notional value for purposes of illustration*]	400	4 728
2	Vessel freight and premium ($/t)	Ocean freight from Gulf of Arabia to destination ports based on charter hire rates - updated annually	80	946
3	Import charges (in $/t)	Import charges comprises of Insurance, ocean loss, LC Charges and port dues applicable to import of LPG	20	236
4	Cost of use of the import terminal in $/t	Depending if rented, thru-put arrangement or owned	40	473
5	Customs duty (% of 1+2)	Customs duty for Rwanda stock in Tanzania	4.8	57

6	Import Parity cost in Dar es Salaam (1+2+3+4+5)	The price that Marketers would pay in case of actual import of product at the sourcing port	544.8	6 440
7	Transfer cost from Dar es Salaam to Kigali main depot ($/t)	By road tankers	180	2 128
8	Cost of use of the main depot in Kigali ($/t)	Cost of the use of the main depot in Kigali	50	591
9	Import Parity cost in Kigali (6+7+8)	The price that Marketers would pay ex Kigali depot, for those who do not import or do not pool in the importation system	774.8	9 158
10	Marketer Margin ($/t)	Covers the investment in cylinders, the development of the distribution network, the testing and maintenance of the cylinders, the cost of filling, the maintenance of the filling plants and the mandatory security stock of LPG	200	2 364
11	Primary bulk transportation cost	Per equalized primary bulk transportation cost between the Kigali depot and the approved filling plants	40	473
12	Ex Filling Plant price (9+10+11)	The price the Distributors will pay for the refills	1014,8	11 995
13	Distributor margin		30	355
14	The maximum selling price of the distributor (12+13)	The price paid by the Retailer	1044,8	12 350
15	The maximum Retailer margin ($/t)		20	236
16	The end-user price ($/t)		1064,8	12 586

Supplemental decrees that can accelerate the use of LPG

The following regulatory and policy steps have been shown to have an accelerating effect on consumer adoption and use of LPG, and investment in the LPG sector:

- Regulation to ban logging;
- Regulations to limit the supply of charcoal and wood fuel: limitation of production, limitation of transportation to cities of a certain size, limitation on the licensing of transporting companies of charcoal and wood fuel;
- Regulation to limit the supply of kerosene by increasing the tax on kerosene;
- Regulation to limit, waive or zero-rate (for VAT) the import taxes, duties and VAT on LPG, on LPG transportation and on LPG equipment (cylinders, regulators, gas stoves); and
- Standards for LPG stove quality, to improve the average efficiency level of LPG burners.

39. Summary Review and Recommendations: Existing Rwanda LPG Regulations

This Chapter reviews the existing LPG regulations in Rwanda[75] for the following characteristics, compared to international best practices in LPG regulation:

1. Missing elements that break the consistency of the BCRM and the responsibility chain;
2. Elements that undermine or break the consistency of the BCRM;
3. Elements that, through a lack of clarity or specificity, leading to the distortion of the BCRM; and
4. Elements that lack sufficient accuracy or definition;

and makes recommendations for enhancement, where applicable.

Summary of the analysis of the existing regulations

The analysis of the existing Regulation RURA 43 of 4 November 2019 and of the set of corresponding Rwanda standards leads to the following evidence:

The distribution of LPG cylinders under the control of Marketers is the central issue to be addressed in the regulation, rather than the LPG fuel supply chain upstream of this. In the regulation, the cylinder and the cylinder provider are not regarded as critical. Instead, bulk LPG is at the center of today's regulations in Rwanda.

This leads to market actors not undertaking and not appreciating the needed responsibilities (tasks) of proper cylinder cylinder management and safety (refilling, certification, maintenance, transportation), and obfuscates who is ultimately responsible for failures to comply and for safety incidents that may result. A refilled cylinder can be dangerous and circulates among many parties (including the consumer) without direct control by its owning Marketer. It is thus necessary for the regulation to focus primarily on the cylinder, its circulation mode, and how to assign responsibilities for cylinder control and safety.

The key premise is that that there is no LPG supply chain without cylinders and without cylinder providers.

Inevitably, this means that the LPG regulator(s) must do more work. It is much simpler to regulate a few bulk LPG facilities and their owners than to supervise a robust and widespread distribution network. However, this extra regulatory work is essential, if LPG consumption and supply are to grow rapidly, safely, and sustainably.

In that view, the following points are not entirely defined or can be misinterpreted in the regulations:

A. <u>The BCRM (Branded Cylinder Recirculating Model) as the Model of distribution.</u> Rwanda's current LPG regulations do not define BCRM as the Model of reference (i.e., the swap and recirculation of all cylinders to industrial-grade filling plants where the cylinders must be inspected, removed and replaced if necessary, before returning refilled in the market; no

75 RWANDA LPG Regulation (RURA) No. 43 of 4 November 2019

cylinder shall be owned by the consumer and refilled in a public non-industrial-grade filling point, because this process is inherently not safety compliant).

B. The Marketer and its central role for realizing the potential of the LPG market under BCRM is not adequately specified. The Marketer invests in cylinders (owns the cylinder asset), organizes the distribution network, operates the refilling of the cylinders and the bulk supply, performs the necessary maintenance of the cylinders, and is responsible of the compliance with the safety rules, the continuity of fuel and cylinder supply, and the expansion of the market to meet demand. It is the responsibility of the Marketer to decide among the different last-mile distribution processes.

C. Strong recommendation: to issue a License only to the Marketer. Fragmentation of licenses into several types leads to uneven, and ultimately insufficient, compliance with the safety rules and with the BCRM. Fragmented licenses means fragmented roles, leading direcly to unsafe malpractices and to unfair competition, such as cross filling generated by an importer not engaged in the investment of cylinders. This is the main reason why countries like Kenya or Nigeria have had longstanding difficulties in developing their LPG markets well and regularly experience LPG safety accidents. These malpractices have already started to emerge in Rwanda, according to Marketers.

The BCRM implies that, under the Marketer License, the Marketer is the sole party allowed to apply for the permits of, and be responsible for:

- The importation of LPG
- The importation of cylinders – exportation of cylinders
- The construction and operation of Filling Plants and Bulk Depots, solely or jointly with other marketers
- The contracting of transportation of LPG or of cylinders
- The appointment of exclusive Distributors

D. Recommendation: to improve the set of conditions for granting the Marketer License and permits to construct Filling plants.

Some of the key points set by the BCRM are not included:

- Requirement to have a business plan from the applicant for the license or the permit, showing the number of cylinders projected to be added in 10 years' time, the corresponding system of refill and LPG supply, and the areas of coverage of the distribution network and of the cylinder deployment.
- Requirement for the license/permit to issue, that the business plan is consistent with the national LPG Master Plan, to ensure the proposed number of cylinders and the areas of coverage of the distribution are consistent with the Master Plan.

  This allows also the authorities ensure no overcapacity of storage and refilling in one area and under capacity of storage and refilling in another area.

It also allows the authorities to ensure the Marketer will be operating above its financial break-even point, and thus profitable enough to invest in more cylinders and more distribution over time.

- Legal requirement of a minimum number of cylinders to be invested in order to grant a license to a Marketer.
- A minimum insurance coverage value to be contracted by the applicant,
- Guarantees of knowledge and skills regarding the activity of distribution of LPG in cylinders.

E. Regarding the Annex to the Regulation

- Annex A, B and C: To split the rules for bulk storage with liquid transfer (filling plant) from the rules for bulk storage without liquid transfer (bulk tank for consumer), especially the safety distances. To be added: the safety distances depending on the technology of the storage: aerial pressurized tank (not refrigerated), mounded horizontal tank and mounded with sarcophagus spheres. The diagrams in Figure 50 on page 186 provide a more comprehensive set of safety distances than Annex A (see Chapter 41, page 239) and articles 6 to 12 of the regulations.
- Annex E: it is recommended to separate the Marketer License from the permits' fees paid by the Marketer (permits of importation of LPG, of cylinders, of filling plant construction and operation, of appointment of a distributor)
- Annex F: it is recommended to replace "brand-owner" by Marketer, "licensee" by Marketer, and "license" by permit, in connection with adding a clear definition of the "Marketer".

F. Regarding the Safety Rules vs. the Rwanda Standards

The existing standards (RS) do not entirely cover needed safety rules, especially regarding the operations and safety management of installations. It is necessary to assemble the standards with the needed additional requirements in an LPG Safety Book. (See the section titled *The LPG Safety Book* in Chapter 35 starting on page 153, which provides an illustration of it.)

Concerning the RS mentioned in the regulations, it is recommended to review certain statements, such as:

- RS 130: art 3.7 – the loading of cylinders is recommended to be in pallets.
- RS 130: art 3.9 – only a licensed Marketer (cylinder investor), not a mere brand-owner (or any other party), may refill cylinders.
- RS 138: art 7.2 – the unified valve clip-on type is a self-closing valve which is inherently not entirely tight due to its design; thus, a maximum of leak flow rate is recommended to be mentioned (for example, 0.5 gram per minute, depending the type of valve and the manufacturer). Imposing a unified valve prevents the public and industry from benefitting from better quality values or improved valves, such as the the POL (manual closing valve), with devices of level content, for example.

- RS 140: for Commercial Butane quality, a maximum permitted content of olefins and of butadiene should be mentioned. These products are considered as unhealthy when combusted.
- RS EAS 900 – concerning markings. This shall be at a minimum in accordance with ISO RS 13769. The tare weight must be checked by the Marketer prior first filling and painted on the body. The brand name should be embossed on the body to avoid the risk of the cylinder being stolen and rebranded with a new welded collar. The marking should include "Propane" to ensure the cylinder can be refilled with propane in the future, and therefore can be identified if necessary, to avoid filling propane into butane-rated cylinders. Cylinders should be manipulated in pallets, not by hand. Pallets protect the cylinders and the protect the workers who handle the loading and unloading of trucks.

G. Issues that are not in the regulations and are recommended to be:

- *Critical requirements for obtaining licenses and permits.* As part of a Marketer's application for its license and/or its permits, the Marketer must be required to (i) commit to invest in a minimum number of cylinders, (ii) commit to maintaining conditions that avoid over-capacity filling of cylinders, (iii) present its current business plan, and (iv) conform the business plan to the national LPG Master Plan, and (v) commit to executing on its business plan in conformity and alignment with the national LPG Master Plan. Licenses and permits, including renewals, should not be granted without these conditions being met by the Marketer.
- *Definition and implementation of BCRM.* BCRM must be defined and implemented explicitly as the model of distribution to recirculate the cylinder to the Marketer owning the cylinder, including (i) strict prohibition of filling via skids or trucks in the proximity of the consumer; (ii) rules of competition that including respect of cylinder ownership by the Marketer; and (ii) strong prohibition against cross-filling, cylinder interchangeability, and the transportation of third-party cylinders.
- *The central role of Marketers.* The central role of the Marketer must be defined, and must be implemented via a license giving the Markter (and only Marketers) the right to apply for permits for importation of LPG, importing or manufacture of cylinders, exporting cylinders, and constructing and operating filling plants. Licenses must not be available to parties that only import LPG, that transport LPG without the order of a Marketer, and/or that wholesale cylinders without the permission of the Marketer. The existence of such parties violates the BCRM and harms the safe and sustainable development of the LPG cylinder market.
- *Replace "Wholesaler" by Exclusive Distributor.* A Distributor must have the obligation to report to the Marketer with whom it contracts on where the Marketer's cylinders have been sold, while a wholesaler does not.
- *LPG Safety Book.* An LPG Safety Book must be created to capture comprehensively all the safety rules and procedures associated with cylinders and fixed installations (filling plants, storage, depots), thereby completing the missing points in the national standards and norms. The requalification of cylinders, pressure testing, and replacement of valves are recommended to be part of the capacity and procedures of cylinder inspection/rejection in the filling plant. This maximizes sector efficiency and cylinder throughput, and it avoids the transportation cost and labor time associated with sending cylinders to separate requalification centers.

Requalification centers are only required for repairing the cylinder body and destressing welding in a dedicated oven. For day to day inspections, painting, pressure testing and valve replacement, it is more efficient to perform the tasks directly in the filling plant.

- *Interim prohibition of LPG as a transport fuel.* At the early stage of the LPG market, when growth is driven mainly by, and benefits are created mainly by, consumer adoption of LPG for cooking, it is important to delay as long as possible the adoption of LPG as car fuel (usually called Autogas), to avoid chaos in and conflict with the development of the residential and institutional use of LPG cylinders for cooking.
- *Co-investment in shared facilities.* Provisions should be provided which encourage co-investment by Marketers in common logistics infrastructure such as filling plants, bulk depots, and intermediate cylinder depots. These co-investments can be designed with or without the participation of the state. Their effect will be to reduce the cost of filling and storage market-wide.
- *Strategic storage.* Provisions should be provided that every Marketer must have a security storage capacity in its facilities covering month of sales and, including its logistics chain and cylinder inventory, up to 60 days of sales, consistent with the recommendations in this Plan (see Volume 4, Chapter 45) for achieveing the MINICOM strategic storage policy target.

40. Line by Line Regulation Review and Recommendations

Column of the existing text in the regulations[76]	Column of comments and recommendations
CHAPTER ONE: GENERAL PROVISIONS	
Article One: Purpose of this Regulation *The purpose of this regulation is to establish a regulatory framework for Liquefied Petroleum Gas (LPG) industry in Rwanda.*	Recommendation is that the regulation addresses only the LPG distribution of LPG in cylinders and in bulk. Autogas and LPG production are not included
Article 2: Definition of terms *In this Regulation, the following terms have the following meanings:*	
1. Authorization to upgrade: *a legal document issued by the Regulatory Authority granting rights to re-allocate and upgrade LPG facilities;*	
2. Bobtails gas truck: *a road tanker with gas filling unit;*	Requires to be more precise. A bobtail truck is only a small road tanker capable to refill stationary bulk tank to consumers. The bobtail shall not be allowed to refill cylinders from the truck (safety rules of RID/ADR)
3. Bulk LPG: *LPG container in a receptacle of a capacity exceeding eighty (80) kilograms;*	Bulk LPG is the activity of delivering LPG from a truck into a stationary tank at the customer's premises.
4. Bulk storage: *storage of capacity exceeding eighty (80) kilograms;*	Storage TANK of capacity exceeding 80 kg. to avoid an interpretation of group of cylinders summing 80 kg capacity
5. Bulk Storage Facility: *a facility that accommodates storage tanks or vessels disposed in groups in a manner the storage vessels in any one group do not exceed SIX (6) unless a fire wall is erected bet-ween the groups and such storage facility does not include a filling unit;*	Installation rather than facility, emphasis should be made on the storage but also on the piping and the safety distances within the premises of the consumer

76 This column has been retyped for purpose of inclusion in this document by an outside typist from hardcopy docments and therefore may contain minor typographical errata, which should not detract from its meaning.

6. Consumer: *any person supplied or entitled to be supplied with LPG but does not include a person supplied with LPG for delivery or supply to another person;*	
7. Consumer site: *a facility used to store bulk LPG for own consumption by an end user;*	
8. Container: *a recipient of LPG either a cylinder or bulk;*	…or a bulk tank
9. Cylinder: *Transportable, refillable container manufactured and marked to a national or international standard and with a water capacity not exceeding eighty liters (80);*	
10. Distributor: a person, firm, company, institution, organization or a cooperative society appointed by a brand owner and engaged in the business of purchase and sale of liquefied petroleum gas to consumers;	Instead of "brand owner": Marketer. then requires the definition of Marketer. comment: Brand owner doesn't describe the cylinders are the assets (property) of the Marketer. Brand owning can be problematic when reselling an LPG business, if the brand cannot be sold, or if the brand is accessed through a "brand use agreement", like VIVO Energy using the Shell brand without ownership.
11. Filling: the packaging of LPG into cylinders	
12. LPG Licensee: a holder of a legal document Issued by the Regulatory Authority, granting rights and obligations to the operator engaged in one of the LPG business of Importation, exportation, transportation, storage, wholesale, distribution and retail of Liquefied Petroleum Gas;	Recommendation of definition: The LPG Marketer. a licensed company entitled to develop the LPG distribution chain through all the activities required for a permanent supply of LPG in safe cylinders of its registered brand name, consisting in importation of LPG, cylinders and tanks; construction and operation of bulk depots and Filling Plants; construction and operation of cylinder depots; distribution of refilled cylinders to contracted Distributors or through its own means of marketing; contract its own means of bulk and cylinder transportation; and agreement on mutual hospitality or joint venture on a common logistics facility like an import terminal, bulk depots and Filling Plant
13. License: a legal document issued by the Regulatory Authority granting rights and obligations to the operator engaged in one of the LPG business of importation, exportation, transportation, storage, wholesale, distribution and retail of Liquefied Petroleum Gas;	Recommendation the license for Cylinders and LPG importation, refilling, transporting, exporting and appointing distributors is only given to Marketers. The cylinder investment, the main barrier, requires the investor to control the flow of LPG and its assets. It is key to not give a license of LPG importation or for a filling plant

	to someone not engaged in the investment in cylinders and distribution network.
14. LPG: Liquefied Petroleum Gas	Either Commercial Butane, either Commercial Propane or a blend of both
15. LPG business: *a concern carrying on the importation, exportation, storage, transport, wholesale or retail of LPG;*	To be added: LPG businesses are: Marketer, Distributor, Retailer. Transporting activity can be either done by the Marketer or the Distributor or subcontracted to a transporting company by the Marketer. NB: given the complexity of the control of recirculation of cylinders, a branded Distributor is required instead of wholesaler, who has no obligation to respect the ownership of the cylinder
16. LPG plant: *a combination of the minimum required facilities as cited in article 5 of this regulation;*	A facility to refill LPG cylinders fully equipped for control of the cylinders, prior and after refilling, as per the description in the LPG Safety Book
17. LPG Storage: the storing of LPG in premises consisting of tanks or cylinders in transit for sale or consumer use;	
18. Major Accident: undesirable incidental and unplanned event which involves severe personal Injury or death;	
19. Person: include company, entity or individual person involved in LPG business	
20. Premises: include any installation on land or vehicle storing LPG-	
21. Regulatory Authority: *Rwanda Utilities Regulatory Authority,*	
22. Re-validation: the method or procedure by which a cylinder is subjected to periodic inspection in accordance with the Rwanda Standard for cylinder requalification to determine its acceptability for continuous use and distribution;	Note: it is the responsibility of the Marketer to ensure the cylinder is accepted before each refill in the filling plant of the Marketer. Re-validation may refer to the periodic pressure test with valve replacement and re-painting of the cylinder, tasks that can be done in the premises of the filling plant.
23. Retail: the sale of LPG in bulk or in cylinders to the consumer for their own	
24. Rwanda Standard Board: National institution m charge of standards development (RSB),	
25. RS: Rwanda Standard, which is the specification or code of practice declared by the Rwanda Standard Board;	
TO BE ADDED: The LPG Safety BOOK	It is recommended, when setting the safety rules, to refer to the LPG Safety Book, which sets forth all the safety rules of construction, safety distances, and norms <u>and</u>

	operations, including the safety management system. The LPG Safety Book will refer to the Rwanda Standards
26. Seal: a tamper proof cover fitted on the valve of a filled cylinder by the brand owner or by a third, party with the brand owner's written authority to maintain the authenticity of the LPG inside the cylinder	
27. Seller of LPG in cylinders: any wholesaler or retailer of LPG in cylinders;	It is recommended to define as per the responsibilities: Distributor instead of wholesaler (the distributorship agreement with the Marketer will set a series of obligations, targets and sanctions regarding the safety of cylinder-handling and respect of cylinder ownership). The Retailer remains with the obligations of safety and respect of ownership.
28. Substandard product: any product which doesn't meet any specification prescribed in relevant standard;	
29. Upgrade: the relocation of existing storage tanks, installation of additional storage tanks, installation of filling unit to the bulk storage facility, replacement of storage tanks where there is an increase in total storage capacity, total demolition and rebuilt of an LPG Plant or bulk storage facility where there's either increase in capacity or change of location of the facilities;	
30. Unified Valve: the valve specified in RS138;	A unified valve is limiting the marketing capacity of a Marketer, who may be interested to propose superior quality valves or with additional embedded devices. A unified valve encourages the illegal cross filling of cylinders, what stops the investment in cylinders. The RS138 only describes the automatic Self closing valve and even not the “camping gas” type of valve used with the 6kg cylinders. ISO 14245 and ISO 15995 can be used in addition to bridge this gap, provided the requirement to use a unified valve is discontinued. Moreover, it is expected the Marketer can choose safer valves like the one manually operated by a wheel (EN13153). These valves should be compulsory for the 35-38 kg cylinders, at least.
31. Wholesaler: an intermediary person or entity in the LPG distribution channel that buys LPG in large quantity m cylinders and sells it to retailers rather than to consumers.	It is recommended to use the concept of Distributor, representing the Marketer in a given territory under a distributorship agreement. Every Distributor can only have and deal with one brand of cylinders. It is against the BCRM

	to allow Distributors (or wholesalers) to handle or exchange cylinders of more than one brand.
To be ADDED The BCRM: the only authorized Distribution Model of LPG in cylinders	Branded cylinders belong to the Marketer. Cylinders must be swapped empty against refilled ones (refilling in service-stations or mobile units in proximity to the end-user is forbidden, in particular for reasons of safety) The responsibility in the safety chain is attached to the ownership of the cylinder, the Marketer. The deposit system is the way the end-user gets access to a cylinder, belonging to a Marketer, so the end-user will not incur any charges or responsibilities for cylinder maintenance, re-validation and replacement. The BCRM is the key reference for the consistency of application of the safety rules.
To be ADDED: The National LPG Master Plan	The approved National LPG Master Plan is the frame to the analysis of the business plan submitted by the applicant Marketer to obtain the license. The same Master Plan is also taken as reference to authorize the construction or upgrade of Filling Plants by Marketers. That is, all licenses and permits must be issued in strict compliance with the BCRM, and only to applicants who are in compliance and alignment with the Master Plan.
<u>*Article 3: Scope of this Regulation*</u> *This Regulation shall apply to the following activities:* • *importation of LPG;* • *installation or upgrade of an LPG plant;* • *installation of a Storage of LPG in* • *upgrade of a storage of LPG in Bulk;* • *transportation of LPG in Bulk or Cylinder;* • *wholesale, Distribution or retail of LPG in cylinders; and* • *reticulation of LPG m residential or commercial building.*	In order to ensure safety in the responsibilities chain, it is central to segment the activities with the cylinder, the pivotal element, consistently, clearly, and without overlap. 1: import cylinders and LPG; refill cylinders; appoint distributors and transporters; contract, install and supply bulk consumers = the Marketer 2: provide access to cylinders against deposits, transport cylinders in own trucks and recirculate empty and refilled cylinders, develop network of outlets and home delivery system = the exclusive Distributor of a given Marketer 3: outlets = the Retailer (the outlet may be owned by the Marketer, such as a service station, or may be independent, or may be bypassed as in the case of direct-to-home delivery by the Marketer or its Distributor)
CHAPTER II TECHNICAL REQUIREMENTS FOR INSTALLATION OF AN LPG PLANT	
Section One: General requirements for installation of an LPG Plant	

Article 4: Location of plot planned for LPG plant	
Any plot planned for construction and installation of an LPG Plant shall comply with the requirements of the master plan of that particular area, the environment law, Rwanda Building Code, and any other applicable laws and standards.	The plot is recommended to have a minimum size of [ ] hectares to fulfill the safety distances, to be located in areas where housing is restricted in a distance of 100m of the fence of the Filling Plant. The procedure of approving a plot for a Filling Plant should include a Risk Assessment study, giving the impact in the surroundings of the project.
Article 5: Required facilities for an LPG plant *An LPG plant must have at least the following facilities:*	Ideally, these should be detailed into the LPG Safety Book
i. storage tanks;	Including the facility to discharge or load bulk trucks. Storage can be of 4 different technologies: aerial pressurized, horizontal mounded tanks, walled and mounded and spheres, refrigerated tanks.
ii. warehouse for cylinders and accessories.	The cylinders must be palletized in dedicated areas with safety distances and transferred from the distributor truck to the filling plant using forklifts
iii. filling unit,	Filling Hall with all equipment of safety and control of the cylinders (as detailed in the LPG Safety Book)
iv. offices.	
v. Firefighting system	Based on water cooling at a flow rate of 7L/m^2/mn for 2 hours, with a calculated water tank capacity and at least 2 water pumps for redundancy purposes, including powder extinguishers, gas detector, flame detector, remote closing valve on liquid phase pipe, etc. (see the LPG Safety Book)
vi. parking yard for customers; and	
vii. parking yard for bulk supply road tankers.	
Upon completion of the plant installation, testing of all installed facilities must be carried out by accredited company checking for leakage, prior to any operation.	This provision should be detailed in the procedure of commissioning of a filling plant, with the list of certificates, the manufacturer files of the tanks, the specifications of all the equipment and machinery, etc.
The tests reports must be submitted to the Regulatory Authority for approval prior any operation.	Provisions for issuance of the permit to start operations must be detailed in the same procedure
Section 2: Distances required from an LPG plant to the neighboring infrastructures	

<u>Article 6: Distance from LPG plant to roads</u> *The distance from a property line of an LPG plant to the median line of the National Roads Class 1 shall be not less than twenty-two (22) meters.* *The distance from a property line of an LPG plant to the median line of the District's and City of Kigali Roads class 2 shall be not less than twelve (12) meters.* *Without prejudice to paragraph above, the dimensions of the road reserve for City of Kigali and other urban areas must be determined in accordance of the master plan of the City of Kigali or other urban area*	Ideally all these distances should be included in the LPG Safety Book
<u>Article 7: Distances from bulk storage tanks, cylinders' storage areas to the neighboring property boundaries</u> *The minimum safety distances for LPG plant installation must comply with the distance specified in Annex A, while Safety distances for LPG cylinders storage area to the neighbouring property boundaries must comply with the distance specified in Annex B of this regulation.*	Annex A (see further below) should be included in the LPG Safety Book. These distances must depend on the storage capacity and the technology of storage (not mentioned in Annex A)
<u>Article 8: LPG plant to other flammable and explosive products storage facilities</u> *The distance from a property line of an LPG plant to the plot boundaries of storage facilities of other flammable products must be at least thirty (30) meters.*	In most international standards, 30m is acceptable if the risk assessment on a BLEVE scenario results in no fatalities. Usually the Marketers (and their insurance companies) require the distance defined by a Risk Assessment study, if the plot is surrounded by housing and offices.
<u>Article 9: LPG plant to power line</u> *The horizontal clearance from LPG tanks to the line conductors of the high and medium voltage power line must be at least fifteen (15) meters from power lines of 0,4 KV to 220KV and twenty (20) meters from 400 KV lines.*	In some regulations high voltage power lines are considered as "open fire". Some others use a similar distance. Is not appropriate to construct and operate a filling plant this close to a power line.

Section 3 : Specific requirements with regard to parking yards and other related salerooms	
<u>Article 10: Parking yards</u> *An LPG Plant must have a parking yard sufficient to accommodate Bulk Road tankers and be located at five (5) meters away from Bulk storage tanks of LPG filling lines and comply with national standards especially to RS 135-2.*	
<u>Article 11: Office Buildings</u> *Office buildings and related salerooms at an LPG Plant must comply with provisions of Rwanda Building Code.*	
Section 4 : Installation of plant facilities	
<u>Article 12: Installation of storage tanks</u> *An LPG storage tank must be:*	
1. made of mild steel, designed, manufactured, inspected and tested m accordance with national standards RS 135-3, RS 135-4 and any other subsequent standard adopted by Rwanda Standards Board;	This requirement is not enough. Control of the welding through X-ray tests, and of the metal plate quality by lab test of a sample, should be added.
2. installed aboveground or Buried in accordance with RS 135-3.	The correct cases are "aerial pressurized tanks" – "horizontal mounded tanks" – walled and mounted spheres" – "refrigerated tanks". We recommend this chapter to be reviewed in the LPG Safety Book.
In case of group of storage tanks:	These distances are supposed to vary with the above technology and with the total storage capacity, after control of a risk assessment study.
1. the distance between adjacent tanks within a group of tanks must be a quarter (1/4) of sum of diameters of adjacent storage tanks as specified in RS 135-3;	
2. the number of storage tanks In any one group must not exceed six (6). Each storage tank in one group must be 7.5 meters at least from the nearest storage tank in another group unless a fire wall is erected between the groups; and	
3. when firewalls are used to separate groups of storage tanks, the direct distance from each storage tank in one group to the nearest storage tank in another group must be four (4) meters at least	

Article 13: Compulsory Devices on storage tanks	
Each storage tank must be equipped with the following devices:	
1. Two (2) pressure relief valves at least and each of them must have a direct communication with the vapour space of the storage vessel;	
2. the vent pipes fitted to the relief valve outlets for storage tanks of capacity exceeding nine thousand (9,000) liters;	
3. Content gauging device and a device indicating the maximum liquid level.	
Article 14: Installation of Filling Unit and testing	
Pipes, dispensers or bullets and pumping units, hoses, nozzles, associated valves, weighing scales and all other equipment of filling unit must be installed in accordance to RS 135-3	The RS 135-3 is not enough to describe a filling plant with safe operations.
After the assembly of pipelines, they be must be tested prior to their usage.	
Article 15: Fire alarm, Emergency shutdown systems and Firefighting systems *An LPG Plant must incorporate an emergency shutdown system to stop the flow of LPG, pumps and filling equipment.*	
An alarm system easily accessible at a proper location must be part of the plant safety system.	
Every Storage facility or LPG plant must be equipped with firefighting protection before its operational and comply with National Standard with regard to requirements set in RS 135-3 and table set forth in Annex D of this Regulation.	
Section 5 : Decommissioning of LPG plant	
Article 16: Decommissioning process *The decommission of an LPG plant that is no longer in operation must be communicated to the Regulatory Authority m writing within fifteen (15) days prlor the expected date of decommissioning.*	

Article 17: Disposal of decommissioned plant equipment *Any plant equipment to be decommissioned must be disposed of by the licensee and on his cost in accordance with applicable laws and standards.*	
CHAPTER III: MANAGEMENT OF LPG CONTAINERS	
Article 18: Cylinders management	Clarify: In a Filling Plant or also in an Outlet or in a depot of cylinders (Distributor)?
All empty LPG Cylinders must be handled with the same precaution as filled cylinders.	Cylinders should be handled in pallets for their storage and transport: this is not mentioned, and should be.
All LPG licensees shall ensure that:	
1. the valves of all empty cylinders received for filling are closed properly;	
2. no cylinders are stored in a horizontal	
3. cylinders are positioned on suitable, robust shelves constructed of a noncombustible material;	
4. cylinders are always stored at or above ground level and at least three (3) m away from openings which include but not limited to basements, drains, manholes and culverts where vapor might collect;	
5. cylinders are stored in such away they are accessible for inspection at all times and that every container is readily removable	
6. cylinders that are full arestored separately from containers that are empty, and both should be stored in clearly demarcated areas; and	
7. after filling, each cylinder is checked by weighing or by ullage space determination to ensure that it is still within the appropriate mass indicated on the cylinder.	This is part of the procedure of filling and testing cylinders in a Filling Plant
Article 19: Registration and re-validation of LPG cylinders *All LPG Licensees involved in cylinder business are required to register all their cylinders.*	Only Marketers own and are responsible for their cylinders
Every imported new cylinder shall be checked by the competent authority to confirm its tare weight (weight of empty cylinders).	Tare weight must be checked by the Marketer, for every cylinder, at the importation stage, but also after replacement of the valve and repair (change of collar). The tare weight must appear on the body of the cylinder.
All Licensees shall re-validate every ten (10) years all cylinders registered under their name with the supervision and certification of a competent authority.	Recommendation to separate "pressure test and change of valve" from revalidation, which implies heating the cylinder in an oven.

	5 years of periodical pressure test if cylinders are not transported with pallets, 10 years if cylinders transported with pallets. (Cylinders should always be transported with pallets.)
Re-validation period should decrease to 5 years when the LPG cylinder age is more than 20 years' old.	If cylinders are transported with pallets, it is not necessary to contemplate a threshold of 20 years. A scheme to limit the validity of a cylinder could be design after 40 years of use, using a burst test on a sample of cylinders of a given batch documented by the manufacturer file of each batch. If the sample passes the test, then the entire series of cylinders of that batch is validated for 10 years more.
<u>Article 20: Reassessment of cylinders</u>	
Cylinders that have been set aside shall be examined by a competent person who shall decide whether they are suitable for filling or shall be sent for reconditioning or rejected leaking cylinders and cylinders with damaged or leaking valves shall be safely vented. Leaking or damaged valves shall be repaired or replaced. *Cylinder weld leaks shall be repaired as authorized by the competent authority* *For cylinders leaking through the body other than at a weld, the cause of the leak shall be determined; such cylinders shall then be rejected*	NOT RECOMMENDED: never repair a weld leak. In all cases of leakages on the body at the welding or not, the cylinder must be scrapped. It is recommended to re-write these articles under the control procedures, first prior to re-filling of a cylinder and second after refilling of a cylinder.
Rejection criteria guidelines for physical and material defects on the cylinder shell are specified in RS ISO 10691	In case of rejection, a control procedure to scrap the cylinders is necessary, to ensure they are not recycled in a parallel market.
<u>Article 21: Specifications of LPG cylinders</u> *LPG cylinders allowed for importation or to be manufactured in the country must fulfil the following specifications:* *1. meet the standard capacities and fitted with unified valves;* *2. be with a safety relief unified valve with appropriate dimension;* *3. be of steel material or composite type.*	Note: the specifications for procurement of cylinders is a complete set with reference to respective norms (at least 7 different norms compose a specification) including, the design of the cylinder, the drawing, the type of steel, the type of welding, the calculation sheet of the cylinder, the protection of the body, and the permanent markings. The cylinder specifications must use the norms regulated by the Authorities. The specification, the manufacturer set of constructing file, the certificate of pressure test, the certificate of proof of tightness of the cylinder, the certificate of the quality of the steel and the certificate of quality of the welding (x ray test). All these documents must be taken into account to issue a certificate of approval for use in Rwanda, stating the serial number. (A portion of these considerations is addressed in RS ISO 22991, 4706 and 11119.)

Article 22: Cylinder marking, sealing and weigh scale	
Any must be checked before being filled to ensure that the markings specified in RS 135-4[77] are clearly visible and legible. *An LPG Licensee must, upon refilling, ensure that a cylinder valve and safety valve is properly closed, sealed and complies with specifications.* *The check-weigh scales must be calibrated by the competent authority at least twice (2) a year.*	The Marketer is responsible for ensuring the procedure of filling, of control prior and after filling is being followed in all manners. A branded seal (sometimes with serial number) on top of the valve will witness it.
Article 23: Transportation of LPG containers	
The transportation of LPG in bulk or in cylinders must be carried out by an appropriate vehicle marked or labelled with the appropriate signs.	The bulk truck must comply with a specific list of safety features (set forth in the LPG Safety Book). The cylinder truck must comply with another specific list of features. Every truck plate must be registered in the police file, under the responsibility of the Marketer ordering the transportation activity (a truck is attached to an activity ordered by a Marketer). Drivers must follow training and safety certification (bulk truck driver, different from cylinder truck driver). The Marketer is responsible to ensure the training and certification is done (every 2 years). Every Marketer must have a no-alcohol no-drug policy, and ensure control (blood test) from time to time.
The vehicle involved in LPG transportation must display at least two (2) notices painted on or securely attached to both sides of the vehicle and display the following words written in capital letters or the corresponding pictograms: danger —no smoking — no naked lights as specified in the national standard RS 135-2.	
Article 24: Training of personnel	
The LPG Licensee must ensure that employees carrying out the Inspection, filling and handling of containers receive the appropriate technical and practical trainings in cylinder handling to minimize the risk of injury, explosion, fire outbreak suffocation and damage to the cylinders.	See comment on Article 23

[77] RSB has indicated that RS 135-4 has been withdrawn.

Article 25: Bulk storage at consumer sites	
All activities related to installation of bulk storage at consumer sites shall be only undertaken by qualified installers.	The Marketer is responsible for the installation, the compliance to the LPG Safety Book, for the tightness certificate of the installation, for the safety of the truck deliveries, and for the periodical pressure test of the tank and the relief valve.
Consumers must be informed about potential hazards in using LPG and about the safety features of appliances and their installation.	The Marketer is responsible for safety education, safety training, and safety emergency plan, whenever applies.
CHAPTER IV: LICENSING REGIME FOR INSTALLATION AUTHORIZATION TO LPG PLANT OR BULK STORAGE FACILITY	
Article 26: Application for an installation license of an LPG plant or bulk storage facility *Any person who intends to install an LPG plant or a bulk storage facility shall apply for an LPG plant Installation license to the Regulatory Authority.*	NOT RECOMMENDED (not consistent with the BCRM). Only a Marketer or a group of Marketers, having invested in cylinders, can apply for the permit to construct and the permit to operate a filling plant.
The Application letter shall be addressed to the Director General of the Regulatory Authority and accompanied by the following documents:	
a. *a copy of the land documents registered under the project developer name;*	OK – proof of the right to use the land + with a risk assessment study validating the plot
b. *a copy of construction permit issued by the Competent Authority;*	OK
c. *a copy of an environmental impact assessment certificate;*	OK
d. *a copy of a business registration certificate;*	OK
e. *detailed drawings design of the proposed LPG plant or bulk storage facility,*	OK – the layout complying with the LPG Safety Book requirements IMPORTANT: the layout and project description will include a business plan proving the lack of filling capacity in the hinterland of the project. A specific condition requires the projection of investment of cylinders in the coming 5 years. Other justification is to share investment with other marketers to reduce the cost of CapEx. The business plan must show consistency with the National LPG Master Plan.
f. *proof of payment of the license application fee as specified in Annex E of this regulation; and*	Payment of the permit application fee by the Marketer

g. *any other information as shall be required by the Regulatory Authority.*	
The Regulatory Authority shall notify the applicant the decision taken thereof within twenty-one (21) working days.	
<u>Article 27: Validity of LPG plant or bulk storage facility installation license</u>	This type of article is never seen in international LPG regulations. Renewing a license by a Marketer for a Filling Plant every 3 years, may imply the license is not renewed. In that case, the Marketer cannot justify to invest in a filling plant with a typical 8-10 years payback period. Recommendation to include the renewal of the operations permit of the filling plant in the renewal of the license of Marketer. If the intention is to collect revenues for RURA, it is recommended to include instead a "special LPG development fee" in the price of LPG, a common practice in many countries.
The LPG plant or bulk storage facility installation license shall be valid for a period of three (3) years.	
When the license is expired before starting the installation works, such license shall cease to have effects and the applicant shall apply for a new license in accordance with the provisions of this regulation	
An extension period for the expired license while construction and installation works are ongoing shall be given based on extension period of construction permit	
<u>Article 28: LPG plant or bulk storage facility installation license fee</u>	
An LPG plant or bulk storage facility installation license shall be issued to the applicant upon the presentation of proof of payment of the license fee as specified in Annex E to this regulation	The aim of the Authorities would be to ensure registration of all installations of bulk LPG at consumers. Thus, safety audits by the Authorities can be conducted.
<u>Article 29: LPG plant or bulk storage facility installation license transfer</u>	
In the event that a licensee initiates the transfer of LPG plant or bulk storage facility installation license transfer to another person, the licensee must seek for an approval from the Regulatory Authority;	
The transferee shall be considered as the applicant to assume the LPG plant or bulk storage facility	Comment on Article 27 applies

installation license. The duration of the above installation license and the license terms and conditions shall remain the same.	
<u>Article 30: Suspension of LPG plant or bulk storage facility installation license</u>	
The licensee must install the LPG plant or bulk storage facility in accordance with the approved design plans, and standardized building material, falling to do it; the Regulatory Authority shall suspend the LPG plant or bulk storage facility installation license until regulation is complied with.	The Marketer can only operate the installation after reception of the conformity to the LPG Safety Book requirements, duly witnessed by the Authorities. Any failure in complying with the safety rules of the operation of the filling plant is declared a violation of the law, and sanctions apply. IMPORTANT: in the case of suspension of the operations of a filling plant, and if the Marketer has no alternative, the Authorities must ensure the cylinders of the sanctioned Marketer be temporary refilled in one or more other Filling Plants, for the necessary time until the suspension is terminated.
<u>Article 31: Revocation of an LPG Plant or bulk storage facility installation license</u> *The Regulatory Authority may revoke the LPG plant or Bulk storage facility installation license before its expiration when it determines that revocation is needed in order to respond to.* *a. abandonment of licensed activities,* *b. submittal of false or deliberately misleading data or information to the Regulatory Authority in response to the Authority request or m response to monitoring reporting Inspection or audit requirements;* *c. failure of the licensee to cooperate with the Regulatory Authority' inspection and audits;* *d. liquidation of the licensed company;* *e. revocation of the construction*	In the case of revocation of a filling plant, and if the Marketer has no alternative, the Authorities must find a solution to ensure the cylinders of the sanctioned Marketer are temporarily or permanently refilled in one or more other Filling Plants, for the necessary time until the suspension is terminated.
<u>Article 32: Application for authorization to upgrade an LPG plant or bulk storage facility</u> *Any person who intends to upgrade an existing LPG plant or a bulk storage facility shall apply in writing to the Regulatory Authority for an authorization_*	<u>Only a Marketer can apply for the permit to upgrade and to operate the upgraded Filling Plant.</u>
The application shall describe the purpose and type of upgrading by indicating Infrastructures or facilities to be upgraded.	<u>The same application and procedure for the permit to construct and the permit to operate a Filling Plant,</u>

The application for upgrading an LPG plant or a bulk storage facility must be accompanied by the following documents:	
a. *an application letter addressed to the Director General;* b. *a copy of the rehabilitation permit issued by the competent Authority* c. *a copy of installation license where applicable* d. *detailed designs related to the upgrading* e. *Agreement between the Bulk storage facility owner and the filling owner in case the filling unit to be upgraded is different from the storage facility owner; a Proof of payment of application for upgrading as specified in Annex C to this regulation.* *The Regulatory Authority shall notify the decision taken thereof within twenty-one (21) working days.*	
Article 33: Appeal on LPG plant or bulk storage facility installation license and upgrade authorization matters *Where the applicant is not satisfied with the decision of the Regulatory Authority refusing to grant the license, suspending or applying revocation of LPG plant or Bulk storage facility installation license or upgrade authorization, he/she may appeal before a competent Court of* *The Regulatory Authority decisions shall remain effective until overruled by a final judicial decision on the appeal.*	It is recommended that only a Marketer can apply for a permit to construct and operate a filling plant, alone or jointly with other marketers. The Authorities will have to ensure that the business plan of the upgrade is consistent with the LPG National Master Plan and is not creating over-capacity of refilling leading to economic difficulties for all the other filling plants.
CHAPTER V: *LICENSING REGIME FOR AN LPG PLANT OR A BULK STORAGE FACILITY OPERATIONS*	
Article 34: Application for an LPG plant or bulk storage facility operations license *Any person who intends to operate a bulk storage facility or an LPG plant must apply in writing to the Regulatory Authority for an LPG plant or bulk storage facility operations license.*	NOT RECOMMENDED: ONLY A MARKETER CAN APPLY for a PERMIT to CONSTRUCT followed by a PERMIT to OPERATE a FILLING PLANT, because the Marketer is also responsible to invest in the cylinders

The applicant must submit an application letter to the Director General of the Regulatory Authority accompanied by the following documents:	
a. a 5 years' business plan of the project stating the following:	The business plan must be consistent with the National LPG Master Plan and avoid filling over-capacity
i *a copy of the contract to fill LPG into cylinder between the applicant and a licensed brand owner who has allocated him a minimum capacity of forty (40) tons of empty cylinders;*	NOT RECOMMENDED – Not consistent with the BCRM Instead, the business plan must indicate the number of cylinders the applicant will invest in, and the density of the distribution network it will undertake to develop.
ii *Maximum quantity of LPG, the bulk storage facility can store.*	Not only the bulk storage capacity, but above all the number and type of scales (1 scale is 1000T filling capacity per year)
b. weighing scale calibration certificate from a competent authority,	This is part of the procedure for the permit to operate
c. proof of payment of the license application fee as specified in Annex E of this regulation;	Proof of the payment by the Marketer of the application for the permit
d. a copy of proof of valid insurance of the LPG plant or bulk storage facility; and	This requirement must be part of a minimum Insurance coverage for a liability of 10 million USD applying to the Licensing of Marketer, which include the insurance covering the risk of a filling plant.
e. any other information as shall be required by the Regulatory Authority	
The Regulatory Authority shall notify the applicant of the outcome of the application within a period not exceeding twenty-one (21) working days	
<u>Article 35: Obligations under the LPG plant or bulk storage facility operations license</u> *Any person licensed to carry out LPG plant or bulk storage facility operations has the following obligations:*	
1. not fill LPG into cylinders or operate a bulk storage facility unless the licensee is the brand owner or has the express consent of the cylinder brand owner through a written agreement;	Note: ONLY MARKETERS may own and operate Filling Plants. Cylinder owner = Marketer, rather than "brand owner": it brand ownership does not define the property rights in the cylinders; the concept of brand owner has been shown internationally to be not viable for court (legal) proceedings. Prohibition of refilling cylinders belonging to any other Marketer, unless agreed in writing by the cylinder-owning Marketer.
2. not fill and sell LPG to a non-licensed wholesaler;	THERE SHOULD BE ONLY EXCLUSIVE BRANDED DISTRIBUTORS, with a distributorship agreement with mention of all these rights and obligations. No cylinder sale or resale is allowed without a distributorship agreement with a Marketer.

3. ensure that cylinders to be filled have been tested and re-validated m accordance with relevant standards on the required time.	Specific procedure referring to several standards should be used as a reference (LPG Safety Book)
4. to conduct a fire safety assessment of the LPG plant or bulk storage facility at least twice (2) a year;	Safety management should also be included with monthly firefighting exercises
5. only fill LPG into cylinders that conform to National Standard particularly RS 135-4;	
6. ensure that all filled cylinders have accurate net weights and be displayed on the body of the cylinder, and	
7. ensure that all filled cylinders are fitted with an appropriate seal;	Appropriate seal indicating the Filling Center where refilled.
8. the licensee shall provide the sample of LPG to the competent authority for standard compliance verification when deemed necessary.	
Article 36: Validity of an LPG plant or a bulk storage facility operations license *An LPG plant or a bulk storage facility operations license shall be valid for a period of Five (5) years renewable.*	Since the payback period for such investment is rather like 7-8 years, the (5) years period seems short. In addition, no additional investment will be made before renewal, which compromises the safety. RECOMMENDED that the filling plant is audited every 5 years for good safety keeping,
Article 37: license fee for LPG plant or a bulk storage facility operation *An LPG plant or bulk storage facility operation license shall be issued to the applicant upon the presentation of proof of payment of the license fee as specified m Annex -E to this regulation.*	Recommendation to include the renewal of operation permit of a filling plant in the renewal of the license of Marketer. If the intention is to collect revenues for RURA, it is recommended to rather include a "special LPG development fee" in the price of LPG, a common practice in many countries.
Article 38: Renewal of an LPG plant or a bulk storage facility operations License *When the license is the applicant shall apply for license renewal in accordance with the provisions of this regulation.* *The Licensee shall make an application for a license renewal at least thirty (30) working days prior to the expiration of the current LPG plant or a bulk storage facility operation License_*	

Article 39: Transfer of LPG plant or a bulk storage facility operations License *In the event that LPG plant or a bulk storage facility operation is transferred from the licensee to another person, the licensee shall seek for an approval from the Regulatory Authority;* *The duration of the license and the license terms and conditions shall remain the same.*	To another Marketer or a group of Marketers
Article 40: Suspension of an LPG plant or a bulk storage facility operations license *The Regulatory Authority shall suspend the LPG plant or a bulk storage facility operations license in order to respond to failure to comply with license terms and conditions.*	
Article 41: Revocation of an LPG plant or a bulk storage facility operations License *The Regulatory Authority may revoke a license before its expiration when it determines that revocation is needed in order to respond to:* a. *abandonment of licensed activities;* b. *failure of the licensee to cooperate with the Regulatory Authority' inspection and audits,* c. *submittal of false or deliberately misleading data or information to the Regulatory Authority m response to the Authority request or in response to monitoring reporting inspection or audit requirements;* d. *liquidation of the licensed company;* e. *persisting in non-compliance to this regulation and license obligations.*	This article may have to consider 2 cases: Case of a filling plant being dangerous, and not complying with the safety rules, and therefore must be suspended until an upgrade to compliance is achieved. It must be stated where the relevant cylinders will be refilled temporarily, in case of no alternative. After temporary suspension, the filling plant can be closed down and dismantled, or transferred to another Marketer. Case of administrative lack of compliance but the plant itself is complying with the safety rules. Suspension must be notified, with penalties, and an administrative decision taken as to where the cylinders will be refilled during the suspension.
CHAPTER VI: LICENSING REGIME FOR IMPORTATION, TRANSPORTATION AM) DISTRIBUTION OF LPG	
Article 43: General requirements for *Importation and transportation of LPG* *Any person who intends to conduct a business of importation or transportation of LPG must apply for LPG importation or transportation License to the Regulatory Authority.*	ONLY A LICENSED MARKETER that has invested in cylinders can apply for a permit to import LPG Importers that are not Marketers violates the BCRM

The application shall be accompanied by the following documents for both types of licenses: *a. a copy of a business registration certificate;* *b. a business plan of at least five (5) years;* *c. copies of insurances and inspection certificates of trucks or lorries to be used;* *d. a valid certificate of calibration for the LPG tank mounted on each vehicle;* *e. log books for each vehicle and its trailer if applicable;* *f. proof of access to a suitable parking yard;* *g. proof of payment of the license application fee as specified in Annex-E of this regulation.*	A copy of the Marketer license A copy of the certified Balance sheet showing the cylinders assets (or cylinder purchase invoices) A copy of the Filling Plant permit where the LPG will be discharged, (owned Filling Plant or 3rd party filling agreement) The list of Trucks details (own trucks or contracted trucks) including capacity, plates and certificate of compliance The certificates of the trucks drivers
*The Regulatory Authority must notify the applicant of the outcome of the application within a period not exceeding twenty-one (21) working days_*	
	MISSING: the PERMIT to IMPORT CYLINDERS
Article 44: Specific requirements for LPG importation license	
The applicant of LPG importation license shall submit along with other documents stipulated in article 43 of this regulation, a copy of agreement with depots owner, storage facilities or proof of ownership of bulk storage facility.	
Article 45: Obligations under an LPG importation license	
Any person licensed to import LPG in bulk must submit to the Regulatory Authority before the 10th day the last calendar month of the quarter the following information: • *total quantity in metric tons of LPG imported;* • *a copy of new agreements with depots owners or storage facilities or proof of new ownership of bulk storage facility* *Any person licensed to import LPG in bulk shall not offer for sale to any person unless such a person is m possession of a valid LPG Storage license issued by the Regulatory Authority or to a consumer for their own use*	ONLY for the MARKETER (because no other party may be permitted to import LPG): OBLIGATION of reporting “importation volumes, filling volumes and sales volumes, in cylinders and in bulk”

Article 46: Specific requirements for license of LPG transportation in Bulk *The applicant for LPG transportation license shall submit the transport agreement with a holder of valid license along with other documents as stipulated in article 43 of this regulation for:* i *Importation of LPG in bulk; or* ii *The Bulk storage facility in operations;* iii *The Proof of ownership of storage facility (this IS where the transporter also owns storage facility).*	ONLY for the MARKETER The Marketer has the option to use its own registered trucks (Road Tankers), Or To contract trucks with Transporter. Very often, because of the safety compliance, the Marketer owns the Tank of the Road Tanker, and contracts the Trailer with independent companies. The full responsibilities fall on the Marketer.
Any person intending to operate an LPG Bobtails truck shall declare his/her facility to the Regulatory Authority with all requirements as specified in article 35,43 of this Regulation and the above mentioned requirements in this article but also comply with RS 135-4 and RS 135-2.	
The specific filling sites shall be identified and notified to the Regulatory Authority through his application as well as comply with RS 135-4	
Article 47: Obligation under LPG transportation in Bulk *No licensed person to transport LPG in Bulk shall permit any of his road transport vehicles to load from or discharge LPG into an LPG bulk storage facility that does not possess a valid bulk storage facility operations license under this Regulation*	Only the licensed Marketer is authorized to order a transportation by truck (own or contracted). He remains completely liable of all movement of product.
Article 48: Specific requirements for Transportation of an LPG into Cylinders	There are 2 types of transportation cases: Case A: delivery for supplying retail outlets or at home delivery (one way refilled/ return empty) Case B: mass delivery to intermediate cylinder depots belonging to Marketers, cylinders being transported as for case A

The applicant for LPG transportation license shall submit a copy of a valid Transport Agreement with a holder of valid license of wholesale of LPG in cylinders along with other documents as stipulated in article 43 of this Regulation *The Regulatory Authority must notify the applicant the outcome of the application within a period not exceeding twenty-one (21) working*	In Case A : the right to transport cylinders is inherited from the Marketer license; the Marketer then decides either to drive its own trucks or to mandate an appointed exclusive Distributor that will have its own trucks and drivers. The distributorship agreement sets all the obligations for the Distributor. In Case B : only the Marketer is authorized to organize the transportation. Responsibility to report the list of trucks (including the trucks of the Distributors) falls on the Marketer.
Article 49: Obligations under the License of LPG transportation in cylinders *No person shall undertake transport of more than five (5) filled LPG cylinders by road, except in accordance with the terms and conditions of a valid license issued by the Regulatory Authority* *The licensee shall not transport LPG in cylinders from or to a non-licensed LPG plant operator, wholesaler or non- authorized retailer*	ONLY under the Marketer and Marketer's Distributor RECOMMENDED: At any time, it is prohibited for Marketers and Distributors to transport cylinders belonging to other Marketers At any time, it is prohibited for any one not having a license of Marketer and/or a registered Distributorship Agreement to transport refilled or empty cylinders, without the written consent of the entitled Marketer
Article 50: Validity of License for Importation and transportation of LPG *License for Importation and transportation of LPG shall be valid for a period of Five (5) years renewable_*	The principle of limiting the permit to transport of cylinders does not address any issue, except potentially collecting fees for RURA. Recommendation is to include such income for RURA in the LPG price structure, not via such fees.
Article 51: License fee for importation, transportation and distribution of LPG *A license for importation, transportation and distribution of LPG shall be issued to the applicant upon the presentation of proof of payment of the license fee as specified in Annex -E to this regulation*	The principle of limiting the permit to transport of cylinders does not address answer any issue, except potentially collecting fees for RURA. Recommendation is to include such income for RURA in the LPG price structure, not via such fees.
Article 52: Renewal of License for importation, transportation and distribution of LPG *When the license is expired, the applicant shall apply for license renewal in accordance with the provisions of this regulation.* *Any Licensee for Importation, transport, distribution of LPG shall make an application for a license renewal at least thirty (30) working days prior to the expiration of the valid license.*	The principle of limiting and renewing the permit to transport of cylinders does not address answer any issue, except potentially collecting fees for RURA. Recommendation is to include such income for RURA in the LPG price structure, not via such fees.

Article 53: Suspension of license for importation and transportation of LPG *The Regulatory Authority shall suspend the license for importation and transportation of LPG in order to respond to failure to comply with license terms and conditions.*	In case of failure to comply with the safety rules (LPG, driver and traffic), the Marketer should be sanctioned with penalties, and the trucks must be suspended until compliance is restored and verified. Responsibility falls on the Marketer.
Article 54: Revocation of an LPG importation license *The Regulatory Authority may revoke the license before its expiration when it determines that revocation is needed in order to respond to:* a. *abandonment of licensed activities;* b. *liquidation of the licensed company;* c. *submittal of false or deliberately misleading data or information to the Regulatory Authority m response to the Authority request or in response to monitoring reporting Inspection or audit requirements* d. *failure of the licensee to cooperate with the Regulatory Authority' inspection and audits; and* e. *persisting in non-compliance to this regulation and license obligations.*	In case of failure to comply with the safety rules (LPG, driver and traffic), the Marketer should be sanctioned with penalties, the trucks must be suspended until compliance is restored and verified. Responsibility falls on the Marketer.
Article 55: Appeal on license for importation and transportation of LPG *Where the applicant is not satisfied with the decision of the Regulatory Authority refusing to grant the license, he/she may appeal before a Competent Court of Law-* *The Regulatory Authority decisions shall remain effective until overruled by a final judicial decision on the appeal.*	Issue solved in the rights and obligations of the Marketer

Article 56: Transfer of license for importation, transportation and distribution of LPG *In the event that the license for importation, transportation and distribution is transferred from the licensee to another person, the licensee shall seek for an approval from the Regulatory Authority* *The duration of the license and the license terms and conditions shall remain the same.*	Issue solved in the conditions of approval of the transfer of LPG business and assets to another Marketer.

CHAPTER VII: LICENSING REGIME FOR OF LPG IN CYLINDERS	
Article 57: Requirements for LPG wholesale license *Any person who intends to conduct a business of wholesale of LPG into cylinders shall apply in writing to the Regulatory Authority_* *The Applicant for a license shall submit an application letter to the Director General of the Regulatory Authority accompanied by the following documents:*	RECOMMENDATION: The LPG wholesale license is replaced by the Distributorship Agreement granted by the Marketer and registered with the Authorities by the Marketer
a. a copy of a business registration certificate;	
b. a list indicating quantity of cylinders and brand's owners including cylinders' serial numbers-	The cylinders belong to the Marketer not to the Distributor. Since the BCRM is based on the swapping of cylinders, a cylinder of given serial number will be swapped by another with a different number. The proof of this for a Distributor is the debit note of the cylinder deposits paid to the Marketer in order to access specific cylinders for distribution.
c. weighing scale calibration certificate from a competent authority;	Not consistent with the BCRM: only a Marketer (cylinder owner) can refill cylinders, not a Distributor or a Retailer
d. proof of:	
i *ownership of a licensed LPG Cylinder brand-*	Only the Marketer owns a registered brand of cylinders (or has a license to use someone's else brand). In order to own branded cylinders, the entity must apply to the authorities receive a license to be a Marketer.
ii *copy of distributorship agreement from LPG Cylinder brand owner.*	Distributorship agreement from the Marketer
e. proof of payment of the license application fee as specified in Annex -E of this regulation.	Recommended the license collected by the Marketer and paid to the Authorities
Any seller of LPG in cylinders shall issue customers with a receipt that shall have at least the following information:	Necessity to be specific: instead of "seller": any Marketer, Distributor or Retailer shall issue an invoice with the following information

a. The names address and telephone number of the wholesaler or Retailer;	
b. The date of the sale;	The date of the sale
c. The brand of the cylinder sold;	The brand of the cylinders containing LPG of the transaction
d. The serial number of the cylinder sold	Serial number is optional (information not manageable for the sale of LPG; only in case of an accident it helps to know which Marketer is responsible for the cylinder and its safety, and which manufacturer supplied the Marketer with the cylinder)
e. The net weight in kilograms of the cylinder sold;	The number of refills per type (6kg, 12kg, 9kg etc.) and the number of empty cylinders collected per type The number of additional cylinders for deposits
f. The unit and total price of the transaction.	The unit price per refill, the unit price for deposit and the total
The Regulatory Authority must notify the applicant of the outcome of the application within a period not exceeding twenty-one (21) working days.	
Article 58: Obligation under the LPG Wholesale License	Rights and obligations of the Distributor
An LPG wholesale licensee shall have the following obligations:	Operates exclusively under a distributorship agreement with a Marketer
i *Sign an agreement with the Retailer;*	Signs a Retailer agreement for the branded cylinders of the Marketer. Report the details of the outlet to the Marketer (Marketer's responsibility). Provides stock of cylinders and display cages and sign board of the Marketer to the retailer.
ii *distribute only LPG in cylinders that conform to RS 135-4;*	Distribute only the cylinders of the Marketer
iii *maintain a record of all LPG cylinders purchased and sold;* iv *provide to the Regulatory Authority a copy of a signed agreement for supply between a wholesale or supplier and retails;*	Keep the copies of all debit notes or invoices for proof of the sale of refills and of deposit collection, according to accounting rules in the country. Reports monthly to the Marketer, who will report to the authorities.
v *ensure that his/her retailers comply with the provisions of this regulation;*	Ensure the Retailer complies with the safety rules and the obligations set forth in the distributorship agreement. Particularly: it is prohibited to interchange cylinders of different brands.
vi *Ensure that his/her retailers comply with the LPG price published by the Regulatory Authority from time to time.*	
Article 59: LPG Wholesale License fee *A license for LPG wholesale shall be issued to the applicant upon the presentation of proof of payment of the license fee as specified in Annex -E to this regulation*	RECOMMENDATION The license fee should be replaced by a levy included in the LPG price structure. The Marketer is responsible of the activity of each of its Distributors.

Article 60: Content of the records with regard to LPG cylinders	
The LPG cylinders records must contain at minimum the following information and shall be maintained for a period of not less than one (1) *a. the serial number of each cylinder,* *b. the brand of each cylinder,* *c. date of purchase of each cylinder-* *d. the name of the business entity from which the cylinders were bought;* *e. date of resale of each cylinder;* *f. the name of the retail distributor to which the cylinders were sold; and* *g. the net weight of each cylinder sold.*	Details of the seller: Marketer, Distributor or Retailer shall issue an invoice or a debit note and keep record of all digitalized or paper transaction (debit note or invoice), with the following information: Name of the seller / Name of the consumer The date of the sale or collected deposit The brand of the cylinders Serial number is optional (information not manageable for the sale of LPG, only in case of an accident it helps to know which Marketer is responsible for the cylinder and its safety, and which manufacturer supplied the Marketer with the cylinder) The number of refills per type (6kg, 12kg, 9kg etc.) and the number of empty cylinders collected per type The number of additional cylinders for deposits The unit price per refill, the unit price for deposit and the total
Article 61: Validity of LPG wholesale license *LPG wholesale license shall be valid for a period of five (5) years renewable.* *Article 62: Renewal of an LPG wholesale license* *When the license is expired, the applicant shall apply for license renewal in accordance with the provisions of this regulation_* *The Licensee shall make an application for a license renewal at least thirty (30) working days prior to the expiration of the current wholesale* *Article 63: Suspension of LPG wholesale license* *The Regulatory Authority shall suspend the LPG wholesale license in order to respond to failure to comply with license terms and conditions.*	RECOMMENDED to have the MARKETER be RESPONSIBLE for the CONTINUITY, the SUSPENSION and the REVOCATION of the DISTRIBUTORSHIP AGREEMENT In particular, if the Distributorship agreement is revoked, prior to revocation, the Marketer must engage a means to continue the supply of refills in the Outlets the Distributor was supplying. The Marketer is responsible of the continuity of supply of refills in the country. Important: The Marketer has to keep track of its cylinders and the stock of cylinders at the retail Outlets.

Article 64: LPG wholesale license transfer

*In the event that the license LPG wholesale license is transferred from the licensee to another person, the licensee shall seek for an approval from the Regulatory Authority_*

It is the responsibility to the Marketer to register any changes to its distribution network with the authorities (list of appointed Distributors, list of Distributors' trucks and plates, cylinder depots of the Distributors, list of respective Outlets).

The duration of the license and the license terms and conditions shall remain the same.

In case the Authorities discover Distributors and/or Retailers not complying with the regulations and the safety rules, it is up to the Marketer to apply (and/or pass on) sanctions to the Distributor and to the Retailer.

Article 65: Revocation of an LPG wholesale license

The Regulatory Authority may revoke the license before its expiration when it determines that revocation IS needed in order to respond to:

a. *abandonment of licensed activities;*
b. *submittal of false or deliberately misleading data or information to the Regulatory Authority m response to the Authority request or in response to monitoring reporting Inspection or audit requirements;*
c. *failure of the licensee to cooperate with the Regulatory Authority' inspection and audits;*
d. *liquidation of the licensed company; and*
e. *persisting in non-compliance to this regulation and license obligations.*

Article 66: Appeal on LPG wholesale license

Where the applicant is not satisfied with the decision of the Regulatory Authority refusing to grant the license, he/she may appeal bef01? a Competent Court of Law.

The Regulatory Authority decisions shall remain effective until overruled by a final judicial decision on the appeal.

CHAPTER VIII:
INSTALLATION AND OPERATION OF A RETICULATION OF LPG RESIDENTIAL OR COMMERCIAL BUILDINGS

Article 67: Requirements for a License to install a reticulation of LPG in residential or commercial buildings

Any person who intends to install a reticulation of LPG in residential or commercial buildings shall apply for a license m writing to the Regulatory Authority.

For safety rules constraint, it is recommended that for consistency of responsibility only a licensed Marketer can:

a. sign a contract of bulk installation, with or without reticulated supply system, to consumers
b. do the installation and lend the tank and the meters

The applicant shall submit an application letter to the Director General of the Regulatory Authority accompanied by the following documents: *a. A copy of Construction Permit issued by the competent Authority where it is required;* *b. A copy of land document where it is required;* *c. Environmental impact assessment certificate if applicable; and* *d. proof of payment of the license application fee as specified in annex -E of this regulation;*	c. ensure the installation is proof (certificate of tightness) and complying with the safety rules (LPG Safety Book) d. do the supply (the stock remains under the Marketer's ownership until used) e. do the invoicing f. reconcile stock keeping g. engage with safety audits h. provides safety training In this case, there is no need of a license, but rather a permit for each installation.
The Regulatory Authority must notify the applicant of the outcome of the application within a period not exceeding twenty-one (21) working days.	
<u>Article 68: Requirements for a License to operate a reticulation of LPG in residential or commercial buildings:</u> *Prior to operating a reticulation of LPG m residential or commercial buildings, the operator must inform the Regulatory Authority to conduct an inspection to ensure that all installations comply with applicable standards and license obligations.*	For safety rules constraint, it is recommended that for consistency of responsibility only a licensed Marketer can: i. sign a contract of bulk installation with or without reticulated supply system to consumers, j. do the installation and lend the tank and the meters k. ensure the installation is proof (certificate of tightness) and complying with the safety rules (LPG Safety Book) l. do the supply (the stock remains under the Marketer) m. do the invoicing n. reconcile stock keeping o. engage with safety audits p. provides safety training In this case, there is no need of a license, but rather a permit for each installation
The applicant intending to operate a reticulation of LPG in residential or commercial buildings shall submit an application letter addressed to Director General accompanied by the following documents- *a. a copy of a business registration certificate* *b. proof of access to legal supply of LPG, either of:* i *being a holder of a valid license of importation of LPG; or* ii *Bulk storage facility; or* iii *supply agreement with a holder of a valid license of importation of LPG or Bulk Storage Facility.* *c. valid type-approval, verification and calibration certificates of the metering equipment to connected consumers issued by the competent authority.*	

The Regulatory Authority shall notify the applicant the decision taken thereof within twenty-one (21) working days. *Provisions on revocation, transfer, appeal, fees, suspension, renewal and validity of an LPG reticulation license shall be applied as they are applied in LPG plant installation or operation licensing regime of this regulation.*	
CHAPTER IX: MONITORING AND ENFORCEMENT	
Article 69: License monitoring *The Regulatory Authority shall monitor the performance of each license holder for full compliance with all terms and conditions of the* *The Regulatory Authority shall include terms and conditions in the license requiring licensees to report on financial, technical, accidents and fires Issues, organization and other data needed to allow the Regulatory Authority to effectively monitor license compliance.* *The Regulatory Authority may also perform physical Inspections of the license holder's facilities and corporate records on license holder's premises_ These Inspections may be conducted on an announced and unannounced basis.* *The inspections and audits shall be conducted during normal business hours, except when the Regulatory Authority has a reasonable basis to believe that non-compliant activities are occurring outside of normal business hours.*	Could be added: The LPG Marketers are invited to form an LPG Association of Marketers to represent the sector, to simplify and accelerate the dialogue between the private sector and the Authorities.
Article 70: Reporting of accidents and fires *Any accident involved in LPG business which causes Injury to employees, property damage, or Injury to other persons and any fire in which LPG is directly or indirectly involved shall be reported by the licensee in writing to the Regulatory Authority not later than forty-eight (48) hours from the occurrence of the incident.*	

Article 71: License enforcement action

If the Regulatory Authority determines that the licensee has failed to comply with any term or condition of the license, the Regulatory Authority must send a written warning to the licensee including a deadline for correction of the alleged license violation

If the license holder, after receipt of the warning from the Regulatory Authority, does not cure the alleged non-compliance, the Regulatory Authority may open a license enforcement proceeding, which may consist of monetary sanctions, license modification, suspension and revocation.

If the licensee cures the license violation following receipt of the Regulatory Authority notice, the Regulatory Authority may still commence a license enforcement proceeding in order to impose financial sanctions or license modification, suspension and revocation in order to address the historic violation.

Comment:

Any sanction to stop operations, suspend operations or close down operations must be carefully taken, starting with finding the solution to not leave the customers of the sanctioned Marketers without access to cylinders and refills.

For example: the Authorities can take a written decision to designate a temporary refiller and Distributor of the sanctioned branded Marketer.

Similar decisions can be taken to sieze assets and distribution infrastructure (Distributors and Retailers) and place them under the control of a specific entity, in case of repeated compliance failures, such as not respecting the regulations against cross filling, underfilling, brand interchanges, etc., not complying with the safety rules, creating repeated LPG scarcity, and/or failing to finance ongoing operations.

CHAPTER X: REGULATORY SANCTIONS

Article 72: Compliance with laws and regulations

The licensee IS required to comply with the provisions of this regulation and all applicable laws. The non-compliance with provisions of this regulation or the license terms and conditions shall lead to administrative sanctions.

Article 73: Administrative Sanctions

Any person who contravenes the provision of this regulation shall be liable to an administrative sanction provided for In Annex F of this regulation.

CHAPTER XI: TRANSITIONAL AND FINAL PROVISIONS

Article 74: Transitional period

Any existing activity related to LPG business conducted by any natural or legal person, must apply for LPG license within three (3) months from the effective date of this regulation.

Any LPG plant or storage facility that is already operating shall be given a grace period of one (1) year from the commencement of this regulation to comply with the provisions of this regulation.

LPG business licenses issued by the Regulatory Authority prior the commencement of this regulation remain valid until their expiration date.

Article 75: Repealing provision

The liquefied petroleum gas regulation 2012 and all other prior regulatory provisions contrary to this regulation are hereby repealed

Article 76: Commencement

This regulation shall come into force on the date of its signature by the Chairperson of the Regulatory Board

41. Analysis and Recommendations on the Safety Rules

Many issues regarding the safety rules and their consistency are not mentioned, but are strongly recommended. The guide for the LPG Safety Book shows how to enhance the existing RS with the missing points together with the rationale for each point. The recommendation is to compose an LPG Safety Book from the existing RS and Chapter 37 (*Guide for the LPG Safety Book*). This is an important work to be done, requiring the participation of many stakeholders.

The following are important elements that should be added:

- Absence of reference of the Agreements Concerning the International Carriage of Dangerous Goods by Rail (UNECE RID) and Road (UNECE/ADR[78]) rules for the design of the cylinder and the transportation of bulk LPG and cylinders
- Absence of the maximum rate of filling of a cylinder: 85% of the water capacity at 15°C, which requires defining how the cylinder is designed before making a calculation using the RS of reference
- Absence of the requirement of a cylinder manufacturer file for every batch of cylinders received. The file includes all the documents evidencing the safety compliance of the construction of the cylinder and must remain in custody at the Marketer's place of business.
- Absence of requirement to transport cylinders in pallets
- Absence of rules concerning the allowed lifespan of cylinders and their periodic pressure tests, the timing of which depending upon whether the cylinders are transported in pallets or not
- Absence of requirement that all cylinders must be constructed to be able to hold Commercial Propane, even if the main product is Commercial Butane
- Necessity to review the wording ("Marketer" instead of licensee or brand owner, "Distributor" instead of Wholesaler)
- Absence of requirement of implementation of a Safety Management System for Depots and Filling Plants, including permanent improvement methodology, training of staff, and fire-fighting exercises (such as ISRS[79] of DNV, for example)
- Absence of requirement of conditions for acceptance of a plot of land for constructing a filling plant, such as conducting a risk assessment study.
- Absence of a list of accepted storage technology, with corresponding safety distances for the storage
- Absence of requirement of the minimum list of equipment necessary for filling and for the safety of a filling plant

[78] See https://unece.org/about-adr

[79] See https://www.dnvgl.com/services/isrs-for-the-health-of-your-business-2458

- Absence of requirement of the minimum water flow of the spray/cooling of aerial tank storage: such as 7L applied to the surface of the tank (m^2) per minute, and 2 hours of spray with 2 water pumps, or none of this in the case of mounded storage
- Absence of limitation on the stock of LPG in cylinders at the retail outlets
- Absence of conditions of approval of the permit to export cylinders (new or old), with the instructions for the Customs authorities

Review of the Safety Rules' Annexes

Annex A-B-C-D: It is necessary to separate the safety distances for Tanks with liquid transfer from Tanks without liquid transfer, and according to storage capacity. In each case the water capacity range will be different.

Annex A

For Tanks with liquid transfer, the distances are below international standards.

The Annex A is recommended to be reviewed and included in the LPG Safety Book rather than in the law.

ANNEX-A:

MINIMUM SAFETY DISTANCES FROM BULK STORAGE TANKS TO THE NEIGHBOURING PROPERTY BOUNDARIES

<table>
<tr><th rowspan="2">Water capacity of storage vessel Liters</th><th colspan="6">Minimum distances</th></tr>
<tr><th>From aboveground vessel to points of gas release</th><th>aboveground storage to bull dings and property boundaries</th><th>From buried and mounded storage to bud dings property and points gas release</th><th>From sealed surface equipment to building and property boundaries</th><th>From open flame equipment to building and property boundaries</th><th>Netween above LPG storage vessels</th></tr>
<tr><td>500 < V < 2250</td><td>5.0</td><td>5.0</td><td>3.0</td><td rowspan="6">3,0</td><td rowspan="6">5,0</td><td rowspan="6">¼ of sum of diamater of adjacent storage vessels</td></tr>
<tr><td>2250 <V< 9000</td><td>7,5</td><td>7,5</td><td>75,0</td></tr>
<tr><td>9000<V <67 500</td><td>9.5</td><td>9.5</td><td>7,0</td></tr>
<tr><td>67 500 < V < 135 000</td><td>15,0</td><td>15,0</td><td>15,0</td></tr>
<tr><td>135 000< V < 265 000</td><td>15,0</td><td>22.5</td><td>15.0</td></tr>
<tr><td>V > 265 000</td><td>15.0</td><td>30.0</td><td>15.0</td></tr>
</table>

Annex B

Some distances are too short (15m for schools/hospitals should be 100m when the capacity is above 200T).

Annex B is recommended to be reviewed and included in the LPG Safety Book rather than in the law.

ANNEX - B:

MINIMUM SAFETY DISTANCES OF CYLINDERS STORAGE AREAS

Total Kg of LP gas stored (T)	**From buildings and boundary of the premises**	**From thoroughfares, sidewalks and line of adjoining property of school, church, etc.**
T< 1000	3,0	5,0
1000<T < 3000	5,0	5,0
3000 < T < 5000	7,5	7,5
5000 <T < 20 000	10,0	10,0
T > 20 000	15.0	15.0

Annex C

Annex C is recommended to be reviewed, and included in the LPG Safety Book rather than in the law.

ANNEX -C:
SAFETY DISTANCES FROM REMOTE LOADING CONNECTIONS

Remote Loading connections at the LPG bulk storage tanks to:	**Minimum required Distance**
Cylinders Filling Area	5m
Cylinder Storage Area	3m
Plant boundaries, Offices, Sale rooms	7,5m
Schools, Churches, hospitals, open fire	15m
Storage tank of capacity up to 67,000 Liters	3m
Storage tank of capacity from 67,000 to 135,000	6m
Storage tank capacity exceeding 135 000 L	9m
Driveways within premises	5m

Annex D

Fixed spray of 7L/m^2/minute and two pumps during two hours applies to any aerial tank with liquid transfer (not mounded tanks) and for aerial tanks without liquid transfer above 20,000 liters. This should be reviewed and adjusted.

ANNEX-D:
SUMMARY OF FIRE PROTECTION DETAILS

Installation LPG capacity (L)	Fire precautions
500-2250	Water supply for fire brigade use — within 100m, 2 x 9 kg dry powder extinguishers
2 251-9000	Water supply for brigade use — within 100m 20 mm hose reel 2 x 9 kg dry powder extinguishers
9 001-45 000	Consideration should be given to providing a means of applying cooling water to the storage vessels. 20 nun hose reel 2 x 9 kg dry powder extinguishers
45 001-67 500	Fixed or portable monitors or fixed sprays (or a combination) 20 mm hose reel 2 x 9 kg dry powder extinguishers
> 67500	Automatic fixed sprays and hydrant and hose 20 mm hose reel 2 x 9 kg dry powder extinguishers
Road tanker filling or deliveries - more than twice a week	Protection appropriate to the site 20 mm hose reel 2 9 kg dry powder extinguishers

Rwanda National LPG Master Plan

Volume 4

Supply Chain Plan

Contents

List of Tables

List of Figures

XV. Infrastructure, Logistics and Storage Strategy and Plan

This Part estimates the dimensioning of all the components of the LPG supply chain: cylinders, filling plants and associated logistics for the development of the Rwanda LPG sector.

To achieve this goal, one must consider the planning of actions and the necessary and incompressible prerequisites for implementing the LPG sector development programme.

A timeline of actions is shown in Volume 1, Chapter 18.

To summarize,

- From decision-making to filling plant implementation: 24 months
- From decision-making to delivery of cylinders and trucks: 6 months

The LPG market being a spot market for consumers, the infrastructure must be put in place before the actual needs of the market are known.

The elements of the supply chain are listed below as required to serve the projected consumption under each demand scenario, assuming that the decisions and actions to implement the Plan are taken quickly.

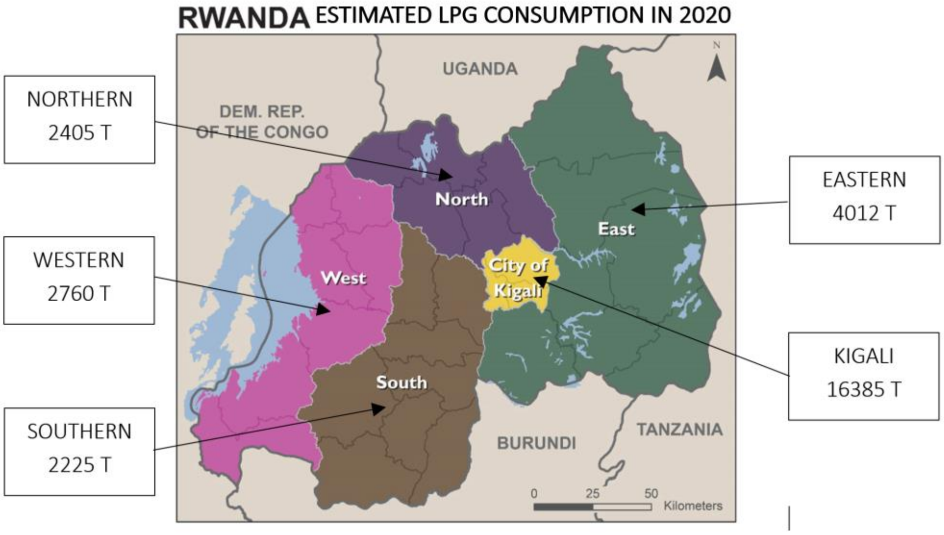
The years 2021 and 2022 will be years of transition, during which the existing supply chain will have to be pushed to its maximum through the adoption of shift work and one-off investments in the means of production.

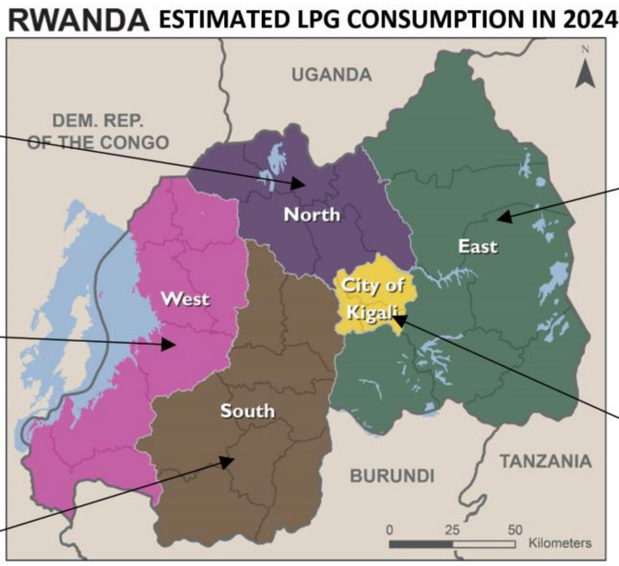
42. Volume Projections

Volume 2 elaborates different scenarios of LPG market development.

The elements of the future supply chain capacities for these scenarios would be:

Figure 52. Maps of LPG capacity requirements, 2020, 2024, 2030 by scenario





NORTHERN	2024
BAU +LI	11 395 T
BAU +HI	12 666 T
NST-1	28 381 T

WESTERN	2024
BAU +LI	12 773 T
BAU +HI	13 955T
NST-1	32 936 T

SOUTHERN	2024
BAU +LI	11 487 T
BAU +HI	12 384 T
NST-1	30 154 T

EASTERN	2024
BAU +LI	13 966 T
BAU +HI	14 848 T
NST-1	33 821 T

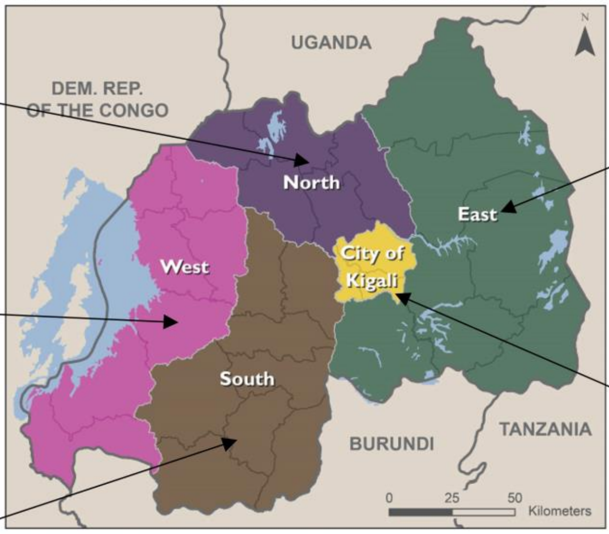
KIGALI	2024
BAU +LI	30 465 T
BAU +HI	32 493 T
NST-1	41 580 T

RWANDA ESTIMATED LPG CONSUMPTION IN 2030

NORTHERN	2030
BAU +LI	34 812 T
BAU +HI	42 072 T
NST-1	50 129T

WESTERN	2030
BAU +LI	36 594 T
BAU +HI	45 496 T
NST-1	57 010 T

SOUTHERN	2030
BAU +LI	31 004 T
BAU +HI	39 406 T
NST-1	51 213 T



EASTERN	2030
BAU +LI	33 854 T
BAU +HI	42 701 T
NST-1	55 743 T

KIGALI	2030
BAU +LI	44 991 T
BAU +HI	46 650 T
NST-1	49 342 T

The total yearly volumes are split in bulk and cylinders activities. Most of the cylinder volumes come from household consumption. The instutitional volumes are approximately 15% cylinder and 85% bulk.

The cylinder and bulk volume breakdowns are shown in the following table.

Table 43. Cylinder and bulk LPG fuel volumes by scenario, 2020, 2024, 2030

	National cylinder and bulk tonnage/year		
	2020	2024	2030
BAU	27,297 T/y	73,086 T/y	145,770 T/y
BAU +LI	27,296 T/y	80,086 T/y	181,254 T/y
BAU +HI	27,297 T/y	86,347 T/y	216,325 T/y
NST-1	27,296 T/y	166,872 T/y	263,431 T/y

	Estimated cylinder segment tonnage/year		
Scenario	2020	2024	2030
BAU	20,016 T	43,124 T	108,916 T
BAU +low intervention	20,016 T	47,762 T	139,087 T
BAU +high intervention	20,016 T	53,439 T	171,369 T
NST-1	20,016 T	131,506 T	216,700 T

	Estimated bulk segment tonnage/year		
Scenario	2020	2024	2030
BAU	7,281 T	29,962 T	36,854 T
BAU +low intervention	7,280 T	32,324 T	42,167 T
BAU +high intervention	7,281 T	32,908 T	44,956 T
NST-1	7,281 T	35,366 T	46,731 T

43. Cylinders

To estimate the number of cylinders to ensure the annual LPG tonnage dedicated to cooking, we will consider a 12 kg cylinder equivalent : 2 cylinders of 6kg are equivalent to one 12 Kg cylinder; one cylinder of 35kg is equivalent to 2.90 cylinders of 12 Kg.

Further in the Chapter, a differentiation of 6-12-35kg cylinders will be made.

Cylinder rotation rate par year:

To define the need of cylinders related to the annual consumption, the LPG industry defines the cylinder rotation rate, which is the average number of re-fillings of the cylinder in a year. This rate is referred to "the cylinder rotation rate per year."

This rate is the $\frac{Annual\ LPG\ consumption\ of\ LPG\ in\ cylinder}{Number\ of\ existing\ Cylinders\ in\ marketers\ 'assets}$

If one of these parameters is not available, the rotation rate must be estimated using benchmarks from similar LPG markets in similar countries.

Having only the data on cylinder imports in Rwanda available for the period 2015 to 2019, it was necessary to estimate the existing cylinder park by applying a theoretical turnover rate of 2.9 (corresponding to rotation rate values of emergent LPG markets) to the volume of 2014. It is important to note that the size of the 2014 cylinder park has a very small influence on the estimate of the 2024-2030 cylinders fleet. The volume of LPG in 2014 being 4,240 tons, the estimated cylinder park for the same year is 4,240,080 kg/(12 kg x2.9), or about 122,000 cylinders in 12 Kg-eq.

Adding this estimated cylinder fleet of 122,000 cylinders to the imported cylinders 2015-2019, the total cylinder park in 2019 is estimated at 501,678 cylinders.

Experiences of other SSA LPG markets demonstrate that the rotation rate on the existing markets segments, which are predominantly urban, where there are many sales points in the city and the availability of the product is higher versus rural areas, where availability of cylinder is less frequent and where scarcity of LPG supply can oblige customers to own two cylinders for back-up purposes.

Therefore, for 2020, two figures are assumed:

- **2.70 for the urban areas**
- **2.30 for the rural areas**

When BCRM is fully implemented and respected, it would increase the rotation rate. To reflect that likelihood, the cylinder rotation rate is modelled to increase by 0.5 from 2020 to 2030. The rotation rate will change with volumes in rural and urban areas.

Table 44. Estimated cylinder rotation rates by region, 2020 to 2030

	Cylinder rotation rate					
High case	**Rwanda average**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	2.68	2.70	2.59	2.62	2.65	2.58
2021	2.73	2.75	2.67	2.69	2.72	2.66
2022	2.78	2.80	2.74	2.76	2.78	2.73
2023	2.84	2.85	2.80	2.82	2.83	2.80
2024	2.89	2.90	2.86	2.87	2.88	2.85
2025	2.93	2.95	2.91	2.92	2.93	2.90
2026	2.98	3.00	2.95	2.97	2.98	2.94
2027	3.02	3.05	2.99	3.01	3.03	2.98
2028	3.06	3.10	3.01	3.04	3.07	3.01
2029	3.09	3.15	3.04	3.07	3.11	3.03
2030	3.11	3.19	3.06	3.10	3.15	3.04

In combination with the demand scenario projections, the predicted cylinder inventory requirements are:

Table 45. Estimated 12kg-eq cylinders required by province, by scenario, to 2030

			Rwanda	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
SCENARIO	**BAU**	**2020**	651,419	455,295	38,631	49,922	49,239	58,332
		2024	1,416,215	720,188	154,348	182,011	176,475	183,194
		2030	3,023,308	972,193	449,317	560,748	570,832	470,217
	LOW INTERVENTION	**2020**	651,419	455,295	38,631	49,922	49,239	58,332
		2024	1,543,394	763,925	171,167	206,110	204,264	197,929
		2030	3,838,585	1,032,456	625,609	766,380	763,800	650,340
	HIGH INTERVENTION	**2020**	623,830	446,353	37,172	47,239	47,367	45,698
		2024	1,544,306	799,596	159,274	203,922	214,195	167,319
		2030	4,587,703	1,044,559	813,925	965,361	925,488	838,370
	NST1 Target	**2020**	658,605	180,244	102,311	128,020	127,286	120,744
		2024	4,092,716	1,093,431	724,815	800,441	699,000	775,029
		2030	6,033,580	1,139,614	1,172,233	1,315,487	1,172,042	1,234,205

Then, the additional number of 12 Kg equivalent to be added every year is:

Table 46. Estimated incremental 12kg-eq cylinders required by province, by scenario, 2021-2030

			Estimated number of 12kg-eq cylinders to be added annually					
			Rwanda	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
SCENARIO	BAU	2020	122,152	83,986	8,239	10,045	9,610	10,271
		2024	184,064	56,098	28,376	35,222	35,949	28,419
		2030	336,615	32,248	68,387	83,752	83,268	68,960
		TOTAL	2,369,615	585,467	389,930	492,911	510,033	391,275
	LOW INTERVENTION	2020	122,152	65,025	8,516	15,720	13,222	19,669
		2024	231,546	66,656	35,976	45,603	47,525	35,784
		2030	503,907	22,296	114,251	130,526	119,045	117,789
		TOTAL	3,186,646	626,795	566,882	704,513	706,784	581,671
	HIGH INTERVENTION	2020	122,152	83,986	8,239	10,045	9,610	10,271
		2024	289,897	79,705	45,316	58,335	61,697	44,844
		2030	691,962	17,143	173,122	178,632	139,325	183,740
		TOTAL	4,086,025	682,193	784,992	928,167	887,731	802,943
	NST1 Target	2020	122,731	82,845	8,219	10,118	9,448	12,101
		2024	1,074,747	213,958	212,246	230,437	195,120	222,985
		2030	387,298	25,671	85,709	98,143	89,362	88,413
		TOTAL	5,381,707	755,835	1,114,147	1,245,068	1,105,283	1,161,374

Some Rwandan LPG marketers have their own specific size of cylinders, 3kg, 15 Kg, 20 Kg, 50 Kg. Their quantities are exceptionally low related to the national number of cylinders. Accordingly, the analysis will focus on 6, 12 and 35 Kg cylinders.

Based on the Rwandan Marketers' reports of existing cylinders and assuming they will not change their strategy regarding sizes to deploy, then for each 1,000 cylinders in the market, there are 391 x 6kg, 597 x 12kg, and 12 x 35kg. The estimated number of cylinders imported from 2015 to 2019 is 431,000, corresponding to 369,000 12kg-equivalent. The number of additional cylinders per size, per region and per scenario would be:

Table 47. Cylinder requirements by size, province, and scenario, in 2024 and 2030

			Estimated number of new cylinders/year																	
			Rwanda			Kigali City			Southern Province			Western Province			Northern Province			Eastern Province		
			6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg
SCENARIO	BAU	2020	38,870	81,665	1,617	26,725	56,149	1,112	2,622	5,508	109	3,196	6,716	133	3,058	6,425	127	3,268	6,867	136
		2024	58,570	123,056	2,437	17,851	37,504	743	9,029	18,971	376	11,208	23,548	466	11,439	24,034	476	9,043	18,999	376
		2030	107,114	225,045	4,456	10,262	21,560	427	21,761	45,721	905	26,650	55,992	1,109	26,496	55,669	1,102	21,944	46,104	913
		TOTAL	754,030	1,584,214	31,371	186,300	391,416	7,751	124,079	260,689	5,162	156,848	329,537	6,526	162,296	340,984	6,752	124,507	261,588	5,180
	LOW INTERVENTION	2020	38,870	81,665	1,617	20,692	43,473	861	2,710	5,693	113	5,002	10,510	208	4,207	8,839	175	6,259	13,150	260
		2024	73,680	154,801	3,065	21,211	44,563	882	11,448	24,052	476	14,511	30,488	604	15,123	31,773	629	11,387	23,924	474
		2030	160,347	336,889	6,671	7,095	14,906	295	36,356	76,383	1,513	41,534	87,263	1,728	37,881	79,588	1,576	37,481	78,748	1,559
		TOTAL	1,014,015	2,130,442	42,188	199,451	419,046	8,298	180,386	378,991	7,505	224,182	471,005	9,327	224,904	472,523	9,357	185,092	388,878	7,701
	HIGH INTERVENTION	2020	38,870	81,665	1,617	26,725	56,149	1,112	2,622	5,508	109	3,196	6,716	133	3,058	6,425	127	3,268	6,867	136
		2024	92,247	193,812	3,838	25,363	53,287	1,055	14,420	30,296	600	18,563	39,000	772	19,633	41,248	817	14,270	29,980	594
		2030	220,188	462,613	9,161	5,455	11,461	227	55,089	115,742	2,292	56,842	119,425	2,365	44,334	93,146	1,845	58,467	122,840	2,433
		TOTAL	1,300,205	2,731,725	54,095	217,079	456,082	9,032	249,790	524,809	10,393	295,350	620,529	12,288	282,483	593,495	11,753	255,503	536,810	10,630
	NST1 Target	2020	39,054	82,052	1,625	26,362	55,387	1,097	2,615	5,495	109	3,220	6,765	134	3,006	6,316	125	3,851	8,090	160
		2024	341,993	718,525	14,229	68,083	143,042	2,833	67,538	141,898	2,810	73,327	154,060	3,051	62,089	130,448	2,583	70,955	149,077	2,952
		2030	123,241	258,930	5,127	8,169	17,163	340	27,273	57,301	1,135	31,230	65,614	1,299	28,436	59,744	1,183	28,134	59,109	1,171
		TOTAL	1,712,501	3,597,957	71,249	240,513	505,316	10,007	354,530	744,866	14,750	396,190	832,394	16,483	351,710	738,941	14,633	369,558	776,440	15,375

The lead time to acquire cylinders will be compatible with the timeline for Plan implementation under each scenario.

44. Filling Plants

The LPG market in Rwanda is an emerging one, and a multitude of small filling plants is being deployed in the country comprising one simple tank and simple scales without safety devices, without safety management, and without control and maintenance of the cylinder.

This private sector-driven strategy risks dragging the LPG market into an developmental impassse, in which BCRM implementation will fail. As a result, this BCRM-non-compliant strategy will tend to block the BCRM-compliant strategies (and the recommenations of this Plan) from taking hold and growing the market; cylinder investment will be limited by illegal cross-filling; and increasing accidents will frighten consumers away from use of LPG.

➲ It is strongly recommended to transition away from small skid-based filling plants to large, structured, industrial-grade regional filling plants, well organized and staffed and equipped with all necessary safety equipment, truck transportation pallets, and safety management procedures. (See Annex Chapter 75 for a typical design of such a plant.)

In the LPG supply chain, the mass primary transport (semi-trailer transport of the liquid product), the filling, and the cylinder primary transport (transport of large quantities of cylinders (800-900 cylinders) from the filling center to the depot) must meet an economic transportation optimization:

➲ The positioning of the filling plant must be as close as possible to the sales area without putting the public at risk, but must also be as large as possible to minimize filling costs, management costs, maintenance staff and machine costs, and the safety staff and equipment costs. As a general rule, it is recommended to aim for a minimum filling plant size of at least 25KT/year filling capacity, to **minimize filling cost** and **maximise safety level.**

Nevertheless, the mass primary transport must be favored with the cylinder primary transport because, in the former case one transports only the product, and in the latter one transports the product plus the weight of the cylinder steel (steel weight approximately equaling LPG weight).

➲ When the consumption of the region is less than 10-15 KT/year, the recommended strategy is to have a cylinder depot supplied by large, palletized trucks from the closest filling plant. This regional depot will comprise a large fenced area with guards and forklifts to load and unload pallets of cylinders, under the control of the filling plant. It would hold a stock of cylinders to be dispatched to the marketing companies and distributors.

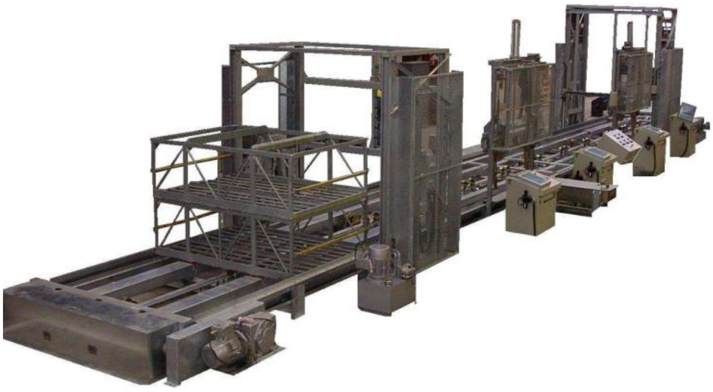
This approach must factor in the cost of cylinder secondary transport.

Palletization:

Regarding the transportation and the life cycle of the cylinders, palletization is essential. It creates significant economic, safety and operational advantages for:

- **Transportation:** as cylinders in pallets are protected until delivery to the retailer. In a traffic accident, falling cylinders and damaging the valve are avoided.

- **Cylinder handling**: Cylinders are no longer handled by operators but by forklifts and under the filling hall, by the palletizer. This significantly reduces the loading and unloading time of trucks.
- **Storage in filling plants and** distributors: The ability of pallets to be germinated allows storage of up to 8 heights of empty cylinders or 5 heights of full cylinders, or more than 79 cylinders per square meter.
- **Running stock**: A stock tool of palletized cylinders allows the operator to be able to prevent any momentary shutdown of production and the sudden influx of truck and avoid load failures during frequent changes of Marketers. In Marketers' warehouses, cylinders can be handled either by hand or with forklifts.



- **Life cycle of th+e cylinder**: economies accrue in cylinder maintenance because there are fewer shocks to the whole cylinder and no valve deterioration, prolonging the life cycle of the cylinder for 10-20 years.

Table 48. Geographic deployment strategy for filling plants

Province	District	Town/ Area	Reasons
Kigali City	Gasabo	Kabuga/Rusororo	It is astrategic location for the following reasons: 1-Some of the Marketers already have fuel storage depots and could be planning to have LPG storage, SP in particular. 2-It is located along the Rusumo-Kayonza-Kigali road, used by importation trucks arriving from Tanzania before they enter Kigali city. 3-It is also where the Central corridor railway is anticipated to pass, if not end.
		Jabana	1-It is known for a fuel depot location. 2-It is located on the Gatuna-Kigali road, a road used by importation trucks arriving from Mombasa-Kenya and located just before entering Kigali city.
	Kicukiro	Gahanga	1-It is a location where at least 2 licensed Marketers have or plan to establish storage and filling facilities as mentioned from the GLPGP consultation for development of the Master Plan. 2-It is also located on the national road to the new under-construction Bugesera Airport and also on the way to the Burundi border. 3- It is also located just at the outskirts of the Kigali City urban area, in an area quickly developing into a formidable urban zone.
Northern	Musanze	Musanze	1-It is the most commercially vibrant town in the Northern region (also known for tourism).

			2- It is also one of the six secondary cities targeted for quick infrastructure development by GoR and already has basic infrastructure in place.
Southern	Muhanga	Muhanga	1-It is the most commercially vibrant town in the Southern region, only 45 minutes from Kigali for any quick logistical supplies. 2- It is also one of the six secondary cities targeted for quick infrastructure development by the GoR and already has basic infrastructure in place. 3- It is also at the confluence of the Southern and Western provinces and is thus capable of supplying not only the Southern province but also western areas, e.g., Ngororero and Karongi.
Eastern	Kayonza	Kayonza	1- It is located along the Rusumo-Kayonza-Kigali road, receiving importation trucks from Dar es Salaam. 2-It is also at the confluence of most of the Districts and towns of the Eastern province and also the two national borders, i.e., Rusumo from Tanzania and Kagitumba from Uganda.
Western	Rusizi	Kamembe	1-It is the most vibrant commercial town in the Western province after Rubavu and can serve other districts like Nyamasheke and Karongi. 2- It is one of the six targeted secondary cities, with basic infrastructure already in place. 3-It is also located at the border of Democratic Republic of Congo (DRC) and, with strong trading ties with DRC, is a potential source of consumers and room for expansion, if cross-border commerce is allowed.

Filling capacity

Regarding the filling capacity, a global ratio in use in LPG filling activity is 1 scale for 1,000 T/year of filling capacity per shift (in case of two shifts, the capacity rises to 2,000T/year; this why the filling capacity is expressed in number of scales).

The following tables present the filling plant deployment strategies over time for each demand scenario[80].

Low intervention scenario

Year 2020-2022: maintaining existing filling plants.

Year 2022-2024: 1 filling plant in Kigali region supplying depots (S, W, N, E).

Year 2024: additional filling plant in Eastern supplying Northern depot.

80 BAU is excluded, because it represents the organic development of the sector in the absence of this Plan.

Year 2024: additional filling plant in Western supplying Southern depot.

Year 2024: Kigali filling is working in 2 shifts.

Year 2027: additional filling plant in Northern.

Year 2028-2030: additional Filling plant in the Southern region.

Table 49. Filling capacity requirements by province by year, Low case

	ESTIMATED YEARLY FILLING CAPACITY					
Low interv	**Rwanda**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	0 Filling Plant	Maintaining the mini- filling plant activity				
2021	0 Filling Plant	Maintaining the mini- filling plant activity				
2022	1 Filling Plant	1 Filling Plant	Maintaining the mini- filling plant activity			
2023	1 Filling Plant	1 Filling Plant	Maintaining the mini- filling plant activity			
2024	3 Filling Plant	1 FP 2 shift	depot	1 Filling Plant	depot	1 Filling Plant
2025	3 Filling Plant	1 FP 2 shift	depot	1 Filling Plant	depot	1 Filling Plant
2026	3 Filling Plant	1 FP 2 shift	depot	1 Filling Plant	depot	1 Filling Plant
2027	4 Filling Plant	1 FP 2 shift	depot	1 Filling Plant	1 Filling Plant	1 Filling Plant
2028	5 Filling Plant	1 FP 2 shift	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2029	5 Filling Plant	1 FP 2 shift	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2030	5 Filling Plant	1 FP 2 shift	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant

	ESTIMATED YEARLY FILLING CAPACITY (MT)					
Low interv	**Rwanda**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	20,016 T/y	20,016 T/y				
2021	24,104 T/y	24,104 T/y				
2022	30,704 T/y	19,741 T/y	10,963 T/y			
2023	108,121 T/y	23,131 T/y	15,936 T/y			
2024	58,440 T/y	36,535 T/y		10,679 T/y		11,227 T/y
2025	57,981 T/y	28,429 T/y		14,420 T/y		15,132 T/y
2026	70,090 T/y	30,903 T/y		19,152 T/y		20,035 T/y
2027	84,163 T/y	33,237 T/y		24,948 T/y	14,895 T/y	11,083 T/y
2028	100,394 T/y	35,454 T/y	13,969 T/y	17,944 T/y	18,844 T/y	14,182 T/y
2029	118,647 T/y	37,239 T/y	17,699 T/y	22,464 T/y	23,285 T/y	17,959 T/y
2030	139,087 T/y	38,674 T/y	22,135 T/y	27,639 T/y	28,134 T/y	22,506 T/y

Filling needs in the years 2021 to 2023 can be easily ensured by the existing supply chain.

High intervention scenario

Year 2020-2022: maintaining existing filling plants.

Year 2022-2024: 1 filling plant in Kigali region, while maintaining existing filling plants (S, W, N, E).

Year 2024: additional filling plant in Northern supplying Eastern depot.

Year 2024: additional filling plant in Western supplying Southern depot.

Year 2024: Kigali filling is in 2 shifts.

Year 2026: additional filling plant in Eastern region.

Year 2027: additional filling plant in Southern region.

Year 2028-2030: Kigali filling is in 2 shifts.

Table 50. Filling capacity requirements by province by year, High case

	ESTIMATED YEARLY FILLING CAPACITY					
High interv	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020		Maintaining the existing- filling plant activity				
2021		Maintaining the existing- filling plant activity				
2022	1 Filling Plant	1 Filling Plant	Maintaining the existing- filling plant activity			
2023	1 Filling Plant	1 Filling Plant	Maintaining the existing- filling plant activity			
2024	3 Filling Plant	1 Filling Plant	depot	1 Filling Plant	1 Filling Plant	depot
2025	3 Filling Plant	1 Filling Plant	depot	1 Filling Plant	1 Filling Plant	depot
2026	4 Filling Plant	1 Filling Plant	depot	1 Filling Plant	1 Filling Plant	1 Filling Plant
2027	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2028	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2029	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2030	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant

	ESTIMATED YEARLY FILLING CAPACITY (FILLING SCALES)					
High interv	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	20 Filling scales	20 Filling scales				
2021	25 Filling scales	25 Filling scales				
2022	33 Filling scales	21 Filling scales	12 Filling scales			
2023	43 Filling scales	25 Filling scales	18 Filling scales			
2024	53 Filling scales	28 Filling scales	depot	12 Filling scales	13 Filling scales	depot
2025	67 Filling scales	31 Filling scales	depot	17 Filling scales	18 Filling scales	depot
2026	82 Filling scales	34 Filling scales	depot	24 Filling scales	14 Filling scales	10 Filling scales
2027	100 Filling scales	36 Filling scales	14 Filling scales	18 Filling scales	19 Filling scales	14 Filling scales
2028	120 Filling scales	37 Filling scales	18 Filling scales	23 Filling scales	24 Filling scales	18 Filling scales
2029	144 Filling scales	39 Filling scales	23 Filling scales	29 Filling scales	29 Filling scales	24 Filling scales
2030	171 Filling scales	40 Filling scales	30 Filling scales	36 Filling scales	35 Filling scales	31 Filling scales

	ESTIMATED YEARLY FILLING CAPACITY (MT)					
High interv	**Rwanda**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	20,016 T/y	20,016 T/y				
2021	24,875 T/y	24,875 T/y				
2022	32,661 T/y	20,680 T/y	11,981 T/y			
2023	42,659 T/y	24,618 T/y	18,041 T/y			
2024	53,439 T/y	27,822 T/y		12,481 T/y	13,135 T/y	
2025	66,515 T/y	30,809 T/y		17,418 T/y	18,288 T/y	
2026	82,108 T/y	33,622 T/y		23,705 T/y	14,304 T/y	10,477 T/y
2027	99,664 T/y	35,563 T/y	13,716 T/y	17,734 T/y	18,757 T/y	13,894 T/y
2028	120,133 T/y	37,184 T/y	18,004 T/y	22,902 T/y	23,799 T/y	18,244 T/y
2029	144,278 T/y	38,793 T/y	23,368 T/y	29,004 T/y	29,331 T/y	23,783 T/y
2030	171,369 T/y	40,039 T/y	29,868 T/y	35,889 T/y	34,939 T/y	30,633 T/y

Filling needs in the years 2021 to 2023 can be easily satisfied by the existing value chain.

NST-1 Target scenario

Year 2020-2021: maintain existing filling plants.

Year 2022: 1 filling plant in each region (Kigali, Southern, Western, Northern, Eastern).

Year 2027: Kigali filling is in 2 shifts.

Year 2028: Western, Northern region filling is in 2 shifts.

Year 2029: Southern, Eastern region filling is in 2 shifts.

Table 51. Filling capacity requirements by province by year, NST-1 case

	ESTIMATED YEARLY FILLING CAPACITY					
NST1 Target	**Rwanda**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020		Maintaining the existing- filling plant activity				
2021		Maintaining the existing- filling plant activity				
2022	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2023	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2024	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2025	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2026	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2027	5 Filling Plant	1 FP 2shifts	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2028	5 Filling Plant	1 FP 2shifts	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2029	5 Filling Plant	1 FP 2shifts	1 Filling Plant	1 FP 2shifts	1 FP 2shifts	1 Filling Plant
2030	5 Filling Plant	1 FP 2shifts	1 FP 2shifts	1 FP 2shifts	1 FP 2shifts	1 FP 2shifts

	ESTIMATED YEARLY FILLING CAPACITY (MT)					
NST1 Target	**Rwanda**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	20,016 T/y	20,016 T/y				
2021	34,384 T/y	34,384 T/y				
2022	59,367 T/y	20,100 T/y	9,224 T/y	10,491 T/y	9,510 T/y	10,043 T/y
2023	95,962 T/y	28,751 T/y	15,967 T/y	17,993 T/y	16,145 T/y	17,106 T/y
2024	131,506 T/y	36,650 T/y	22,639 T/y	25,430 T/y	22,725 T/y	24,062 T/y
2025	143,763 T/y	37,144 T/y	25,395 T/y	28,631 T/y	25,701 T/y	26,892 T/y
2026	153,813 T/y	37,155 T/y	27,742 T/y	31,366 T/y	28,253 T/y	29,297 T/y
2027	168,710 T/y	38,387 T/y	30,952 T/y	35,079 T/y	31,690 T/y	32,603 T/y
2028	181,724 T/y	39,173 T/y	33,819 T/y	38,404 T/y	34,774 T/y	35,554 T/y
2029	199,341 T/y	40,920 T/y	37,550 T/y	42,714 T/y	38,755 T/y	39,402 T/y
2030	216,700 T/y	42,543 T/y	41,248 T/y	46,988 T/y	42,706 T/y	43,215 T/y

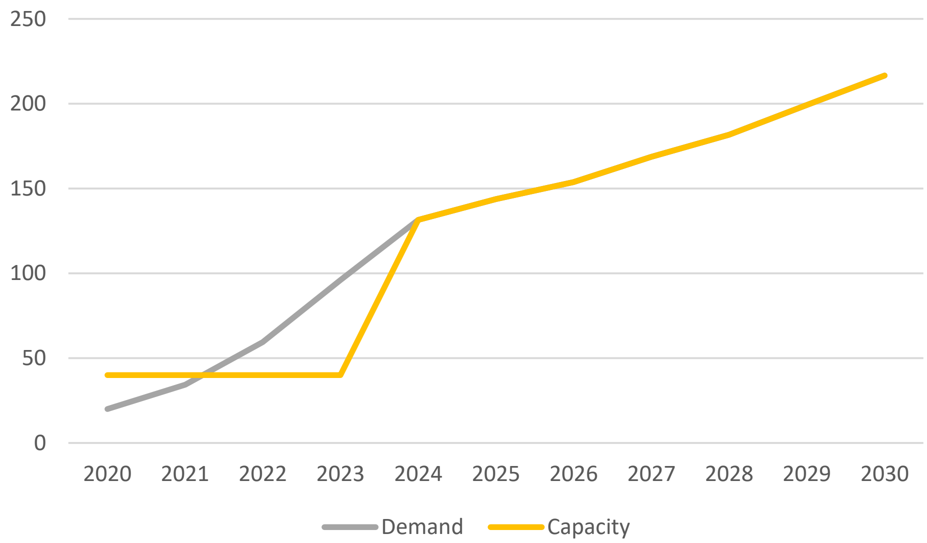
Filling needs in the years 2021 might be met by working double shifts, as necessary. Year 2023 could be critical; if at least the Kigali plant is not implemented by then, it would delay the scenario.

Cylinder filling demand versus cylinder filing capacity

Absent specific plans from existing Marketers regarding new filling capacity, it is assumed hypothetically that the country could have at least the near-term filling capacity of 20 filling scales (20,000 tonnes per year). On this basis, working in two shifts, country would theoretically be able to fill 40,000 tonnes per year until the first new filling plant comes on line under this Plan.

Then, in matching the cylinder filling demand with the anticipated filling capacity, it appears that the year 2022 will be problematic for the NST1 scenario:

Figure 53. NST-1 filling capacity vs demand



This is due to the fact that the surge of demand associated with the NST-1 Target scenario between 2021-2023 outpaces the ability to construct enough new filling capacity to serve that demand. The supply chain must catch up to the demand by 2024, in order for the NST-1 LPG goal to be achieved.

45. Storage

The following types of storage are distinguished for purposes of this Plan:

- **Logistic storage** required for the effective working of the supply chain, notionally one week of consumption. This is the level of storage that the private sector would normally aspire to maintain, for maximum bankability.
- **National strategic storage** required by the GoR through the Downstream Petroleum Policy in development by MINICOM. The desired requirement is to have strategic stocks of 2 months of supply, under the aegis of the Government, to provide a buffer against possible supply shocks.
- **Private sector strategic storage** required by the MINICOM policy. This storage would be operated by the private sector, and would add another one month of strategic stocks, bringing the national buffer inventory to 3 monrhs in total. As of this writing, assignment of the capital and operating costs of this added strategic storage between the private sector and the government has not been settled.

Logistic storage

The objective of the logistic storage is to guarantee the filling of cylinders considering the hazards of primary transport and possible local over-consumption of LPG.

The primary transport could be affected by weather, road conditions, blockage on the road (accidents, collapsed bridge, etc.), and import delays, such as delays in ocean shipping.

➲ It is recommended that one week of logistic storage be targeted for each filling plant, comprising 2-3 days as spare stock and 5 days as working stock. The rotation rate will be 1/52, i.e., one replenishment per week per filling plant storage. This high rate of rotation of the filling plant storage provides a good optimization of the capital costs and keeps the cost effect on refilling low.

National strategic storage

By definition, national strategic storage is a product reserve that must be constantly available, released on Government orders when necessary. This product reserve is a physical insurance policy: unless an emergency situation arises, it could remain in its tanks for several years, or indefinitely.

This strategic storage must be sufficient to cover the consumption of LPG in cylinders and in bulk. The GoR decision on the duration of consumption to be reserved has a political dimention, and while ultimate decisions may thus be taken on political grounds, it is nonetheless important to consider the economic implications of the investments necessary to build and maintain the national strategic storage.

Prior to the analysis presented in the report, a project was proposed by a major LPG Marketer in Rwanda, to the GoR to build and operate a national strategic storage facility, adjunct to which would be private sector storage and a filling plant owned and operated solely by SP. This is referred to as the Rusororo project.

The Rusororo project proposes strategic storage of 7,300 MT, which is sufficient to cover 2 months' national LPG consumption up to 2022, depending on the demand scenario. The technical analysis of this project is described in Annex Chapter 84.

Strategy recommendation

➲ Instead of multiple storage sites, for reasons of cost-effectivness, it recommended to place the national strategic storage at one central site near Kigali, where LPG consumption will be the greatest. Based on the scenario, it could be structured in three expansion phases: 2022, 2024 and 2030:

Table 52. National strategic storage build-out strategy, by scenario, to 2030 sufficient to store two months' national LPG consumption

	NATIONAL STRATEGIC STORAGE Capacity		
	2022	2024	2030
BAU	7 300 MT	12 000 MT	24 000 MT
BAU +LI	7 300 MT	13 000 MT	30 000 MT
BAU +HI	7 300 MT	14 000 MT	36 000 MT
NST-1	7 300 MT	28 000 MT	44 000 MT

Private sector strategic storage

The private sector storage, co-located in regional filling plants, would represent 30 days' consumption.

➲ It is recommended to separate the private sector storage requested by the GoR into a logistic storage component, which insures the efficient running of the filling plant, and a strategic storage component.

If the private sector is required to pay for the strategic storage at its filling plants, it will significantly affect the sector's bankability, as detailed in Volume 5 (see Table 72 on page 285),

Table 53. Private sector strategic, logstic and operational storage strategy, by scenario, to 2030 sufficient to store one months' national LPG consumption

	∑ PRIVATE SECTOR OPERATION STORAGE capacity		
	2020	2024	2030
BAU		4 000 MT	8 000 MT
BAU +LI		5 000 MT	10 000 MT
BAU +HI		5 000 MT	12 000 MT
NST-1		10 000 MT	15 000 MT

	∑ LOGISTIC STORAGE Capacity		
	2020	2024	2030
BAU		900 MT	1 800 MT
BAU +LI		1 200 MT	2 300 MT
BAU +HI		1 200 MT	2 800 MT
NST-1		2 300 MT	3 500 MT

1 month

The estimated cost of the 1-month strategic storage in the private sector represents some US $15 to 24 million capital cost, depending on the scenario, plus the cost of the stored fuel in the reserve, plus facility operating costs.

At a high level, the probable cost of the national strategic storage and the private sector strategic storage investment is potentially as much as US $75-125 million, depending of the scenario. If amortized over 7 years, excluding financing, ignoring operating costs, but adding the cost of the product (45KT at $700/T or more), and divided by 145KT to 263KT of operating volume, the cost of this storage amounts to about US $85 to 95/MT added to the price structure, representing an increase of some 5-8% or more to the end-user price. The cost of such storage is therefore most appropriately a public sector obligation.

As detailed in Volume 5 (see Table 73, page 285), the burden on the private sector can be minmized by treating a portion of the supply chain's ordinary fuel inventory—in filling plants, trucks and cylinders—as contributing to the private sector's share of the reserve.

The following table calculates the contribution from this strategy, based on treating 50% of normal operating inventories as part of the national buffer:

Table 54. Private sector 50% inventory allocation to strategic reserves, by scenario, to 2030

		Estimated yearly stock MT		
		Low interv	High interv	NST1
2024	1/2 Cylinders	8,286 MT	9,266 MT	23,693 MT
	1/2 FP storage	770 MT	830 MT	1,605 MT
	1/2 Bulk trucks	637 MT	713 MT	1,753 MT
	TOTAL	**9,693 MT**	**10,809 MT**	**27,051 MT**
2030	1/2 Cylinders	22,130 MT	27,526 MT	35,300 MT
	1/2 FP storage	1,743 MT	2,080 MT	2,533 MT
	1/2 Bulk trucks	1,854 MT	2,285 MT	2,889 MT
	TOTAL	**25,727 MT**	**31,891 MT**	**40,723 MT**

By treating 50% of the LPG in cylinders, filling plants and the bulk truck fleet as usable toward strategic reserves in event of a supply shock, the supply-chain LPG inventory would represent 1.6 to 1.9 months of consumption based on the scenario:

	Estimated yearly stock in months		
	Low interv	High interv	NST1
2024	1.5 Months	1.5 Months	1.9 Months
2030	1.7 Months	1.8 Months	1.9 Months

In consequence, the amount of storage required at the national strategic storage level falls significantly, as shown here:

Table 55. Net strategic storage requirement with 50% inventory allocation, by scenario, to 2030

	Estimated new strategic storage		
	Low interv	High interv	NST1
2024	10,300 MT	10,800 MT	14,700 MT
2030	19,600 MT	22,200 MT	25,100 MT

This way, the cost of the strategic storage would fall to around US $50/MT (a reduction of as much as 47%), a far more feasible burden on prices and/or margins.

Logistic storage details

Table 56. Filling plant logistic storage capacities by scenario, by year

A) Low case

	ESTIMATED THEORETICAL LOGISTIC CYLINDER+BULK STORAGE CAPACITY					
Low interv	**Rwanda**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	535 Tons	535 Tons				
2021	664 Tons	664 Tons				
2022	860 Tons	430 Tons	430 Tons			
2023	2,468 Tons	1,234 Tons	1,234 Tons			
2024	2,278 Tons	1,324 Tons	depot	467 Tons	depot	488 Tons
2025	2,319 Tons	1,195 Tons	depot	550 Tons	depot	573 Tons
2026	2,604 Tons	1,271 Tons	depot	653 Tons	depot	679 Tons
2027	2,930 Tons	1,347 Tons	depot	778 Tons	399 Tons	406 Tons
2028	3,302 Tons	1,422 Tons	424 Tons	502 Tons	480 Tons	474 Tons
2029	3,716 Tons	1,491 Tons	503 Tons	596 Tons	571 Tons	555 Tons
2030	4,175 Tons	1,555 Tons	596 Tons	704 Tons	669 Tons	651 Tons

B) High case

	ESTIMATED THEORETICAL LOGISTIC CYLINDER+BULK STORAGE CAPACITY					
High interv	**Rwanda**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	535 Tons	535 Tons				
2021	681 Tons	681 Tons				
2022	932 Tons	449 Tons	483 Tons			
2023	1,193 Tons	546 Tons	647 Tons			
2024	1,628 Tons	625 Tons	depot	474 Tons	529 Tons	depot
2025	1,910 Tons	687 Tons	depot	581 Tons	641 Tons	depot
2026	2,322 Tons	747 Tons	depot	715 Tons	467 Tons	393 Tons
2027	2,697 Tons	790 Tons	419 Tons	458 Tons	561 Tons	468 Tons
2028	3,131 Tons	828 Tons	510 Tons	564 Tons	668 Tons	561 Tons
2029	3,639 Tons	866 Tons	623 Tons	688 Tons	785 Tons	678 Tons
2030	4,207 Tons	897 Tons	758 Tons	827 Tons	904 Tons	821 Tons

C) NST-1 Target case

	ESTIMATED THEORETICAL LOGISTIC CYLINDER+BULK STORAGE CAPACITY					
NST1 Target	**Rwanda**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	535 Tons	535 Tons				
2021	873 Tons	873 Tons				
2022	1,467 Tons	440 Tons	239 Tons	266 Tons	233 Tons	290 Tons
2023	2,372 Tons	630 Tons	416 Tons	455 Tons	394 Tons	477 Tons
2024	3,209 Tons	800 Tons	580 Tons	633 Tons	546 Tons	650 Tons
2025	3,476 Tons	814 Tons	640 Tons	702 Tons	608 Tons	713 Tons
2026	3,702 Tons	820 Tons	692 Tons	762 Tons	662 Tons	767 Tons
2027	4,024 Tons	849 Tons	761 Tons	841 Tons	734 Tons	839 Tons
2028	4,311 Tons	870 Tons	824 Tons	913 Tons	799 Tons	905 Tons
2029	4,690 Tons	911 Tons	905 Tons	1,005 Tons	881 Tons	988 Tons
2030	5,066 Tons	949 Tons	985 Tons	1,096 Tons	964 Tons	1,072 Tons

The storage at the filling plants increases in industry standard tank-size increments: elongated ("cigar") tanks would be multiples of 50 or 100m^3 (50 m^3, 100 m^3,200 m^3, etc.) and spherical tanks, multiples of 500 m^3 (500 m^3, 1000 m^3, 2000 m^3, 3000 m^3, 5000 m^3, etc.).

Figure 54. Examples of cigar-type and spherical storage tanks

46. Transportation

Bulk primary transport

The capacity of bulk trucks depends on the regulations regarding the authorized axle load; it runs from 20T to 28T of LPG capacity. For the calculation hereafter, 24T LPG trucks (BVW 38T) will be assumed.

On the Mombasa or Dar es Salaam routes, a bulk truck will spend on average 8 days (round trip). Considering this bulk truck is working 300 days/year (6 days/week, 50 weeks/year), the total load of LPG transported will be 900 MT/truck/year.

Here is the detail per province:

Table 57. Bulk truck capacity requirements by province, scenario and year

A) Low case

<table>
<tr><th></th><th colspan="6">ESTIMATED NUMBER OF BULK PRIMARY TRANSPORT TRUCKS/Year</th></tr>
<tr><th>Low interv</th><th>Rwanda</th><th>Kigali city</th><th>Southern Province</th><th>Western Province</th><th>Northern Province</th><th>Eastern Province</th></tr>
<tr><td>2019</td><td colspan="6"></td></tr>
<tr><td>2020</td><td>22 bulk trucks</td><td colspan="5">22 bulk trucks</td></tr>
<tr><td>2021</td><td>27 bulk trucks</td><td colspan="5">27 bulk trucks</td></tr>
<tr><td>2022</td><td>34 bulk trucks</td><td>22 bulk trucks</td><td colspan="4">12 bulk trucks</td></tr>
<tr><td>2023</td><td>61 bulk trucks</td><td>43 bulk trucks</td><td colspan="4">18 bulk trucks</td></tr>
<tr><td>2024</td><td>58 bulk trucks</td><td>34 bulk trucks</td><td colspan="2">12 bulk trucks</td><td colspan="2">12 bulk trucks</td></tr>
<tr><td>2025</td><td>64 bulk trucks</td><td>32 bulk trucks</td><td colspan="2">16 bulk trucks</td><td colspan="2">17 bulk trucks</td></tr>
<tr><td>2026</td><td>78 bulk trucks</td><td>34 bulk trucks</td><td colspan="2">21 bulk trucks</td><td colspan="2">22 bulk trucks</td></tr>
<tr><td>2027</td><td>94 bulk trucks</td><td>37 bulk trucks</td><td colspan="2">28 bulk trucks</td><td>17 bulk trucks</td><td>12 bulk trucks</td></tr>
<tr><td>2028</td><td>112 bulk trucks</td><td>39 bulk trucks</td><td>16 bulk trucks</td><td>20 bulk trucks</td><td>21 bulk trucks</td><td>16 bulk trucks</td></tr>
<tr><td>2029</td><td>132 bulk trucks</td><td>41 bulk trucks</td><td>20 bulk trucks</td><td>25 bulk trucks</td><td>26 bulk trucks</td><td>20 bulk trucks</td></tr>
<tr><td>2030</td><td>155 bulk trucks</td><td>43 bulk trucks</td><td>25 bulk trucks</td><td>31 bulk trucks</td><td>31 bulk trucks</td><td>25 bulk trucks</td></tr>
</table>

based on 900 MT transported/year

B) High case

<table>
<tr><th></th><th colspan="6">ESTIMATED NUMBER OF BULK PRIMARY TRANSPORT TRUCKS/Year</th></tr>
<tr><th>High interv</th><th>Rwanda</th><th>Kigali city</th><th>Southern Province</th><th>Western Province</th><th>Northern Province</th><th>Eastern Province</th></tr>
<tr><td>2019</td><td colspan="6"></td></tr>
<tr><td>2020</td><td>22 bulk trucks</td><td colspan="5">22 bulk trucks</td></tr>
<tr><td>2021</td><td>28 bulk trucks</td><td colspan="5">28 bulk trucks</td></tr>
<tr><td>2022</td><td>36 bulk trucks</td><td>23 bulk trucks</td><td colspan="4">13 bulk trucks</td></tr>
<tr><td>2023</td><td>47 bulk trucks</td><td>27 bulk trucks</td><td colspan="4">20 bulk trucks</td></tr>
<tr><td>2024</td><td>59 bulk trucks</td><td>31 bulk trucks</td><td colspan="2">14 bulk trucks</td><td colspan="2">15 bulk trucks</td></tr>
<tr><td>2025</td><td>74 bulk trucks</td><td>34 bulk trucks</td><td colspan="2">19 bulk trucks</td><td colspan="2">20 bulk trucks</td></tr>
<tr><td>2026</td><td>91 bulk trucks</td><td>37 bulk trucks</td><td colspan="2">26 bulk trucks</td><td>16 bulk trucks</td><td>12 bulk trucks</td></tr>
<tr><td>2027</td><td>111 bulk trucks</td><td>40 bulk trucks</td><td colspan="2">35 bulk trucks</td><td>21 bulk trucks</td><td>15 bulk trucks</td></tr>
<tr><td>2028</td><td>133 bulk trucks</td><td>41 bulk trucks</td><td>20 bulk trucks</td><td>25 bulk trucks</td><td>26 bulk trucks</td><td>20 bulk trucks</td></tr>
<tr><td>2029</td><td>160 bulk trucks</td><td>43 bulk trucks</td><td>26 bulk trucks</td><td>32 bulk trucks</td><td>33 bulk trucks</td><td>26 bulk trucks</td></tr>
<tr><td>2030</td><td>190 bulk trucks</td><td>44 bulk trucks</td><td>33 bulk trucks</td><td>40 bulk trucks</td><td>39 bulk trucks</td><td>34 bulk trucks</td></tr>
</table>

C) NST-1 Target case

	ESTIMATED NUMBER OF BULK PRIMARY TRANSPORT TRUCKS/Year					
NST1	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	22 bulk trucks	22 bulk trucks				
2021	38 bulk trucks	38 bulk trucks				
2022	66 bulk trucks	18 bulk trucks	11 bulk trucks	13 bulk trucks	13 bulk trucks	11 bulk trucks
2023	107 bulk trucks	33 bulk trucks	16 bulk trucks	20 bulk trucks	20 bulk trucks	17 bulk trucks
2024	146 bulk trucks	41 bulk trucks	25 bulk trucks	28 bulk trucks	25 bulk trucks	26 bulk trucks
2025	160 bulk trucks	42 bulk trucks	28 bulk trucks	32 bulk trucks	29 bulk trucks	29 bulk trucks
2026	171 bulk trucks	43 bulk trucks	30 bulk trucks	34 bulk trucks	32 bulk trucks	31 bulk trucks
2027	187 bulk trucks	44 bulk trucks	34 bulk trucks	39 bulk trucks	35 bulk trucks	35 bulk trucks
2028	202 bulk trucks	45 bulk trucks	37 bulk trucks	42 bulk trucks	39 bulk trucks	38 bulk trucks
2029	221 bulk trucks	46 bulk trucks	41 bulk trucks	47 bulk trucks	43 bulk trucks	43 bulk trucks
2030	241 bulk trucks	47 bulk trucks	46 bulk trucks	52 bulk trucks	48 bulk trucks	48 bulk trucks

Cylinder primary transport

The cylinder primary transport (based on 900 cylinders per palletized semi-trailer, approximately 10MT/trip and 2,000MT/Year) would supply the entrepots from the associated filling plants.

Based on the distance and time from filling plant to the entrepot, a cylinder primary transport truck will work 300 days/year (6days/week x 50 weeks/year), and the total load of LPG per year will be:

Kigali-Southern province: 1.5 days go and back	2,000 MT/year
Kigali-Western province: 1.5 days go and back	2,000 MT/year
Kigali-Northern province: 1 day go and back	3,000 MT/year
Kigali-Eastern province: 1 day go and back	3,000 MT/year
Southern-Western province: 2 days go and back	1,500 MT/year
Eastern-Northern province: 2 days go and back	1,500 MT/year

Table 58. Cylinder truck capacity requirements by province, scenario and year

A) Low case

Low interv	Rwanda	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
	ESTIMATED NUMBER OF CYLINDER PRIMARY TRANSPORT TRUCKS/Year					
2019						
2020	2 cyl trucks		0,6 cyl trucks	0,0 cyl trucks	0,5 cyl trucks	0,5 cyl trucks
2021	3 cyl trucks		0,8 cyl trucks	0,7 cyl trucks	0,7 cyl trucks	0,6 cyl trucks
2022	4 cyl trucks		1,2 cyl trucks	1,0 cyl trucks	1,0 cyl trucks	0,9 cyl trucks
2023	6 cyl trucks		1,7 cyl trucks	1,5 cyl trucks	1,5 cyl trucks	1,2 cyl trucks
2024	7 cyl trucks		3,1 cyl trucks		4,2 cyl trucks	
2025	10 cyl trucks		4,2 cyl trucks		5,7 cyl trucks	
2026	13 cyl trucks		5,6 cyl trucks		7,6 cyl trucks	
2027	7 cyl trucks		7,3 cyl trucks			
2028						
2029						
2030						

B) High case

High interv	Rwanda	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
	ESTIMATED NUMBER OF CYLINDER PRIMARY TRANSPORT TRUCKS/Year					
2019						
2020	2 cyl trucks		0,6 cyl trucks	0,0 cyl trucks	0,5 cyl trucks	0,5 cyl trucks
2021	3 cyl trucks		0,8 cyl trucks	0,7 cyl trucks	0,7 cyl trucks	0,6 cyl trucks
2022	4 cyl trucks		1,3 cyl trucks	1,1 cyl trucks	1,1 cyl trucks	0,9 cyl trucks
2023	7 cyl trucks		1,9 cyl trucks	1,6 cyl trucks	1,7 cyl trucks	1,4 cyl trucks
2024	6 cyl trucks		3,6 cyl trucks			1,9 cyl trucks
2025	8 cyl trucks		5,0 cyl trucks			2,6 cyl trucks
2026	7 cyl trucks		6,9 cyl trucks			
2027	0 cyl trucks					
2028						
2029						
2030						

In the NST-1 Target scenario, there is no need for added cylinder primary transport.

Cylinder secondary transport / cylinder distribution

The cylinder transport from filling plants to the retail network, called cylinder secondary transport or cylinder distribution, is generally not integrated in an LPG Master Plan, because this element of the supply chain does not require specific skills, specific knowledge and specific equipment; it is very often subcontracted by the Marketers to independent entrepreneurs who already own and operate small general purpose trucks. However, this requires attention in the NST-1 Target scenario, given the massive distribution needs that will have to be put in place in a very short period of time. The capacity of existing, available light trucks may be inadequate, and the growth needed in the distribution truck fleet may require a large volume of vehicle financing over a short period of time.

All the cylinders leaving the filling plant will be distributed via the sales network. This distribution will be done by small trucks of BVW 3.5T, BVW 5T, BVW 15T, etc., by car, and even by motorcycle. To make estimates of the transport needs, a mix of trucks transporting 4, 6, 9 or 12 pallets of 35 cylinders or 140, 210, 315, 420 cylinders in ratio of 30%, 30%, 20%, 20% of volumes will be assumed, making two rotations per day, equal to 2,880 tonnes of distribution per year.

Table 59. Cylinder distribution truck capacity requirements under NST-1, by year

	CYLINDER SECONDARY TRANSPORT -NST1 CASE											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
Volume to be transported		34 383 T/y	59 367 T/y	95 962 T/y	131 506 T/y	143 763 T/y	153 812 T/y	168 709 T/y	181 723 T/y	199 341 T/y	216 700 T/y	
Number of 4 pallets trucks		10	18	29	39	43	46	50	54	59	64	
Number of 6 pallets trucks		7	12	19	26	29	31	33	36	40	43	
Number of 9 pallets trucks		3	5	8	12	13	14	15	16	18	19	
Number of 12 pallets trucks		3	6	10	13	14	15	17	18	20	21	
CUMULATED per year	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**TOTAL**
Number of 4 pallets trucks		10	7	11	11	4	3	4	4	5	5	64
Number of 6 pallets trucks		7	5	7	7	2	2	3	3	3	3	43
Number of 9 pallets trucks		3	2	3	3	1	1	1	1	2	2	19
Number of 12 pallets trucks		3	2	4	4	1	1	1	1	2	2	21
TOTAL		23	17	25	24	8	7	10	9	12	12	148

47. Other Assets

Pallets

The standard pallet capacity is 7 rows of 5 cylinders, or 35 cylinders in total.

Palletization machines and running-stock pallets for filling plants are in included in the filling plant costing (see Part XXI (Project Annexes)).

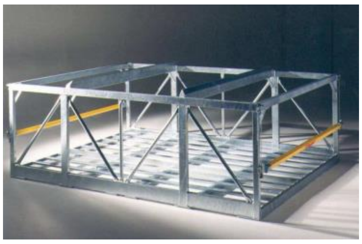


Table 60. Pallet requirements by scenario and year

	ESTIMATED NUMBER OF PALETTS		
	2020	2024	2030
BAU		1 975	4 987
BAU +LI		2 187	6 368
BAU +HI		2 447	7 847
NST-1		6 021	9 922

Cylinder cages

The cylinders in the retail network will be presented in cages or display racks. The cages will be positioned in the larger sales point such as service stations and supermarkets, where the quantity of cylinders will be at least 12.

These cages are designed to ensure the following functions:

- Store the cylinders in a safe, vertical position;
- Protect the cylinders against shock and severe weather,
- Make the cylinder delivery easy for the delivery staff and the seller; and
- Protect against theft / piracy.

Cages contain 12, 20 or 24 cylinders. The number of cylinders in the sales network depends on the number of retail points and the final distribution structure, which could represent some 5-8% of the cylinder park; based on data from other SSA countries, it is expected that only 2-3% would be equipped with cages.

Table 61. Cylinder cage requirements by scenario and year

	ESTIMATED NUMBER OF CAGES		
	2020	2024	2030
BAU		2 718	7 367
BAU +LI		2 762	7 377
BAU +HI		3 089	9 175
NST-1		7 898	11 767

48. Summary

The investment requirements for these assets is presented in Volume 5.

The totals, using the ISS option, are (in US$ millions):

	BAU	Low case	High case	NST-1 Target case
Total private sector assets	134.9	141.7	169.7	205.5
National strategic storage	42.5	49.5	52.9	72.3
Total	177.4	191.2	222.6	277.8

Note: Per the ISS option, the above totals assume that private sector LPG fuel within the supply chain assets is offset 50% against the strategic storage requirement proposed by GoR. These amounts exclude the cost of the LPG fuel being stored in the strategic reserve facility.

49. Procurement Strategy

LPG cylinder requirements

The implementation of the LPG Master Plan involves an annual injection of LPG cylinders into the market of 100,000-200,000 cylinders at start-up, rising to 600,000-700,000 per year at the end of the programme. The LPG cylinder park in 2030 should be 2.5 to 5 million cylinders, based on the scenario, all of which will need to be maintained (hot repair) and retested periodically (10-year cycle).

The main alternative to supply this large quantity of cylinders is importation; there are many well qualified international manufacturers able to meet this demand. This could be complemented by local manufacturing from a factory that would have to be built.

In principle, these are private sector decisions, subject to compliance with cylinder standards and regulations in each case.

Below are advantages and disadvantages of these two alternatives and a summary of the technical and budgetary needs for the construction of a cylinder manufacturing plant.

Table 62. Cylinder acquisition strategies with their advantages and disadvantages

	Importation	Local manufacture
Advantages	- Flexibility on quantities - Ease of adaptation to demand	- Manufacturing cost - Local labour employment - Forced production rhythms - Reactivity - Cylinder hot repairing capability
Disadvantages	- Costs - Deadlines	- Requires local skills (welding, stamping, X-raying) - Finding and retaining well qualified management - Need to find export market in which to compete, when national demand for new cylinders eventually decreases

Technical description

The production line would have to produce at least 3 types of cylinders: 6 kg, 12 kg, 35 kg.

The nominal capacity of the production line would be 125 cylinders of 12 kg per hour with an efficiency of 80%. Effective capacity would be 100 cylinders per hour.

- 1 shift: 240,000 cyl/year (6 days/week)
- 2 shifts: 450,000 cyl/year (6 days/week)
- 3 shifts: 700,000 cyl/year

The cylinders of 6 and 12 kg will be formed by 2 assembled parts whereas the cylinders of 35 kg will be formed in 3 parts (2 cylinder caps + 1 central ring).

The main constituents of the manufacturing are:

- The manufacturing of the cylinder halves
- The manufacturing of the central body for 35 kg
- The manufacturing of the base rings and valve-guards
- The assembly and finishing

The minimum size plot to install such a manufacturing plant is 1ha. The size of manufacturing building would be around 2,000m², office 300m², the remainder dedicated to storage.

Institutional procurement

Procurement applies to two elements of LPG service:

- Initial installation
- Regular refills

The cost of initial installation depends on the LPG volume. The LPG volume is a function of the number of people being catered for, and the nature and frequency of the meals. In best practice, and with adequate financing, the LMC can cover the cost of installation, provided the institution commits to buying LPG from the LMC for a defined quantity and time period, 5-10 years being ideal (for the LMC). This is commonly done under a supply agreement that contains a pricing formula to address variables such as changes in the international LPG price, the cost of delivery, the inflation rate, and so on.

Regular refills can be performed as specified in the supply agreement.

Alternatively, an institution which invests in its own bulk tank can buy LPG from the lowest bidder on a spot basis.

The sizes of installations are shown indicatively in the table below:

Table 63. Estimated LPG installations requirements for institutions

		Population		LPG consumption (est.)		Installation requirements			
Institution Type	Number	Total	Average	Annual vol. MT	Monthly vol. kg	Type	Size	Units / site	Total units
Nursery schools	3,210	226,706	70.6	0.54	45.1	Cylinder	12	4	12,840
Primary schools	2,909	2,503,705	860.7	6.60	549.7	Tank	1	1	2,909
Day secondary schools	1,235	495,285	400.9	3.07	256.1	Tank	0.5	1	1,235
Sec. boarding schools	181	163,000	902.0	13.83	1,152.3	Tank	2	1	181
Other boarding schools	234	211,330	902.0	13.83	1,152.3	Tank	2	1	234
Police (detention)	220	8,000	36.4	0.74	61.9	Cylinder	12	5	1,100
Correctional facilities	13	70,000	5,384.6	110.06	9,171.6	Tank	5	1	13

Hospitals		Number of beds		LPG consumption (est.)		Installation requirements			
Health facilities	Number	Total	Average	Annual vol. MT	Monthly vol. kg	Type	Size	Units / size	Total units
Health centres	N/A	11,335	22.7	0.46	38.6	Cylinder	12	4	2,000
District hospitals	37	6,193	167.4	3.42	285.1	Tank	0.5	1	37
Provincial hospitals	4	682	170.5	3.48	290.4	Tank	0.5	1	4
National referral hospitals	7	2,189	312.7	6.39	532.6	Tank	1	1	7
Total health facilities	548								

Table 64. Summary of LPG installation requirements for current institutions

Type of facility	No. of units
12kg cylinders	15,940
0.5 MT tanks	1,276
1 MT tanks	2,916
2 MT tanks	415
5 MT tanks	13

LPG supply

Key goals for Rwanda's LPG supply strategy include:

- *Cost reduction*. Reduce costs in the portions of the price build-up where it is possible to do so (namely, in bulk transportation elements and in trader/ocean importer premiums);
- *Price stability*. Mitigate possible rent-seeking or price volatility that could be caused by monopolistic or oligopolistic behavior by third parties in the critical path of LPG ocean and overland logistics; and
- *Supply security*. Mitigate potential shortages caused by third parties, through increased control over portions of the supply chain, and develop domestic production in the form of renewable LPG (bioLPG), to the extent this is determined to be feasible following more detailed study.

Cost reduction and price stability measures

To reduce the costs of LPG obtained by importation and mitigate price volatility, Rwanda can

1. Pool the import volumes of the individual Rwandan Marketers and negotiate long-term take-or-pay sales and purchase agreements with East African maritime importers for regular deliveries in defined quantities to supply the aggregated market need, in whole or in part.
2. Pool Rwanda's import volumes with those of a large Marketer or pool of Marketers in a neighboring country that imports LPG (i.e., Tanzania or Kenya). This would increase the negotiating power of both the Tanzanian or Kenyan parties and the Rwandan Marketers.
3. Rwandan Marketers may integrate into bulk transport operations between the import terminal and their Rwandan storage facilities. This would allow the Marketers to avoid paying for some, or all, of the profit margin earned by independent bulk trucking companies.

Rwanda cannot influence the regional LPG index price for imports (Saudi CP). Because the far larger LPG markets of Rwanda's neighbours are already served by semi-refrigerated LPG vessels of at least 10,000 MT capacity (justified at 200,000 MT of market volume and upwards), there is no opportunity for Rwanda to improve ocean transport cost by adding its own volumes[81].

Any dedicated ocean import storage that Rwanda might justify for its own use, based on its projected market volumes, would support only a pressurized vessel with capacity of 3,000-8,000 MT. On a cost-per-tonne basis, such a vessel would be much more expensive than the 10,000+ MT semi-refrigerated vessels already serving the East African LPG market. (The rotation rate of a supply vessel must be once or twice a month.) Additionally, a semi-refrigerated vessel in the spot market can be as expensive as a small pressurized vessel in time-charter.

Optimizing pooled importation and procurement under long-term sale and purchase contracts

➲ It is recommended to pool acquisition of imported LPG under long-term contracts. This approach creates the following advantages:

- Pooling of purchases improves the negotiation power of the buyers with the seller. By means of a take-or-pay contract, the buyers' committed volumes reduce the seller's quantity risk and scheduling risk, and the buyers may realize a reduction in the seller's premium (what the seller charges above the cost of the product itself).
- A stable supply schedule reduces the chance of the seller needing to employ an LPG vessel hired from the spot market at much higher cost (which would be passed on to the buyer), by creating a regular, defined delivery cycle that supports the use of time-chartered vessels.

However, it is also recommended that the buyer pool commit to purchasing less than 100% of the expected volume needed, with the remainder to be acquired on a spot basis. This approach creates the following additional advantages:

- If there is a temporary oversupply or reduction in need, the buyers are not obligated to continue to purchase LPG at 100% of the projected level of need during that period.
- Buyers can take advantage of price arbitrages (time-based or source-based) via the spot market for quantities not subject to the long-term contract, without undermining the overall benefit from the contract, and without taking undue price or quantity risks, which are hedged by the contracted portion.
- If the contracted supplier(s) experience a temporary shortage or delay, the buyers are in good position to make up for it through their ongoing spot market purchasing.

The pool could be implemented contractually by and amongst its participants, with one Marketer selected to act as the lead contracting party with the seller on behalf of the other buyers. The GoR (e.g., RURA) should ensure that fair and effective coordination and governance occurs, in part so that smaller Marketers are not put at any unfair disadvantage by larger Rwandan rivals in the design or practice of this scheme, and to ensure the lead Marketer fulfills its role impartially.

[81] The next step is fully refrigerated vessels in the range of 40,000 MT serving a market of 800,000 to 1 million MT and requiring new, larger port infrastructure to handle the larger vessels.

Additional options for improving supply security

Maritime port storage and terminaling capability

Considering the yearly projected volumes for Rwanda—3,500-4,000 MT/month by 2024, 10,000-20,000 MT/month by 2030—having storage on an Indian Ocean port of 4,000 MT by 2024 could ensure the reception of cargoes that Rwanda controls, from one to three times par month. The purpose of having such storage (whether via direct ownership, rental or otherwise) would be to increase the security of a portion of Rwanda's LPG supply. It would not necessarily create cost savings.

There are several options for this port storage:

1. Duplicate AGOL's strategy in Mombasa by utilizing floating storage: a rented or owned LPG ship could be supplied by an oceanic LPG carrier on a buoy mooring system in Mombasa or Dar es Salaam, connected to a small buffer tank onshore from which to load LPG bulk trucks.
2. Rent part of the volume in an existing storage facility from an importer that has overcapacity and would benefit from Rwanda's quantity contribution to drive down prices. In Dar es Salaam, Oryx (a Swiss-based pan-African energy company) could be such a candidate.
3. Build a shared storage facility with one or more operators. The lead operator will carry out the operations on the site, and all the partner operators will benefit from the contribution of the Rwanda quantities toward purchased product volumes.
4. Build a complete independent storage facility and assume control of the operation of this storage.

Such storage is not in fact likely to serve projected market needs until 2027, allowing a long planning window.

Before considering the advantages and disadvantages of these options, essential questions must be answered:

- What is the best legal form of the company operating this marine supply storage?

    Will it be a Tanzanian or Kenyan company? A joint venture with a local or Rwandan Marketer and GoR?
- Which customs regime will be adopted for this storage?
- What fiscal regime will be adopted?
- What party/ies will be the owner(s)?
- Which entity will be responsbile for this strategic storage, its economics, and its governance, Government versus private sector?
- What entity will manage the operations?
- What party will trigger supplies?
- Would an agreement with the Kenyan or Tanzanian government be required?

The following table presents advantages and disadvantages to be considered:

Table 65. Imported LPG procurement strategies with their advantages and disadvantages

Option	**Advantages**	**Disadvantages**
Floating storage	• Solution easy to develop; many LPG carriers are available on the market • The floating storage could then be mobile and change port based on political, social or environmental factors • Small investment in buffer tank onshore LPG carrier can be rented	• Port duties • Buffer tank onshore being small, good organization is requested to empty the floating storage and avoid demurrage • Operation team onshore is needed • Crew for the vessel is needed
Renting a part of existing storage	• Rent or throughput agreement; solely opex costs • Terminal already connected to LPG jetty • All services are available and supplied by operator (monitoring, maintenance, filling of trucks, safety, etc.) under contract	• Need for clear and well defined contract (access, services, guaranty of service) • Need for strong reliability of the operator • Volume could be limited in the future • The supply/importation must be coordinated with the partner
Building a shared storage	• A large part of utilities infrastructure is already in place • All services are available and supplied by operator (monitoring, maintenance, filling of trucks, safety, etc.)	• A qualified operator must be named and compensated • Capex requirement • Time to develop and construct the project • Need for strong reliability of the operator (with guaranties of operations) • The supply must be coordinated with the partner
Building independent storage	• Complete independence of supply and management	• Need to find land not far from LPG jetty in adequate harbor • Need time to develop and construct the project • Need to operate the storage

Budgetary considerations

The following budgetary approach could give a rough idea of the costs +/-30%:

- Option: Construction of a storage capacity of 4000 MT in an existing LPG premises including engineering, authorization process, civil works, the tanks, pump room, LPG and fire water network, electricity:

  Type of storage – mounded 3,000 USD/MT of storage [~US$ 12M]

  Type of storage – above ground 2,000 USD/MT of storage [~US$ 9M]

  Excluded: land, road access, utilities access, extra cost for deep foundations, customs duties, VAT and other taxes.

- Option: Renting a volume in existing premises:

  5-8% of the Capex

- Option: construction of a new marine terminal:

  Estimated ratio for 15 000 MT storage including engineering, authorization process, civil works, the tanks, 4 truck loading bays, pump room, all necessary utilities, buildings, LPG and fire water network, electricity, etc.:

Type of storage - mounded	3,000 USD/MT of storage [~US $45M]
Type of storage - above ground	2,000 USD/MT of storage [~US $30M]

  Estimated cost of pipeline If necessary (base 14”) including engineering, civil works, pipes, mechanical items, electrical items, instrument items, road crossings 1,000 USD/m

  Excluded: land, road access, utilities access, extra cost for deep foundations, customs duties, VAT and other taxes.

Note: Estimating floating storage renting costs and operation costs would require a deeper analysis.

Estimated planning timeline

In the case of new marine terminal construction, the necessary time from decision making to the commissioning would be 2.5-3 years (assuming land is available).

BioLPG production

As described in Volume 2, bioLPG could be produced in Rwanda from feedstocks such as urban municipal solid waste, without byproducts such as biodiesel or biogasoline/biopetrol. BioLPG could serve a portion of national LPG demand at a factory gate price that is below the landed cost of imported LPG, while avoiding import risks such as supply disruption, foreign exchange volatility, etc.

50. Project Implementation Timelines

BAU scenatio

Table 66. BAU technical and project implementation timeline

ITEMS: BAU SCENARIO*	2021		2022		2023		2024		2025		2026		2027		2028		2029		2030	
Adoption of master plan	X																			
GoR implementation of BCRM (recommended)		X	X																	
GoR interventional measures (if any)		X	X																	
Cylinder procurement		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Truck procurement		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
KIGALI filling plant/storage: decision-making through implementation		X	X	X																
SOUTHERN filling plant/storage: decision-making through implementation											X	X	X	X						
WESTERN filling plant/storage: decision-making through implementation					X	X	X	X												
NORTHERN filling plant/storage: decision-making through implementation											X	X	X	X						
EASTERN filling plant/storage: decision-making through implementation			X	X	X	X														

** If the private sector adopts the regional, industrial-grade filling plant strategy recommended in the Plan*

Low intervention scenario

Table 67. Low case technical and project implementation timeline

ITEMS: LOW INTERVENTION SCENARIO	2021		2022		2023		2024		2025		2026		2027		2028		2029		2030	
Adoption of master plan	X																			
GoR implementation of BCRM		X	X																	
GoR interventional measures		X	X																	
Cylinder procurement		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Truck procurement		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
KIGALI filling plant/storage: decision-making through implementation	X	X	X																	
SOUTHERN filling plant/storage: decision-making through implementation											X	X	X	X						
WESTERN filling plant/storage: decision-making through implementation			X	X	X	X														
NORTHERN filling plant/storage: decision-making through implementation									X	X	X	X								
EASTERN filling plant/storage: decision-making through implementation			X	X	X	X														

High intervention scenario

Table 68. High case technical and project implementation timeline

ITEMS: HIGH INTERVENTION SCENARIO	2021		2022		2023		2024		2025		2026		2027		2028		2029		2030	
Adoption of master plan	X																			
GoR implementation of BCRM		X	X																	
GoR interventional measures		X	X																	
Cylinder procurement		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Truck procurement		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
KIGALI filling plant/storage: decision-making through implementation		X	X	X																
SOUTHERN filling plant/storage: decision-making through implementation									X	X	X	X								
WESTERN filling plant/storage: decision-making through implementation			X	X	X	X														
NORTHERN filling plant/storage: decision-making through implementation			X	X	X	X														
EASTERN filling plant/storage: decision-making through implementation							X	X	X	X										

NST-1 Target scenario

Table 69. NST-1 Target case technical and project implementation timeline

ITEMS: NST1 TARGET SCENARIO	2021		2022		2023		2024		2025		2026		2027		2028		2029		2030	
Adoption of master plan	X																			
GoR implementation of BCRM		X	X																	
GoR interventional measures		X	X																	
Cylinder procurement		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Truck procurement		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
KIGALI filling plant/storage: decision-making through implementation		X	X	X																
SOUTHERN filling plant/storage: decision-making through implementation		X	X	X																
WESTERN filling plant/storage: decision-making through implementation		X	X	X																
NORTHERN filling plant/storage: decision-making through implementation		X	X	X																
EASTERN filling plant/storage: decision-making through implementation		X	X	X																

Rwanda National LPG Master Plan

Volume 5

Investment and Financing Plan

Contents

List of Tables

List of Figures

XVI. Investment Plan

This Part describes the investment requirements along the full supply chain to serve the three consumption growth scenarios of this Plan beyond the BAU scenario:

1. Interventional scenario, low case;

2. Interventional scenario, high case; and

3. NST-1 Target scenario.

It examines:

- The total investment and financing need for the sector under these three scenarios (Low, High, NST-1 Target);
- How the investment capital could be apportioned among those existing LPG companies in Rwanda that would, presumably, desire and use such financing to grow and to maintain market shares, consistent with the supply chain strategy set forth in Volumes 1 and 4;
- The optimal structure, characteristics and operational choices for a generic LPG firm to be an Industry Leader firm that can lead the scale-up of the LPG sector and lead in the attraction of outside financing to the sector;
- Whether, and under what conditions, such a firm is bankable;
- How that bankability and/or end-user prices are affected by key external factors such as national strategic storage investment requirements;
- How bankability and end-user prices are affected by firm configurations other than the Industry Leader design (e.g., PAYG, small Marketer without in-house filling capability, etc);
- The financing environment faced by Rwandan LPG companies;
- Structures and recommendations for how best to finance the sector and individual, qualified firms within it, to maximize bankability (including liquidity) while keeping LPG as affordable and accessible as possible to the public.

Because the Rwanda private sector companies were in general unwilling to disclose their proprietary plans and/or operating and financial details for use in preparation of this Plan, it was not possible to construct financial and financing models for specific firms and specific projects. Therefore, modelling of the sector and of cetain exemplar types of firm were done on a pro-forma basis, based on a combination of Rwandan industry data and benchmarks and assumptions from other relevant East African and SSA LPG markets.

51. Investment Requirements and Considerations at the Sector Level

Although the private sector LPG companies in Rwanda were not willing to disclose detailed proprietary information, whether or not for attribution, data gathered from survey questionnaires, interviews, and RURA reports provided a high level view of the Rwanda commercial LPG ecosystem. As mentioned in Volumes 1 and 3, current main roles under Rwanda's LPG regulatory framework are importers and two types of marketers with branded cylinders: those with their own filling plants and bulk storage, and those without. (These current roles are not BCRM-compliant.)

The industry composition shown in the table below indicates that nine LPG Marketers operated across all three modalities in 2020. (The company names are kept anonymous per their request.) As noted later in this Chapter, their relative market shares provide insight into the composition of the sector and how it could most easily and effectively be expanded and financed. Of those nine, four have market shares by volume above 10%, and the top two have shares of 33% and 23%, respectively, as of September 2020.

As noted in Volume 2, the leading companies have undertaken certain structural changes already to improve their cost positions, including efforts to disintermediate distributors (Wholesalers) and to backward integrate into bulk transport.

Based on Rwanda-based meetings and interviews, the main financing approach used by the owners of Rwandan LMCs has been self-financing, which has permitted a steady rate of growth but is unlikely to be a sustainable financing modality as the market becomes very large, if these companies seek to preserve (or improve upon) their market shares.

Because the sector has largely self-financed, it also means that the financial sector in Rwanda has had very limited exposure to investing and lending in the LPG sector. This, in itself, as a possible barrier to a large-scale, rapid ramp-up of LPG financing from local funding sources. (As has been made clear in many parts of this Plan document, the LPG sector has many important differences from the other, larger subsectors of the overall hydrocarbon sector.)

As mentioned in Volumes 2 and 3, it is not prudent at this stage of Rwanda's LPG market development to welcome a flood of new market entrants in the importing or Marketer roles. Such an influx could be counterproductive during the period of rapid scale-up and regulatory stabilization of the sector coinciding with the time horizon of this Plan, due to (i) the challenges of regulating a very large number of players to high standards of compliance, (ii) the probability of brand confusion arising among consumers, (iii) difficulty in financing large numbers of smaller players, (iv) keeping industry costs under control so that consumer prices remain relatively stable, (v) the strategy of investing in and deploying only larger, industrial-grade, regional filling facilities (for the reasons set forth in other Chapters), and (v) the importance of, and need for, a sufficient depth of management expertise and facilities capability regarding safety, especially cylinder safety.

Based on Rwanda-based meetings and initial explorations with industry executives, there are several integrated operators that, because of their larger industry share, could be good initial recipients of advisory resources and blended capital to serve as Rwanda's Industry Leaders for growth. This does not imply that players below 1% market share should be excluded. What this implies is that to be catalytic, the larger LPG Marketers should be engaged as first-movers.

Based on the supply chain strategy recommended in Volume 4, Rwanda is likely to have a two-tiered Marketer group for the foreseeable future, in which Industry Leaders are relatively integrated along the supply chain and operate the regional filling facilities (and any associated strategic storage), and other Marketers utilize these regional facilities on a hosting basis. (This is a common approach in SSA, and in fact has been developed to an extremely high degree of capability and cost efficiency in Morocco, the leading SSA LPG market, where filling and storage are jointly owned as common user facilities, operating on a quasi-utility basis for benefit of the entire market.)

Table 70. Ranked LPG Marketing company market shares as of September 2020; company names concealed

Company Name	LPG Cylinder Brand Owner	LPG Filling Plant Ownership	Bulk LPG Importer	2019 Mkt Shares
1	*Yes*	*Yes*	*Yes*	*33.0%*
2	*Yes*	*Yes*	*Yes*	*23.3%*
3	*Yes*	*Yes*	*Yes*	*15.5%*
4	*No*	*No*	*Yes*	*12.4%*
5	*Yes*	*Yes*	*Yes*	*6.9%*
6	*Yes*	*Yes*	*Yes*	*3.9%*
7	*Yes*	*Yes*	*Yes*	*1.6%*
8	*Yes*	*Yes*	*Yes*	*1.4%*
9	*Yes*	*Yes*	*Yes*	*1.0%*
10	Yes	No	No	
11	Yes	Yes	Yes	
12	Yes	No	No	
13	Yes	No	No	
14	Yes	No	No	
15	Yes	No	No	
16	No	No	Yes	
17	No	No	Yes	
18	Yes	No	No	
19	Yes	No	No	
20	Yes	Yes	No	
Total Shares				99.21%

Source: RURA and company research and surveys in Rwanda by GLPGP.

Interviews with leaders of LPG Marketers indicate that, in general, they aspire to grow in conjunction with GoR objectives for LPG scale-up pursuant to NST-1, to the extent practical for them to do so.

In many cases, constraints and needs they express include:

- Advisory assistance,
- Capital,
- Technical resources,
- Support to further develop consumer channels, and
- A more enabling regulatory environment.

As discussed in Volume 3, the implementation of strong BCRM, with an organized and regulated treatment of cylinder assets, their filling, their safety and safety liabiilty, and their ownership, could encourage investment, in the view of Rwanda LPG industry executives. The scope of this need is within the funding capabilities of the international blended funding community (including Rwanda's international financial cooperation partners/donors).

A key issue for the industry is the GoR requirement for strategic LPG storage reserves. The industry welcomes these if fully paid for by GoR. However, any requirement that a portion of such reserves be paid for by industry (in terms of investment in the facilities and the reserve fuel supply, and operational spending) would put significant pressure on the firms' finances and, in consequence, render them less bankable or unbankable or, instead, force them to raise prices, thereby undermining the future demand potential they are meant to serve.

The GoR's policy as defined thus far would ideally have private sector strategic storage (PSS) account for 1 month of national reserves, with national strategic storage (NSS) (presumably GoR-funded) accounting for 2 months. This 3 month buffer would be above and beyond all existing LPG stored in the value chain in consequence of its normal operations.

PSS would be co-located with private sector filling plants. GoR would work with the industry to facilitate the building of an additional 2 months of NSS.

This approach is hereafter called Option 1, or the "Non-integrated strategic storage" (NISS) approach.

As outlined in Volume 4, there is an alternative approach, hereafter called Option 2, or the "Integrated strategic storage" (ISS) approach.

The investments under these two Options are the same in the areas of cylinders, filling plants, logistical storage, bulk primary transport, cylinder transport, pallets and cages.

They differ significantly in how the national strategic LPG reserve is built up, accounted for, and invested in.

The following table summarizes the key differences:

Table 71. Comparison of NISS and ISS strategic storage options

Option 1: NISS	**Option 2: ISS**
3 months' combined strategic storage	3 months' combined strategic storage
2 months in NSS	Approximately 1.1-1.5 months in NSS (range is based on the market's size in a given year)
1 month in PSS, co-located with private sector facilities	No need for PSS
LPG already in the value chain that is not needed for immediate consumption is not counted	50% of supply chain LPG (in plants, trucks, and cylinder inventory), equal to approximately 1.5-1.9 months, is counted toward the 3 month total (range is based on the market's size in a given year)

As discussed in Volume 4, it is not workable for the private sector to pay the costs of the NSS; it would force the wholsesale price of LPG to increase significantly. The costs of NSS must therefore be a state responsibility, if the LPG sector is to have the ability for meaningful growth and impact in connection with NST-1.

That leaves two questions:

1. How much NSS is actually required under each option (paid for by GoR)? and
2. How much PSS is required, and is that paid for by the private sector or by GoR?

The qualitative answers are (1) much less under Option 2 than Option 1, and (2) none. These answers are quantified later in this Chapter.

➲ It is recommended, as discussed and analyzed further below, that Option 2 be the investment and funding route of choice for strategic storage reserves. It achieves the same LPG penetration and usage ambitions for the country, provides adequate physical insurance against supply shocks, but at far lower investment cost for both industry and GoR.

The following two tables outline the investment requirements to serve the demand projections to 2030 under these two strategic storage options.

Table 72. Total investment requirement to 2030 by scenario under strategic storage Option 1 (NISS)

INVESTMENT REQUIREMENT		BAU	Low	High	NST-1
CYLINDERS	NATIONAL	$41,453,116	$56,522,761	$73,111,264	$96,998,654
FILLING PLANTS	KIGALI	$9,839,500	$9,460,000	$9,918,400	$9,932,300
	SOUTHERN	$8,437,100	$8,750,400	$9,330,500	$9,870,600
	WESTERN	$8,832,100	$9,426,650	$9,652,300	$10,265,400
	NORTHERN	$8,646,600	$9,108,500	$9,889,200	$10,065,800
	EASTERN	$8,621,800	$8,904,400	$9,561,200	$10,262,600
	TOTAL	$44,377,100	$45,649,950	$48,351,600	$50,396,700
	Palettization in Filling plant	$5,101,000	$5,195,000	$5,790,000	$6,270,000
	Palets in the logistic network	$1,575,147	$2,119,093	$2,699,805	$3,359,994
	TOTAL	$6,676,147	$7,314,093	$8,489,805	$9,629,994
STRATEGIC STORAGE	PRIVATE SECTOR PORTION	$15,075,000	$19,350,000	$22,125,000	$22,950,000
BULK PRIMARY TRANSPORT	NATIONAL	$21,295,981	$28,650,135	$36,501,357	$45,427,124
CYLINDER PRIMARY TRANSPORT	NATIONAL	$1,872,200	$1,702,000	$851,000	$0
CAGES	NATIONAL	$1,868,848	$1,889,600	$2,449,920	$3,082,560
	TOTALS	$132,618,392	$161,078,539	$191,879,946	$228,485,033
NATIONAL STRATEGIC STORAGE - GOR PORTION		$60,090,000	$67,878,000	$80,809,000	$99,892,000
COST OF THE LPG IN THE RESERVE (private sectoe+GOR)		$20,818,596	$26,323,857	$31,800,863	$37,136,704
430 $/T					
OPTION 1 GRAND TOTAL		$213,526,988	$255,280,396	$304,489,809	$365,513,736

Table 73. Total investment requirement to 2030 by scenario under strategic storage Option 2 (ISS)

INVESTMENT REQUIREMENT		BAU	Low	High	NST-1
CYLINDERS	NATIONAL	$41,453,116	$56,522,761	$73,111,264	$96,998,654
FILLING PLANTS	KIGALI	$9,839,500	$9,460,000	$9,918,400	$9,932,300
	SOUTHERN	$8,437,100	$8,750,400	$9,330,500	$9,870,600
	WESTERN	$8,832,100	$9,426,650	$9,652,300	$10,265,400
	NORTHERN	$8,646,600	$9,108,500	$9,889,200	$10,065,800
	EASTERN	$8,621,800	$8,904,400	$9,561,200	$10,262,600
	TOTAL	$44,377,100	$45,649,950	$48,351,600	$50,396,700
	Palettization in Filling plant	$5,101,000	$5,195,000	$5,790,000	$6,270,000
	Palets in the logistic network	$1,575,147	$2,119,093	$2,699,805	$3,359,994
	TOTAL	$6,676,147	$7,314,093	$8,489,805	$9,629,994
STRATEGIC STORAGE	PRIVATE SECTOR PORTION				
BULK PRIMARY TRANSPORT	NATIONAL	$21,295,981	$28,650,135	$36,501,357	$45,427,124
CYLINDER PRIMARY TRANSPORT	NATIONAL	$1,872,200	$1,702,000	$851,000	$0
CAGES	NATIONAL	$1,868,848	$1,889,600	$2,449,920	$3,082,560
	TOTALS	$117,543,392	$141,728,539	$169,754,946	$205,535,033
NATIONAL STRATEGIC STORAGE - GOR PORTION		$42,488,000	$49,492,000	$52,890,000	$72,278,000
COST OF THE LPG IN THE RESERVE (GOR)		$12,165,689	$15,319,960	$17,028,244	$20,351,662
OPTION 2 GRAND TOTAL		$172,197,081	$206,540,499	$239,673,190	$298,164,695

As is readily apparent from the above tables, Option 2 saves Rwanda almost US $70 million, a roughly 15% reduction of the total investment requirement, under the NST-1 Target scenario. The amount saved is about US $50 million in the Low case and US $65 million in the High case.

In these tables, the following types of entity are associated with each category of asset investment:

Table 74. Mapping of asset categories to investing entity types

Cylinders	Marketers (with partial asset financing by the consumer via cylinder deposits)
Filling plants and associated storage	Marketers having filling plants
Private sector strategic storage	Marketers having filling plants, if required
Bulk primary transport	Marketers or independent bulk transport firms
Cylinder primary transport	Marketers who self-distribute, or Distributors
Cages	Marketers, Distributors and Retailers, based on location

Analytic methodology

The detailed financing analysis and resulting recommendations for sector bankability are based on:

1. Operational and asset data for the LPG supply chain modalities:
    a. Importers;
    b. LPG Marketers with and without filling facilities;
    c. Distribution channel designs and the associated players; and
    d. Costs and margins associated with each node and task along the full supply chain;
2. Analysis of the financial and economic details of the existing LPG value chain in Rwanda
    a. Using Rwandan data where available; and
    b. Applying industry standard benchmarks and ratios from other East African and SSA countries where not;
3. Sizing of the optimal supply-side infrastructure and assets needed over time, according to each scenario of future demand (see Volume 4);
4. The sizing, costing and deployment strategy of the assets over time to serve the projected demand under each scenario (see Volume 4);
5. The economic effects of the Option 1 and Option 2 approaches to strategic storage reserve policy requirements;
6. International commodity prices and forex over time;
7. Business model and operational tradeoffs Marketers must make, between preserving margins (and liquidity) on the one hand and moderating increases in retail prices as import costs rise and modalities (such as storage investment, home delivery) are imposed on the other hand;
8. The operators' strategies, managerial skills and capital resources;
9. The optimal mix of owner equity, commercial capital/loans, and donor/concessional capital in the capital stack;
10. Best practices in regulatory policy, safety and operational planning (see Volume 3); and
11. Economic/financial simulations and stress-testing (e.g., of returns, of debt coverage) based on the foregoing factors under the Low, High and NST-1 demand scenarios.

High-level conclusions

Based on the detailed analysis and discussion which follows, it is concluded that the major Rwanda LPG companies and modalities' operations, under the conditions outlined further below, represent a sound financial and operational case for financing for rapid growth using blended financing structures.

The second tier companies, including Marketers without the ability to own and operate industrial-grade filling facilities, may also be good financing cases, but have three main issues:

1. Quantum of investment may be too small for most funders (although an SPV or NBFI vehicle could address this, as outlined in the next Chapter);
2. The main asset for investment is cylinders, which are much riskier than fixed assets like filling plants and bulk storage; larger, integrated companies with filling and storage assets thus represent a more bankable asset mix than larger, integrated firms (Industry Leader-class firms); and
3. Management and business planning capability may require enhancement in some cases.

Financeability is also predicated on other variables such as:

1. The development of an investment friendly LPG regulatory structure through the BCRM to help protect the investments;
2. Government policy and communications to encourage consumers to switch to LPG from biomass;
3. Alignment and structuring of the investments with the strategies and return and risk requirements of capital providers;
4. The maintenance of an LPG pricing environment that ensures adequate margins to operators, justifies investments, and justifies the outside financial commitments needed to generate funding for the asset investments;
5. Judicious use of risk-mitigating instruments and policies;
6. Sound business and financial plans by LPG Marketers to be funded;
7. Continued favorable operational cost economics; and
8. Availability of sufficient, accommodative blended financing terms (costs of funding, returns, tenors, and structures).

52. Investment Requirements and Considerations at the Firm Level

Given that individual business plans from private sector players were not provided for analysis, an industry-level composite ("IndCo") model was developed as a starting point for analysis. The IndCo aggregates the economics of the entire sector. Thus, it represents an average firm in the sector, in a quantitative sense, scaled up to reflect 100% of the sector's assets and activities.

Excluded from IndCo are the activities of independent distributors and retailers, because these very numerous small enterprises by their nature would not be part of major financing transactions of the sector or of one or more Industry Leader firms.

Note that the recommended Industry Leader business strategy includes transitioning toward direct (in-house) distribution to retailer points to the extent possible; this is already an emerging trend amongst the current Rwanda industry leaders.

The investments needed sector-wide to grow the market according to any one of the Low, High and NST-1 demand scenarios are significant relative to the existing asset base and cash flow capability of the sector, and they will require sizable investment participation from private sector firms.

If the basic (and unlikely) assumption were made that each operator could provide its pro-rata participation in the required investments (based on RURA-supplied existing tonnage market share information from the end of 2019), the top 2-3 companies could only provide 50-60% of the capital needed to execute under NISS Option 1—and only if they are able to scale up their financing proportionate to the growth of consumption, which is not at all assured.

For purpose of analyzing an individual Industry Leader-type firm, IndCo was scaled down to reflect an "average" company with a 20% market share. (Of course, 20% is not the average market share; the 20% value is chosen to reflect what a leading, but not necessarily dominant, firm might have, and is a reasonable target for the quanta of capital required in the Industry Leader class of company.) This market Industry Leader of 20% market share is hereafter called "ProformaCo".

Although there are no PAYG LPG operators active in Rwanda today, there are several small-scale operators in Kenya and Tanzania that have been funded with (in most cases) concessional capital, and which have amassed a customer base in aggregate around 10,000 households. While this level of market acceptance is very far removed from the 1-2 million hoped to be transitioned to LPG in Rwanda, the PAYG model is of interest to some stakeholders because it targets a specific consumer barrier to LPG adoption in a way that conventional LPG distribution does not: namely, the size of the fuel purchase transaction.

But there are huge tradeoffs that must be made for the PAYG model to be bankable when used with LPG. To assess under what conditions PAYG LPG is (a) bankable and (b) price-competitive with conventionally distributed LPG on a monthly or annual basis—two goals that are presently in conflict—a variant of the ProformaCo was modelled in which ProformaCo operates as a pure PAYG company (PAYGCo).

(The 20% market share is used for PAYG, despite this being unrealistic based on the historical evidence of PAYG in the LPG market, in order to facilitate a straightforward comparison between ProformaCo and PAYGCo.)

A separate Chapter hereafter is devoted to the PAYGCo and its model.

ProformaCo is also referred to hereafter as investment Case A, and PAYGCo as investment Case B.

The fact that each gets a "Case" does not make them equally deserving of capitalization, nor of equal amounts of capitalization.

The following sections analyze the investment and funding needs of IndCo, ProformaCo, and PAYGCo. All three are also subjected to sensitivity and stress tests across all three demand scenarios (Low, High, NST-1).

Total and net capital requirements under Option 1 (NISS)

Under Option 1/NISS, the next set of tables shows the levels of overall capitalization (total asset value of investments) and then the share of debt and equity that would be needed. These tables do not yet take into account that the consumers would fund (that is, reimburse) a large portion of the cylinder requirement. A set of following tables shows the effect of the consumer deposits on the financing requirement.

Table 75. Investment requirements to 2030 by firms' market share and scenario (NISS)

		Investment Capital Requirements *		
		Low	High	NST-1
Company	*2019 Mkt Shares*	*$228,956,539*	*$272,688,946*	*$328,377,033*
1	*33.0%*	$75,659,113	$90,110,568	$108,512,800
2	*23.3%*	$53,392,267	$63,590,589	$76,576,954
3	*15.5%*	$35,571,720	$42,366,184	$51,018,136
4	*12.4%*	$28,355,343	$33,771,425	$40,668,170
5	*6.9%*	$15,888,712	$18,923,574	$22,788,116
6	*3.9%*	$8,936,362	$10,643,274	$12,816,826
7	*1.6%*	$3,676,046	$4,378,198	$5,272,306
8	*1.4%*	$3,282,054	$3,908,951	$4,707,231
9	*1.0%*	$2,374,809	$2,828,416	$3,406,030
10	*0.8%*	$1,820,112	$2,167,767	$2,610,465
	100.0%	*$228,956,539*	*$272,688,946*	*$328,377,033*

** Based on scenario investment capital needs and the market shares of the LPG Marketers.*

Based on benchmarked blended finance capitalization trends of a 75% debt to 25% equity ratio, Table 76 below shows the level of debt financing that each operator would be required to mobilize.

The basis of these assumptions are data from GLPGP research, conversations with DFIs and blended funding sources as to maximum comfort levels for debt to equity, and Convergence Blended Finance research as of 2019-20 on blended funding trends. This is discussed in Chapter 56 in the section titled *Structuring financing at the firm and project level* (see page 336).

Table 76. Gross debt requirements to 2030 by firms' market share and scenario (NISS)

		Debt Capitalization Requirements		
		Low	High	NST-1
Company	*% Debt*	*$228,956,539*	*$272,688,946*	*$328,377,033*
1	*75.0%*	$56,744,335	$67,582,926	$81,384,600
2	*75.0%*	$40,044,200	$47,692,942	$57,432,715
3	*75.0%*	$26,678,790	$31,774,638	$38,263,602
4	*75.0%*	$21,266,507	$25,328,569	$30,501,127
5	*75.0%*	$11,916,534	$14,192,681	$17,091,087
6	*75.0%*	$6,702,272	$7,982,456	$9,612,619
7	*75.0%*	$2,757,034	$3,283,648	$3,954,230
8	*75.0%*	$2,461,541	$2,931,713	$3,530,423
9	*75.0%*	$1,781,107	$2,121,312	$2,554,523
10	*75.0%*	$1,365,084	$1,625,825	$1,957,849
	Total Debt	*$171,717,404*	*$204,516,709*	*$246,282,775*

Below is the level of equity financing that each operator could be required to mobilize.

Table 77. Gross equity requirements to 2030 by firms' market share and scenario (NISS)

		Equity Capitalization Requirements		
		Low	High	NST-1
Company	*% Equity*	*$228,956,539*	*$272,688,946*	*$328,377,033*
1	*25.0%*	$18,914,778	$22,527,642	$27,128,200
2	*25.0%*	$13,348,067	$15,897,647	$19,144,238
3	*25.0%*	$8,892,930	$10,591,546	$12,754,534
4	*25.0%*	$7,088,836	$8,442,856	$10,167,042
5	*25.0%*	$3,972,178	$4,730,894	$5,697,029
6	*25.0%*	$2,234,091	$2,660,819	$3,204,206
7	*25.0%*	$919,011	$1,094,549	$1,318,077
8	*25.0%*	$820,514	$977,238	$1,176,808
9	*25.0%*	$593,702	$707,104	$851,508
10	*25.0%*	$455,028	$541,942	$652,616
	Total Equity	*$57,239,135*	*$68,172,236*	*$82,094,258*

The size of debt and equity financing requirements highlights the extent of the need for catalytic capital to enable the sector to invest at the firm-level, and build out the sector according to this Plan. That is precisely the sort of role that scaled blended capital can play.

The following three tables, again under Option 1, show the levels of required overall net capitalization—the total capitalization minus the contribution from consumer cylinder deposits—and then the debt and equity that would be needed. The key finding is that the mechanism of funding of cylinder inventory growth from consumer's deposits has a tremendous impact on the capital needs of, and indeed on the bankability of, Marketers.

Table 78. Net investment requirements to 2030 by firms' market share by scenario (NISS) (net of consumer cylinder deposits)

Company	2019 Mkt Shares	Investment Capital Requirements * Low	High	NST-1
		$193,548,407	$227,381,816	$264,717,595
1	33.0%	$63,958,430	$75,138,743	$87,476,420
2	23.3%	$45,135,152	$53,025,045	$61,731,683
3	15.5%	$30,070,553	$35,327,064	$41,127,719
4	12.4%	$23,970,189	$28,160,320	$32,784,205
5	6.9%	$13,431,522	$15,779,432	$18,370,393
6	3.9%	$7,554,354	$8,874,899	$10,332,146
7	1.6%	$3,107,545	$3,650,762	$4,250,212
8	1.4%	$2,774,485	$3,259,481	$3,794,683
9	1.0%	$2,007,545	$2,358,476	$2,745,734
10	0.8%	$1,538,632	$1,807,594	$2,104,398
	100.0%	$193,548,407	$227,381,816	$264,717,595

** Based on scenario investment capital needs and the market shares of the LPG Marketers.*

Table 79. Net debt requirements to 2030 by firms' market share and scenario (NISS) (net of consumer cylinder deposits)

Company	% Debt	Debt Capitalization Requirements Low	High	NST-1
		$193,548,407	$227,381,816	$264,717,595
1	75.0%	$47,968,823	$56,354,057	$65,607,315
2	75.0%	$33,851,364	$39,768,783	$46,298,763
3	75.0%	$22,552,915	$26,495,298	$30,845,789
4	75.0%	$17,977,642	$21,120,240	$24,588,154
5	75.0%	$10,073,642	$11,834,574	$13,777,795
6	75.0%	$5,665,765	$6,656,175	$7,749,109
7	75.0%	$2,330,659	$2,738,072	$3,187,659
8	75.0%	$2,080,863	$2,444,611	$2,846,012
9	75.0%	$1,505,659	$1,768,857	$2,059,301
10	75.0%	$1,153,974	$1,355,695	$1,578,299
	Total Debt	$145,161,305	$170,536,362	$198,538,196

Table 80. Net equity requirements to 2030 by firms' market share and scenario (NISS) (net of consumer cylinder deposits)

		Equity Capitalization Requirements		
		Low	High	NST-1
Company	*% Equity*	*$193,548,407*	*$227,381,816*	*$264,717,595*
1	*25.0%*	$15,989,608	$18,784,686	$21,869,105
2	*25.0%*	$11,283,788	$13,256,261	$15,432,921
3	*25.0%*	$7,517,638	$8,831,766	$10,281,930
4	*25.0%*	$5,992,547	$7,040,080	$8,196,051
5	*25.0%*	$3,357,881	$3,944,858	$4,592,598
6	*25.0%*	$1,888,588	$2,218,725	$2,583,036
7	*25.0%*	$776,886	$912,691	$1,062,553
8	*25.0%*	$693,621	$814,870	$948,671
9	*25.0%*	$501,886	$589,619	$686,434
10	*25.0%*	$384,658	$451,898	$526,100
	Total Equity	*$48,387,102*	*$56,845,454*	*$66,179,399*

Total and net capital requirements under Option 2 (ISS)

Pursuant to Option 2, the three tables below show the levels of gross overall capitalization (prior to cylinder deposits) and the associated the debt and equity needed under each demand scenario. After these three tables, the next three show the same analysis on a net basis.

Table 81. Investment requirements to 2030 by firms' market share by scenario (ISS)

		Investment Capital Requirements *		
		Low	High	NST-1
Company	*2019 Mkt Shares*	*$141,728,539*	*$169,754,946*	*$205,535,033*
1	*33.0%*	$46,834,459	$56,095,837	$67,919,433
2	*23.3%*	$33,050,849	$39,586,559	$47,930,413
3	*15.5%*	$22,019,585	$26,373,894	$31,932,849
4	*12.4%*	$17,552,507	$21,023,465	$25,454,684
5	*6.9%*	$9,835,421	$11,780,347	$14,263,349
6	*3.9%*	$5,531,782	$6,625,675	$8,022,202
7	*1.6%*	$2,275,544	$2,725,526	$3,299,998
8	*1.4%*	$2,031,655	$2,433,409	$2,946,311
9	*1.0%*	$1,470,053	$1,760,752	$2,131,874
10	*0.8%*	$1,126,685	$1,349,483	$1,633,921
	100.0%	*$141,728,539*	*$169,754,946*	*$205,535,033*

** Based on scenario investment capital needs and the market shares of the LPG Marketers.*

Table 82. Gross debt requirements to 2030 by firms' market share and scenario (ISS)

		Debt Capitalization Requirements		
		Low	High	NST-1
Company	*% Debt*	*$141,728,539*	*$169,754,946*	*$205,535,033*
1	*75.0%*	$35,125,844	$42,071,878	$50,939,575
2	*75.0%*	$24,788,137	$29,689,919	$35,947,810
3	*75.0%*	$16,514,689	$19,780,420	$23,949,637
4	*75.0%*	$13,164,380	$15,767,599	$19,091,013
5	*75.0%*	$7,376,566	$8,835,260	$10,697,511
6	*75.0%*	$4,148,836	$4,969,256	$6,016,651
7	*75.0%*	$1,706,658	$2,044,144	$2,474,999
8	*75.0%*	$1,523,741	$1,825,057	$2,209,733
9	*75.0%*	$1,102,540	$1,320,564	$1,598,906
10	*75.0%*	$845,014	$1,012,113	$1,225,440
	Total Debt	*$106,296,404*	*$127,316,209*	*$154,151,275*

Table 83. Gross equity requirements to 2030 by firms' market share and scenario (ISS)

		Equity Capitalization Requirements		
		Low	High	NST-1
Company	*% Equity*	*$141,728,539*	*$169,754,946*	*$205,535,033*
1	*25.0%*	$11,708,615	$14,023,959	$16,979,858
2	*25.0%*	$8,262,712	$9,896,640	$11,982,603
3	*25.0%*	$5,504,896	$6,593,473	$7,983,212
4	*25.0%*	$4,388,127	$5,255,866	$6,363,671
5	*25.0%*	$2,458,855	$2,945,087	$3,565,837
6	*25.0%*	$1,382,945	$1,656,419	$2,005,550
7	*25.0%*	$568,886	$681,381	$825,000
8	*25.0%*	$507,914	$608,352	$736,578
9	*25.0%*	$367,513	$440,188	$532,969
10	*25.0%*	$281,671	$337,371	$408,480
	Total Equity	*$35,432,135*	*$42,438,736*	*$51,383,758*

Under Option 2, the three tables below show the levels of LPG industry capitalization and then the debt and equity that would be needed, net of the effect of cylinder deposits.

Table 84. Net investment requirements to 2030 by firms' market share by scenario (ISS) (net of consumer cylinder deposits)

		Investment Capital Requirements *		
		Low	High	NST-1
Company	*2019 Mkt Shares*	*$106,320,407*	*$124,447,816*	*$141,875,595*
1	*33.0%*	$35,133,776	$41,124,012	$46,883,053
2	*23.3%*	$24,793,734	$29,021,015	$33,085,142
3	*15.5%*	$16,518,418	$19,334,774	$22,042,432
4	*12.4%*	$13,167,353	$15,412,360	$17,570,720
5	*6.9%*	$7,378,231	$8,636,205	$9,845,626
6	*3.9%*	$4,149,773	$4,857,301	$5,537,521
7	*1.6%*	$1,707,043	$1,998,090	$2,277,905
8	*1.4%*	$1,524,086	$1,783,939	$2,033,763
9	*1.0%*	$1,102,789	$1,290,812	$1,471,578
10	*0.8%*	$845,204	$989,310	$1,127,854
	100.0%	*$106,320,407*	*$124,447,816*	*$141,875,595*

** Based on scenario investment capital needs and the market shares of the LPG Marketers.*

Table 85. Net debt requirements to 2030 by firms' market share and scenario (ISS) (net of consumer cylinder deposits)

		Debt Capitalization Requirements		
		Low	High	NST-1
Company	*% Debt*	*$106,320,407*	*$124,447,816*	*$141,875,595*
1	*75.0%*	$26,350,332	$30,843,009	$35,162,290
2	*75.0%*	$18,595,301	$21,765,761	$24,813,857
3	*75.0%*	$12,388,813	$14,501,080	$16,531,824
4	*75.0%*	$9,875,515	$11,559,270	$13,178,040
5	*75.0%*	$5,533,674	$6,477,153	$7,384,219
6	*75.0%*	$3,112,330	$3,642,976	$4,153,141
7	*75.0%*	$1,280,282	$1,498,568	$1,708,428
8	*75.0%*	$1,143,064	$1,337,954	$1,525,322
9	*75.0%*	$827,092	$968,109	$1,103,684
10	*75.0%*	$633,903	$741,982	$845,890
	Total Debt	*$79,740,305*	*$93,335,862*	*$106,406,696*

Table 86. Net equity requirements to 2030 by firms' market share and scenario (ISS) (net of consumer cylinder deposits)

		Equity Capitalization Requirements		
		Low	High	NST-1
Company	*% Equity*	*$106,320,407*	*$124,447,816*	*$141,875,595*
1	*25.0%*	$8,783,444	$10,281,003	$11,720,763
2	*25.0%*	$6,198,434	$7,255,254	$8,271,286
3	*25.0%*	$4,129,604	$4,833,693	$5,510,608
4	*25.0%*	$3,291,838	$3,853,090	$4,392,680
5	*25.0%*	$1,844,558	$2,159,051	$2,461,406
6	*25.0%*	$1,037,443	$1,214,325	$1,384,380
7	*25.0%*	$426,761	$499,523	$569,476
8	*25.0%*	$381,021	$445,985	$508,441
9	*25.0%*	$275,697	$322,703	$367,895
10	*25.0%*	$211,301	$247,327	$281,963
	Total Equity	*$26,580,102*	*$31,111,954*	*$35,468,899*

➲ Based on LPG industry and financial sector discussions both in Rwanda and in East Africa, it is recommended that the financing needs be structured into three tranches, commencing in 2021, 2025, and 2029, respectively.

With respect to cylinders, these tranches would be revolvers. Doing this dramatically reduces the financial strain on the operators for financing their growth pursuant to the Plan. That is because cylinders are the major portion of the investments costs, and they become self-financing in future years through the receipt of cylinder deposits, as long as (i) at least 100% of the cylinder cost is covered by the deposit amount, as is presently the case, and (ii) the rate of growth in cylinder inventory is approximately linear year over year.

Where the rate of growth is exponential, the financing need is determined by the peak inventory growth period over the tranche, rather than the average or starting inventory growth.

As mentioned above, Option 2 requires less firm capitalization than Option 1, assuming that the private sector is required to pay only for the PSS portion of the total strategic reserve in the country.

Recommended institutional roles and structures for the categories of investments

➲ Cylinders: Fund the initial revolver tranche for cylinders to trigger immediate cylinder investments for the Plan.

This will stimulate the 2021 roll-out of the cylinders to begin the cycle of cylinder investment, deposits, and reinvestment. This is the top priority, because cylinders are critical to LPG penetration. Existing filling capacity could handle the initial cylinder surge through the addition of second shifts. DFIs, MDBs, impact investors, local banks, and possibly GoR resources as allocated from the Ministry of Finance should be considered to provide revolver cylinder financing.

➲ Filling Plants, Cages and Pallets: These fixed assets should be funded over longer windows such as 7 years and up. For purposes of analysis as part of this Plan, they are modelled at 7-year debt, since the tolerance of local banks would be tested beyond 7 years' exposure. This is where guarantees and on-lending facilities from organizations such as the AfDB, World Bank, KfW and other DFIs could make a major impact. They could provide concessional and blended project finance and other loans with longer maturities and/or deferred interest payments. This is particularly important because the size of the funding is considerably beyond the capabilities of the resources of the Rwanda banking sector on its own.

➲ Bulk and Cylinder Transport: These assets should also be funded at 7 years or longer terms. A benefit of these assets is that lease financing from suppliers may be possible. However, since these assets would be exported to Rwanda, dealers are likely to want outright sales to the buying companies. Therefore, funding will also need to be longer term debt.

Cylinder revolver

➲ To facilitate firm level access to capital, a two-tiered approach from supportive institutions such as KfW is recommended, to catalyze outside capital. The tier difference is in the size of incremental cylinder financing. Local banks plus DFIs such as KfW could serve as lead funders. The smaller size of the aggregate needs for debt and equity for cylinders also means that the impact of each increment of capital is more pronounced. Additionally, this structure helps local banks get comfortable with cylinder financing, because as cash is deposited by an operator based on consumer deposits on cylinders, the bank could then repay itself and issue a next draw for funding the next wave of new cylinders.

A reference can be taken from the FMO-led investment in LPG in Bangladesh. In this situation, FMO deployed approximately US $20M of debt and equity. This then catalyzed approximately US $60M from other sources. (The Bangladesh “Industry Leader” firm was Omera.)

LPG Non-Bank Financial Institution (NBFI) and SPV

➲ An LPG-NBFI is recommended to be established to aggregate transactions, LPG sector financing expertise (such as from GLPGP[82] and increasingly from Rwanda), and structure investments and lending to LPG sector entities and modalities in Rwanda. To establish an LPG-NBFI, one or more DFI co-funders could provide the budget-allocated expenses of approximately $1.5M to $3M for design, administrative set-up, operating resources, and implementation of operations of the NBFI. Thereafter, the ongoing operational budget would approximate $1M to $1.5M depending on design of operations – for example if it is co-housed in an existing bank like BRD. The LPG sector would pay borrowing and commitment fees that would cover a portion of the on-going costs of the NBFI.

➲ The LPG funding/NBFI institution can also be funded or co-funded through a special-purpose vehicle (SPV) that would allow a variety of blended funding providers to participate in appropriately structured tranches. For example, infrastructure has a particular grouping of investors in the international blended funding, commercial and impact communities. Likewise, providers of guarantees could back-stop some of the risks of the SPV for domestic funders.

---

[82] GLPGP personnel have designed successful blended capital deployment mechanisms in sectors such as banking, SMEs and MSEs, healthcare, and agri-business in Africa and Latin America. NBFIs for LPG have been proposed for several countries but none has been put into force as of this writing.

This is an area where an LPG-focused SPV or non-bank financial institution could be established to facilitate the assessment, underwriting, deployment, risk management, and administration of the cylinder financing window. This could be linked to the World Bank's efforts with BRD to fund clean energy. GLPGP has structured both SPVs and NBFIs to mobilize DFI on-lending to specific sector and initiatives.

53. Pro-forma Firm-Level Financial Analysis

The following are the detailed projected financial analyses of the variations of the sector-level composite IndCo and then the pro-forma LPG Industry Leader firm ProformaCo. *Case A* is based on the current, widespread distribution model in Rwanda (and most of the world), and *Case B* examines the PAYG approach. The analysis is performed under the Low, High and NST-1 Target scenarios. The analytic approach is to establish the operating profiles under the various industry growth scenarios, quantify the related investments as noted in this Plan, and then match these with the possible appropriately-structured funding and risk mitigation sources. The scenarios are therefore stress-tested for their ability to provide the cashflows to service debt and to provide appropriate returns to equity.

A major part of the sensitivity analysis is the assumption of the operating structure of each case of IndCo or the ProformaCo. An important choice is the type of distribution, as this has tremendous variations on cost structures. These are noted in the section *Key Assumptions*.

About ProformaCo

A. *Business Model:* The ProformaCo variants in this Chapter are intentionally structured as vertically integrated LPG Marketers with investment in cylinders, filling plants, bulk and cylinder transportation, pallets and cages. ProformaCo would also transition to import using its own fleet of bulk transport trucks, as that in-house fleet is built up. The usage of third-party fleets from Kenya and Tanzania can cost approximately US $180/tonne versus US $160-165/tonne when done in house. In addition, the investment in vehicles becomes more justifiable as LPG Marketers perceive that their business upside and scale potential justifies such investments. The model was stress tested according to different distribution modalities, such as direct retail, independent distribution, and home delivery.

B. *Industry Macro Components:* ProformaCo is also analyzed according to each demand scenario (Low, High, and NST-1). As expected, the larger the demand growth assumptions, the more intense the asset investments side to meet this demand, the lower the financial return, and the higher the debt service requirement.

C. *Core Assets Investment Programme:* The asset investment levels and timing were analyzed for the three demand scenarios. The net financing need for cylinders is modelled based on the peak growth year in each tranche, which represents the highest amount to be drawn down from a revolver as described above. The other assets are financed from multi-year debt obtained at the start of each tranche, sized to the investment budget. That is, for these other assets, the gross financing and net financing needs are the same.

D. *The GoR Strategic Storage Investment Programme:* ProformaCo was also analyzed at various levels of contribution to PSS and NSS storage facilities and reserves.

E. *The Bankability of ProformaCo's Projects:* ProformaCo's operational capacity was analyzed with respect to the forecasted supply-side asset commitments outlined herein and requirements of an optimized blended funding capital stack across each tranche. This was done using the the projected operational results of the asset roll-out and calculating the required returns and prospective covenants for various capital providers.

The findings from these analyses lead directly to recommendations for structuring and mobilizing the needed funding, plus technical assistance and related risk-mitigation options.

Developing industry business cases

For any of the actual LPG operators' profiles to be appropriately modelled out case by case for funding and for other investment support, further data will need to be collected and models built around their specific details. Possibly, technical assistance from the donor community, GLPGP, and/or other resources could assist qualified individual operators where needed to do this to the standards and requirements of prospective institutional funding sources. As previously mentioned, most of the major financing for the Rwanda LPG sector to date has come from internal, or affiliated, sources, rather than from financial sector institutions.

Key Assumptions

Understandably, LPG operators do not want their proprietary operating or financial information in the public domain, and therefore little such information was disclosed to contribute to the analysis here. Some provided cylinder counts and tonnage volumes. With RURA assistance, certain tonnage level information was obtained for 2015 through mid-July, 2020. These data were combined and interpolated to create the IndCo composite and, in turn, the ProformaCo Industry Leader example company.

The following detailed industry and financial analysis is thus based on the most relevant data and modeling assumptions available as of this writing. For modeling, the route was taken of building the most operationally realistic composite profile of the LPG supply chain from 2021 to 2030.

A key concern for bankability is that ProformaCo (and any variant of it) demonstrate its bankability and economic sustainability, which includes being capable of servicing debt (interest and principal payments) and generating adequate, risk-adjusted returns to equity. Possibly, insurability of its assets and operations may be a requirement for certain capital providers.

The role of strategic storage reserves is important in that respect. If a firm must invest in some level of strategic storage under a national scheme to insure physically against national supply shocks, but that firm never actually sells the reserve fuel, its economic performance is significantly degraded. The analysis therefore explores the GoR policy directive that LPG (as other petroleum products) have a 90-day reserve supply on hand in addition to the operational and logistical volumes normally present in the value chain. As mentioned earlier in the Plan, the amount of fuel in the normal supply chain is very large, proportionally, compared to the amount of fuel in the supply chains of other petroleum products. This creates the opportunity to have a more nuanced, better optimized approach to protecting against possible supply shocks.

Accordingly, the Option 2 (ISS) recommendation has been made to avoid the liquidity and profitability impacts to the sector from the policy as originally conceived, and the possibility of large LPG retail price increases to offset those impacts, while preserving the insurance function that the policy intends.

The analysis examined a range of cases for IndCo and ProformaCo, from Option 2 with no need for extra private sector storage investment to "fully burdened" Option 1, in which industry must cover the costs of both the PSS and the NSS, and various steps in between these two cases.

A number of remaining assumptions affect firm and sector economics. Based on the modelling, six of them are potentially significant.

1. Distribution network strategy. The main distribution strategies now utilized in Rwanda were modelled, in various combinations. The choice of distribution mode(s) has a material effect on firm profitability—and on whether consumers adopt LPG more quickly, or less quickly; that is, on whether

the market grows more quickly or more slowly. The_modalities in Rwanda comprise six viable options, per discussions with multiple Rwanda LPG Marketers. The choice of distribution channel can affect the price (or cost) to the end consumer, the revenue per tonne to the Marketer, the Marketer's operating expense level, and the rotation rate of the cylinder, and (to an extent) the nature, and cost, of marketing activities (communications, sales promotions, etc.) the Marketer undertakes.

The modalities are (i) in-house distribution to independent retailer; (ii) in-house distribution to an owned retail point; (iii) independent distribution to an independent retailer; (iv) independent distribution to an owned retail point; (v) in-house distribution to an independent retailer plus home delivery; (vi) independent distribution to an independent retailer plus home delivery; and (vii) PAYG with home delivery. Most commonly, an owned retail point means a petrol service station.

Each modality has its own revenue structure and cost structure as seen by the Marketer (although the cost structures overlap one another in some respects, and share elements in common among some of them). The projected 2021 revenue to the Marketer was projected to be US $1,031 per MT for owned retail points, US $933 for in-house distribution to independent retailers, US $837 for independent distribution, and $1,751 for PAYG LPG (based on the experience of the 2019 PAYG LPG pilot programme in Rwanda). The PAYG case was also modelled to determine whether a lower end-user price could be economically feasible for a PAYG operator. This is discussed later in this Part.

Distribution costs range from US $20 to $48 per tonne based on the modality, with the home delivery cases being at the high end of that range.

Because of the powerful demand-stimulating effect of home delivery, as discussed in Part VI, the Industry Leader has been modelled on the basis that it will maximize home delivery and absorb the cost thereof.

The cost structure for the sector players is taken Table 25 in Volume 2 (see page 97) and was projected forward in each year to reflect the effects of changes in Saudi CP (the USD-denominated commodity index price for imported LPG) and in RfW vs. USD forex.

2. Revenues. Revenue forecasts were based on the actual retail pricing in Rwanda in 2020 as collected from operators and RURA, and forecasted annually to 2030 to reflect a pricing strategy that Marketers would always increase prices just enough to cover increases in costs, thereby preserving their unit margins. (This is a normal practice in the LPG industry worldwide, when prices are not regulated.) It was assumed for analysis purposes that prices would be free of any regulatory cap. On this basis, revenue per tonne from owned retail points grows from $1,031 per tonne in 2021 to $1,312 in 2030. The revenues in the other modalities evolve proportionately.

3. Cost of Goods. The main component is the cost of the LPG fuel, as delivered to the filling plant gate. (For Marketers without filling plants, a hosted filling fee is applied.)

   As Rwanda presently has a low LPG penetration and is a young LPG market, the "best practices" of LPG marketing and bottling companies in established East Africa and SSA markets were adapted to model operational expenses, adjusted for early-experience risk. The largest operational cost per tonne is labour. In filling plants, this component would need to be brought to the efficiency levels of established LPG companies in established markets. Non-personnel costs per tonne include line items such as utilities and other support resources. For the ProformaCo analysis, an integrated LPG Marketing company with owned bottling (filling) capacity (LMC-B) is assumed to bear a set of internal filling-related costs and make investments in filling assets. A Marketer that outsources bottling (LMC-

O) avoids the capex but pays a hospitality charge to another Marketer (and LMC-B) that fills the LMC-O's cylinders under a hospitality agreement.

4. Forex. The ongoing supply of imported LPG and imported fixed assets are generally denominated in USD, and some or all of the expected debt financing will be in USD. The analysis distinguished between hard foreign currency-based costs and local currency-based costs in order to stress-test margins and financial returns based on forex projections. and also their ability to cover hard capital-based asset investment and financing.

   The estimated forward FX rates of the Rwandan Franc as projected by the IMF and FX trading entities are shown below:

	2021	2025	2030
USD/RwF (Currency Appreciation/Deprec)		*10.82%*	*30.93%*
RwF/USD FX	1,028	1,399	2,245

   Consideration of currency risks was discussed with international financial institutions and currency risk hedging groups such as MFX. Mitigation of RwF risk was deemed by them to be "exotic currency hedging". There may be a likelihood of involving such institutions in the blended capital mix to mitigate repayment risk due to currency fluctuations. The predominance of hard currency-indexed LPG costs and the currency impact of lowering local currency operating expenses—such as labor and operating expenses in filling—appear to weigh favorably for LPG operators in the projections.

   The operating expenses of bottling LPG and distribution within Rwanda (filling, labor, distribution, marketing) are often in local currency. For this work, much of the Rwanda-based costs are in local currency. In addition to these operating expenses, the research team have been informed through local diligence with operators, that the mark-ups on the distribution channel should be assumed to be indexed in USD as traders and others involved in the importation and distribution of LPG will want to maintain their USD margins.

5. Other opex. Such costs include:
   a. Cost build-up elements between Saudi CP and landed cost at the filling plant gate.
   b. Filling-related costs.
   c. Distribution costs as described above.
6. Depreciation. Industry conventions of 12 years for cylinders and 15 years for plant, transportation and related equipment such as pallets and cages were used.
7. Corporate income taxes. Rwanda's marginal corporate tax rate is 30%, as reported by the World Bank and BNR. For modelling the ProformaCo, the taxes are assumed to be activated when there are profits before taxes. No tax loss carry-forwards were assumed, as this would be speculative given that the GoR may consider to provide LPG infrastructure-related tax incentives such as tax holidays during the early years of the sector expansion (and as recommended in this Plan).

Below is a summary table of key opex cost assumptions used in the analysis. These values are best estimates based on interviews with operators in Rwanda but are also, importantly, evidenced in, and comparable with, other, well-established SSA and East Africa LPG markets, adjusted for Rwanda's present scale and relevant geographic and other factors.

Table 87. Schedule of LMC Opex modelling assumptions

Schedule for Op Ex Calculations (per MT)	*LMC-B*	*LMC-O*	*PAYG*
Personnel costs (RwF to USD-equiv. .cost)	$20	$20 - $25	$20 - $25
Non-personnel operating costs (RwF to USD-equiv. cost)	$15	$15	$15
PAYG-specific opex (RwF to USD-equiv. costs)			$20
External (hosted) filling costs		$8 - $10	$8 - $10
In-house filling costs	$6		
Cylinder distribution costs	$24	$24	$49
Marketing/advertising costs (as % of gross margin)	5%	5%	5%

Financial, Investment and Blended Funding Analysis

Once the operating and financial flows are established, the next step is to ascertain the bankability of the investment scenarios, based on:

Size: Quantum and structure of capital required;

Capital Sourcing: Potential blended capital sources and availability (domestic and foreign);

Terms: Likely funding terms (amounts, costs, hurdle rates, collateral, payback timelines);

Capitalization Mixes: The structures and supportable mixes of debt and equity in the blended capitalization;

Projected Financial Returns: The established financial returns available to potential debt and equity providers;

Risk-Mitigation: The ability to de-risk such capital via mitigation sources; and

Recommendations: Prioritization of the types of blended capital that could be realistically approached to support the supply-chain build-out at the ProformaCo level. Ideally this same analysis can be applied to the individual integrated LPG Marketers based on market share information to assess their possible bankability. As of present, further industry and company-specific analysis can be conducted once management teams provide more information.

Under Option 2, the following is an example of the detailed financial projections under the NST-1 Target scenario, on a "net financing" basis (i.e., consumer cylinder deposits help to fund increases in cylinder inventories). The first investment flow below shows cylinder costs if financed each year vs. raising a single revolving financing facility in each multi-year tranche to finance the peak funding need in each tranche.

Table 88. Net firm-level financing needs by year and tranche, NST-1 Target case (net of consumer cylinder deposits)

Entity's Market Share:	100%
Demand Scenario:	NST1
Cylinder Tranche Funding Type:	*Highest*

	Tranche 1				*Tranche 2*				*Tranche 3*		
(USD 000's)	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**Totals**
Total New Cyl Costs	$8,161	$13,629	$19,705	$19,823	$5,539	$4,215	$6,299	$5,267	$7,217	$7,143	$0
Net Financed Costs	*$19,823*	*$0*	*$0*	*$0*	*$6,299*	*$0*	*$0*	*$0*	*$7,217*	*$0*	*$33,339*
Bottling Plant & Pallets	$22,519	$28,649	$794	$1,301	$2,793	$368	$1,459	$1,144	$679	$320	$60,027
Bulk & Cylinder Transportation	$0	$6,225	$9,118	$8,856	$3,054	$2,504	$3,712	$3,243	$4,390	$4,325	$45,427
Cages	$0	$475	$680	$689	$187	$134	$226	$181	$263	$249	$3,083
Private Sector Storage	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
National Strat Storage	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	$42,342	$35,349	$10,593	$10,847	$12,333	$3,006	$5,397	$4,567	$12,548	$4,894	$141,876

The line items above are, for clarity:

- Total New Cylinder Costs are the investments expected each year in cylinders.
- Net Financed Costs (cylinders) is the amount representing the peak amount of cylinder financing and investment that will be needed in any one tranche, since the growth in cylinders in each tranche is largely self-funding once consumer deposits are received.
- Bottling Plant and Plant Pallets are the filling and holding infrastructure.
- Bulk and Cylinder Transportation are the bulk LPG volume and the smaller transportation of LPG in cylinders.
- Cages are cylinder related.
- Private Sector Storage (PSS) and National Strategic Storage (NSS) are the additional investments made by the private sector and the GoR in LPG storage capacity. The PSS and NSS amounts above reflect the Option 2 approach.

The overall results for the Low, High, and NST-1 under Option 2 are captured below.

Table 89. Firm-level investment performance results under Option 2 (ISS), by scenario

A) NST-1 Target case

Macro Demand and Operator Scenario Assumptions				Additional Storage Investment		Fiscal Assumption
Demand Growth Scenario	Operator Type 1	Paygo Offered	Distrib Channel 2	Additional Private Sector Strategic Storage Investment	GoR National Storage Ownership	Tax Rate to LPG Cos
NST1	LMCB	No	Ind Rtlr to Home	None	0%	30%

Cylinder Financing	Equity Returns	Capitalization Ratios 3		Leverage Ratios		Debt Service Ratios	
Cylinder Funding Approach	IRR	Equity/Capital	Debt/Capital	Max Debt/EBITDA	Avg Debt/Avg EBITDA	Avg EBITDA/Avg Debt Svc	Min EBITDA/Debt Svc
Net Financing	27.48%	25%	75%	14.0x	3.0x	2.6x	0.5x

1) LMCB = Marketer with filling capacity. Fully integrated. 2) See MP distribution table for definitions. 3) Capital = Debt+Equity.

B) High Case

Macro Demand and Operator Scenario Assumptions				Additional Storage Investment		Fiscal Assumption
Demand Growth Scenario	Operator Type 1	Paygo Offered	Distrib Channel 2	Additional Private Sector Strategic Storage Investment	GoR National Storage Ownership	Tax Rate to LPG Cos
High	LMCB	No	Ind Rtlr to Home	None	0%	30%

Cylinder Financing	Equity Returns	Capitalization Ratios 3		Leverage Ratios		Debt Service Ratios	
Cylinder Funding Approach	IRR	Equity/Capital	Debt/Capital	Max Debt/EBITDA	Avg Debt/Avg EBITDA	Avg EBITDA/Avg Debt Svc	Min EBITDA/Debt Svc
Net Financing	37.62%	25%	75%	12.5x	2.6x	1.7x	0.8x

1) LMCB = Marketer with filling capacity. Fully integrated. 2) See MP distribution table for definitions. 3) Capital = Debt+Equity.

C) Low Case

Macro Demand and Operator Scenario Assumptions				Additional Storage Investment		Fiscal Assumption
Demand Growth Scenario	Operator Type 1	Paygo Offered	Distrib Channel 2	Additional Private Sector Strategic Storage Investment	GoR National Storage Ownership	Tax Rate to LPG Cos
Low	LMCB	No	Ind Rtlr to Home	None	0%	30%

Cylinder Financing	Equity Returns	Capitalization Ratios 3		Leverage Ratios		Debt Service Ratios	
Cylinder Funding Approach	IRR	Equity/Capital	Debt/Capital	Max Debt/EBITDA	Avg Debt/Avg EBITDA	Avg EBITDA/Avg Debt Svc	Min EBITDA/Debt Svc
Net Financing	37.78%	25%	75%	11.5x	2.5x	1.7x	0.8x

1) LMCB = Marketer with filling capacity. Fully integrated. 2) See MP distribution table for definitions. 3) Capital = Debt+Equity.

Of note is that while the NST-1 case generates more total EBITDA than the High case, the leverage is higher in NST-1 than in High, so the debt service ratios in NST-1 are less favorable. That is, the faster the growth rate, the more challenging it is for the ProformaCo to cover its debt service obligations. (This argues for maximizing the use of concessional capital as a tool to support faster sector growth.)

In addition, while NST-1 has better overall average EBITDA/average debt service ratio than the High case, the minimum of that ratio (that is, the ratio applicable to the year of greatest financial stress on the firm) is better for the High case than NST-1. The reason is that the amount of leverage is higher in NST-1 than in the High case due to the way NST-1 accelerates investment.

For equity investors, the returns are higher in the High case than in the NST-1. This would be also the same perspective the private sector operators would take.

For the Low case, the debt service ratios are rounded and therefore appear to be the same as the High case, but in fact are slightly different.

The tables below show, for IndCo (representing the entire sector), a pro-forma income statement for each growth scenario.

Table 90. Sector-level income statements by year, by scenario, ISS

A) NST-1 Target case

Entity's Market Share:	100%
Demand Scenario:	NST1
Cylinder Tranche Funding Type:	Highest

FINANCIAL RESULTS

Income Statement (USD 000's)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Totals
Filling Revenues	$42,383	$75,970	$122,010	$165,762	$184,285	$211,066	$226,869	$248,274	$273,977	$299,616	$1,850,211
Filling Costs	$32,496	$59,348	$95,140	$129,411	$144,906	$169,133	$181,287	$199,281	$220,674	$242,040	$1,473,715
Gross Margins	$9,886	$16,622	$26,870	$36,351	$39,378	$41,934	$45,583	$48,993	$53,303	$57,576	$376,497
OpEx	$4,563	$7,153	$10,624	$13,660	$13,353	$13,966	$13,093	$14,359	$14,693	$12,121	$117,585
EBITDA	$5,324	$9,470	$16,246	$22,691	$26,026	$27,968	$32,490	$34,634	$38,610	$45,454	$258,912
Depreciation & Amort	$7,606	$8,742	$10,384	$12,036	$13,764	$14,116	$14,641	$15,080	$16,363	$16,958	$129,688
EBIT	($2,282)	$728	$5,862	$10,655	$12,261	$13,852	$17,849	$19,555	$22,247	$28,496	$129,224
Interest	$7,584	$6,961	$5,715	$4,469	$4,191	$3,939	$2,744	$1,549	$1,454	$1,631	$40,238
Profit Before Taxes	($9,866)	($6,233)	$147	$6,186	$8,070	$9,913	$15,106	$18,006	$20,793	$26,865	$88,986
Taxes	$0	$0	$44	$1,856	$2,421	$2,974	$4,532	$5,402	$6,238	$8,059	$31,526
Net Income	($9,866)	($6,233)	$103	$4,330	$5,649	$6,939	$10,574	$12,604	$14,555	$18,805	$57,460

(USD 000's)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Totals
Debt Service Ratios											
Total Principal	$0	($12,214)	($12,214)	($12,214)	($12,214)	($11,714)	($11,714)	($11,714)	($3,217)	($6,397)	($93,613)
Total Interest	($7,584)	($6,961)	($5,715)	($4,469)	($4,191)	($3,939)	($2,744)	($1,549)	($1,454)	($1,631)	($40,238)
Total Debt Service	($7,584)	($19,175)	($17,929)	($16,683)	($16,405)	($15,653)	($14,458)	($13,263)	($4,672)	($8,028)	($133,851)
EBITDA	$5,324	$9,470	$16,246	$22,691	$26,026	$27,968	$32,490	$34,634	$38,610	$45,454	
EBITDA to Debt Service	0.70x	0.49x	0.91x	1.36x	1.59x	1.79x	2.25x	2.61x	8.26x	5.66x	

Min Coverage	0.49x
Average Coverage	2.56x

B) High case

Entity's Market Share:	100%
Demand Scenario:	High
Cylinder Tranche Funding Type:	*Highest*

FINANCIAL RESULTS

Income Statement *(USD 000's)*	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Totals
Filling Revenues	$33,053	$48,262	$67,427	$85,772	$103,039	$129,889	$149,538	$177,712	$209,894	$246,034	$1,250,621
Filling Costs	$25,343	$37,702	$52,578	$66,962	$81,021	$104,084	$119,493	$142,643	$169,058	$198,755	$997,640
Gross Margins	$7,710	$10,560	$14,849	$18,809	$22,018	$25,806	$30,045	$35,069	$40,836	$47,279	$252,981
OpEx	$3,558	$4,544	$5,871	$7,068	$7,466	$8,594	$8,630	$10,278	$11,257	$9,954	$77,220
EBITDA	$4,152	$6,016	$8,978	$11,741	$14,552	$17,211	$21,415	$24,791	$29,579	$37,325	$175,761
Depreciation & Amort	$3,759	$4,095	$4,520	$4,965	$8,430	$9,057	$9,754	$10,562	$12,639	$13,703	$81,486
EBIT	$393	$1,921	$4,459	$6,776	$6,121	$8,154	$11,661	$14,229	$16,940	$23,622	$94,275
Interest	$3,144	$2,897	$2,404	$1,911	$3,472	$4,751	$3,694	$2,637	$2,910	$3,093	$30,916
Profit Before Taxes	($2,751)	($977)	$2,054	$4,864	$2,649	$3,403	$7,967	$11,592	$14,029	$20,529	$63,359
Taxes	$0	$0	$616	$1,459	$795	$1,021	$2,390	$3,477	$4,209	$6,159	$20,126
Net Income	($2,751)	($977)	$1,438	$3,405	$1,854	$2,382	$5,577	$8,114	$9,820	$14,370	$43,233

(USD 000's)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Totals
Debt Service Ratios											
Total Principal	$0	($4,832)	($4,832)	($4,832)	($4,832)	($10,361)	($10,361)	($10,361)	($6,531)	($12,130)	($69,075)
Total Interest	($3,144)	($2,897)	($2,404)	($1,911)	($3,472)	($4,751)	($3,694)	($2,637)	($2,910)	($3,093)	($30,916)
Total Debt Service	($3,144)	($7,730)	($7,237)	($6,744)	($8,305)	($15,112)	($14,055)	($12,998)	($9,442)	($15,224)	($99,991)
EBITDA	$4,152	$6,016	$8,978	$11,741	$14,552	$17,211	$21,415	$24,791	$29,579	$37,325	
EBITDA to Debt Service	1.32x	0.78x	1.24x	1.74x	1.75x	1.14x	1.52x	1.91x	3.13x	2.45x	

Min Coverage	0.78x
Average Coverage	1.70x

C) Low case

Entity's Market Share:	100%
Demand Scenario:	Low
Cylinder Tranche Funding Type:	*Highest*

FINANCIAL RESULTS

Income Statement *(USD 000's)*	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Totals
Filling Revenues	$32,232	$46,067	$63,477	$79,553	$93,481	$115,459	$131,146	$153,819	$178,531	$206,147	$1,099,911
Filling Costs	$24,713	$35,988	$49,498	$62,107	$73,506	$92,520	$104,796	$123,465	$143,797	$166,533	$876,922
Gross Margins	$7,519	$10,080	$13,980	$17,446	$19,975	$22,939	$26,350	$30,354	$34,734	$39,614	$222,989
OpEx	$3,470	$4,337	$5,527	$6,556	$6,773	$7,640	$7,568	$8,896	$9,575	$8,340	$68,683
EBITDA	$4,049	$5,742	$8,452	$10,890	$13,202	$15,299	$18,781	$21,458	$25,159	$31,274	$154,307
Depreciation & Amort	$3,508	$3,791	$4,144	$4,499	$7,619	$8,100	$8,652	$9,281	$10,748	$11,522	$71,865
EBIT	$540	$1,951	$4,309	$6,390	$5,583	$7,199	$10,130	$12,177	$14,412	$19,752	$82,442
Interest	$2,856	$2,635	$2,192	$1,748	$3,149	$4,295	$3,345	$2,396	$2,422	$2,437	$27,475
Profit Before Taxes	($2,316)	($683)	$2,117	$4,642	$2,434	$2,904	$6,784	$9,781	$11,989	$17,315	$54,967
Taxes	$0	$0	$635	$1,393	$730	$871	$2,035	$2,934	$3,597	$5,194	$17,390
Net Income	($2,316)	($683)	$1,482	$3,249	$1,704	$2,033	$4,749	$6,847	$8,392	$12,120	$37,578
(USD 000's)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Totals
Debt Service Ratios											
Total Principal	$0	($4,343)	($4,343)	($4,343)	($4,343)	($9,311)	($9,311)	($9,311)	($5,769)	($9,555)	($60,629)
Total Interest	($2,856)	($2,635)	($2,192)	($1,748)	($3,149)	($4,295)	($3,345)	($2,396)	($2,422)	($2,437)	($27,475)
Total Debt Service	($2,856)	($6,977)	($6,534)	($6,091)	($7,491)	($13,606)	($12,657)	($11,707)	($8,191)	($11,992)	($88,104)
EBITDA	$4,049	$5,742	$8,452	$10,890	$13,202	$15,299	$18,781	$21,458	$25,159	$31,274	
EBITDA to Debt Service	1.42x	0.82x	1.29x	1.79x	1.76x	1.12x	1.48x	1.83x	3.07x	2.61x	

Min Coverage	0.82x
Average Coverage	1.72x

➲ Based on the above data, the recommendation is to focus on financing of the High case, because it provides high LPG penetration by 2024 and 2030 without the pressure of lowering equity rates of return and with less credit requirement. Below is an analysis of the High case, under strategic storage Option 2 (ISS).

If demand does not develop along the High case trajectory, then the investments in each future year / tranche can be scaled back proportionally.

Table 91. Sector-level net financing requirements, by tranche, High case (ISS)

TRANCHES OF NET INVESTMENTS

Entity's Market Share:	**100%**
Demand Scenario:	**High**
Cylinder Tranche Funding Type:	*Highest*

Funding Tranches & Investment Type	***2021*** ***Tranche 1***	***2025*** ***Tranche 2***	***2029*** ***Tranche 3***	***Totals***
Total New Cylinder Costs	$5,346,975	$9,694,341	$12,762,817	$27,804,134
Bottling Plant & Pallets	$27,445,859	$26,096,086	$3,299,460	$56,841,405
Bulk & Cylinder Transportation	$7,797,846	$16,788,116	$12,766,395	$37,352,357
Cages	$502,400	$1,109,120	$838,400	$2,449,920
Private Sector Storage	$0	$0	$0	$0
National Strategic Storage	$0	$0	$0	$0
Total Investment Budget	***$41,093,080***	***$53,687,663***	***$29,667,072***	***$124,447,816***

**Difference in type of cylinder tranche funding accounts for the difference between Capitalization Chart and Investment Chart.*

Under Option 2, the scenario yields solid cash flows after servicing debt, and the returns to equity, at about 37%, are safely above the 20% benchmark sought by most emerging markets private equity funders.

Table 92. Sector-level IRR and cashflows by year, High case (ISS)

Cashlow Analysis (USD 000's)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Totals
Net Income	**($2,751)**	**($977)**	**$1,438**	**$3,405**	**$1,854**	**$2,382**	**$5,577**	**$8,114**	**$9,820**	**$14,370**	**$43,233**
+ Depreciation & Amort	$3,759	$4,095	$4,520	$4,965	$8,430	$9,057	$9,754	$10,562	$12,639	$13,703	$81,486
+ Non Cash Charges	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Free Cash Flow From Ops	**$1,008**	**$3,118**	**$5,958**	**$8,370**	**$10,285**	**$11,439**	**$15,331**	**$18,676**	**$22,460**	**$28,073**	**$124,719**
- Principal Debt Repayments	$0	$4,832	$4,832	$4,832	$4,832	$10,361	$10,361	$10,361	$6,531	$12,130	$69,075
Cash Flow After Debt Pmts	**$1,008**	**($1,714)**	**$1,125**	**$3,538**	**$5,452**	**$1,078**	**$4,970**	**$8,315**	**$15,929**	**$15,943**	**$55,644**
									Tax Adj EBITDA	$26,128	
									Terminal Mult	**5.0x**	
									Terminal Value	$130,639	
Less: Equity Fundings	$10,273				$13,422				$7,417		
Net FCF to Equity (Net of Inv)	($9,265)	($1,714)	$1,125	$3,538	($7,970)	$1,078	$4,970	$8,315	$8,512	$146,582	
IRR to all Equity Classes	37.62%										

Under Option 1, if (as an arbitrary choice for sake of example) GoR pays for 50% of the strategic storage requirements, the results change significantly. The net financing requirement rises by approximately $51M (+41%) and equity returns fall dramatically, to about 20%.

Table 93. Sector-level net financing requirements, by tranche, High case (ISS-NISS hybrid) (net of consumer cylinder deposits)

Entity's Market Share:	**100%**
Demand Scenario:	**High**
Cylinder Tranche Funding Type:	*Highest*

Funding Tranches & Investment Type	***2021 Tranche 1***	***2025 Tranche 2***	***2029 Tranche 3***	***Totals***
Total New Cylinder Costs	$5,346,975	$9,694,341	$12,762,817	$27,804,134
Bottling Plant & Pallets	$27,445,859	$26,096,086	$3,299,460	$56,841,405
Bulk & Cylinder Transportation	$7,797,846	$16,788,116	$12,766,395	$37,352,357
Cages	$502,400	$1,109,120	$838,400	$2,449,920
Private Sector Storage	$4,500,000	$5,831,250	$731,250	$11,062,500
National Strategic Storage	$17,742,000	$0	$22,662,500	$40,404,500
Total Investment Budget	***$63,335,080***	***$59,518,913***	***$53,060,822***	***$175,914,816***

**Difference in type of cylinder tranche funding accounts for the difference between Capitalization Chart and Investment Chart.*

Table 94. Sector-level IRR and cashflows by year, High case (ISS-NISS hybrid)

Cashlow Analysis	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Totals
(USD 000's)											
Net Income	**($5,936)**	**($4,040)**	**($766)**	**$1,601**	**($296)**	**$357**	**$3,766**	**$6,518**	**$6,636**	**$10,813**	**$18,654**
+ Depreciation & Amort	$5,242	$5,578	$6,003	$6,448	$10,302	$10,929	$11,626	$12,434	$16,071	$17,134	$101,766
+ Non Cash Charges	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Free Cash Flow From Ops	**($694)**	**$1,538**	**$5,237**	**$8,049**	**$10,006**	**$11,285**	**$15,392**	**$18,952**	**$22,707**	**$27,947**	**$120,420**
- Principal Debt Repayments	$0	$7,216	$7,216	$7,216	$7,216	$13,369	$13,369	$13,369	$7,156	$18,604	$94,729
Cash Flow After Debt Pmts	**($694)**	**($5,677)**	**($1,979)**	**$834**	**$2,790**	**($2,084)**	**$2,023**	**$5,583**	**$15,551**	**$9,343**	**$25,691**
									Tax Adj EBITDA	$26,128	
									Terminal Mult	**5.0x**	
									Terminal Value	$130,639	
Less: Equity Fundings	$15,834				$14,880				$13,265		
Net FCF to Equity (Net of Inv)	($16,527)	($5,677)	($1,979)	$834	($12,090)	($2,084)	$2,023	$5,583	$2,285	$139,982	
IRR to all Equity Classes	20.58%										

If 100% of the strategic storage is paid for by the private sector, the funding need for the scenario rises by approximately another US $52M and the IRR falls to about 10%, well below the level of commercial bankability.

Moreover, the cashflows after debt service are negative. This means that the debt cannot be amortized. In such a scenario, debt could not start to be repaid until 2028. Financial structuring would become much more complicated. A repayment moratorium could be discussed, but this then limits the capacity of domestic and external commercial sector funders to participate.

Table 95. Sector-level IRR and cashflows by year, High case (fully-burdened NISS)

Cashlow Analysis *(USD 000's)*	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Totals
Net Income	**($9,120)**	**($7,103)**	**($3,586)**	**($289)**	**($3,242)**	**($2,384)**	**$1,956**	**$4,922**	**$3,452**	**$7,255**	**($8,138)**
+ Depreciation & Amort	$6,725	$7,061	$7,485	$7,931	$12,174	$12,800	$13,497	$14,305	$19,502	$20,565	$122,045
+ Non Cash Charges	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Free Cash Flow From Ops	**($2,395)**	**($42)**	**$3,900**	**$7,642**	**$8,932**	**$10,416**	**$15,453**	**$19,227**	**$22,953**	**$27,821**	**$113,907**
- Principal Debt Repayments	$0	$9,599	$9,599	$9,599	$9,599	$16,377	$16,377	$16,377	$7,781	$25,077	$120,383
Cash Flow After Debt Pmts	**($2,395)**	**($9,640)**	**($5,699)**	**($1,957)**	**($667)**	**($5,961)**	**($924)**	**$2,851**	**$15,173**	**$2,744**	**($6,476)**
									Tax Adj EBITDA	$26,128	
									Terminal Mult	**5.0x**	
									Terminal Value	$130,639	
Less: Equity Fundings	$21,394				$16,338				$19,114		
Net FCF to Equity (Net of Inv)	($23,789)	($9,640)	($5,699)	($1,957)	($17,005)	($5,961)	($924)	$2,851	($3,941)	$133,383	
IRR to all Equity Classes	10.44%										

The foregoing table demonstrates the case for GoR paying for its strategic storage requirement.

A further analysis was performed to consider the case where the GoR chooses to fund the private sector's payment for strategic storage (under Option 1) through tax credits or similar mechanisms, rather than pay for it directly. As shown in the following table, even in the event that the GoR provides a tax holiday to the sector (i.e., to participating firms), the cashflow situation is unviable for the private sector.

Table 96. Sector-level IRR and cashflows by year, High case (NISS and tax holiday)

Cashlow Analysis *(USD 000's)*	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Totals
Net Income	**($9,120)**	**($7,103)**	**($3,586)**	**($289)**	**($3,242)**	**($2,384)**	**$2,794**	**$7,032**	**$4,931**	**$10,365**	**($602)**
+ Depreciation & Amort	$6,725	$7,061	$7,485	$7,931	$12,174	$12,800	$13,497	$14,305	$19,502	$20,565	$122,045
+ Non Cash Charges	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Free Cash Flow From Ops	**($2,395)**	**($42)**	**$3,900**	**$7,642**	**$8,932**	**$10,416**	**$16,291**	**$21,337**	**$24,433**	**$30,930**	**$121,444**
- Principal Debt Repayments	$0	$9,599	$9,599	$9,599	$9,599	$16,377	$16,377	$16,377	$7,781	$25,077	$120,383
Cash Flow After Debt Pmts	**($2,395)**	**($9,640)**	**($5,699)**	**($1,957)**	**($667)**	**($5,961)**	**($86)**	**$4,960**	**$16,652**	**$5,854**	**$1,061**
									Tax Adj EBITDA	$37,325	
									Terminal Mult	**5.0x**	
									Terminal Value	$186,627	
Less: Equity Fundings	$21,394				$16,338				$19,114		
Net FCF to Equity (Net of Inv)	($23,789)	($9,640)	($5,699)	($1,957)	($17,005)	($5,961)	($86)	$4,960	($2,462)	$192,480	
IRR to all Equity Classes	16.54%										

54. Pay-as-you-go Marketers

It is useful to consider the financial characteristics and performance of an LPG Marketer implementing a pay-as-you-go (PAYG) business model.

In the absence of detailed financial and operating data from the sole pilot programme a PAYG LPG company (from 2019), the financial model of the "traditional" LPG Marketer was adapted to create a PAYG model using disclosed and/or publicly available information about differences in assets and cost structure between the two operating models.

Two sub-models require consideration. In the first, the PAYG LPG Marketer attempts to match (or come closer to) the average price per kg of a "traditional" LPG Marketer, without passing on its added PAYG asset costs to the consumer. In the second case, the Marketer solves for the price premium (or other revenue enhancement) that must be charged per kg vs. "traditional" LPG Marketers' end-user pricing, in order for the PAYG LPG Marketer to deliver similar financial returns (on a percentage basis) to investors.

Because Rwanda has no LPG pricing regulation, PAYG LPG companies are generally free to experiment with a variety of pricing models, including subscription fees, sign-up fees, service call fees, recurring equipment charges, and so on, in addition to charging for the LPG actually used. And, indeed, East African PAYG LPG companies have experimented with combinations of these approaches during their pilot programs. Therefore, for purposes of analysis, all such revenue-generating charges are treated as an averaged all-in cost per kg of LPG. The exception is that the cost of the cylinder is deemed recovered through a deposit or deposit-like payment, just as with the "traditional" LPG Marketer. This approach does not disadvantage the PAYG LPG Marketer in the analysis by deferring or extending the time when the cost of the PAYG cylinder is recovered from the end-consumer.

Other differences in firm economics are that PAYG LPG Marketers, by virtue of charging only for the actual LPG used, forego the economic benefit of LPG gain (see Annex Chapter 82 for its definition and discussion); they may have to spend additionally on service calls to the consumer's home to swap-out empty cylinders for filled ones, ensuring the integrity of the smartvalve; they may experience some logistical cost savings through improved knowledge and predictive capability regarding when and where cylinders must be swapped; and they may experience a reduced level of piracy through the geographic tracking and control capabilities provided by wirelessly-communicating smartvalves. To understand the extent that these differences can affect financial performance will require detailed analysis of internal, proprietary financial and operating data from PAYG LPG companies, which data were not available.

For purpose of the analysis, the possibility of losses of PAYG cylinders (and smartvalves), or interruption in their income streams, due to piracy (or due to hacking) was not included. The question of how much immunity PAYG LPG cylinders may have against piracy and other black market interference must be answered through market experience over time, after (and if) the PAYG LPG model achieves meaningful scale.

The cost structure (as detailed in the next Chapter) was adapted to overt and disclosed differences in PAYG operating modalities. All cost structure assumptions that were carried forward from the averge model of a "traditional" LPG Marketer in Rwanda may be different in the case of actual PAYG LPG competitors. The findings and conclusions about the exemplar PAYGCo are thus hypothetical, but they are useful as illustrations of the direction and magnitude of the implications of adding smartvalves/smartmeters to the asset base of a PAYG LPG company.

PAYG intellectual property (IP) licensing

Some PAYG LPG companies that have intellectual property (IP) related to the PAYG technologies have expressed an interest in developing a parallel revenue stream from the licensing of their IP (patents, know-how, etc.) to other LPG Marketers. Such a revenue stream could improve the financial performance and bankability of those PAYG LPG Marketers that own relevant IP. However, it does not improve the financial performance and bankability of those PAYG LPG Marketers who must license IP from the IP-owners; to the contrary, it adds an additional business cost for the licensees. Thus, at the ecosystem level, spreading the cost of PAYG LPG equipment across IP-owning and IP-licensing PAYG LPG companies has no net effect on the sector as a whole, it merely shifts the rents from one set of PAYG LPG companies to another.

Qualitiative considerations

The nascent PAYG LPG subsector offers potentially useful capabilities, services and payment modes to a certain subset of prospective LPG consumers, albeit with very significantly increased asset costs. The critical questions are, how large will that consumer subset be over time, and with what financial risks and results for the PAYG LPG Marketers and their investors in light of competitive forces?

PAYG LPG companies that compete by matching or approximating the average price per kg (over the lifespan of the consumer) of traditional BCRM LPG companies are likely to be financeable only via concessional capital, and the total quantum of investment to be financed increases by a large multiple vs. traditional BCRM LPG companies, given what smartvalves cost now, and are expected to continue to cost in the best possible future scenarios. The total cylinder/smartvalve investment requirement under the PAYG model is likely to be 3X to achieve the same scale as the total cylinder investment for “traditional” BCRM LPG modalities, and the net financing requirement could be as much as 20X higher. (Details on this multilple based on the earlier Rwanda PAYG LPG pilot programme are provided in the next Chapter.)

PAYG LPG companies that do not attempt to compete with traditional LPG companies on average price per kg, but instead target non-LPG users, may find themselves with limited scale-up potential. This could happen for two reasons. First, because new PAYG LPG users may eventually choose to switch to a traditional LPG company upon determining that their cost per kg is lower with the traditional company. (This happened at a significant level for the first-generation PAYG LPG companies and their customers in Kenya, during the early and mid 2010s.) Second, the number of households that are willing, and remain willing, to pay significantly more per kg for PAYG LPG than they would pay for LPG provided by a traditional BCRM firm – primarily because the cylinder refill cost under PAYG can be broken up into many small, daily transactions rather than one larger, monthly to bimonthly transaction – may be a niche subset of the overall household market for LPG.

The potential size of the addressable and retainable customer segments for PAYG LPG companies over the long term are not currently possible to estimate from the limited available data. Also, the competitive response of traditional LPG companies to PAYG LPG companies, if the PAYG LPG companies develop meaningful market share at the expense of established players, is not possible to determine in advance.

To the extent they can obtain sufficiently patient, concessionary risk-capital to expand, the operational experience gained while attempting to scale up—experience that tests the limits of their target market, of competitive forces, and of profit potential—will begin to provide the answers.

PAYG LPG is thus a worthy business experiment.

But, like any commercial experiment, it is not guaranteed to become a major solution to achieving large-scale LPG adoption and use. 2020 saw a second generation of PAYG LPG companies in East Africa (but not Rwanda) define and refine their value propositions to consumers, refine their market position, test their marketing and operational approaches, debug their technologies, and attempt to scale. The first generation, which arose in Kenya from 2012, did not survive.

XVII. Financing

55. Financial Structuring Analysis and Recommendations

This Chapter builds upon the earlier investment analysis to define and recommend structuring solutions for the required financings that (i) meet the financial performance and covenant needs of prospective funding sources, (ii) ensure adequate cashflow (i.e., debt service capacity) for the Industry Leader companies (and any other participants in sector financing), (iii) avoid financial pressures that could cause the financed companies to increase prices beyond the levels already reflected in the current scenarios of future demand, thus putting realization of the scenarios at heightened risk.

The gross quanta of the private sector investments (under strategic storage Option 2/ISS) are $142mm, $170mm, and $206mm for three scenarios, respectively.

In addition, under Option 2, the GoR would have a requirement, pursuant to the MINICOM policy, to fund a further $65mm, $70mm, and $93mm of national strategic storage facilities and fuel reserves, respectively.

In the Option 1 case, with the private sector funding the PSS component of the strategic storage reserve, the private sector gross investment quanta increase to $161mm, $192mm, and $228mm, respectively, and the GoR costs increase to $94mm, $113mm, and $137mm, respectively.

As explained in the preceding Chapter, the private sector funding need is significantly reduced by the consumer cylinder deposits in the case of conventional LPG distribution models, and slightly reduced in the case of the PAYG model.

➲ There are certain conditions that would make Rwandan LPG Industry Leaders maximally bankable, all of which are therefore strongly recommended:

1. *A supportive industry structure* must be in place to unlock and encourage LPG investment. This includes the BCRM and GoR's mandates (soft or directive) to the population to convert to non-biomass fuel sources like LPG for cooking. Likewise, the GoR must ensure industry is able to price high enough to generate needed debt service and financial returns, but is not able to price-gouge (see the recommendations in Volume 3, Chapter 38). These factors will provide comfort to capital and risk mitigation sources that income and cash flow will be adequate over all the investment tranches.
2. *Credible business plans* supported by demonstrated capability to execute on them. Economic returns must be well laid-out to convince the capital and risk mitigation sources that there is ample reason to finance the Rwandan LPG companies and/or modalities.
3. *Transparent LPG-specific financial accounting and reporting* that enable and facilitate due diligence and ongoing monitoring and management of the business. For some operators, particularly those with multiple product lines besides LPG, the accounting and financial details of the LPG business are obscure, being blended in reports and ledgers with those of other operations; if not addressed, this is a barrier to LPG-specific financing of such firms.
4. *Appropriate credit characteristics for the funded LPG operators*, such as strong debt service capability, well evidenced in their business and financial plans.

5. *Appropriate returns on equity investment* are also important. Adequate returns are attainable if the investment sizing and the associated economic models of the LPG companies are appropriately structured. In the event that GoR wants private industry to partner financially with it to build out National Strategic Storage, incentives to the industry to do so must be kept as an option. These could include: GoR providing its own funding; investment incentives including income tax holidays; GoR-facilitated guarantees on debt funding from development banks and other funders; outreach to the international funders such as the World Bank Group for resources ranging from actual capital funding to technical assistance grants to help LPG companies position to become more bankable.
6. *Well-defined cash flows* (EBITDA and free cash flows from operations) that result from the investments. These must comfortably cover the debt (concessional and non-concessional) service requirements.
7. *Well-conceived execution pathways*, once funding is provided. For example, a credible distribution strategy and capable channel management that maximize consumer adoption and minimize cost of service.

Financing tranches

The funding cycles are broken into three main intervals (Tranches 1, 2 and 3) that correspond to milestone periods in the Plan. They commence in 2021, 2025 and 2029, respectively. Tranche 1 intentionally coincides with the NST-1 time horizon of 2024. Each tranche covers the investing needs until the following tranche.

For capital sources, taking the approach of an aggregated funding across tranches rather than piecemeal financing is more efficient, because it provides predictable exposure timing. This consequently provides better credit exposure, risk profiling and mitigation planning.

The composition of these tranches is laid out in the below table across the three growth scenarios. The tranches are sized based on consumer cylinder deposits being used as a funding source for Marketers' ongoing cylinder acquisitions. Using the Low case as an example, the drop in the financing requirement due to the deposits is from US $142mm to $106mm. In the High case, the aggregate funding drops from $170mm to $124mm; in the NST-1 Target case, from $206mm to $142mm.

Table 97. Net capitalization requirements by funding tranche, by scenario
(net of consumer cylinder deposits)

CAPITALIZATION of SELECTED SCENARIOS				
Funding Rounds	*2021 Tranche 1*	*2025 Tranche 2*	*2029 Tranche 3*	*Totals*
Low Intervention	$37,330,858	$48,181,110	$20,808,439	$106,320,407
High Intervention	$41,093,080	$53,687,663	$29,667,072	$124,447,816
GoR/NST1	$99,129,761	$25,303,470	$17,442,363	$141,875,595

Each tranche was analyzed for bankability within the tranche. The capitalization, capital costs, and structural assumptions for supporting the tranches are based on numerous conversations with prospective funding sources regarding Rwandan and other comparable markets with regards to funding LPG projects. Despite the fact that certain DFIs – the largest potential source of funding – cannot participate in fossil fuel-based fundings, the size of their various asset bases, debt and equity windows, and range of risk mitigation and technical assistance resources, position the DFIs that can participate as leading candidates to catalyze overall funding resources for implementing the Plan.

Based on conversations with World Bank representatives, the World Bank's Clean Cooking Fund is an option for Rwanda to target technical assistance and consumer-financing resources applicable to LPG from its $20mm Rwanda clean cooking window. In addition, with KfW and the EU as the lead grant sponsors of this Master Plan, the likelihood of attracting like-minded DFIs, impact-oriented funding sources, and development capital sources is heightened. As noted, the DFIs, IFIs, and MDBs often work in consortiums, such as the IFC's co-funding consortium, the Master Cooperation Agreement (MCA). If any leading catalytic blended capital sources such as DFIs can be convinced of bankability, this will catalyze numerous forms of capital, technical assistance, and risk mitigation resources to fund key areas of the supply chain. This in turn would crowd-in both non-commercial and otherwise less-interested commercial capital sources seeking a de-risked situation. In this instance, the catalytic capital acts as the spark for the mobilization of blended capital.

The assessment and structuring of the preliminary capitalization are based on:

1. The total investments required under each scenario.
2. A ratio of 75% to 25% debt to equity. This ratio is based on data from Convergence Blended Finance research on capital structures of approximately US $50 to $60 billion of blended funding structures between 2017 and 2019, correlated with LPG industry experience in more developed SSA markets.
3. A breakdown of concessional to non-concessional debt of 53% to 47%. This ratio could vary based on the interest of various types of funders, but it is consistent with blended funding trends as reported by research from the Convergence Blended Finance and the Global Impact Investment Network (GIIN) on impact investments. This was cross-referenced with numerous conversations on project capitalization ratios with leading blended funding suppliers (development finance institutions, international banks, private equity firms, impact investors and local banks).
4. The cost of capital used is a weighted cost of capital developed by blending current market rates for concessional and non-concessional debt with the equity hurdle rate generally applicable for SSA markets. Again, this was verified with prospective lead financing participants both in and outside Rwanda.
5. The US Export Import Bank also provided further verification on funding and risk insurance pricing for Rwanda exposure.
6. The blended cost of debt comes to 10.2%, reflecting 8% concessional debt costs and 12.36% non-concessional costs. The later rate is based on benchmarking Rwandan sovereign USD issuances via Bloomberg data services.

Timing is a critical issue. GoR's goals for reducing biomass use significantly by 2024 are a tight timetable for scale-up of LPG, and due to the cumulative effect of the LPG investments on the reduction in biomass use, up-front delays can severely reduce LPG growth as of 2024.

For the aforementioned capitalization needs for each scenario, the operational metrics, credit metrics, and equity metrics all indicate that the three scenarios offer possibilities for funding from blended finance sources. The primary issue is the high initial leverage in the beginning of the build-out years. This issue is most pronounced under the NST-1 Target scenario. This is captured in the figures shown below.

Table 98. Key project financial metrics for LPG 'Industry Leader' firms, by scenario

Assumptions	Low	High	NST1
Entity's Market Share:	100%	100%	100%
Demand Scenario:	Low	High	NST1
Cylinder Tranche Funding Type:	Highest	Highest	Highest
Select Capitalization Metrics and Statistics			
Debt to EBITDA			
Max Levarage	6.92x	7.42x	13.96x
Average Leverage	2.48x	2.56x	2.98x
EBITDA to Debt Service			
Min Coverage	0.82x	0.78x	0.49x
Average Coverage	1.72x	1.70x	2.56x

Cases where the equity returns are below 20% represent below-market equity rates of return. There are some examples of this kind of equity financing taking place in markets like Rwanda, but as exceptions, not as the rule. Funding for firms with below-market equity returns might be found from some concessional pockets within DFIs and impact investors, or from foundations, but typically not from commercial equity sponsors.

In addition, the ability to attract concessional equity funding at the levels needed across the three scenarios is more challenging when the pool of funders is narrow.

➲ The recommendation, therefore, is to design the project economics so that bankability is maximized across the widest possible arc of the blended funding community, by increasing the attractiveness to commercially-targeted equity sources. A constraint on this is that end-user prices should not rapidly rise solely to offer more comfort to funding sources. Rather, bankability should be maximized within the existing price structure, noting that reasonable increases to the landed cost of LPG in bulk in Rwanda from import routes are appropriate to pass on, without extra mark-up, to the consumer.

The High growth scenario provides the most consistent series of returns above the 20% hurdle rate for equity investors. That is, if the High case can be aimed for and realized, it has the best overall financing characteristics and the lowest sensitivities to financial risk factors.

(To jump up to NST-1 therefore argues for various supportive financial measures from GoR and Rwanda financial cooperation partner countries and DFIs to reduce the risk sensitivities and increase bankability in the NST-1 case. Again, it should not be a surprise that other countries that have successfully financed and executed on NST-1 LPG growth scenarios have done so utilizing major state companies that are, in part or in whole, sovereign-funded.)

Technical assistance

These capitalization quanta do not include technical assistance (which might appear as a grant within the concessional portion), but such funding is small relative to the overall capital requirements. It is estimated that technical assistance for investment preparations, financing, associated demand-related programs, enabling environment enhancements, and technical development of LMC-Bs for investment, would be in the range of US $3 million. (See Part X (Annexes to Volume 1), Chapter 20, for details.) Technical assistance facilities provided by bilateral, multilateral, and foundation donors should be applied-for in order to cover these costs.

Firm-level analysis and recommendations

The analysis applied at the IndCo composite level is next applied to ProformaCo (Case A) and, for comparison, PAYGCo (Case B).

1. Case A. The financial modelling used for IndCo is applied to ProformaCo. Again, the High case is recommended as the ideal planning scenario for purposes of highest bankability coupled with least sensitivity to financial risk factors. The major change in the ProformaCo modelling is scale. ProformaCo represents financing quanta that are, in principle, representative of a single Industry Leader LPG firm in Rwanda under this Plan. (It was decided not to apply economies of scale to IndCo that do not already exist in ProformaCo.) A second difference that must be accounted for in preparation of a detailed business plan and financial plan for an actual Rwandan LPG firm, rather than a pro forma example of a firm, is the timing (and location) of its investment or co-investment in filling facilities. Filling plants are step-function investments, as shown in Volume 4, and under the Plan, depots and filling plants are rolled out regionally in synch with the development of a critical mass of demand in each region. Each actual firm must develop its own plan for when each step-investment in filling assets and associated transport assets must be made, and how these fit into the proposed tranches. The ProformaCo model smooths this filling plant investing into more, smaller steps that would be likely for a specific firm in practice. However, the investing schedule is still likely to be broadly representative of the needed capacity steps of a specific firm when viewed at the tranche level, across the growth scenarios.
2. Case B. The ProformaCo model is rerun with the revenue, cost structure and asset base of a PAYG LPG company of equal market share.

The key PAYG model sensitivity additions are:

1. Pricing (maximizing returns case). On the revenue side, the PAYG model charges a premium per kg over the conventional LPG sales and distribution business models. Where the 2021 end-user price is notionally US $1.03 per kg (with ProformaCo selling at a wholesale price below this), PAYGCo is at US $1.75. That was the prevailing tariff for the PAYG LPG pilot programme in Rwanda in 2019, adjusted for changes to Saudi CP and the RwF forex since that time.
2. Pricing (maximizing affordability case). The PAYGCo analysis also examined what the minimum PAYG price could be per kg in order to generate a return on equity equal to that of ProformaCo under the same growth scenario. (The result for 2021 is $1.21 per kg).
3. Cylinder deposits/sign-up costs. PAYGCo does not collect a cylinder deposit from the consumer. Rather, it collects what may be called a sign-up fee, which includes provision of all needed equipment and (in the case of the earlier pilot programme) 2 kg of prepaid LPG usage. The net benefit to PAYGCo from the sign-up fee is modelled at US $9.53 (again, based on the pilot programme data). Thus, the net financing benefit of cylinder deposits that is so impactful for a ProformaCo is minimal for a PAYGCo. The PAYGCo could choose to charge a much higher sign up fee, but doing so has been deemed in the PAYG LPG subsector as contrary to the logic of the PAYG model, in which the primary goal is to minimize transaction-size barriers for the consumer.
4. Consumer equipment costs. The cost of the consumer equipment (cylinder plus, in this case, the smartvalve that makes the PAYG model work) is considerably higher—as much as US $50 higher—as

shown in the table below). For modelling purposes, the sign-up fee was netted against the asset value, rather than against the financing.

Table 99. PAYG equipment costs and deposit offsets for the base year of 2021

Assumed cylinder cost for the sector (12kg-eq)	US $18.44
PAYG LPG smartvalve[83]	$50.00
Total PAYG Costs/Cylinder to Mktr	$68.44
PayGo Consumer Cylinder Deposit	$9.53
Net PAYG Cost/Cylinder	$58.91

5. Consumer equipment financing. The financing need for the cylinders and smartvalves was calculated on an ongoing rather than revolving basis, because these costs are only minimally offset by the sign-up fee. By contrast, in non-PAYG business models, the cylinder deposits repay (in a cashflow sense) the full cylinder investment costs. The impact is to increase the overall financing costs of the consumer equipment for PAYGCo.

6. Filling operations. As previously mentioned, PAYGCo is modelled as an LMC-O—it does not invest in its own filling plants, but utilizes the filling capacities of others. (Some existing PAYG companies seek to un-integrate the LPG supply chain by inserting themselves between fillers/Marketers and distribution/consumers, essentially performing a distribution, customer sales and service, and information technology function. Others seek to become full-function Marketers, potentially acquiring filling assets as they become sufficiently large, or by being acquired by an existing, larger LMC-B firm, as happened with M-Gas (the PAYG LPG company) and CircleGas (the acquiring LMC-O company) in Kenya, as one example.)

7. Strategic storage. Because PAYGCo is an LMC-O, it is assumed that it would avoid any need to pay anything toward strategic storage (applicable in Option 1/NISS, but not in Option 2/ISS).

Case A (ProformaCo)

Below are the details of the High case scenario analysis of ProformaCo, maintaining a 20% market share. As noted, if this scenario includes a pro-rata (20%) cost share of all national strategic storage assets, it does not generate the minimum targeted 20% equity rate of return. The minimum threshold is met only at the point that GoR funds at least 50% of the storage, or provides an equivalent offset. For ProfomaCo, based on current pricing economics building to an off-taker (wholesale) price of US $933/tonne, this is still not an attractive

83 A number of PAYG LPG companies active in East Africa were interviewed, and their indicative costing for smartvalves (including smartmeter and a communications device) has been consistently around US $50 per unit. It s hypothesized that, at very large scale of deployment, this cost might fall to as low as $30-35 in later years. At $30, the economics of the PAYG business model improve, but the overall nature of its economic differences in comparison to conventional LPG cylinder distribution is not significantly altered.

economic proposal. Effectively, it becomes viable only when GoR assumes at least 80% of the funding; but even at 28.7% IRR, equity investors may not want to have exposure to this risk.

Table 100. IRR sensitivity to private sector share of strategic storage cost, High case

Demand Growth Scenario	*Operator Type*	*Strategic Storage Type*	*GoR Role in National Storage*	*IRR*
High	*LMCB*	*Combined*	*100%*	*37.62%*
High	*LMCB*	*Combined*	*80%*	*29.25%*
High	*LMCB*	*Combined*	*50%*	*20.58%*
High	*LMCB*	*Combined*	*0%*	*10.44%*

The following table breaks down of the investment funding needs under Case A, assuming a 20% cost burden on the LPG Marketer.

Table 101. Pro forma LPG Marketer spending including 20% NSS cost share, by year, High case

(USD 000's)	Tranche 1				Tranche 2				Tranche 3		
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Totals
Total New Cyl Costs	$501	$806	$1,019	$1,069	$1,277	$1,504	$1,673	$1,939	$2,281	$2,553	$0
Net Financed Costs	*$1,069*	*$0*	*$0*	*$0*	*$1,939*	*$0*	*$0*	*$0*	*$2,553*	*$0*	*$5,561*
Bottling Plant & Pallets	$905	$1,224	$971	$2,389	$977	$2,051	$2,059	$132	$393	$267	$11,368
Bulk & Cylinder Transportation	$0	$422	$600	$537	$686	$777	$875	$1,020	$1,203	$1,350	$7,470
Cages	$0	$28	$35	$37	$44	$52	$58	$67	$79	$89	$490
Private Sector Storage	$300	$300	$600	$600	$345	$765	$675	$548	$293	$0	$4,425
National Strat Storage	$2,274	$2,274	$1,274	$1,274	$0	$0	$0	$0	$4,533	$4,533	$0
	$4,548	$4,248	$3,481	$4,838	$3,991	$3,645	$3,667	$1,767	$9,053	$6,238	$29,315

The depressed returns from this are shown below. Importantly, the cashflows are negative until 2027, so this is not a credit-safe approach.

Table 102. Firm-level IRR and cashflows by year, High case, 20% NSS cost share

Cashlow Analysis (USD 000's)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Totals
Net Income	**($1,824)**	**($1,421)**	**($717)**	**($58)**	**($648)**	**($477)**	**$391**	**$984**	**$690**	**$1,451**	**($1,628)**
+ Depreciation & Amort	$1,345	$1,412	$1,497	$1,586	$2,435	$2,560	$2,699	$2,861	$3,900	$4,113	$24,409
+ Non Cash Charges	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Free Cash Flow From Ops	**($479)**	**($8)**	**$780**	**$1,528**	**$1,786**	**$2,083**	**$3,091**	**$3,845**	**$4,591**	**$5,564**	**$22,781**
- Principal Debt Repayments	$0	$1,920	$1,920	$1,920	$1,920	$3,275	$3,275	$3,275	$1,556	$5,015	$24,077
Cash Flow After Debt Pmts	**($479)**	**($1,928)**	**($1,140)**	**($391)**	**($133)**	**($1,192)**	**($185)**	**$570**	**$3,035**	**$549**	**($1,295)**
									Tax Adj EBITDA	$5,226	
									Terminal Mult	**5.0x**	
									Terminal Value	$26,128	
Less: Equity Fundings	$4,279				$3,268				$3,823		
Net FCF to Equity (Net of Inv)	($4,758)	($1,928)	($1,140)	($391)	($3,401)	($1,192)	($185)	$570	($788)	$26,677	
IRR to all Equity Classes	10.44%										

The recommended route is demonstrated below, with GoR taking 100% of the storage need or deferring this request. The economic impact is captured below. Note the IRR and cashflow improvements.

Table 103. Firm-level financial metrics and cashflows by year, High case, ISS

Macro Demand and Operator Scenario Assumptions				*Additional Storage Investment*		*Fiscal Assumption*
Demand Growth Scenario	*Operator Type 1*	*Paygo Offered*	*Distrib Channel 2*	*Additional Private Sector Strategic Storage Investment*	*GoR National Storage Ownership*	*Tax Rate to LPG Cos*
High	***LMCB***	***No***	***Ind Rtlr to Home***	***Combined***	***100%***	***30%***

Cylinder Financing	*Equity Returns*	*Capitalization Ratios 3*		*Leverage Ratios*		*Debt Service Ratios*	
Cylinder Funding Approach	*IRR*	*Equity/Capital*	*Debt/Capital*	*Max Debt/EBITDA*	*Avg Debt/Avg EBITDA*	*Avg EBITDA/Avg Debt Svc*	*Min EBITDA/Debt Svc*
Net Financing	***37.62%***	***25%***	***75%***	***12.5x***	***2.6x***	***1.7x***	***0.8x***

1) LMCB = Marketer with filling capacity. Fully integrated. 2) See MP distribution table for definitions. 3) Capital = Debt+Equity.

Cashlow Analysis *(USD 000's)*	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Totals
Net Income	**($550)**	**($195)**	**$288**	**$681**	**$371**	**$476**	**$1,115**	**$1,623**	**$1,964**	**$2,874**	**$8,647**
+ Depreciation & Amort	$752	$819	$904	$993	$1,686	$1,811	$1,951	$2,112	$2,528	$2,741	$16,297
+ Non Cash Charges	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Free Cash Flow From Ops	**$202**	**$624**	**$1,192**	**$1,674**	**$2,057**	**$2,288**	**$3,066**	**$3,735**	**$4,492**	**$5,615**	**$24,944**
- Principal Debt Repayments	$0	$966	$966	$966	$966	$2,072	$2,072	$2,072	$1,306	$2,426	$13,815
Cash Flow After Debt Pmts	**$202**	**($343)**	**$225**	**$708**	**$1,090**	**$216**	**$994**	**$1,663**	**$3,186**	**$3,189**	**$11,129**
									Tax Adj EBITDA	$5,226	
									Terminal Mult	**5.0x**	
									Terminal Value	$26,128	
Less: Equity Fundings	$2,055				$2,684				$1,483		
Net FCF to Equity (Net of Inv)	($1,853)	($343)	$225	$708	($1,594)	$216	$994	$1,663	$1,702	$29,316	
IRR to all Equity Classes	37.62%										

Case B (PAYGCo)

The analysis below shows the premium pricing per kg that the PAYGCo would, in theory, be able to charge for refills and achieve the same equity IRR as ProformaCo (assuming the other assumptions about Capex and

Opex are reasonably accurate). The result is about US $1.21 in 2021, significantly below the $1.75 per kg that was most commonly paid by customers under the 2019 PAYG LPG company's pilot programme in Rwanda. However, the financing need to achieve that IRR and serve the same numbers of customers as ProformaCo, all else being equal, is significantly greater, rising from US $5.7 million for ProformaCo to US $48 million for PAYGoCo.

From an impact standpoint, a dollar invested in ProformaCo consumer-equipment assets goes eight times farther – serves eight times as many households – than the same dollar invested in PAYGOCo consumer-equipment assets.

Table 104. PAYG LPG firm-level financial metrics and cashflows by year, High case, ISS

Macro Demand and Operator Scenario Assumptions				Additional Storage Investment		Fiscal Assumption
Demand Growth Scenario	Operator Type 1	Paygo Offered	Distrib Channel 2	Additional Private Sector Strategic Storage Investment	GoR National Storage Ownership	Tax Rate to LPG Cos
High	LMCB	Yes	Paygo	Combined	100%	30%

Cylinder Financing	Equity Returns	Capitalization Ratios 3		Leverage Ratios		Debt Service Ratios	
Cylinder Funding Approach	IRR	Equity/Capital	Debt/Capital	Max Debt/EBITDA	Avg Debt/Avg EBITDA	Avg EBITDA/Avg Debt Svc	Min EBITDA/Debt Svc
Ongoing	37.08%	25%	75%	10.0x	2.0x	1.7x	0.8x

1) LMCB = Marketer with filling capacity. Fully integrated. 2) See MP distribution table for definitions. 3) Capital = Debt+Equity.

Cashlow Analysis (USD 000's)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Totals
Net Income	$149	$766	$1,834	$2,832	$2,480	$2,651	$3,986	$5,223	$6,043	$7,545	$33,507
+ Depreciation & Amort	$843	$1,058	$1,329	$1,614	$2,540	$2,941	$3,386	$3,902	$4,735	$5,414	$27,763
+ Non Cash Charges	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Free Cash Flow From Ops	$992	$1,824	$3,163	$4,445	$5,020	$5,592	$7,372	$9,125	$10,778	$12,959	$61,270
- Principal Debt Repayments	$0	$2,799	$2,799	$2,799	$2,799	$5,537	$5,537	$5,537	$4,771	$5,648	$38,229
Cash Flow After Debt Pmts	$992	($976)	$363	$1,646	$2,220	$54	$1,834	$3,588	$6,007	$7,312	$23,041
									Tax Adj EBITDA	$12,343	
									Terminal Mult	5.0x	
									Terminal Value	$61,717	
Less: Equity Fundings	$4,499				$7,305				$4,705		
Net FCF to Equity (Net of Inv)	($3,507)	($976)	$363	$1,646	($5,084)	$54	$1,834	$3,588	$1,302	$69,029	
IRR to all Equity Classes	37.08%										

56. Financing the Investments

Financial sector overview

The key assets for the growth of LPG consumption require significant, ongoing funding, year upon year. Rwanda's financial market is developing, but it has relatively limited capacity to unilaterally fund the Master Plan investments.

Thus, outside blended funding will need to be mobilized. The table below outlines Rwanda's financial system assets as reported by the National Bank of Rwanda (Central Bank 2018/19 Annual Report).

Table 105. Rwanda financial sector assets by institution type, 2019

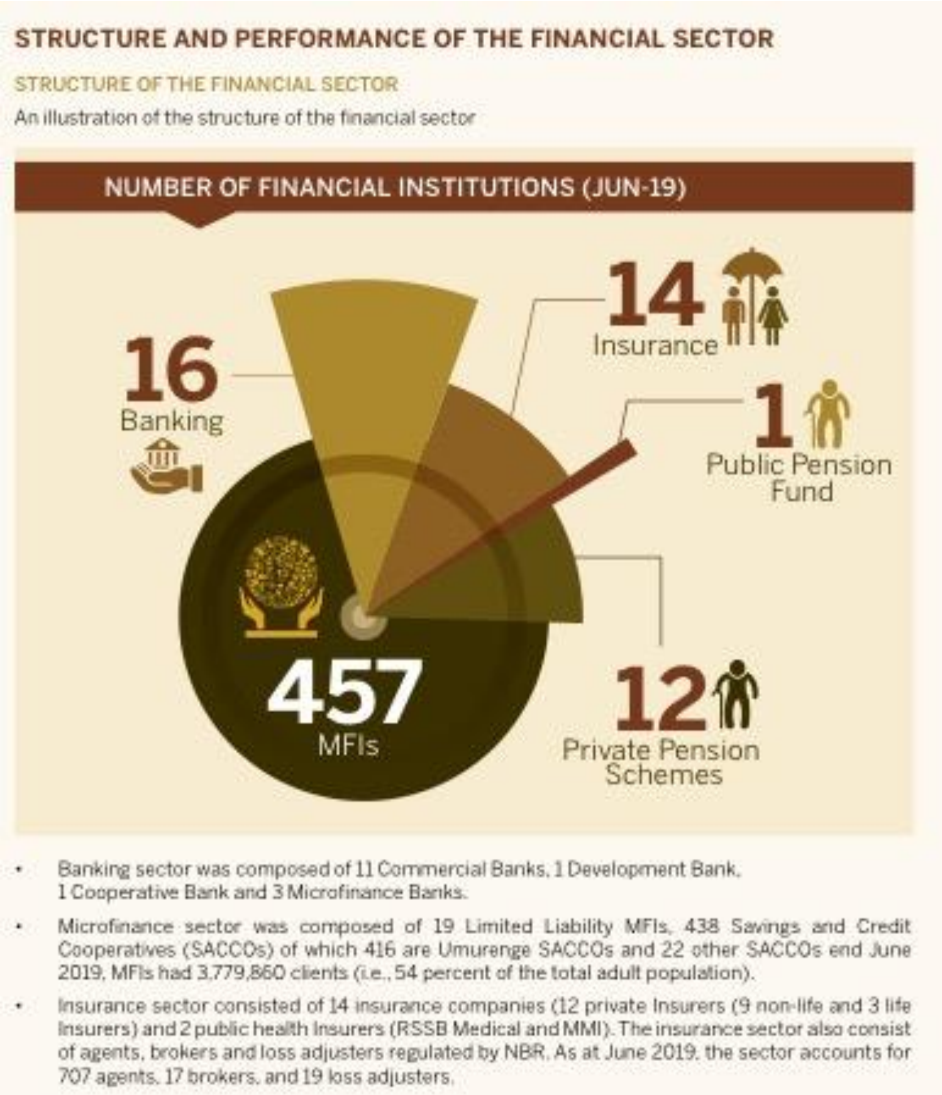
Type of Institution	% of Assets	USD Assets
Banks	66.1%	$3,251,459,000
Pension Funds	17.0%	$836,230,000
Insurance Companies	9.7%	$477,143,000
Microfinance	6.4%	$314,816,000
Other	0.8%	$39,352,000
Total Assets in System	**100.0%**	**$4,919,000,000**

Source: GLPGP research and NBR data from 2018/2019 Annual Report

The size of investments for Rwanda cannot be supported by the $3.25 billion in banking assets in Rwanda, given its constraints on exposure to specific asset classes, risk categories, sectors, and so on. The financing quanta for Rwandan LPG would put the sector at over 10% of banking assets in the case of the NST-1 Target scenario. Outside capital to crowd-in financial resources at scale is needed.

The depth of Rwanda's financial sector's assets is an important element in determining the capacity of local institutions to fund the investment needed to develop the LPG value chain to scale. The key variables include liquidity, statutory restrictions on lending or investment exposure to specific sectors, balance sheet flexibility to lend or invest longer than short term (twelve month) funding, lending collateral requirements, and the expected return on capital. As with many other developing economies, the financial sector in Rwanda is regulated and, due to scarcity of perceived "safe investment" opportunities, alternative opportunities such as government securities become highly attractive for the financial sector's investment portfolios. This trade-off often then becomes the major alternative for would-be funders who might otherwise consider investing in private sector modalities and projects such as the LPG sector. The Rwandan financial sector is profiled below as reported by the National Bank of Rwanda's 2019 Annual Report. The take-away is that there is the relatively modest array of capital sources and liquidity, at approximately $4.9 billion, is constrained as to its ability to fund the LPG sector's capital needs.

Figure 55. Structure and performance of the Rwanda financial sector
Source: National Bank of Rwanda's 2019 Annual Report

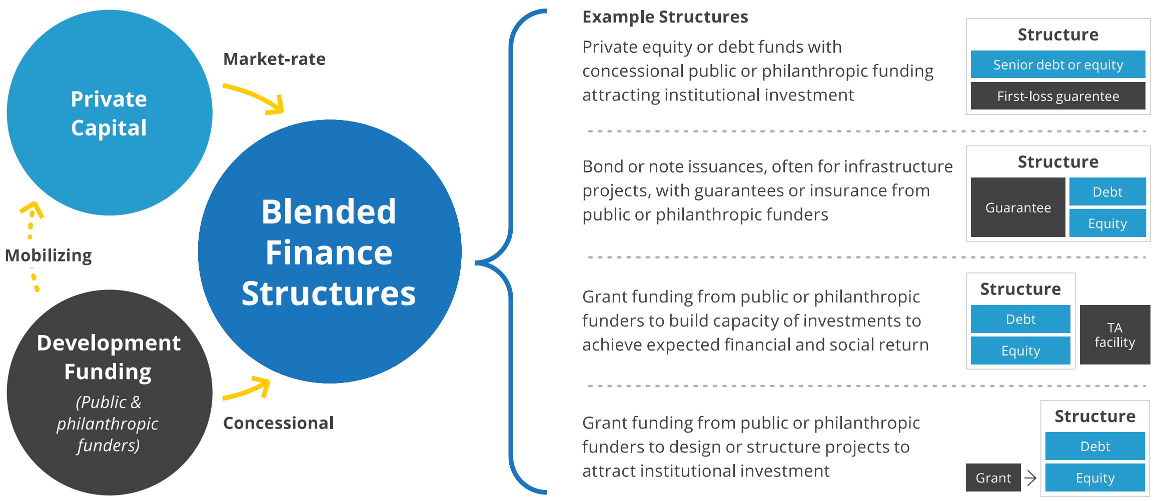


Use of the blended capital ecosystem

The starting ecosystem for blended finance envisioned in this Plan is captured in the diagram below, extracted from the Convergence Blended Finance database (2020). As the diagram's flows suggest, the preferential approach to funding for implementing the Plan is a logical mixing of finance (debt/equity) and other resources (guarantees/risk-mitigation/technical assistance grants). The outcome of mixing these elements properly is not only more appropriately-sized, -structured, and -priced funding, but also the enhancement of the probability of successful and sustainable implementation.

This can be achieved by mobilizing concessional (likely below-market priced) quasi-public funding, non-commercial funding and grant resources, and non-concessional commercial/private sector capital. The objective is to achieve scalable capital with accommodative terms: pricing of capital, sizing, grace periods, maturities, collateral, guarantees, complemented by other critical resources such as potential technical assistance grants to assist the operators on the LPG value chain to plan and execute effectively.

Figure 56. Common blended finance mechanisms and structures
Source: Convergence Blended Finance (2020)



GLPGP has spoken in early terms with leading domestic and international blended funding institutions with the objective of constructing a realistic path to funding the Plan projects starting in 2021. Given that construction of LPG-related fixed infrastructure such as storage and filling plants typically entails up to 2 years of preparatory processes and construction, the current discussions were conducted to establish potential interest, capabilities, and the conditions that would facilitate indicative levels of commitment by leading institutional sources. A consensus interest emerged for considering meaningful participation in a blended financing mobilization.

➲ For the purpose of efficiently mobilizing financial resources at scale, it was recommended to engage with groups accustomed to working together. This includes, for example, DFIs such as AfDB, FMO, IFC, KfW, and OPIC (USDFC) for debt and/or equity capital sourcing, and other risk mitigation sources such as SIDA and US EXIM. In Rwanda, initial conversations were held with the World Bank, Development Bank of Rwanda, Bank of Kigali and Kenya Commercial Bank.

Critical path steps to mobilizing financing to implement the Master Plan

➲ In order to meet as much of the GoR's 2024 and 2030 LPG-related objectives as possible, as quickly as possible, actions must be promptly taken to:

- Prepare technical, business and financing plans for LPG sector expansion projects, firm by firm (plus NSS assets), and including cylinder procurements;
- Make certain the regulatory environment that will govern the sector over the life of the Plan and of the financing;
- Determine which LPG firms, via fair and transparent criteria and processes, should receive priority assistance and financing, to act as first-movers and leaders (that is, as the Industry Leaders) to drive LPG market expansion;
- Develop a queue of prioritized projects (supply side and demand side);

- Provide industry stakeholders with technical support to finalize detailed plans and enhance execution capability;
- Provide GoR (in particular, RURA) with technical support to build LPG-specific capacity;
- Create mechanisms for the funding to reach the stakeholders that, in turn, will make the needed supply-side investments;
- Establish the needed supportive regulatory and fiscal conditions, which may include investment incentives; and
- Start to mobilize blended funding resources, as soon as possible, comprising (i) quick funding (notionally around US $3mm) for TA, pilot programs, demand support measures, training, and initial project preparations, and (ii) less-quick, large-quantum funding for project engineering, procurements, cylinder financing, and funding of new infrastructure and major business operational expansions.

Raising blended capital resources to support the LPG sector scale up (on both the supply side and demand side) will take time. The process can easily take 4 to 9 months, depending on the channel. Cylinder-related funding is of highest priority, because there is no spare cylinder capacity in the country with which to create new customers, and because cylinder procurements can be organized and executed quickly. This would allow unmet demand to be served immediately, with supply being ramped up through increasing labor time in the existing filling plants and increasing spot-market imports.

The supply-side technical planning, engineering, documentation, and construction of key assets such as filling and storage can take an estimated 18 to 24 months. This would suggest that the construction process should commence between 2021 and 2022. In the NST-1 case, supply infrastructure would play catch-up to the projected demand for the first two years of Plan implementation. In the other scenarios, supply could keep up successfully with the projected demand through rapid cylinder procurement and doubling of labor shifts initially, in parallel to building and then operating new infrastructure.

Alternative financing options

The use of carbon credits as well as results-based financing (RBF) are additional options that can complement using the major sources of concessional and non-concessional capital and risk mitigation.

1. The use of carbon credits has been initially discussed in the context of LPG development in Rwanda as well as elsewhere in SSA. A major impediment remains the limited size of the market for LPG carbon credits and the attribution for the ownership of these credits—consumers, or the LPG Marketers, or the stove manufacturers, for example—while it is the Marketers that actually need the financing to commence their investment activities in cylinders. The structural issues and frameworks for attribution of these credits in order to bank them toward fundable assets in the near term in Rwanda needs to be further analyzed.
2. The World Bank's Clean Cooking Fund has expressed interest in exploring LPG development and asset-related funding in Rwanda for potential fit within its mandate. To date, CCF has indicated that the US $20mm portion of the CCF allocated to Rwanda is potentially applicable to LPG for both technical assistance activities and demand-support mechanisms. For example, a portion of the yearly cylinder investment needs could be funded through such a financing window, if the window

rules could be adapted to include the cylinders as part of the financed consumer clean cooking equipment kit.

Structuring financing at the firm and project level

The recommendations for structuring the MP's blended investment options and bankability/fundability are done in the context of using blended financing options, since this avenue provides the most accommodating and sizable avenue for capital and LPG development resources.

The pro-forma capital structure and costs of capital (debt and equity) used for modelling the firms' and projects' capitalization and financial returns are based on capital markets research, the outcomes of discussions with major Rwandan banks and other financial sector institutions, with DFIs that are active in Rwanda, Africa and in other sectors, and with investment groups that are familiar with Rwanda and could be funders of LPG projects under the "right" conditions. Several of the LPG operators in Rwanda also provided feedback on existing funding arrangements with banks; these have indicted a range of 12% to 18% interest on 12-month revolving facilities in local currency terms.

What is clear upon analyzing the capital and operational asset/investment needs is that the operators can benefit from both technical assistance and financial support to expand their operational capacities to meet the Plan objectives. To do this, additional capital (technical assistance, working capital financing, and capital expenditure funding) is in demand.

The goals of designing/using blended capitalization are to: 1) provide key timely technical resources and build-out capital for the project stakeholders to plan in detail, build and operate the key supply-side operations; 2) gain access for them to scarce capital resources; 3) lower the costs of financing and provide better structural terms such as longer maturities; and 4) better match funding of longer-term capital with the timing of economic returns from the investments.

(Funding required for demand-side programs is expected to be possible solely using grant or concessional funding.)

Cylinder financing

In each tranche, the approach is to analyze the funding needs to identify the peak drawdown amount within the tranche, and this is used as the maximum requested revolver funding for that tranche[84]. Under this approach, revolving funding is targeted. (This is a structure already used to some extent by some LMCs). This is enabled by the standard LMC business model, in which the consumer provides a deposit equal to or greater than the cost of the cylinder, against which the LMC can borrow internally at no cost. This means that the LMC can receive the cash deposited, repay the funders, and then draw down the revolving line to fund the

[84] A revolver approach cannot be used for the PAYG modality, because PAYG does realize an adequate level of up front consumer payments (whether sign-up fees or equipment deposits or other) to make a revolver possible. That is, PAYG cylinder (and smartvalve) assets require structural debt, rather than inventory working capital finance.

next cycle of cylinders in the upcoming period or year within a given tranche. This makes the cylinder funding more of a working-capital type of financing.

To achieve the High and NST-1 cases, it may be necessary to provide some consumers with up-front cost incentives, such as a discounted initial payment on the cylinders, to stimulate demand. If this were implemented through the LMCs, it may be advisable for a form of subsidy (or RBF) to be arranged through the GoR on behalf of the consumers. Given this potential need in order to stimulate even higher consumer cylinder demand, the 4-year facility model appears sensible.

A 4-year commitment from funders also enables an LMC to continuously plan for and add to the required cylinder inventory year on year to achieve its own targets in line with the Master Plan. At the sector (IndCo) level, this is an overall \$59mm, \$75mm, and \$99mm between 2021 and 2030 in the Low, High and NST-1 Target scenarios, respectively. The amounts for specific firms would be proportionally less, based on their projected market shares. (At a 20% share, the amounts are in \$12mm, \$15mm, and \$20mm.) Importantly, this latter size of funding is feasible for blended capital providers. In the case of Bangladesh, for example, FMO made a \$20mm catalytic investment in LPG operator Omera which stimulated approximately \$60mm of overall capitalization. IFC has several investments in the LPG value chains as well. Along with KfW, for example, these are two groups that could be approached to finance acceptable aspects of the value chain. (In some instances, DFIs will only participate in certain aspects of the needed infrastructure.)

In the case of using the revolver model supported by consumer cash deposits, the peak-funding approach is well-suited to traditional commercial banks. The cash deposits could be a source of comfort for local bankers to provide ongoing credit lines for LMC cylinder purchases. (The challenge in SSA has been the terms such bankers require for such lending.)

In Kenya, one LMC arranged to get supplier-based credit toward its cylinder purchases. This might be an option longer term in Rwanda as the cylinder market grows and the LMCs improve their financial strength.

Financing fixed assets – storage, filling plant-related assets, transportation

For fixed assets, longer term funding commitments were modelled. The targeted funding is for 7-year capital. Based on conversations with the BRD and commercial banks in Rwanda, this may be the edge of their funding maturity tolerance, but with convincing business cases demonstrating solid cash flow generation—if structured with ample equity in the range of 25% to 30% of total capitalization, plus collateral value—such funding may be attainable.

As noted in the debt and equity analysis of this Plan, the ProformaCo firm can sustain a balance sheet capitalization of 75% debt to 25% equity from 2021 to 2030 and is able to service this debt load (interest and yearly amortization).

Structuring the costs of capital

The starting interest rates used to generate the blended cost of 10.2% costs of debt are based on consensus assessments of the typical interest rate spreads over the benchmarks used by representative blended-capital providers. The DFI pricing of rates is typically on a spread over the 12-month Libor or US Treasuries commensurate to the term of the exposure. Several DFIs have indicated that similar pricing could be applied to LPG in Rwanda, as this rate has been referenced for other projects such as solar electricity in Rwanda. A spread of 400 to 600 basis points was assumed for stress testing of the ProformaCo financial model. The pricing grid is shown below. If commitment fees – approximately 1% or slightly more – are incorporated, the yields become approximately 8%.

Table 106. Representative interest rate indices and applicable spreads

	Base Rate	Spread	Implied Rate
12-Month Libor	0.337%	6.000%	6.337%
2-Year US Treasury	0.152%	6.000%	6.152%
3-Year US Treasury	0.197%	6.000%	6.197%
5-Year US Treasury	0.384%	6.000%	6.384%
7-Year US Treasury	0.642%	6.000%	6.642%
10-year US Treasury	1.660%	6.000%	7.660%

Source: Bloomberg and GLPGP

This assessment is then used to establish the potential rate for the concessional portion of the debt. For the non-concessional interest rate, the actual capital markets pricing – in this instance measured by yields to maturity on Rwanda USD denominated international bonds as quoted on Bloomberg – are used as a benchmark. The logic is that the Rwanda sovereign debt sets the minimum commercial market investors' rate expectation. In addition, based on interviews with private debt and equity investors active in Africa, rates of 12% to 13% on USD are considered a "fair" starting point for corporate exposure in Rwanda.

Corroborating this is the November 2020 Bloomberg bond database on the Rwanda Treasury bond issued internationally and paying USD. Its coupon is 12.475% and is issued in dual currencies. This sets the risk floor for commercial funders. The risk premiums would then be applied to this. DFIs have expressed in interviews that the 8% to 10% USD range could be acceptable for certain types of clean energy projects, if such funding will catalyze the sector's development, as is the case argued here.

Regarding the split of blended debt, the analysis used a proven split from 2021 to 2030 of 53% concessional to 47% non-concessional debt within 75% total debt. This generates the weighted interest rate of approximately 10.2% used in the modelling of the ProformaCo's investment financing. Arguably, the ratios of concessional to non-concessional debt could vary, and then be re-applied to the two classes of the costs of debt. For the purposes of this analysis, the higher end of the costs of financing were used to stress test the ProformaCo model.

Calculation of weighted costs of debt

Table 107. Blended costs of debt for LPG projects

	Ratio	% of Debt	
Concessional Debt Rate	8.0%	53%	4.24%
Non-Concessional Debt Rate	12.68%	47%	5.96%
Blended Cost of Debt			***10.20%***

Design of funding mechanisms

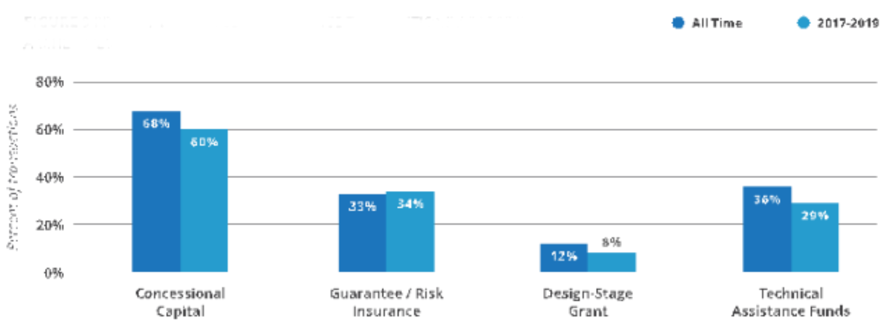
The blended capital considered herein could be funded directly from funding sources through:

1. Direct funding. Direct investment into operating company levels or project levels. For example, funding a common user-access filling and storage facility shared by both private sector operators and the GoR.
2. Pooled funding mechanisms. Aggregating multiple similar investments to benefit from portfolio effects and to leverage the management cost and time of the funder, via the establishment of pooled mechanisms such as SPVs capitalized by blended finance and administered by BRD or a Non-Bank Financial Institutions with sector-expertise drawn from a relevant expert group such as GLPGP.
3. LPG-focused Non-Bank Financial Institution (NBFI). This would essentially serve as a focused development bank for the Rwanda LPG sector. It would on-lend blended capital and also provide technical assistance windows to the sector. It would focus specifically on LPG-related lending and finance. This model has proven effective in numerous development settings where agri-finance, small and mid-sized businesses, and gender- related economic catalyzation have been the objectives. It could be branded in order to help gain sector traction and acceptance.
4. Complementary financial resources. These comprise other development finance-backed capital, risk mitigation, and technical assistance grants through dedicated "windows of such resources" managed and allocated (on-lent) through established locally-operational financial and development institutions, such as the Development Bank of Rwanda or FONERWA. The World Bank's Clean Cooking Fund in Rwanda is one obvious candidate to provide concessional RBF capital and TA grants for the LPG sector, subject to an adjustment of its present scope of activities in Rwanda. Such resources could support, or complement, an LPG NBFI.

Options for creating blended finance

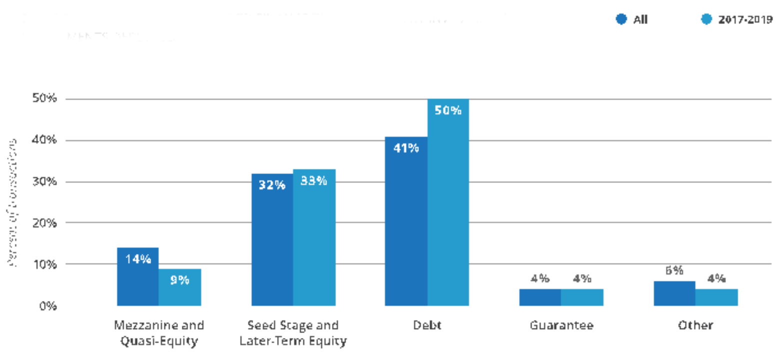
For LPG in Rwanda, both domestic and foreign funding, technical assistance and risk mitigation sources, and the approach to attract such sources, will be important. The following two charts portray the blended funding landscape of instruments and sources. The analysis they present serves as a guide to financing the Plan implementation from targeted blended finance sources; it shows the importance of design resources, on-going technical assistance funds, concessional capital and risk mitigation tools in the execution of blending finance solutions.

Figure 57. Proportion of blended finance transactions across blending archetypes
Source: Convergence Blended Finance database (2020)



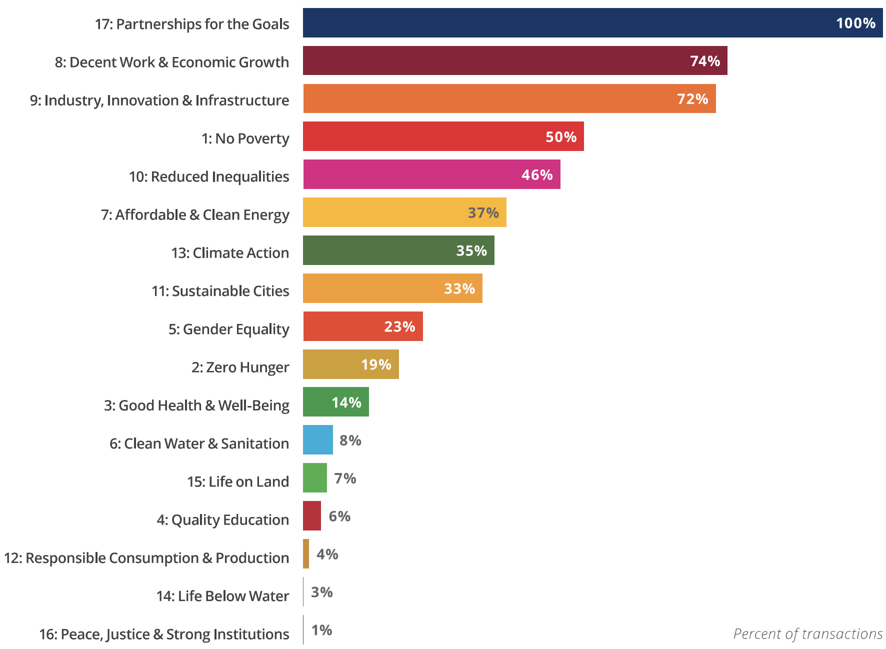
The chart above shows the importance of concessional capital and de-risking arrangements such as guarantees and risk insurance. The chart below shows the importance of concessional debt in blended funding transactions.

Figure 58. Proportion of concessional debt in transactions across types of instrument
Source: Convergence Blended Finance database (2020)



Sourcing the blended funding is also a matter of appropriately matching Rwanda's LPG funding needs to the priority interests and mandates of domestic and non-domestic blended funding and risk-mitigation sources. The chart below shows the areas active for blended funding sources using SDG mapping. Importantly SDG 3, 7, and 13 are high priorities in terms % of blended funding transactions financing initiatives with these themes.

Figure 59. Alignment between blended finance transactions and SDGs, 2014-2019
Source: Convergence Blended Finance database (2020)

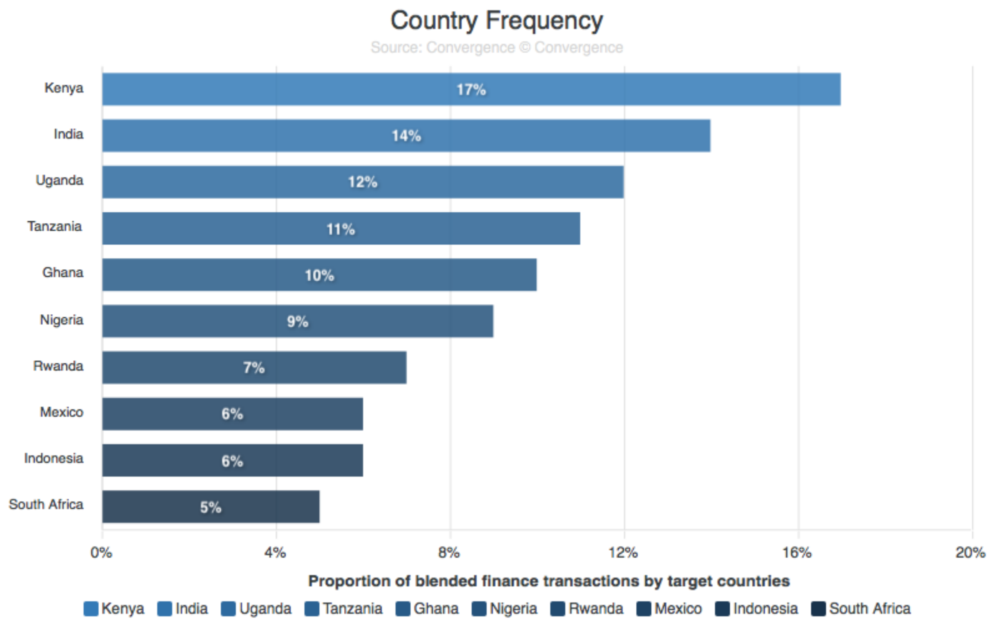


Targeting the right providers of the blended funding is important. For example, several DFIs (the largest participants in blended funding) are prohibited from backing fossil fuel-related initiatives. However, these same DFIs have expressed in interviews that they can support green alternatives, such as bioLPG production.

Non-Rwandan blended funding options

The chart below shows that Rwanda is one of the top recipients of blended capital flows for the 2014 to 2019 period.

Figure 60. Top countries receiving blended capital, 2014-2019
Source: Convergence Blended Finance database (2020)

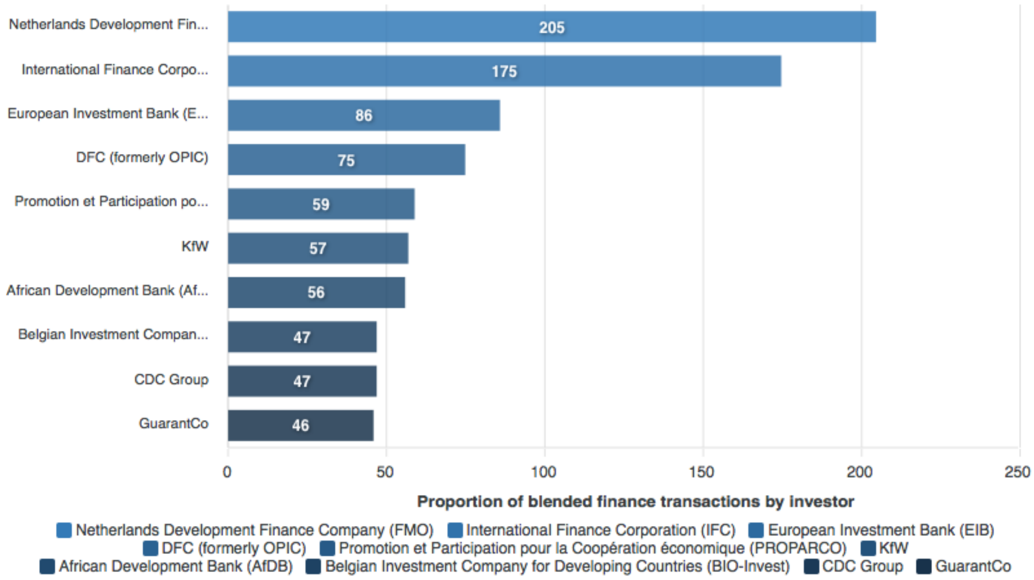


This shows how non-Rwandan blended capital sources are attracted to Rwanda, in general. The recommended approaches for aggregating non-Rwandan blended capital are as follows:

5. Directly funded capital: (i) Debt, concessional and non-concessional; and (ii) equity;
6. Indirectly funded capital: Concessional debt created by using development system-sponsored LPG on-lending financing windows, administered through selected local institutions such as the Green Fund;
7. Creating scalable financing mechanisms: LPG-focused NBFI leveraging the on-lending from indirectly funded capital;
8. Risk mitigation: Loan guarantee mechanisms and first-loss protection;
9. Technical Assistance (TA) grants: Grants focused on capacity building along the value chain, included for creating financeable business plans among Industry Leader operators (and other qualified operators); and
10. Other Innovative Approaches: For example, carbon finance (although this is not seen as a major source of funding at this stage).

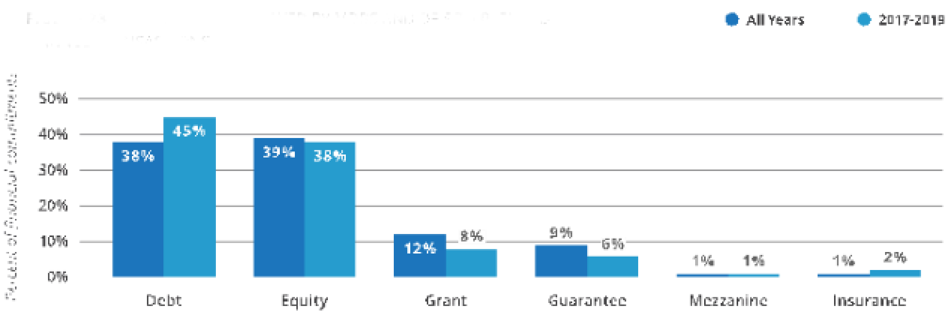
Direct discussions with potentially interested impact-oriented private sector and development finance institutions regarding project capitalization tolerance for the highest level of leverage, and for acting in a lead catalyzing role to crowd-in co-funding, included AfDB, FMO, IFC, KfW, SwedFund, USDFC, and others. The willingness of these groups to have preliminary discussions is an important indication that the recommended blended capital approach could be successful. The leadership role these groups play in mobilizing blended capital is corroborated by the independent blended finance analytical research from 2010 through 2018, as shown below.

Figure 61. Top public investors with a commercial-development mandate, 2010-2018
Source: Convergence Blended Finance database (2020)



The figure below shows the primary range of products used by the leading public institutions in blended finance. Once more-detailed company-level diligence information can be acquired, these avenues should be explored as options to finance the build-out of the various modalities of the LPG sector. Some of the Rwanda LMCs have indicated that they are in process of developing business plans that can be adapted into funding plans. According to Convergence from 2017 to 2019, 29% of blended finance transactions include a component of technical assistance. The funding community views this assistance as a form of risk mitigation, as it enhances the possibility for better investee management and performance.

Figure 62. Instruments deployed by MSDs and DFIs to blended transactions, 2017-2019
Source: Convergence Blended Finance database (2020)



Key conclusions

There is a convincing case to be made for funding the components of the Rwandan LPG industry to create both sustainable and economically scalable impact.

➲ Ideally, the full set of operational assets should be financed together, because investment in one asset type is not useful without investment in all the others, and the fixed assets, whose collateral value is stronger, support the mobile assets (cylinders), whose collateral value is weaker. The preferred approach, therefore, is for Industry Leader LMC firms making, or capable of making, vertical integration into all asset types to be the initial and primary beneficiaries of blended capital on the supply side, in order to create a successful Rwandan track record that can attract additional capital over time and also expand to less integrated firms, potentially through aggregating vehicles such as SPVs and an NBFI.

➲ The burden of paying for strategic storage should not be imposed on the LMCs in order to ensure bankability and avoid major price increases. This can be accomplished by treating a portion (notionally 50%) of the operating and logistical LPG supply within the value chain as a part of the strategic reserve (i.e., Option 2/ISS). This approach also reduces the financial burden on GoR for the national (NSS) share of the reserve.

On this basis, all three of the growth scenarios to 2030 provide adequate operational and financial results for a Industry Leader to cover the financial expectations of blended capital providers over multiple iterations (tranches).

➲ The optimal industry pathway to growth is evidenced from the demand-side data to be direct-to-consumer distribution with a home delivery component.

An important condition behind this Chapter's recommendations on bankability is the presumption of a supportive LPG regulatory regime, as outlined in Volume 3.

57. Financing Recommendations

➲ Recommended actions for implementing the financing options for the Plan include:

1. Develop immediately an LPG investment vehicle, notionally called the Rwanda LPG Financing Mechanism (RLM), as described in the next section. RLM's role would be to facilitate, organize, and streamline the investing and financing of the first tranche of the LPG sector build-out. This vehicle could include demand-side and TA measures in its mandate, but even if not, it should coordinate with the institutions/agencies organizing and supervising such measures.
2. DFIs (e.g., KfW) and like-minded institutions utilize or create appropriate facilities (debt, equity, and technical assistance) to enable first-mover Industry Leaders in the Rwanda LPG sector to take immediate steps to build out their assets and operations, starting with cylinder inventory.
3. DFIs also tap, or create, facilities to support the demand-side measures outlined in the Plan, in a coordinated manner with the supply-side ramp-up. These demand-side measures will contribute to the de-risking of the supply-side investments.
4. DFIs, working with GoR and GLPGP, assist the LMC-Bs to mobilize funding through capacity building and business and financial planning support. KfW, FMO, AfDB and World Bank, among others, are potential partners for this.
5. GoR shares the Plan with industry. This will provide a critical perspective and information to the operators to assist in their business planning. As mentioned earlier in the Plan, the GoR should link the granting and renewal of LPG-related licenses and permits to actions by applicants in furtherance of the Plan. That is, only projects and companies acting in line with the Plan and its recommendations should receive GoR authorizations.
6. Working through GoR and its agencies and institutions, such as MINIFRA, RURA, and others like BRD, begin the programme of mobilizing the LPG private sector to implement the Plan. As part of this, choose the most implementable and bankable Industry Leaders as the leaders and first-movers, and ensure they develop credible plans for:
   a. Asset Investment
   b. Distribution paths to revenue – direct to retail points of sale, direct to consumers, indirect
   c. Operations
7. As recommended in Chapter 61, explore timely the roles for RBF (World Bank CCF) and carbon credit options as supplementary sources of funding for industry and/or for LPG consumers.
8. Approach the range of identified potential blended finance sources, domestic and international, to obtain their interest in providing funding and using or creating appropriate vehicles. This can take 6 to 9 months on average in the case of DFIs, so it must begin swiftly in order for accelerated growth to be possible starting later in 2021 and significant impact on biomass use to be achieved by 2024.

Creating a Rwanda LPG Financing Mechanism (RLM)

➲ Given that the timetable to realizing Rwanda's LPG objectives is immediate, and the quantum of capital needed over time is sizable, it is recommended that a direct and targeted LPG blended financing implementation plan and an executing institutional mechanism/vehicle be established. This blended financing vehicle is provisionally referred to as the **Rwanda LPG Financing Mechanism (RLM)**.

RLM will be a funding conduit to aggregate blended capital with characteristics that match the needs of the growing LPG sector. RLM will also be a non-bank financial institution (NBFI), meaning a purely financing bank and not a traditional commercial bank. The NBFI will operate by lending/funding and will earn a spread on its activities to cover its operating expenses once critical mass of LPG lending/investing is achieved. This threshold would need to be modelled based on known industry operating revenue and expense metrics. (The IndCo and ProformaCo analyses give pro-forma examples of this.) RLM would have operational oversight from both blended finance experts and LPG sector-development experts.

The RLM will catalyze local and international capital, initially targeting DFI capital to crowd-in and catalyze other capital. A preliminary set of candidates for initial backing might include:

- **Technical assistance:** AfDB, World Bank CFF, USAID, UKAID, FMO, KfW, DFID, Swedfund, like-minded DFIs, AfDB, Foundations.
- **Investment capital and/or risk mitigation:** AfDB, KfW, FMO, Swedfund, like-minded DFIs, SIDA, USEXIM, USAID DCA, World Bank, IFC, and USDFC (OPIC).

Not all these groups can engage in fossil-fuel related funding, but the angles of financial innovation and inclusion – for example, micro-finance – may enable participation.

Blended financing operations

RLM will target operating windows to fund:

1. Grants for technical assistance to support the development of bankable financing and operating plans, capacity building, and procurements and project preparation in line with the Plan.
2. LPG value chain's supply-side build out by funding cylinder acquisition, other capital investments (filling/bottling plants, storage, transportation), and linked assets.
3. Ideally, demand-side initiatives such as providing microfinance capital and/or guarantees for demand development, such as those outlined in Part XVIII.

The RLM would be the face of the technical assistance and financing operations to the sector. This means identifying and engaging with LPG-related client prospects (for microfinance and other demand support, TA, grants, and debtor or investee selection). RLM would also provide access to outside risk-mitigation tools for borrowers, such as first-loss facilities.

RLM can possibly be co-hosted in the infrastructure of an established Rwanda banking entity with links to the commercial borrower community and also the development and impact investment community on the funder side. BRD is a likely candidate for consideration as the host. This would lower implementation thresholds and risks of weak brand recognition during the critical launch and early growth window.

Funding of RLM

The RLM would be funded through blended finance commitments via an SPV, provisionally called the "LSPV". By using the LSPV to aggregate funding and resources from interested blended finance sources and concentrate the needed LPG managerial/investment expertise, tranches can be created efficiently and effectively to match and shape projects to the mandates of blended finance backers.

The LSPV should be structured and funded to provide many classes of blended finance institutions with the potential to participate. Its tranches would be specifically structured to facilitate this in terms of asset types, risks, returns, and terms. RLM will need committed capital for technical assistance and blended funding (hard capital and risk mitigation products). The RLM can be designed as an evergreen (open-ended) funded SPV, so that funders can come into it over time. This also aligns with the overall 10-year investment horizon for the Plan.

The LSPV would aggregate concessional and non-concessional capital to the RLM from a variety of investment capital sources. This capital would be "patient capital", meaning structurally accommodative to longer terms, such as 4-10 years, depending on the source, and would be aligned with the tranch structures of the RLM. Some funders will require higher returns and different maturities than others, so the tranches will vary accordingly.

Launch capitalization

Based on comparable SSA vehicles in other sectors, the RLM will need estimated launch capital of US $3mm to $4mm for its design, to engage its team, to establish procedures and plans, to ensure regulatory requirements are satisfied, and to build its operational infrastructure[85].

The model described has been used for numerous other targeted sector initiatives such as medical credit (the FMO backed MCF), clean energy, small and medium enterprises, and agribusiness value chain initiatives. In Kenya and Ghana, for example, USAID created the Finance Ghana Agriculture Programme (FinGAP) and the Kenya Investment Mechanism (KIM). In Liberia, USAID and OPIC created a US $30mm NBFI, the Liberian Enterprise Development Finance Company, to mobilize capital for businesses in post-conflict Liberia in 2007-2008.

---

85 GLPGP senior personnel have experience designing and successfully implementing similar initiatives for sectors such as alternative energy and agribusiness value chains in countries such as Ghana, Kenya, Nigeria and Liberia; these initiatives were public and private partnerships of blended capital and targeted $30mm to $500mm in capital mobilization. They have also designed similar LPG-specific initiatives in SSA which, to date, have not been operationalized.

58. Risks and Mitigations

The early consideration of risks and the integration of risk-mitigation products greatly enhances the scalability of blended finance options. For the purposes of funding the supply-side Industry Leaders, projects, and consumer related initiatives such as microfinance for LPG or cylinder purchases, LPG operators, creditors and equity investors must consider relevant risks. Such risks include the following categories:

- Country risks (regulatory, political, other)
- Industry
- Economic
- Consumer demand
- Execution
- Financing / Fund structure and operation
- Investment process

Country risks

Regulatory and Enforcement Risks. The regulatory landscape in Rwanda applicable to LPG is a critical consideration. As laid out in Volume 3, strengthening Rwanda's regulatory framework for consistency with the BCRM, combined with effective enforcement, are important to unlock investment and in turn boost consumption as new cylinders are obtained and deployed. They serve to maintain a sufficient safety profile for LPG among the public and industry, and to prevent malpractices such as piracy and illegal cross-filling, already emergent in Rwanda, from undermining both safety and sector bankability and sustainability. Governmental enforcement will have to be stepped up and sustained as the market grows and with it, the regulatory burden on GoR.

➲ The Plan recommendation is that major new investment be considered only when it is clear that the regulatory environment has been fully upgraded according to BCRM, with corresponding enforcement capability.

Companies that exercise tight control over cylinder recirculation in their distribution networks, such as via a milk-run or direct home delivery model, can partially self-protect against pirate/black market activity operationally, and this should be encouraged or required, where economically viable, among recipients of capital.

As part of investing, legal stabilization clauses should be sought in any contracts involving the Government. Risk mitigation products may also be utilized where justifiable, as described later in this Chapter.

Additionally, diligence would be undertaken to confirm that the regulatory frameworks for business rights protection (including anti-counterfeiting), investment, and/or microlending are adequate. Use of qualified locally-familiar counsel and accountancies will facilitate such diligence.

Price Regulation Risk. There is a risk that, eventually, the Government may impose some type of regulation on LPG prices, which may include positive effects on consumption (such as equalizing inter-regional price differentials due to transport distances) as well as potentially negative effects on profitability of firms, such as by capping prices or capping the unit margins that can be earned. The LPG investing and corporate community in Rwanda would necessarily lobby the Government to minimize any adverse effects to them of such a change, and to phase in such effects over a reasonably long transition period. Among companies receiving financing, having an operational cost structure in place which is cash-flow resilient (up to a practical point) to potential caps on prices or margins will be a form of self-protection against the possibility of future price regulation by Government. The recommendation that firms vertically integrate throughout the supply chain as much as possible is in line with the objective of cash-flow resilience. (Managements will make cost-benefit and resilience tradeoffs regarding in-sourcing and outsourcing of key assets and operations, firm by firm.)

Capping of margins or end-user pricing would potentially have the largest impact on PAYG LPG companies, and therefore any such regulatory changes should be carefully constructed so that PAYG LPG companies are able to operate profitably, but also so that no loopholes are created for LMCs operating with conventional (non-PAYG) distribution, payment schemes and pricing.

Capping of cylinder deposit amounts would have the opposite effects: conventional (non-PAYG) LMCs would face a significantly greater financing need and debt service for cylinders, while PAYG companies (as the historically price up-front costs) would be largely insulated. (It is expected that almost all sector growth will be driven by the conventional model across all growth scenarios.)

Additionally, concessional capital and risk tools should be utilized where available to offset reductions in financial returns or debt service cashflows caused by a change to the national pricing scheme.

Investing Environment Risks. Rwanda has an overall favorable investment environment. Country risk premiums may also be priced into the overall cost of blended capital, based on the blend and the needs of the funder sources.

Nationalization/Expropriation Risks. To the extent this risk is deemed material, standard project and other insurance would be obtained where appropriate through bodies such as OPIC, MIGA, and other sources noted earlier in this Chapter.

Government Nonperformance/Default on Contractual Obligations. Where the GoR becomes involved in a common-user facility (such as NSS or a future ocean import terminal), or in a financial mechanism or vehicle such as the proposed LPGSPV and RLM, the Government may become contractually committed to funding or other obligations. If the Government were to default, this could have numerous politically sensitive impacts on the public, once they are increasingly tied into the expanded LPG market. Performance guarantees by Government and other key partners and counterparties should be provided for project completion and operational finance commitments as conditions precedent to investment.

Political Risks. Sufficient political and business support are integral to scaling up LPG. To reduce political risk, both local official and private sector partners must commit to the success of local projects, especially ones which are not entirely private sector-sponsored. Political support can be developed by project sponsors and funders, and through linkages by DFIs (for example) to other lending activities in the country. Regarding a shift in future political/policy for LPG investments, various third party insurance products can be considered.

There is also risk attached to complementary policies. For example, present policy discouraging charcoal in Kigali is pro-LPG, but uncertainty about its longevity causes it to be a planning and economic risk. Likewise, the present policy to exempt LPG fuel from VAT (but not imported LPG equipment) affects LPG adoption and consumption growth, and a change to that policy could affect future LPG demand, potentially requiring a slowdown in further cylinder investment. This risk can be mitigated by ongoing constructive dialogue between Government and LPG stakeholders and through the continued building up of the global evidence base (through continuing independent research) that LPG creates important social and environmental benefits for the public when displacing charcoal and firewood for cooking.

Timing Risks for Governmental Decisions and Capacity-Building. The actions and investments described in this report are deemed time-sensitive with respect to achieving intended scale and impacts by 2024 and 2030 at a manageable rate of growth, and delays in governmental decision-making and regulatory enforcement capacity-building can increase the risk of financing occurring, and of under-performance against business targets and on the financial parameters of the recommended investments. To the extent prerequisite actions by Government are delayed, the best solution is to wait. If, after waiting, funders and modalities desire to catch up to the sector growth to 2024 and 2030 as projected in this Plan, increased use of concessional capital could permit acceleration of the scale-up of the sector by increasing its economically sustainable growth rate. Additionally, use of funding structures and mechanisms such as those described earlier in this Chapter could decrease investment lead times for certain types of investment and could increase the rate of transaction flows through project aggregation and risk-pooling; and by continued or renewed technical assistance support (such as the support funded up through the time of this writing by the Clean Cooking for Africa Program) to the Government to assist it in its analytical and decision-making processes and its capacity-building.

Industry risk

LPG Supply, Demand, and Price Movements. As a global commodity, LPG is subject to price movements based on supply and demand dynamics outside of the internal market conditions of the country. This could impact the availability of product in target markets, if prices rise too high. In Rwanda, the market sets prices, which creates both competitive risks to margins (some players choose to absorb more volatility in input prices than others) and volume risks. (This is normal in commodity-dependent businesses.) Additionally, there has been a history of rare but significant import interruptions due to ocean piracy. Generally, margins in Rwanda are in the mid-range by Sub-Saharan African norms, enabling companies to withstand input price volatility relatively well (if they are not over-leveraged). Utilizing the recommended structuring vehicles and blending capital will lower overall break-even margin points for infrastructure assets and companies. In addition, underlying companies and projects will be expected to implement appropriate contingency planning in their operations such as hedging of inputs, including LPG supply. Long term supply contracts with diverse sources and buffer storage will serve as mitigants to these disequilibriums. MIGA and USAID offer programs to insure commodity price risks and these may also be employed, where justifiable.

Consultancy IHS Markit has forecast that global LPG supply will be in surplus at least through 2040, creating relative price stability during the expected investment horizon.

Additionally, commercial quantities of locally price-competitive bioLPG have been introduced into the global market in 2018; by 2030, such quantities could become a significant hedge against potential international LPG supply or price volatility. Rwanda should develop its own bioLPG production as a pro-green initiative as well as a physical hedging mechanism, as outlined in the Plan. Physical hedging of supply with locally produced bioLPG would additionally mitigate against the effects of possible future RwF-USD devaluation on the RwF-denominated LPG price within Rwanda.

Entering into long-term, price-capped contracts for LPG supply hedges further against LPG volume and price risk. This becomes more feasible as the market size grows, as port capacities to handle larger vessels increases, and to the extent that Rwanda pools its importation activities with other East African countries and/or operators.

While it is not needed from a capacity standpoint, the construction and efficient operation of a new open-access LPG import terminal around 2027, which could implement OTS pricing and could act as a complement to the main AGOL LPG import terminal, would mitigate the risk of shortages due to AGOL non-performance or mal-performance and the risk of future price excessive rent-seeking by AGOL or a successor to AGOL in order to favor one LPG Marketer over another, or to disadvantage all Marketers in favor of its own marketing affiliate.

Lastly, aggressively low pricing from new entrants in order to gain market share, could result in loss of market share (or slowed growth) among LPG companies that cannot afford to—or choose not to—match lower price points offered by competitors in the same communities. This risk can be operationally mitigated through focusing on cost efficiency in the supply and distribution chain, increased marketing and customer service (to build customer loyalty), mergers among competitors to achieve improved economies of scale and overall financial strength, and having adequate resiliency in cost structure and cashflows to allow any price wars that may emerge in future to be seen safely through to the end.

Use of Monopoly Power by Dominant Importer. AGOL is the dominant importer of LPG in East Africa and has become a top importer into Rwanda (through its OneGas affiliate) within the last year. It has near-monopoly power in that node of the supply chain along the Kenya import route. This is partially mitigated by Kenyan political leaders' interest to keep LPG prices relatively stable in order to appease voters; political leaders can complain to AGOL (even if they cannot control its governance) in lieu of compelling changes to AGOL's behaviour regarding any abuse of AGOL's dominant position. As mentioned above, AGOL also has the possibility to exercise its market power with respect to allocation of imported LPG among Marketers (including its own affiliated Marketer) in the countries where it operates, and setting prices. An important hedge is the ability to import LPG overland from Tanzania, as many Rwanda LMCs now do. Moreover, Tanzanian exports will be in a position to increase with the start of construction of a major €65 million inland LPG storage facility announced by the Government of Tanzania in June 2019. See also the mitigations discussed above under *LPG Supply, Demand, and Price Movements*,

Energy Alternatives. Price differentials could create a risk regarding substitute fuels at the end of the value chain. Given the level of development of other fuel products, it is expected that the risk of substitution is limited, except among the poorest. While that creates an impacts risk, the likely effect on investment results is expected to be small, based on the modelling performed and presented in this document. In addition, once businesses and consumers have invested in LPG equipment and adapted to it operationally and behaviorally, respectively, a switching barrier (whether economic or psychological or both) is created for abandoning LPG use. That is, LPG use, once begun, is somewhat sticky.

Price Inequality Due to Distance. Because LPG prices are set by the market and transport cost is a material component of price, end-user prices become higher and higher as LPG is sold farther and farther from the main centers of demand. This effect, although taken into account in the Plan demand scenarios, nonetheless reduces LPG adoption and use in more rural areas and in poorer communities compared with its potential, were their LPG pricing similar to Kigali prices. This situation is not likely to be exacerbated in future, but it could be improved through Government action to "universalise" the LPG price through transport cross-subsidy (urban users, who are already better off economically, pay a bit more, while rural users pay significantly less). The reason that urban users pay slightly more and rural users significantly less is that, on a volume basis, most LPG is bought today in urban and peri-urban areas; the volume of LPG in rural areas to be cross-subsidized in this manner will be significantly less, through 2030 and beyond, than the urban/peri-urban volume. Such Government action could result from dialogue with relevant stakeholders regarding this issue, and through advice provided to Government through the Clean Cooking for Africa Program/GLPGP and through technical assistance guidance given by interested DFIs and MDBs.

Economic risks

Currency and Exchange Rate Risks. The income received by the modalities will typically be denominated in the local currency of the project companies; however, the books and assets, capital contributions, and distributions will likely be conducted in U.S. Dollars or Euros, as appropriate. Accordingly, changes in currency exchange rates between USD/Euros and the Rwanda Franc may adversely affect the U.S. Dollar/Euro value of investment vehicles and the income, interest and dividends or other distributions it receives, gains and losses realized on the sale of investments and the amount of distributions, if any, to be made.

Because imported LPG is priced in U.S. dollars, and project companies' turnover (revenue) is in local currency, there is currency risk for the supply chain. Based on projections, this risk could become very significant in 2029 and 2030. Currency hedging and derivative products may be employed to mitigate these risks for both investors and operating companies.

These forex effects have already been included in the modelling of debt service coverage and financial returns for the ProformaCo, which is deemed bankable even when these risks are taken into account, and in the demand forecasts of this Plan.

Interest Rate and Inflation Risks. Currency, interest rates and inflation changes may impact LPG affordability and also the repayment performance of the LPG projects. Interest rate hedging and other approaches can be utilized to insulate from adversely expanding spreads. Inflation should be priced into contracts as appropriate, so as not to erode SPV/RLM and investment performance. Currency hedging should be employed under both project level and SPV/RLM level risk management policies.

Consumer-related risk

Less Demand than Was Forecast. The amount of projected demand may not arise for a variety of reasons, including lack of consumer awareness, lack of affordability, lack of accessibility, and the possible emergence of new competing clean-cooking alternatives to LPG. These potential issues can be mitigated by the work that Clean Cooking for Africa/GLPGP should continue to do in Rwanda (subject to availability of resources) in cooperation with GoR, including working to create awareness of LPG benefits among consumers. Additionally, the investments are staged over time, and can be accelerated or delayed/reduced based on leading indicators (including those specified in this Plan) signaling additional pent-up demand or early saturation of the market.

It should be noted that the Petroleum Institute of East Africa (the main industry body for petroleum products companies in East Africa) launched in 2019-2020 a national public awareness campaign about the benefits of using LPG for cooking targeted at Kenya. Learnings from this campaign should be evaluated for relevance to Rwanda. The scale and duration of the campaign in Kenya was limited to the level of funding provided by donations from industry and charitable sources.

Consumer Repayment Risks (re: Microfinance Loans and Other Installment Payment Schemes). Credit risk in large part will depend on both the selection of on-lending partners and consumer repayment behavior. The analysis of the extension of credit will include diligence of the MFIs and their underlying approaches to customer selection, credit policies, and the target market segments. As a practical matter, consumers will not want to be cut off from LPG once they are using LPG for cooking and have acquired the appliances for cooking and heating with LPG. Nevertheless, as a backstop, the use of blended capital that may be required to underwrite or guarantee or partially guarantee MFI lending will lower the costs of lending, and first loss arrangements with DFIs or other impact investors can protect the performance of the underlying lending portfolio.

New MFI lending for LPG adoption will be piloted in carefully expanding phases, applying lessons from each preceding phase to reduce the risks of later phases.

Ultimately, an aim of the Clean Cooking for Africa Program is for LPG microlending to transition to an entirely local platform of partners with underwriting from one or more of them for the group's activities, thereby creating the option for early exit and monetization of microlending activities.

Execution risks

Execution Risks. Investment projects must be required to have competent, experienced management. The funding vehicles (e.g., SPV, RLM) must do the same. Local partners that will be required, or are desired, where they are competent and experienced will help address local execution risks at the operational and local co-investment level. Ultimately, a sound governance system with international-standard financial reporting at all levels will be among the most important tools for identifying execution risks and responding quickly and appropriately to eliminate or reduce them.

LPG Distribution Execution Risk. The inability to reach the ultimate end users of LPG will be a gating decision point regarding whether to invest in a particular geographic target area. This will also limit the success of the investment vehicles but will protect from over stretching to serve untenable markets.

Counterfeiting, Piracy, and Issues around Safety. Local LPG industry and the management of the investment vehicle(s) must address these issues to the extent they may arise. Complete and effective implementation of the BCRM will significantly derisk this issue. Part of the solution may also come from integrating fragmented operators in the distribution chain vertically and horizontally, offering shared benefits from economic scale and market power.

Price and Cost Structure Risks to Firms. If the Government chooses to regulate LPG pricing or unit margins in future and allocates unit margins amongst the supply chain nodes in a way that ends up not adequately covering the costs at a given node, for whatever reason, the risk of viability of the adversely affected firms is increased. This risk can be addressed in two main ways: (i) The Government should carefully match its pricing formula to the costs and financial requirements (of equity-holders and lenders) at each supply chain node, in order to ensure adequacy at each node, to optimize the overall financial performance of the supply chain (taking into account the financial analysis in this Part), and to balance affordability for consumers against industry profit objectives; (ii) Through utilizing the ISLE indicators presented in this Plan, and consulting with industry and other stakeholders on an ongoing basis, the Government should periodically revise its allocation of unit margins as necessary to ensure the viability and performance of the value chain overall as the sector scales up, and as its conditions change.

Complexity of Coordination of Multiple Investment Projects. The quantity of parallel projects may introduce complexity which could cause delays, overruns in project preparations costs, and execution challenges in excess of projects taken individually. There can be no assurance that management and operation companies can successfully manage such complexity. Conversely, the fact that the projects are all linked through a master investment plan means that no one project will receive and deploy a quantum of growth capital without strong assurance that the linked projects in the supply chain receive proportional, and well-timed, quanta of growth capital, so that all projects are mutual reinforcing.

SPV/NBFI structural and operational risks and mitigants

No Operating History. These vehicle(s) are likely to be recently-formed entities, with no operating history. This may be mitigated by the operating experience and expertise of the Clean Cooking for Africa/GLPGP team, by experienced LPG operating managers on the ground, and by relevant in-country and international project partners, such as BRD.

Liquidity of Investment. The investments may be illiquid, as with all private equity and long term debt investments. The investors will be provided with distributions as appropriate and, if a critical mass of investment is created, it will make the portfolio possible for an exchange listing (as discussed earlier in this Part of the report) or potential financial sale. To the extent possible, the investment project agreements will include terms that give options for forced monetizations or exit pathways under appropriate conditions.

Long Term Investment. An investment in the vehicles is a medium- to long-term investment. The aim of facilitating the creation of sustainable LPG platforms dictates a significant length of time between the initial investment and the return of investment or realization of gains, if any. “Patient capital” will therefore have a role to play in the capital stack.

Restrictions on Transfer and Withdrawal. There may be no market for the investment securities (if securitized), absent an exchange listing. In addition, investments in the SPVs/NBFIs may not be transferable or withdrawable in the usual course of business.

Asset Valuations. Valuations of the LPG assets will be determined by the management of the investment vehicles, or directly by the funders, working with outside valuation experts. The valuations will be based on audited financial information to the extent possible, complemented by best-practice valuation methods and metrics used in the LPG sector globally.

Investment process-related risks

Finding Investments. The ability to prepare projects and execute the investment strategy in reasonable time frame given possible regulatory and other issues will be a major focus. Continuing diligence will permit walking away from projects which cease to offer the return and risk profile meeting investor requirements before significant amounts of capital have been deployed in them.

Ability to Realize Cash Returns and Exits. As with all investment vehicles, continued listings of the vehicles on liquid exchanges, as well as underlying assets, plus trade sales and dividends, are not certain in time or amount. The strategy of listing or shelf registration can mitigate these risks.

Country Development Risk. Part of the feasibility assessment in this Plan involved consideration of favorable national developmental trends such as: attractive demographics; rising per capita income; credit reach;

urbanization; legal and political stability; progressive governmental policies for healthcare, environment and development; growing foreign investment; development of infrastructure (in particular, road networks), etc.

Environmental Hazards (Other Than LPG Accidents). The investments and projects must be implemented following ADR and other best practices and global regulatory standards. In addition, the funds and projects will take appropriate insurance policies against hazardous accidents and occurrences.

Wrong Investment Thesis. If the findings of, and conclusions from, this Plan are wrong, it could result in an initial overinvestment in cylinders, but this is self-correcting by slowing the rate of future expansion of cylinder inventory. If the cylinders were financed with short-term capital (e.g., working capital finance), the corresponding risk of failure to repay debt timely following an overinvestment would be high; however, utilizing the proposed long-term debt structure for cylinder finance, with principal repayment starting only in year two, provides ample time-cushion to mitigate the risk of initial overinvestment in cylinders. Management and advisors should continue to conduct detailed studies in advance of major capital deployments to be maximally confident that the investment thesis is correct and investments are correctly sized.

Risk mitigation sources

DFIs, MDBs, IFIs, private companies and others provide the risk mitigation tools profiled below.

Risk mitigation tools include guarantees, insurance, and other credit enhancements that are often used in combination with impact or related funding to strengthen the creditworthiness of a funding recipient.

Many providers of capital also provide risk mitigation tools which offer potential efficiency in lining up the right combinations of blended funding and risk mitigation for many products and services.

To mitigate risks further, the blended finance approach envisions the use of TA budget (operator education and business planning and management) in addition to the funded capital and risk-mitigation tools. The risk mitigation approach is meant to mix TA, cash, and risk-mitigation insurance structures to provide a comprehensive safety net to operators and the external backers. For example, the FX exposure in Rwanda can be hedged out to 2030 through the use of FX-related hedging or back-stops against devaluation for those funders providing hard currency capital. DFIs, quasi-private, and fully-private sector based entities can provide variants of these products—forex derivates, insurance/guarantees, loss protections, etc.—for fees. FX exposure on imported LPG can also be physically hedged through local LPG production (i.e., bioLPG) whose costs are entirely in RwF.

In addition, the consideration of first-loss or guarantee structures to mitigate downside to debt providers and equity holders in blended finance capital stacks is useful. This would most likely be used for the commercial non-concessional debt first, as concessional debt is often effectively subordinated to commercial debt. In the event that risk mitigation such as first-loss or insurance from entities such as DFIs is arranged, the range of support would be likely 25% to 50% on principal exposure with possible interest coverage. This would also further enhance the credit characteristics of the three LPG funding scenarios. Providers of risk mitigation are numerous but some references already explored either in the context of Rwanda, or other LMIC LPG projects, include: AfDB, AfriExim, IFC, multiple other DFIs, aid institutions such as SIDA, USAID, UKAID, and USEXIM, among others. Where they can engage in fossil fuel-related projects, all of them provide variants of such protections.

XVIII. Consumer Financial Support Programs

This Part describes two key demand-side support programs for consumers:

1. A targeted equipment subsidy scheme for lower-income/lower-SES households, and
2. A microfinance programme for the up front costs to switch to LPG, for such households.

59. ‘Muturage Gas’ Project

Key programme elements

This programme, inspired by the aims of the (unsuccessful) Kenyan programme and the (successful) Indian PMUY programme (about both of which, see further below), comprises the following elements and characteristics:

- **Targeted** to lower-income/lower-SES households *within profitable distribution distance* from private-sector filling and distribution facilities;
- Households *and communities* must demonstrate shared **financial commitment;**
- **Private sector** acquires and **distributes** programme-compliant, branded cylinders and good quality stoves, handles refills, potentially under **territorial concessions** with **performance obligations;**
- **Fully BCRM-compliant;**
- Utilize **home delivery** modality as much as possible;
- The consumer offer is partially **subsidized 6 kg cylinder** and/or RBF-subsidized **2-burner stove** and accessories; the consumer may opt for a 12 kg cylinder if desired;
- **Transport cost equalization / home delivery** cross-subsidy for the private sector, so that the end-user pricing is the same wherever the programme operates;
- Licensed **PAYG** companies can be included as qualifying operators;
- **VAT zero-rating** on fuel and equipment; and
- **Education and sensitization** programs are carried out to the target communities.

Learnings from recent experiences of other SSA countries

➲ Any such Rwandan programme should be mindful of the learnings from recent African examples of similar programs:

Ghana rural LPG programme

- The programme comprised small, fully-subsidized cylinders provided to remote rural communities, using state funds

- Distribution was by the private sector under a concession scheme
- Outcomes: Consumers did not refill the cylinders; the programme was halted for redesign

Kenya Mwananchi Gas programme (first attempt)

- The programme comprised small, partially subsidized cylinders provided to lower-income communities outside the mainstream LPG geography
- Managed by Ministry of Petroleum and the National Oil Company of Kenya (NOCK) with funding from a World Bank petroleum sector development funding window
- Outcomes: Consumers did not refill the cylinders; industry sued government over unfair subsidy allocation to a single company; corruption allegations; safety issues due to cylinder procurement errors
- The programme was halted for redesign with scaled-back goals
- See below for a deeper discussion

Nigeria free cylinder programme

- Small cylinders were provided for free to the public
- Private sector LPG companies bought up the cylinders in order to take them off the market, in order to protect their revenues from their existing customer base

Learnings from the prior project in Kenya

The government of Kenya, working through the NOCK, began offering LPG cooking equipment cost-free to poorer, rural households through its Mwananchi Gas Project in 2018. The project objective was initially defined as deploying 4.8 million cylinders of 6 kg size with burners and grills to poorer households over three years.

In its general concept, this programme was similar to the Indian Pradhan Mantri Ujjwala Yojana (PMUY) scheme, which directed subsidies on both LPG equipment and fuel to below-the-poverty-line Indian households to empower them to access and use LPG, supported by a major expansion of LPG distribution, retail and logistics capacity. Since 2016, 58 million additional Indian households gained access to LPG under the scheme[86]. Conversely, in its initial rollout, the Kenya programme did not develop the level of LPG cylinder and fuel availability, retail density, and consumer uptake of the Indian programme.

The Kenya programme was adversely affected by five key issues:

1. *Procurement problems.* Imported cylinders had high defect rates and were subjected to recall after an initial consumer deployment.

---

[86] www.pmujjwalayojana.com/about.html

2. *Corruption allegations.* Media investigations led to allegations of corruption affecting the procurement of the cylinders, among other aspects of the project.

3. *Geographic and demographic mis-targeting.* 75% of the recipients of LPG kits in NOCK's target communities did not want to switch to LPG and thus never refilled their Mwananchi cylinders.

4. *Logistical capacity*. NOCK were not fully prepared for the logistics (cylinder distribution and refilling) required by the scale of the cylinder deployment.

5. *Legal issues*. Private sector competitors initiated legal action against the Kenya government because it had procured the Mwananchi project cylinders on its own account and then gave them to NOCK to deploy, with no opportunity for NOCK's competitors to benefit similarly or to compete for the opportunity to do so. (By comparison, the Indian LPG market is almost entirely served by three state-owned utility companies, which collectively implemented the distribution function of the PMUY scheme under the direction of the Indian Ministry of Petroleum; in Kenya, the LPG market share of NOCK was around 3%). The Kenyan private sector companies argued that the government's providing free cylinders to NOCK created an unfair (and illegal) competitive advantage for NOCK, to their detriment.

The project was put on hold in 2018 in order to redesign it, to restart the cylinder procurement, and in principle to allow the legal challenges to be adjudicated. The project objective was reset to 3 million cylinders, back-loaded to later years. NOCK engaged a local consultancy to help define a new consumer targeting strategy.

Critical learnings from the Kenya experience are:

1. Conduct an effective and transparent procurement to world-class standards.

2. Carefully select target communities on a geographic and demographic basis, ensuring that the communities (a) desire LPG, (b) at the household level are able and willing to make a financial commitment to the LPG solution (equipment and future refills), (c) are located in existing, profitable distribution areas of the participating LPG Marketer(s).

3. Ensure the partnering LPG company/ies are fully committed to supporting the rollout of the initial LPG kits to households, the educational programme, and providing service to the consumers over the long term.

4. Ensure that the subsidy budget is fully funded for the long term, whether from government, donors, or both.

5. Include an effective communication and education component for the target communities.

6. Work with experts knowledgeable in LPG programme and value chain planning, distribution, consumer education, and design and supervision of pro-poor LPG programs.

7. Conduct one or more pilot programs first, to validate assumptions and assure scalability before embarking on a large-scale rollout.

8. Have a formal, independent monitoring and evaluation component to the programme, with a formal feedback mechanism to make improvements that engaged with all stakeholders and beneficiaries.

Development of a Rwanda pilot programme

➲ As part of the demand-side measures under the Plan, it is recommended for the GoR, working with relevant stakeholders and experts (e.g., GLPGP), to devise and arrange funding and other resources for a pilot programme for 10,000 initial households to validate the feasibility of the concept in the Rwanda context.

This pilot programme should be kept geographically isolated from other proposed demand-side consumer initiaties, to avoid cross-programme interference and confusion among consumers and among project partners, and to ensure that pilot programme results and learnings are not contaminated by other concurrent programs.

60. LPG Microfinance Programme

In 2017, GLPGP organized the first successful LPG microfinance programme in SSA, in Cameroon, called "Bottled Gas for Better Life". The programme has since been expanded in that country. A second programme was then launched in Kenya, and a third is now in preparation in the Democratic Republic of the Congo (DRC). Some independent organizations have copied the programme.

The initial purpose of these programs is to demonstrate to all relevant stakeholders the viability and potential scalability of LPG microlending to consumers, in order that LPG microlending can become a normal fixture of the LPG landscape for lower-income/-SES consumers, their lending institutions, and LPG companies.

This Chapter provides a general outline of such a programme for Rwanda. To implement it on a pilot basis, additional steps must be performed to adapt the programme outline to the specific conditions in Rwanda and the needs and capabilities of the prospective project partners.

Programme goals

The goals are:

1. Accelerate adoption of LPG by lower-income/-SES households as the national LPG supply chain is expanded
2. Create a Rwanda-specific proof of concept to justify local microfinance institutions (MFIs) to incorporate LPG household lending in their regular portfolios

Key elements

- Six-month commercial-rate microloans offered to lower-income/-SES families in Rwanda for an "LPG kit" (described below), comprising all equipment needed to be an LPG consumer and a set of initial cylinder refills
- Consumer surveying to determine community viability
- Community sensitization/education on safe and effective LPG use
- Targeting of new LPG users on a community by community basis
- Communities selected based on ability and willingness of a critical mass of households to become LPG users and pay for refills over the looong term
- Local MFI partners may require or request to do consumer credit screening and/or work with existing clients
- Capacity building through close collaboration with MFIs, public sector stakeholders and LPG Marketing Companies
- Can utilize mobile money/mobile payments where appropriate
- Initial roll-out as a pilot programme within a selected geographic area (peri-urban and/or non-remote rural)
- Based on the success of the pilot, the programme would be scaled up, including to additional geographies and with additional operating partners

Potential structure of partners for pilot programme

Role	Prospective partner(s)
Programme coordination, training	GLPGP microfinance team supported by MINALOC, EDCL
Lender	Rwandan bank, e.g., BRD
Financial agent(s)	Umurenge Savings and Credit Cooperatives (SACCOs)
Screening processes	Saccos, imidugudu, check-off systems through reputable employers
Cookstoves and accessories	Local manufacturer, e.g., SODTECH Ltd
Cylinder and LPG provider	Locally active LMC
LPG kit assembly and logistics	
Consumer education and sensitization	GoR (MINALOC/EDCL)
Monitoring and evaluation	Operationally: GLPGP Independent review and reporting: U. Liverpool
Beneficiary communities	Nominated by GoR (MINALOC), in LMC parter service area, validated via surveying and local leader support
Loan subsidies/underwriting support (optional)	World Bank CCF (with BRD, EDCL)

Enabling conditions

Rwanda has the necessary programme enabling conditions for, at least, peri-urban areas outside Kigali. These include:

1. Existing, viable microfinance institutions with a history of successful consumer lending (in this case, Saccos)
2. Capable LPG marketing and distribution companies already serving the area
3. Prior consumer experience with microloans (for other purposes)
4. A widely-used mobile payments system, to facilitate and streamline payments
5. A relevant governmental body (MINALOC) focused on municipal engagement, and relevant governmental bodies (REG/EDCL) with a focus on expanding consumer LPG adoption
6. A national development bank (BRD) which can, in principle, provide support and underwriting capability to involved MFIs, and which is already involved in the coordination of results-based financing for clean cooking (see below); FONERWA also is believed to have a funding window which might be utilized
7. An independent evaluator (University of Liverpool) with Rwandan clean cooking experience and experience elsewhere in SSA related to LPG microfinance which, with grant support, could undertake the independent M&E function for a Rwandan programme

World Bank Clean Cooking Fund

In addition, the presence of the World Bank Clean Cooking Fund (CCF) in Rwanda, funds from which are available to subsidize LPG stove costs, increases the ability of Saccos to engage in LPG lending and of consumers to obtain and repay loans, if CCF funds are so used.

(Unfortunately, the CCF scheme for clean cooking in Rwanda does not extend to financing of LPG cylinders, only to LPG stoves and accessories. It is recommended that the results-based-financing scheme be amended to allow inclusion of cylinders for maximal effect on LPG adoption, consistent with the aims of the GoR and of the CCF in Rwanda.)

MFI challenges

The following are common challenges cited by MFIs in prior LPG microfinance Bottled Gas for Better Life programs, to be taken into account in the detailed development of a Rwandan programme:

1. Unwillingness of MFIs to provide loan capital from their own balance sheets, particularly at small programme scale.
2. Unwillingness of MFIs to record information used for impact evaluation (e.g., surveys). Even when the MFI are willing, the beneficiaries are not available or willing to take part in any survey once they have received their equipment.
3. MFIs and LPG marketers may see marketing and sensitization in connection with the programme being over and above "business as usual" activities, and may therefore be unwilling to take the lead or contribute to the associated costs.
4. Some MFIs need government authorization or a formal policy directive in order to enter the LPG lending sector.
5. The usual and customary MFI loan process and fees are potentially burdensome for these small loans, both for the beneficiary and the MFI institution.

Detailed programme design process

Establishing a programme involves certain, significant up-front organizational work, including:

- Selection of target community/ies
- Identification and recruitment of appropriate MFI partners
- Sizing, based on data about the community/ies and the capabilities of the MFI and LPG operational partners
- Determination of criteria for consumer participation (which may include credit screening criteria, the need to establish a bank account if none exists, prior LPG experience vs. no prior LPG experience, other eligibility criteria, etc.)
- Selection of equipment (cylinders, accessories, stoves) and pre-procurement arrangements, including negotiation of prices and terms
- Logistical arrangements (procurement, quality assurance, secure storage of equipment, distribution, repossession when necessary, set-up, etc.)
- Detailed definition and timetable of pre-awareness, sensitization, education, demonstration and training programme elements
- Developing support from local leaders

- Legal agreements (MOUs etc.) among project partners, setting forth their responsibilities, obligations and economic interests
- Detailed budgeting, by partner
- Other arrangements

Microloan and LPG kit details

Table 108. Indicative LPG microfinance programme loan parameters

Parameter	Value / Description
Equipment	12 kg branded cylinder (filled), 2-burner stove, regulator and hose
Included refills[87]	5 (notionally)
Loan principal	RwF 86,950 (basic equipment kit option) RwF 174,900 (enhanced equipment kit option)
Repayment schedule	6 payments over a period of 6 months
Fees	Insurance fee, at prevailing rate Loan processing fee, at prevailing/negotiated rate
Deposit	If customers are required to own bank accounts, customers new to the sponsoring bank pay a nominal refundable security deposit[88]
Interest rate	9% over 6 months charged on the loan principal (excluding security deposit), on a declining balance basis
LPG refill price	Per kg: RwF 1,115
LPG kit	
Basic option	6kg cylinder, initial refill, 1-burner stove, regulator, hose, plus 4 more refills
Enhanced option	12kg cylinder, initial refill, 2-burner stove, regulator, hose, plus 4 more refills
Other/alternative options	To be determined upon stakeholder consultation

➲ It is recommended that GoR, GLPGP and RBD (in its CCF role) collaborate on the design and launch of a pilot programme to assess its impactfulness and scalability.

87 By including the fuel in the loan amount, the consumer never has to choose between making a loan repayment and making a cylinder refill payment. This has been shown to improve loan repayment performance as well as LPG acclimation and long-term usage.

88 In practice, the security deposit is typically applied to the final loan payment.

61. Integration with World Bank CCF

In September 2020 it was announced that Rwanda is partnering with the World Bank Clean Cooking Fund (CCF) to support clean cooking efforts. The CCF employs a results-based financing (RBF) mechanism.

RBF highlights

The RBF is a sub-component (3b) under the Energy Access and Quality Improvement Program (EAQIP). It is intended to support the dissemination of improved cooking technologies. In practice, this has meant to date a planning focus on cookstoves and certain accessories thereto, and has excluded financial support for the other major item of consumer LPG equipment, namely, the LPG cylinder.

Therefore, the RBF can subsidize up to 90% of the cost of consumer equipment for non-LPG cooking, but only about 50% of the cost of consumer equipment for LPG cooking.

➲ It is recommended that the RBF programme design in Rwanda be amended to allow LPG cylinders to be included.

The cookstoves that can be supported span a range of efficiency and emissions tiers; of five tiers (with 5 being the cleanest / most efficient and including LPG), tiers 2-5 are permitted to be supported.

The stove efficiency tiers are shown in this table:

Table 109. Rwanda RBF stove tier definitions

Tier	Thermal efficiency (%)	CO (g/MJ)	$PM_{2.5}$ (g/MJd)
5	≥50	≤3	≤5
4	≥40	≤4.4	≤62
3	≥30	≤7.2	≤218
2	≥25	≤11.5	≤300

The programme has a five year lifespan as presently configured, and the funding is matched to a target population objective of 520,000 households in both urban and rural Rwanda.

The consumer is the ultimate beneficiary of the RBF funds, because they act as a stove subsidy.

The RBF funding flows to the stove provider, rather than the consumer, for sake of effectiveness and control. Private sector firms may apply to be considered for RBF support.

BRD is the fund manager for Rwanda and as such approves and enters into grant agreements with stove providers (termed “clean cooking companies” (CCCs)). EDCL provides technical assistance and, in particular, is responsible for determining the elegibility of a given stove for RBF support, working with a stove testing lab and an independent verification agent.

A steering committee chaired by MININFRA oversees the entire process.

CCC eligibility

The Rwanda programme has a well-considered elegibility screen for CCCs, including:

- Memorandum of Understanding in place with EDCL;
- Adequacy of funding / resources to be able to support the dissemination of stoves and after-sale support thereof;
- A satisfactory end-user pricing scheme;
- An adequate business plan;
- Adequate operational capabilities;
- Qualifying products; and
- Product warranties of at least one year and after-sales support capability.

CCC role and LMCs

It is anticipated that most Rwanda LMCs could qualify, if they were to offer LPG stoves as a product (together with cylinders). Where LMCs operate via independent distributors, it is unclear under the disclosed RBF information available as of this writing whether it is the LPG distributor (Wholesaler) or the LPG marketer which would be the RBF counterparty.

➲ It is recommended that the RBF funding counterparty be the LMC, provided the LMC takes responsibility for the LPG stove being provided to new LPG customers for whom RBF funding releases will be triggered. The LMC would be responsible for ensuring that it, and/or its contracted distributors, would meet the operational eligibility requirements, with the LMC undertaking the programme obligations on behalf of itself and its distribution network. This would also serve to accelerate the scale and impact of the RBF, because a Industry Leader LMC capable of selling to tens or even hundreds of thousands of customers can roll out an RBF-backed LPG kit programme rapidly and capably, compared to a local stove-making company (for example).

Note that many LMCs today do not sell the consumer appliances for LPG cooking. This is common in the LPG industry. Operators focus on dissemination of cylinders, not necessarily on appliances. In Rwanda, joining the RBF programme would entail the LMC taking a more holistic approach to its retailing, by ensuring that its end-users can obtain both cylinders and suitable applicances via its retailing network.

For companies operating on a home-delivery basis, this horizontal integration into appliances would entail complications to the business model and distribution mode.

However, experience from LPG microfinance programs in various other countries (see Chapter 60) indicates that such integration, while not normally desired by LMCs, is nonetheless feasible for them, and could be undertaken if they view the rewards as an adequate incentive.

Cashflows

The RBF funds benefit the end-user, but they flow through the CCCs. CCCs claim RBF funding based on milestones applicable to batches of stoves. The milestones are:

- Acquisition of an initial inventory of qualifying stoves
- Sales of qualifying stoves
- Consumer adoption of the stoves, with third party verification
- Realization of environmental and climate impacts from the adopted stoves, with third party verification

The amount of funding depends on the nature of the stove and the economic classification of its user. A percentage of that amount is released at each milestone.

This cycle provides *de facto* working capital finance to CCCs.

The amount of RBF funding toward a given LPG stove is specified in the programme design. It can range from US $31 to US $49, based on the stove type and the end user's status. These values notionally represent about 45% to 70% of the cost of the stove, accessories, and installation thereof.

As previously mentioned, RBF funds do not subsidize the consumer's cost to obtain the LPG cylinder (around US $20). With the cylinder cost included, the subsidy percentages drop to around 35% and 54%, respectively.

This puts LPG equipment at a competitive disadvantage to non-LPG equipment under the RBF scheme, from the consumer's point of view.

From the LPG Marketer's point of view, this scheme would be seen as potentially disadvantageous. The consumer (except in the PAYG case) already provides 100% of the working capital requirement for the cylinder and buys the appliances for cash, so if the LPG company must fund 30%-55% of a stove-specific working capital requirement in order to offer stove products, that represents a drain on its cashflow that the company would not otherwise face.

Thus, for RBF to be effective for LPG companies, and to render LPG kits competitive with non-LPG kits for equivalent households, then the RBF must be adapted to include providing funding towards the cylinders as well as the cooking appliances.

Ways RBF can support other LPG demand-side measures

Among the demand-side programs recommended in this Plan, RBF funding—even if limited to stoves and accessories—could improve the financial characteristics, viability and scalability of both the "Muturage Gas" subsidized equipment programme outlined in Chapter 59, and the LPG "Bottled Gas for Better Life" Rwandan microfinance programme outlines in Chapter 60. Assuming the LMC (in the role of a CCC) qualifies for the RBF, the RBF per-stove funding acts as a direct contributor to a reduction in the consumer's equipment cost in the former, and a direct contributor to the loan underwriting value and loan economics in the latter.

While it is beyond the scope of this Plan document to detail the specifics of an integration of RBF with both of these programs, RBF should be considered in their detailed design as the Plan is implemented.

RBF and PAYG

Chapter 54 discusses the PAYG model in qualitative terms and Chapter 55 in investment and financing terms. Key differences in PAYG LPG from what is described above are that (i) PAYG LPG companies have much higher costs of equipment to bear, due to the presence of a smartmeter on the cylinder; this can cost in the vicinity of US $50 per smartmeter, and (ii) the consumer does not usually pay a significant cost for the equipment up front, because that cost is recaptured over time in the price premium charged by the PAYG LPG company for the LPG kilograms actually used.

A dollar of RBF spent on a conventional LPG equipment kit (even if limited only to the stove and accessories) therefore has a much greater impact, proportionally, on the overall economics experienced by the consumer and by the LPG company than the same dollar spent on a PAYG LPG equipment kit.

That said, PAYG LPG companies (if one or more commences or recommences operations in Rwanda) should be welcomed as CCC applicants for RBF funds, on the same footing as non-PAYG LPG companies. On the presumption that conventional and PAYG LPG companies mostly compete for different types of consumer, the market for each might be expanded through the use of the RBF mechanism.

The RBF registration and M&E activities should clearly distinguish between PAYG LPG and conventional LPG companies, so that the impacts per RBF dollar can be quantified distinctly for each business model, thereby guiding future allocations to whichever model produces the maximum impact.

Finally, it must be noted that the number of households to be supported in moving to clean(er) cooking via RBF over four years is a fraction of the total new LPG-using households projected under the scenarios in this Plan. Therefore, the RBF funding, at its present level, represents a possible market catalyst for LPG (among certain user segments), but is not sufficient to be a universal solution for LPG access.

Rwanda National LPG Master Plan

Volume 6

Impact Potential: Environment, Climate, Health and Economy

Contents

List of Tables

List of Figures

XIX. Environmental, Health, Social and Economic Impact Potential

This Part provides an evidence base and estimation for use by investors, policymakers, industry and researchers to guide the development of LPG infrastructure and distribution systems in Rwanda.

Summary of potential impacts

The projected impacts from accelerated LPG adoption and use across the Low, High and NST-1 Target sccenarios are as follows:

Environmental:

- **Averted deforestation**: 243 – 354 million trees saved between 2021 and 2030
- **Carbon dioxide equivalent (CO_2eq) emissions[89] averted:** 25.6 – 40.1 million MT of CO_2eq emissions averted cumulatively between 2021 and 2030
- **Black Carbon equivalent (BCeq) emissions[90] averted:** 14.9 – 25.8 million MT of BCeq emissions averted cumulatively between 2021 and 2030
- **The economic value of averted CO_2eq emissions in terms of carbon financing:** $ 97 million – $ 152 million cumulatively between 2021 and 2030, using the 2020 prevailing price of carbon

Health:

- **Averted premature deaths:** between 2,600 and 7,700 deaths could be averted cumulatively between 2021 and 2030 due to LPG usage
- **Avoided Disability Adjusted Life Years (DALYs):** 135,700 – 403,700 DALYs between 2021 and 2030
- **Value of labor time gained:** $7 million – $20 million cumulatively between 2021 and 2030

Consumer economics:

- **Annual cost savings to a typical household from switching to LPG from charcoal or purchased firewood:** RwF 15,400 as of 2024 and RwF 35,200 as of 2030[91]

---

89 CO_2eq emissions include carbon dioxide equivalent emissions from carbon dioxide, methane, and nitrous oxide. These were calculated using IPCC conform standards.

90 BCeq emissions includes black carbon equivalent emissions from black carbon, organic carbon, carbon monoxide, and total non-methane organic compounds.

91 Based on an exchange rate of *US$ 1= RwF 975.00*

National economics:

- **Tax revenue (assuming no rate or law changes):** Increase of annual tax revenue of RwF 1.7 billion – RwF 4.4 billion as of 2030[13]
- **Trade balance (assuming no rate or law changes):** Incrase of trade deficit by RwF 43 billion ($ 44 million) – RwF 134 billion ($ 138 million) as of 2030[13]

Impacts modeled

Impact modeling involved quantitative estimation of four distinct impacts from increased LPG adoption and use for household and public institutional cooking under the various scenarios:

- **Impact 1: Environment and climate –** the averted deforestation, carbon dioxide equivalent emissions (considering carbon dioxide, methane, and nitrous oxide), black carbon equivalent emissions (considering black carbon, organic carbon, carbon monoxide, and total non-methane organic compounds), and the economic value of averted CO_2e emissions in terms of carbon financing.
- **Impact 2: Health –** the averted negative health impacts due to decreased burning of firewood and charcoal and resultant household air pollution (HAP). This includes the number of deaths averted, the disability-adjusted life years (DALYs) saved, and the potential economic value that these individuals can now realize from the five main Global Burden of Disease (GBD) outcomes.
- **Impact 3: Consumer household expenditure –** the cost savings/increases for the household due to increased LPG adoption and reduced usage of other fuels.
- **Impact 4: Macro-economic** – the impact of increased LPG adoption on Rwanda's tax base and trade balance.

Where applicable, the analysis calculated the impacts of the BAU case relative to 2020 baseline conditions, in order to determine the probable contribution of LPG to the impacts absent any new interventions, and then calculated the incremental effects of the Low, High, and NST-1 Target scenarios atop of the BAU effects to determine the total impact potential under each of those scenarios. The findings presented below are presented both in aggregate and incrementally, to show the effect of LPG overall, and the net effect of layering on interventions.

Data limitations

The assessment did not address additional potential mechanisms for impact, such as assessing climatic cooling effects from LPG transition. The health analysis is restricted to the five main GBD health outcomes, and does not estimate additional health impacts known to be associated with exposure to HAP, such as cataracts in older women, adverse pregnancy outcomes, etc. As a consequence, some of the positive health impacts of transitioning to LPG may be underestimated. Gender impacts are qualitatively described but not quantitatively modelled.

Data sources and overall approach

The 2020 Rwandan Cooking Fuel Energy and Technologies in Households, Commercial and Public Institutions (CFET) survey was the primary data source for the assessment. CFET is a nationally representative, population-based survey that was conducted in February 2020 (see further details in Volume 2, Part XII).

In order to measure the impact from scaled transition to LPG under the evaluated scenarios, it is important to consider the fuels that households would switch from (baseline fuels), and how much LPG they would potentially consume in the future. Given the nature of the CFET data, a number of assumptions were required to be made across the analyses:

- Fuel transition: In 2020, four main fuels were used by households as primary/secondary fuels for cooking: LPG (used in 5.6% of households); firewood (80.4%), charcoal (18.0%) and crop residues (9.5%). It was assumed that as LPG becomes more widely available, some households will begin using it as a primary or secondary fuel and will gradually reduce, and some will stop, using the other fuels. Given that crop residues were only used in combination with firewood (biomass fuel stacking), the impact of a transition from crop residues to LPG is captured through the transition from firewood. The models therefore focus on firewood and charcoal. The remaining households using charcoal and firewood were projected from an estimation of population growth over the forecasted time period.[92]

- Fuel consumption: The fuel consumption for the impact modelling was based on the projections of the demand modelling that took into account sociodemographic trends and trends in institutional demand for LPG. For households beginning to use LPG, consumption was assumed equivalent to average LPG consumption.[93] It was assumed that the only other changes in LPG consumption for these households would be shifts to more exclusive use of the fuel. Our estimates take into account LPG import and sales price projections that are used throughout this report. No other potential impacts on consumption were directly modelled (e.g. changes in availability of other fuels).

62. Environmental and Climate Impacts

The impact of households changing their cooking fuel from charcoal and firewood to LPG (primary and secondary use) as well as public institutions transitioning from biomass fuels to LPG can have many positive impacts on both the local environment and climate.

92 Note that transition to LPG primary and secondary use for cooking was analyzed.

93 Values were obtained from CFET for all firewood and charcoal users (both primary and secondary use households). For LPG, the same assumption was used as in the demand modeling presented in Volume 2, Part XII (i.e., an LPG consumption of 28.8 kg/capita/year).

For the purpose of this analysis, the environmental impacts from increased LPG use (and corresponding decrease in charcoal and firewood use) were estimated by calculating (1) averted deforestation; (2) carbon dioxide equivalent (CO_2e) emissions[94] averted; (3) Black Carbon equivalent (BCeq) emissions[95] averted; and (4) the potential economic value of averted CO_2e emissions in terms of carbon financing.

Each of the four impact categories were modelled in:

- Absolute terms, in which BAU is compared to a 'zero increase' in LPG over time (see Table 110 below);
- Relative terms, with each of the interventional scenarios compared to the BAU scenario (i.e., resulting in impact estimations to be treated as incremental to the BAU) (see Table 111 through Table 113 below); and
- Overall/cumulative terms, combining relative/incremental impacts from each of the intervention scenarios with the absolute impacts of BAU, compared to a 'zero increase' in LPG (Table 114).

Absolute impact quantification

In absolute terms, increased consumption of LPG in the BAU projection as compared to 'zero increase' in LPG use for cooking in Rwanda would result in cumulative savings, over the studied timeframe (2021-2030), of 185 million trees, 18.6 million MT in CO_2e emission reductions and 11.1 million MT of BCeq emission reductions. In monetary terms, this would be equivalent to US$ 70.6 million of economic value of CO_2e emissions (see Table 110). Annual savings in each of 2024 and 2030 for the four categories of impact are also presented.

Table 110. Summary of environment and climate impacts from BAU compared to zero increase in LPG adoption

Business as usual Scenario			
Impact (compared to zero increase in LPG use)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
Averted deforestation	8.1 million trees saved annually	41.8 million trees saved annually	185 million trees saved cumulatively
Reduction in CO_2e emissions	754 thousands MT reduction in CO_2e emissions annually	4.3 millions MT reduction in CO_2e emissions annually	18.6 million MT reduction in CO_2e emissions cumulatively
Reduction in BCeq emissions	478 thousands MT reduction in BCeq emissions annually	2.5 million MT reduction in BCeq emissions annually	11.1 million MT reduction in BCeq emissions cumulatively

94 CO_2e emissions include carbon dioxide equivalent emissions from carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

95 BCe emissions include black carbon equivalent emissions from black carbon (BC), organic carbon (OC), carbon monoxide (CO), and total non-methane organic compounds (TNMOCs).

Business as usual Scenario			
Impact (compared to zero increase in LPG use)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
Economic value of averted CO_2e emissions (USD)	$ 2.9 millions annually	$ 16.3 million annually	$ 70.6 million cumulatively

Incremental impact quantification relative to business as usual

The impact quantifications relative to the business as usual scenario in 2024, 2030 and cumulatively between 2021 and 2030 are summarized in Table 111 through Table 113 for each of the projected scenarios (Low, High and NST-1 Target scenarios). The largest impacts are to be expected in the NST-1 Target scenario where the speed of the transition to LPG and the total projected consumption are higher than the two other intervention scenarios.

Table 111. Incremental environment and climate impacts from Low Intervention scenario relative to BAU

Low Intervention Scenario			
Incremetal Impact (relative to BAU scenario)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
Averted deforestation	650,000 trees saved annually	15.6 million trees saved annually	58 million trees saved cumulatively
Reduction in CO_2e emissions	60,000 MT reduction in CO_2e emissions annually	1.9 million MT reduction in CO_2e emissions annually	7 million MT reduction in CO_2e emissions cumulatively
Reduction in BCeq emissions	46,000 MT reduction in BCeq emissions annually	1 million MT reduction in BCeq emissions annually	3.8 million MT reduction in BCeq emissions cumulatively
Economic value of averted CO_2e emissions (USD)	$ 228,000 annually	$ 7.3 million annually	$ 26.7 million cumulatively

Table 112. Incremental environment and climate impacts from High Intervention scenario relative to BAU

High Intervention Scenario			
Incremetal Impact (relative to BAU scenario)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
Averted deforestation	1.5 million trees saved annually	21.5 million trees saved annually	83 million trees saved cumulatively
Reduction in CO_2e emissions	136,000 MT reduction in CO_2e emissions annually	2.6 million MT reduction in CO_2eq emissions annually	9.9 million MT reduction in CO_2e emissions cumulatively

High Intervention Scenario			
Incremetal Impact (relative to BAU scenario)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
Reduction in BCeq emissions	103,000 MT reduction in BCeq emissions annually	1.6 million MT reduction in BCeq emissions annually	6 million MT reduction in BCeq emissions cumulatively
Economic value of averted CO_2e emissions (USD)	$ 517,000 annually	$ 10 million annually	$ 37.6 million cumulatively

Table 113. Incremental environment and climate impacts from NST-1 Target scenario relative to BAU

NST-1 Target scenario			
Incremetal Impact (relative to BAU scenario)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
Averted deforestation	14.1 million trees saved annually	28.3 million trees saved annually	169.4 million trees saved cumulatively
Reduction in CO_2e emissions	1.7 millions MT reduction in CO_2e emissions annually	3.7 millions MT reduction in CO_2e emissions annually	21.5 million MT reduction in CO_2e emissions cumulatively
Reduction in BCeq emissions	1.3 million MT reduction in BCeq emissions annually	2.4 million MT reduction in BCeq emissions annually	14.7 million MT reduction in BCeq emissions cumulatively
Economic value of averted CO_2e emissions (USD)	$ 6.4 million annually	$ 14.2 million annually	$ 81.8 million cumulatively

Overall impact quantification

The overall impacts from a transition to LPG for household and institutional cooking under each of the scenarios in comparison to zero increase in LPG use is summarized in Table 114.

Table 114. Cumulate environment and climate impacts by scenario

Each Intervention scenario in addition to business as usual (BAU) scenario			
Total cumulative Impact	BAU+Low Intervention cumulative impacts 2021-2030	BAU+High Intervention cumulative impacts 2021-2030	BAU+NST-1 cumulative impact 2021-2030
Averted deforestation	243 million trees saved cumulatively	268 million trees saved cumulatively	354 million trees saved cumulatively
Reduction in CO_2e emissions	25.6 million MT reduction in CO_2e emissions cumulatively	28.5 million MT reduction in CO_2e emissions cumulatively	40.1 million MT reduction in CO_2e emissions cumulatively
Reduction in BCeq emissions	14.9 million MT reduction in BCeq emissions cumulatively	17.1 million MT reduction in BCeq emissions cumulatively	25.8 million MT reduction in BCeq emissions cumulatively

Each Intervention scenario in addition to business as usual (BAU) scenario			
Total cumulative Impact	BAU+Low Intervention cumulative impacts 2021-2030	BAU+High Intervention cumulative impacts 2021-2030	BAU+NST-1 cumulative impact 2021-2030
Economic value of averted CO_2e emissions (USD)	$ 97.3 million cumulatively	$ 108.2 million cumulatively	$ 152.4 million cumulatively

Averted deforestation

From 2001 to 2019, Rwanda lost 34.5 kilohectares (kha) of tree cover, equivalent to a 6.9% decrease in tree cover since 2000, and generated 8.89 MT of CO_2 emissions[96] from different drivers (e.g. agricultural land use, biomass harvesting etc.). A transition to LPG has the potential to significantly reduce the pace of forest degradation in the country due to unsustainable harvesting of wood fuels used for cooking.

To calculate the potential averted deforestation from increased LPG uptake, the study estimated the total number of trees saved due to reduced firewood and charcoal use. The number of trees saved from each intervention scenario was calculated by considering current (2020) firewood and charcoal consumption in households and public institutions[97], the proportion of this consumption that is produced unsustainably (using the forest non-renewability factor – a measure of how sustainably fuel is sourced from the forest[98]), and the typical mass of a tree.[99] The approach assumes that the same mix of wood type is used nationally and does not change over time, and that charcoal and firewood displaced by LPG use will not then be exported to other countries. If charcoal or firewood are exported, associated deforestation will continue. Regulatory measures to limit charcoal / firewood export growth would ensure full capture of forest-saving benefits caused by increased adoption of LPG.

Results

Using this approach, it is estimated that 57.3 million trees were used for household cooking in Rwanda in 2020. The summary of impacts according to each interventional scenario is presented in Table 115. The total

96 Global Forest Watch – Rwanda. 2020. Note: no tree gains are take into account in these estimates.

97 Calculated from 2020 CFET data. The household and institutional charcoal use was converted to equivalent wood consumption, using a ratio of 7 from Mjumita (2016). This is a global approximation, commonly used in the literature.

98 The forest non-renewability factor (i.e., the % wood taken from forests in a non-renewable manner, applicable to both charcoal and firewood) is estimated in the range of 52% - 66% for Rwanda based on data from Bailis et al. (2017). The calculations assumes the average, 59%.

99 The global average value for the typical mass of a tree, most commonly used in the literature, is 100 kg. Source: Penn State University (2016).

impact quantification (impacts arising from each interventional scenario in addition to the impacts generated by business as usual adoption of LPG) are summarized in Table 116.

Table 115. Annual and cumulative incremental averted deforestation, by scenario relative to BAU

Averted Deforestation			
Number of trees used for household cooking in Rwanda in 2020			57.3 million
Impact (relative to business as ususal)	**Annual impact in 2024**	**Annual impact in 2030**	**Cumulative impact 2021-2030**
Low intervention scenario	650 thousands trees saved annually	15.6 million trees saved annually	58 million trees saved cumulatively
High intervention scenario	1.5 million trees saved annually	21.5 million trees saved annually	83 million trees saved cumulatively
NST-1 Target scenario	14.1 million trees saved annually	28.3 million trees saved annually	169 million trees saved cumulatively

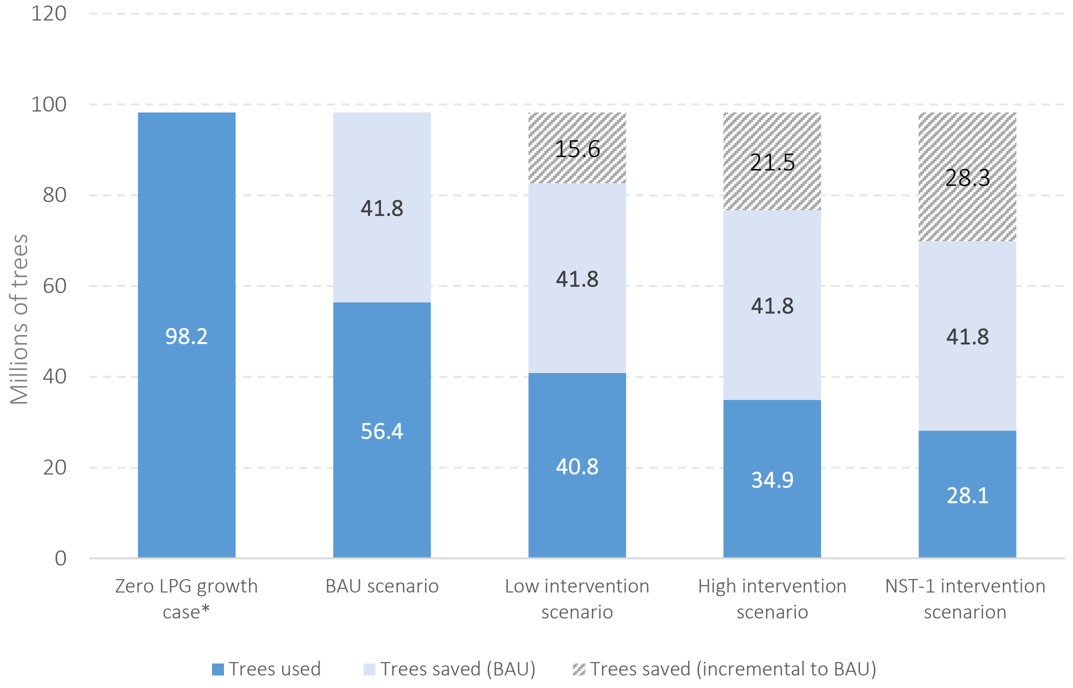
In 2024, between 650 thousand and 14.1 million trees could be incrementally saved per year depending on the scenario (with 14.1 million resulting from implementation of the NST-1), compared to BAU projections (see Table 115). In 2030, the projected savings are between 15.6 million and 28.3 million trees, compared to business as usual projections. **Between 2021 and 2030, the cumulative amount of trees saved relative to business as usual projections were estimated to be between 58 million and 169 million, depending on the LPG intervention scenario.**

In absolute terms, the total cumulative amount of trees saved between 2021 and 2030 was estimated to be in a range of 243-354 million, relative to a zero increase in LPG use (see Table 116 and Figure 63),

Table 116. Cumulative averted deforestation by scenario

Averted Deforestation			
Impact (total)	**Annual impact in 2024**	**Annual impact in 2030**	**Cumulative impact 2021-2030**
BAU+Low Intervention overall impacts	8.75 million trees saved annually	57.4 million trees saved annually	243 million trees saved cumulatively
BAU+High Intervention overall impacts 2021-2030	9.6 million trees saved annually	63.3 million trees saved annually	268 million trees saved cumulatively
BAU+NST-1 cumulative overall 2021-2030	22.2 million trees saved annually	70.1 million trees saved annually	354 million trees saved cumulatively

Figure 63. Total number of trees used and trees saved in the year 2030 by scenario



*Note: *The Zero LPG growth case is an approximation but takes into account both household and institutional cooking*

Averted carbon emissions

Rwanda's greenhouse gas emissions profile is dominated by emissions from agriculture use (39.5%), followed by waste (24.7%), energy (23.1%) and land-use change and forestry (11.4).[100] According to the same report, emissions from the energy sector increased by 44% from 1990-2014, due to "other fuel combustion," including biomass burning. Biomass combustion accounted for around 86% of total energy emissions in 2018[101].

The transition from charcoal and firewood to LPG for cooking will decrease total and per capita carbon emissions through two mechanisms – (i) decreased carbon emissions from fuel use and (ii) decreased fuel production (charcoal).

---

100 USAID. Greenhouse Gas Emissions in Rwanda (2018)

101 African Development Bank Group, 2018. Scaling Up Electricity Access Program Phase II (SEAP II), Rwanda Appraisal Report. September 2018

The total carbon dioxide equivalent (CO_2e) emissions from fuel use were calculated using the Gold Standard technologies and practices to displace decentralized thermal energy consumption (TPDDTEC) Guidelines.[102] This methodology estimates total CO_2e emissions by calculating the carbon dioxide equivalent emissions of three pollutants – carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) – and including Global Warming Potential (GWP) conversion factors.[103]

The CO_2e emissions for different fuel use were calculated by multiplying household and institutional level projected fuel consumption[104] by the net calorific value of the fuel and average stove efficiencies using global averages obtained from literature (see Table 14 in Volume 2, Part XII, page 78). This results in the energy use per fuel (MJd), which was multiplied by the CO_2e emissions factor (in g/MJd) to obtain the total CO_2e emissions (in grams, which were then converted to metric tonnes (MT)). This methodology was used to calculate CO_2e emissions for the four LPG scenarios (BAU, Low intervention, High intervention and NST-1 Target). The CO_2e tonnage differential was calculated by subtracting the CO_2e emissions under the each of the three scenarios from CO_2e emissions in the BAU projections scenario.

The total CO_2e emissions from fuel production were estimated using emissions rates for CO_2, CH_4 and N_2O calculated for the production of charcoal and LPG. In the case of LPG, given that Rwanda imports LPG and is expected to continue to do so to meet the forecasted demand, the emissions from production of LPG may occur outside of Rwanda. Since LPG is a by-product of the petroleum industry, the emissions from fuel production would take place regardless of the increase in LPG consumption[105].

Combining the CO_2e emissions from fuel use and fuel production, an estimated 9.2 million MT of CO_2e emissions were emitted in Rwanda in 2020 from fuel use for cooking.

Results

The summary of impacts according to each scenario relative to business as usual is presented in Table 117. In 2024, between 60 thousand MT and 1.7 million MT of CO_2e emissions could be eliminated per year under the low and NST-1 Target scenarios, respectively, compared to business as usual projections. In 2030, the amount of eliminated CO_2e emissions was estimated to range from 1.9 million MT to 3.7 millions MT. **Cumulatively, the total amount of CO_2e emissions reductions was estimated to range from 7 to 21.5 million MT between 2021 and 2030 due to adoption of LPG.**

---

102 Gold Standard Methodology (2017)

103 CO_2 emissions rate was multiplied by the applicable non-renewability factor; CH_4 and N_2O emissions rate were multiplied by the GWP for a 100-year time horizon (GWP100) factors from IPCC 2014. See Table 199 on page 514.

104 Calculated from 2020 CFET data.

105 Surplus LPG production globally is cleared from the market by the petrochemical and plastics industry, where LPG is utilized as a feedstock. Source: WLPGA (2019).

Table 117. Annual and cumulative CO2e emissions reductions by scenario relative to BAU

Reduction in CO_2e emissions (Incremental)			
Amount of CO_2e emissions emitted in Rwanda in 2020 from fuel ued for cooking			9.2 million MT
Impact (relative to busiensus as usual	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
Low intervention scenario	60,000 MT reduction in CO_2e emissions annually	1.9 million MT reduction in CO_2e emissions annually	7 million MT reduction in CO_2e emissions cumulatively
High intervention scenario	136,000 MT reduction in CO_2e emissions annually	2.6 million MT reduction in CO_2e emissions annually	9.9 million MT reduction in CO_2e emissions cumulatively
NST-1 Target scenario	1.7 million MT reduction in CO_2e emissions annually	3.7 million MT reduction in CO_2e emissions annually	21.5 million MT reduction in CO_2e emissions cumulatively

Table 118 summarizes the total annual and cumulative projected impacts of CO_2e emissions reductions considering the projected impacts from business as usual. **The total cumulative CO_2e emissions reductions between 2021 and 2030 were estimated to be between 25.6 million and 40.1 million.**

Table 118. Summary of total CO_2e emissions reductions from increased LPG consumption over time

Reduction in CO_2e emissions (Total)			
Impact (total)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
BAU+Low Intervention cumulative impacts	754,000 MT reduction in CO_2e emissions annually	6.2 million MT reduction in CO_2e emissions annually	25.6 million MT reduction in CO_2e emissions cumulatively
BAU+High Intervention cumulative impacts 2021-2030	890,000 MT reduction in CO_2e emissions annually	6.9 million MT reduction in CO_2e emissions annually	28.5 million MT reduction in CO_2e emissions cumulatively
BAU+NST-1 cumulative impact 2021-2030	2.5 million MT reduction in CO_2e emissions annually	8 million MT reduction in CO_2e emissions annually	40.1 million MT reduction in CO_2e emissions cumulatively

Averted black carbon emissions

Black carbon (BC) is a key short-term climate-active pollutant with high global-warming potential. Globally, it is estimated that household use of solid fuel contributes 25% of the total BC emissions.[106] In Africa and Asia, where use of solid fuels is highly prevalent, household burning of biomass can contribute to 60 – 80% of total BC emissions.[107] Reducing reliance on biomass for residential cooking will directly reduce global BC emissions.

106 Bond TC et al (2013).

107 Bond TC et al (2013).

To estimate the BCeq emissions (i.e., the CO_2 equivalent of BC emissions) due to reduced firewood and charcoal usage and increased LPG adoption for cooking, the study calculated the total BCeq emissions for each scenario to 2030. To calculate annual BCeq emissions, a three-step approach was used, according to the Gold Standard Methodology: (i) The BCeq emissions per unit of fuel use was calculated using the formula in Gold Standard technologies and practices to displace decentralized thermal energy consumption (TPDDTEC) Guidelines - black carbon methodology; (ii) BCeq emissions per fuel was multiplied by the global warming potential (GWP) of black carbon[108]; (iii) the GWP of BCeq emissions per fuel was multiplied by the total consumption per fuel in kilograms.[109] This calculation estimated the BCeq emissions from fuel use, calculated for LPG, charcoal, and firewood. In addition, the BCeq emissions for charcoal production were calculated following the approach described above but considered the BCeq emissions per fuel production rather than fuel use.[110] Only the production of charcoal was considered, as firewood is often collected (and therefore it is difficult to quantify the BCeq emissions from firewood production) and LPG production produces negligible BCeq emissions.[111]

Results

The total BCeq emissions from cooking in 2020 in Rwanda were estimated to be 5.5 million MT. Table 119 shows results from annual and cumulative impacts relative to business as usual projections.

In 2024, between 46 thousand MT and 1.3 million MT of BCeq emissions could be eliminated under the low and NST-1 LPG adoption scenarios, respectively, compared to business as usual projected trends. In 2030, the amount of BCeq emissions eliminated was estimated to be between 1 million and 2.4 million MT. **Cumulatively, the total amount of reduced BCeq emissions was estimated to be between 3.8 million to 14.7 million MT for the period 2021 to 2030 compared to business as usual projections.**

Table 119. Annual and cumulative CO_2e emissions reductions in 2024 and 2030 by scenario relative to BAU

Reduction in BCeq emissions (incremental impact)			
Amount of BCeq emissions emitted in Rwanda in 2020 from fuel ued for cooking		5.5 million MT	
Impact (relative to BAU scenario)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
Low intervention scenario	46 thousand MT reduction in BC emissions annually	1 million MT reduction in BC emissions annually	3.8 million MT reduction in BC emissions cumulatively
High intervention scenario	103 thousand MT reduction in BC emissions annually	1.6 million MT reduction in BC emissions annually	6 million MT reduction in BC emissions cumulatively

108 The GWP100 value used was 660 based on the PICC 2013 report, Myhre et al. (2013).

109 These values were obtained for all fuel users (both primary and secondary use households).

110 The assessment relied on global averages obtained from literature.

111 Morelli et al, 2017.

Reduction in BCeq emissions (incremental impact)			
Amount of BCeq emissions emitted in Rwanda in 2020 from fuel ued for cooking	5.5 million MT		
Impact (relative to BAU scenario)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
NST-1 Target scenario	1.3 million MT reduction in BC emissions annually	2.4 million MT reduction in BC emissions annually	14.7 million MT reduction in BC emissions cumulatively

The total annual (for 2024 and 2030) and cumulative (2021 to 2030) projected impacts of BQeq emission reductions projected from the intervention scenarios relative to business as usual are summarized in Table 120.

The overall cumulative reduction in BCeq emissions resulting from scaled transition to LPG for cooking in Rwanda is projected to range from 14.9 to 28.8 million cumulatively (2021-2030), depending on the consumption of LPG achieved.

Table 120. Annual and cumulative BCeq emissions reductions in 2024 and 2030 by scenario relative to BAU

Reduction in BCeq emissions (Total)			
Amount of BCeq emissions emitted in Rwanda in 2020 from fuel ued for cooking	5.5 million MT		
Impact (total)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
BAU + Low Intervention cumulative impacts	754,000 MT reduction in BC emissions annually	5.3 million MT reduction in BC emissions annually	14.9 million MT reduction in BC emissions cumulatively
BAU + High Intervention cumulative impacts 2021-2030	581 thousand MT reduction in BC emissions annually	4.1 million MT reduction in BC emissions annually	17.1 million MT reduction in BC emissions cumulatively
BAU + NST-1 cumulative impact 2021-2030	1.8 million MT reduction in BC emissions annually	4.9 million MT reduction in BC emissions annually	28.8 million MT reduction in BC emissions cumulatively

Economic value of averted CO2e emissions through potential carbon financing

Once emitted, CO_2 lasts about 100 years in the atmosphere, meaning that the benefits of abating CO_2 emissions today will continue to be felt over the next century. Therefore, reducing CO_2eq from clean cooking will have positive environmental benefits over the long term. Both the Clean Development Mechanism and Gold Standard Methodologies allow for carbon financing of LPG stoves. The economic value of abated CO_2eq emissions can be estimated by multiplying the total emissions averted through 2030 by the prevailing price of carbon for the latest available year (2019).

It should be noted that there are currently no examples of carbon markets paying for BCeq abatement. To address this, the Gold Standard proposed a new BC methodology in 2017 for household cooking and BC emissions should be possible to value under this methodology in due course. For now, the potential value of BC abatement can be calculated by taking the CO_2e quantities of BC emissions (i.e., BCeq emissions) and multiplying it by the prevailing price of carbon.

The price of carbon was derived from the prevailing carbon values. A 2020 review of global voluntary carbon prices found that clean cookstove/household devices offsets were priced at an average of US$ 3.8 of CO_2e (carbon prices ranged from US $1.4-4.3) and the transacted volume in 2019 corresponded to 6.4 MT CO_2e.[112]

The economic value of reduced carbon was estimated using the observed prevailing carbon price in Africa and multiplying it by the carbon emissions averted.

Results

Table 121 summarizes the economic value of CO_2e emissions annually in 2024 and 2030, and cumulatively between 2021 to 2030.

In 2024, the annual economic value of CO_2e emissions is estimated to range from US$ 228,000 to 6.4 million, relative to business as usual, based on the consumption scenario achieved. The values for 2030 are estimated to range from US$ 7.3 to 14.2 million relative to BAU projections.

The cumulative incremental economic value for CO_2e emissions averted between 2021 and 2030 is estimated to range from 26.7 to 81.8 million, depending on the adoption scenario, relative to BAU projections.

Table 121. Economic value of averted CO_2e emissions in 2024 and 2030 by scenario relative to BAU

Economic value of averted CO_2e emissions (USD) (Incremental impact)			
Impact (relative to BAU scenario)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
Low intervention scenario	$ 228,000 annually	$ 7.3 million annually	$ 26.7 million cumulatively
High intervention scenario	$ 517,000 annually	$ 10 million annually	$ 37.6 million cumulatively
NST-1 Target scenario	$ 6.4 million annually	$ 14.2 million annually	$ 81.8 million cumulatively

Should carbon markets be paying for BCeq abatements in the imminent future, the cumulative economic value for BCeq emissions averted between 2021 and 2030 could range from US$ 14.6 million to US$ 56 million[113], depending on the adoption scenario, relative to business as usual projections.

Table 122 presents the overall/total economic values of CO2e emission reductions considering the impacts from business as usual projections in 2024 and 2030 and cumulatively (2021 to 2030). **The cumulative economic value of national transition to LPG for clean cooking was estimated to range from US$ 97 to 152.4 million, depending on the achieved consumption scenario.**

112 Ecosysem marketplace (2020). Voluntary Carbon and the post-Pandemic recovery.

113 Estimate for BCeq emissions reductions calculated applying the prevailing price of carbon in 2019 (US$ 3.8).

Table 122. Total economic value of CO_2e emissions reductions by scenario

Economic value of averted CO2e emissions (USD) (Total)			
Impact (total)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
BAU+Low Intervention cumulative impacts	$ 3.1 million annually	$ 23.6 million annually	$ 97 million cumulatively
BAU+High Intervention cumulative impacts 2021-2030	$ 3.4 million annually	$ 26.3 million annually	$ 108 million cumulatively
BAU+NST-1 cumulative impact 2021-2030	$ 9.3 million annually	$ 30.5 million annually	$ 152.4 million cumulatively

63. Health Impacts

Transitioning from charcoal and firewood to LPG will have significant health benefits due to reduced personal exposure to HAP from burning these fuels to meet household energy needs. HAP is causally related to ischemic heart disease, stroke, chronic obstructive pulmonary disease (COPD), lung cancer in adults, and acute lower respiratory infection in children (ALRI)[114] as well as other health conditions including adverse pregnancy outcomes and cataracts. These diseases can result in premature mortality or disability that can affect life expectancy. A Disability-adjusted-life-year or "DALY" is a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death.

For the purpose of this study, the health benefits from increased LPG household use, offsetting charcoal and firewood use, was estimated by calculating (1) deaths saved, and (2) DALYs averted due to reduced HAP from exposure to fine particulate matter ($PM_{2.5}$) based on the five main diseases included in the 2016 GBD estimates and listed above. $PM_{2.5}$ is a key health-damaging pollutant from incomplete fuel combustion that is emitted at relatively high concentrations when wood, charcoal, and other solid fuels/kerosene are burned in open fires or cookstoves, but is extremely low for LPG due to its efficient combustion.

Estimation of health benefits for individuals working in institutional settings (e.g., kitchen staff and individuals such as school kids in communal serving areas etc.) was beyond the scope of this assignment and these impacts are generally under-researched. In Rwanda, only one study was identified that looked at the health impacts of carbon monoxide in commercial settings, finding CO concentrations exceeding the safe levels for health[115] as published by the World Health Organization (WHO) Indoor Air Quality Guidelines (WHO, 2014).

The current recommended guideline level for $PM_{2.5}$ is 10 ug/m^3 (annual average) with typical solid fuel using households recording levels 10 to 50 times this safe level for health. Recognizing the challenge of rapidly achieving this level in many lower-and-middle-income country settings, the WHO identified three interim targets for $PM_{2.5}$ concentrations that would offer significant health protection to support efforts towards meeting the WHO guidelines. This includes the well-referenced WHO interim-target 1 level (IT-1), set at 35 ug/m^3.

Compared with combustion of solid fuels or kerosene in the home, LPG has a very clean emissions profile at point of use that consistently delivers low emissions (and subsequent exposures) independently of the operation, age, or condition of the stove used.[116] As such, and in the absence of other indoor or ambient sources of pollution, it is reasonable to assume that exposure to $PM_{2.5}$ in households using LPG exclusively for cooking will be at or below the WHO Interim Target 1 level (35 ug/m^3), as confirmed by studies in the field in Rwanda and other countries[117]. Whilst higher exposure rates have been reported in a number of other

114 Smith et al. (2015).

115 Wolley et al. 2020

116 Smith K.R., et al. (2000); Zhang et al. (2000); MacCarty et al. (2010); Shen et al. (2018)

117 Examples of studies include the HAPIN trial data from Rwanda and India (Sambandan et al. 2020) and the LACE studies from Cameroon (Kypridemos et al. 2020)

studies these are likely due to background ambient air pollution, including from neighboring households that continue to rely on polluting fuels and technologies, and/or from concurrent use of other, more polluting fuels in the homes assessed. We have therefore used the WHO IT-1 annual $PM_{2.5}$ target in LPG using homes as a basis for assessing the health impacts of increased primary/exclusive LPG consumption in adults and children over time.

In terms of personal exposure from firewood combustion (for traditional and improved stove use), the modeling relied on published personal exposure data of $PM_{2.5}$ in Rwanda by Kirby et al. (2019). Data on personal exposure to $PM_{2.5}$ from charcoal combustion (for traditional and improved charcoal stove) were lacking, and therefore a conservative estimate of exposure, based on a third that of combustion of firewood, was used from the same study in Rwanda. See Annex Chapter 79 for a full description of the methodology and assumptions.

'Pre'- and 'post'-intervention (i.e., LPG) exposure values were inputted into the Household Air Pollution Intervention Tool (HAPIT version 3.1.1)[118], a tool based on established GBD methods that is in widespread use for modeling health impacts of interventions to reduce HAP exposure.[119] This tool was used to estimate the deaths saved and ADALYs in Rwanda under each scenario (Low, High and NST-1 Target).[120]

Premature deaths saved and averted DALYs

In 2020, a total of 3,255 deaths and 172,643 DALYs were estimated in Rwanda as a result of cooking with polluting solid fuels (as a result of ischemic heart disease, stroke, COPD, lung cancer in adults and ALRI in children). The total number of deaths that could be saved and DALYs that could be averted (ADALYs) per year due to sustained/ nearly exclusive LPG use (displacing firewood or charcoal use), was estimated using the HAPIT model[121] according to the following two counterfactual scenarios:

(i) In absolute terms (i.e. business as usual projections in comparison to zero increase in LPG use over time); and

(ii) In relative terms (each of the three interventional scenarios – Low, High and NST-1 – relative to business as usual projections in order to quantify the incremental effect).

---

118 See householdenergy.shinyapps.io/hapit3/

119 The HAPIT model uses disease rates and relationships as described in the Institute for Health Metrics and Evaluation's 2013 Global Burden of Disease and Comparative Risk Assessments efforts and estimates potential health changes due to interventions designed to lower household air pollution. See householdenergy.shinyapps.io/hapit3/#

120 A useful intervention lifespan of five years was assumed (with the results divided by five to obtain a per year output), and the default values for Rwanda were used, with a counterfactual of 10 ug/m^3. This counterfactual is a measure of the ideal exposures, below which there is no risk to health.

121 See Annex Chapter 79 for details.

Absolute health impacts quantification

When compared to 'zero increase' in LPG use over time, the consumption of LPG projected by the business as usual scenario was estimated to result in 1,133 adult and child deaths averted, and nearly 59,000 adult and child DALY's saved cumulatively from 2021- to 2030 (see Table 123).

Table 123. Health impacts from BAU compared to zero increase in LPG adoption

Business as Usual Scenario			
Impact (compared to zero increase in LPG use)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
Adult and child deaths saved	87	449	1,133
Adult and child ADALYs	4,671	23,523	58,973

Incremental health impact quantification relative to BAU

The difference between each of the Low, High and NST-1 Target scenarios and the BAU scenario projections, in terms of number of saved deaths and ADALYs (should the corresponding LPG adoption targets be achieved), is presented in Table 124.

Table 124. Incremental health impacts by scenario relative to BAU

Incremetal Impact (relative to BAU scenario)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
Low intervention Demand Scenario			
Adult and child deaths saved	30	373	1,457
Adult and child ADALYs	1,587	19,659	76,743
High intervention Demand Scenario			
Adult and child deaths saved	68	647	2,699
Adult and child ADALYs	3,581	35,558	142,360
NST-1 Demand Scenario			
Adult and child deaths saved	597	1,011	6,523
Adult and child ADALYs	31,516	53,460	344,691

Between 2021 and 2030, a cumulative total of 1,457 to 6,523 deaths could be saved and 76,743 to 344,691 DALYs could be averted, depending on the scenario, relative to the business as usual projections due to increased LPG adoption under conditions of expanded LPG availability.

Overall health impact quantification

The overall health impacts from a transition to LPG for household cooking under each of the scenarios in addition to the 'absolute' impacts estimated in relation to zero increase in LPG use over time is summarized in Table 125.

Table 125. Total health impacts by scenario

Deaths averted			
(total)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
BAU+Low Intervention cumulative impacts	117	822	2,590
BAU+High Intervention cumulative impacts 2021 to 2030	155	1,096	3,832

Deaths averted			
(total)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
BAU+NST-1 cumulative impact 2021 to 2030	684	1,460	7,656
Averted DALYs (ADALYs)			
(total)	Annual impact in 2024	Annual impact in 2030	Cumulative impact 2021-2030
BAU+Low Intervention cumulative impacts	6,258	43,182	135,716
BAU+High Intervention cumulative impacts 2021 to 2030	8,252	59,081	201,333
BAU+NST-1 cumulative impact 2021 to 2030	36,187	76,983	403,664

Figure 64 and Figure 65 summarize the health benefits from a transition to LPG for household cooking in 2030.

The cumulative number of deaths saved was estimated to be in the range of between 2,590 and 7,656 from 2021 to 2030, based on the scenario. Similarly, the cumulative number of ADALYs was estimated to range from 135,716 to 403,664 from 2021 to 2030.

Figure 64. HAP-related deaths and deaths saved by LPG adoption in 2030

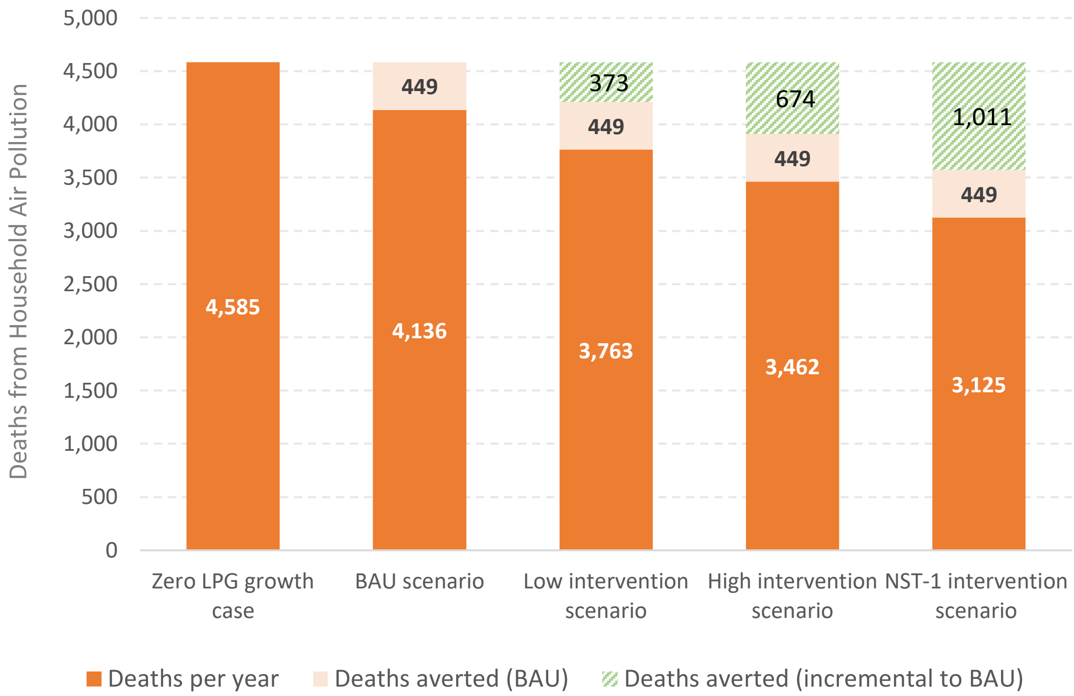
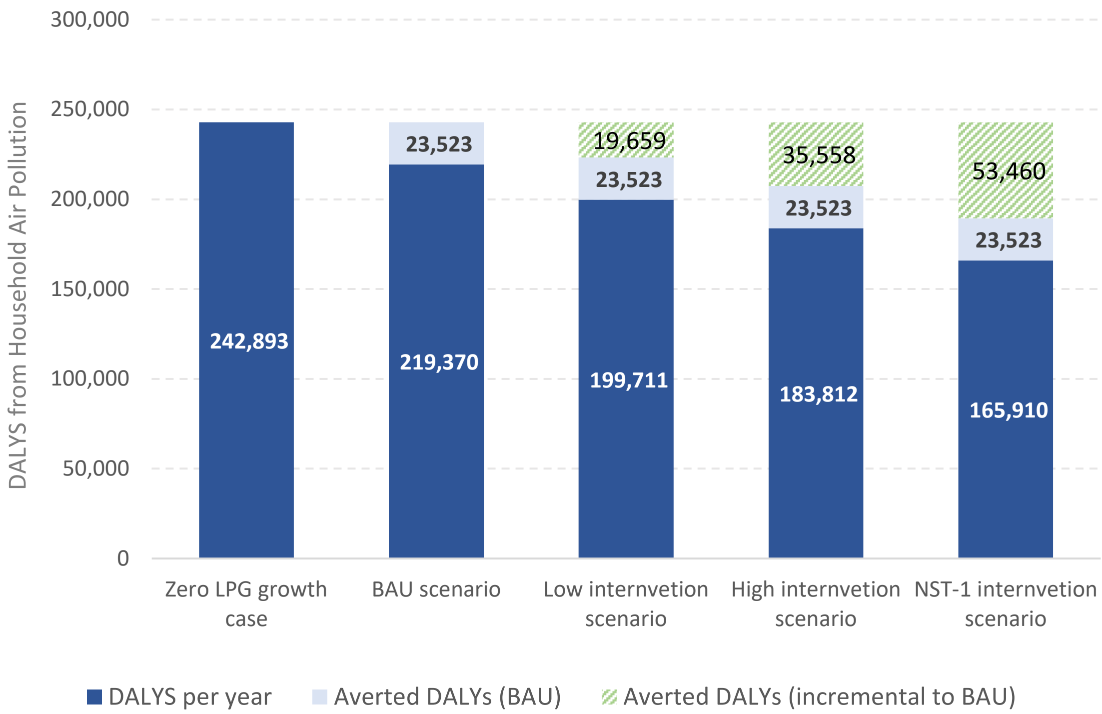


Figure 65. HAP-related DALYs and averted DALYs by LPG adoption in 2030



Economic value of deaths averted and DALYs saved

Economic value of deaths averted: The economic value of the HAP-related deaths averted was estimated by multiplying the annual GDP per capita for 2019 in Rwanda (US$ 801.7)[122] by the total number of adult deaths averted (as calculated above) for working age adults (aged 15-64 years).[123]

Economic value of averted DALYs (ADALYs): The economic value of HAP-related DALYs saved was calculated by multiplying the annual GDP per capita for 2019 (as above) by the number of ADALYs for working age adults (aged 15-64 years).

Results

The economic value of incremental deaths averted and DALYs saved per year due to increased LPG adoption are summarized for each scenario in Table 126.

The economic value of the deaths averted was estimated to range from US$156,000 to US$693,000 cumulatively for years 2021 to 2030, relative to BAU projections. For economic impact of ADALYs, the estimated values ranged between from US$3.6 to US$15.8 million cumulatively from 2021 to 2030, as compared to the BAU projections.

---

122 Source: World Bank Data Indicators (2019).

123 This was calculated as 1 age dependency ratio Source: https://tradingeconomics.com/rwanda/age-dependency-ratio-percent-of-working-age-population-wb-data.html

Table 126. Incremental economic value of health impacts relative to BAU

Economic value of of HAP-related deaths (working age adults – aged 15-64 years)			
Impact (relative to BAU scenario)	Annual economic value of adult deaths averted in 2024 (USD)	Annual economic value of adult deaths averted in 2030 (USD)	Cumulative economic value of adult deaths averted 2021-2030 (USD)
Low intervention Scenario	$3,000	$40,000	$156,000
High intervention Scenario	$7,300	$71,850	$288,000
NST-1	$63,400	$107,400	$693,000
Economic value of ADALYs (working age adults – aged 15-64 years)			
Impact (relative to BAU scenario)	Annual economic value of averted DALYs in 2024 (USD)	Annual economic value of averted DALYs in 2030 (USD)	Cumulative economic value of averted DALYs 2021-2030 (USD)
Low intervention scenario	$72,500	$926,300	$3,6 million
High intervention scenario	$163,900	$1,7 million	$6,6 million
NST-1 Target scenario	$1.4 million	$2.5 million	$15.8 million
Total economic value of adult deaths averted and ADALYs (working age adults – aged 15-60 years)			
Impact (relative to BAU scenario)	Annual economic value of averted deaths +ADALYs in 2024 (USD)	Annual economic value of averted deaths +ADALYs in 2030 (USD)	Cumulative economic value of averted deaths +ADALYs in 2021-2030 (USD)
Low intervention scenario	$75,700	$966,000	$3.8 million
High intervention scenario	$171,000	$1.7 million	$6.9 million
NST-1 Target scenario	$1.5 million	$2.6 million	$16.5 million

The economic value of HAP-related deaths prevented and DALYs averted cumulatively for years 2021 to 2030 was estimated to range from US$3.8 million to US$16.5 million across all interventional scenarios of LPG adoption as compared to BAU projections. Note that these estimates may represent an overestimation of the economic value of deaths averted, as not all working age adults are productive, and because women (who bear the greater burden of HAP exposure), have a lower share of national formal employment income. At the same time, as explained in previous sections, the current methods of estimating the HAP-related health impacts is based only on five GDB outcomes, not including the most recent health outcomes such as diabetes and adverse pregnancy outcome that are included in the latest 2019 GDB estimations.

Overall cumulative economic health impact quantification

The overall cumulative economic health impact of different intervention scenarios compared to the business as usual impact projections are presented in Table 127.

Table 127. Total economic value of averted HAP-related deaths and DALYs for all scenarios

Overall economic value of adult deaths averted and ADALYs (working age adults – age 15-60)			
Impact (total)	Cumulative economic value of averted deaths in 2021-2030 (USD)	Cumulative economic value of ADALYs in 2021-2030 (USD)	Cumulative economic value of averted deaths +ADALYs in 2021-2030 (USD)
BAU+Low Intervention cumulative impacts	$ 279,000 cumulatively	$ 6.4 million cumulatively	$ 6.7 million cumulatively
BAU+High Intervention cumulative impacts 2021-2030	$ 411,000 cumulatively	$ 9.4 million cumulatively	$ 9.8 million cumulatively
BAU+NST-1 cumulative impact 2021-2030	$ 816,000 cumulatively	$ 18.7 million cumulatively	$ 19.5 million cumulatively

Summary of health impact results

Overall, between 2,590 and 7,656 total deaths could be saved cumulatively between 2021 and 2030 depending on the intervention scenario and associated LPG adoption. In addition, 135,716 to 403,664 total DALYs could be averted in the same time frame depending on the scenario.

These values lead to a total economic value (based on the prevailing average wage rate times the labor time and productivity gained from the averted deaths and ADALYs) of US$ 6.7 million to US$ 19.5 million cumulatively for the years 2021 to 2030.

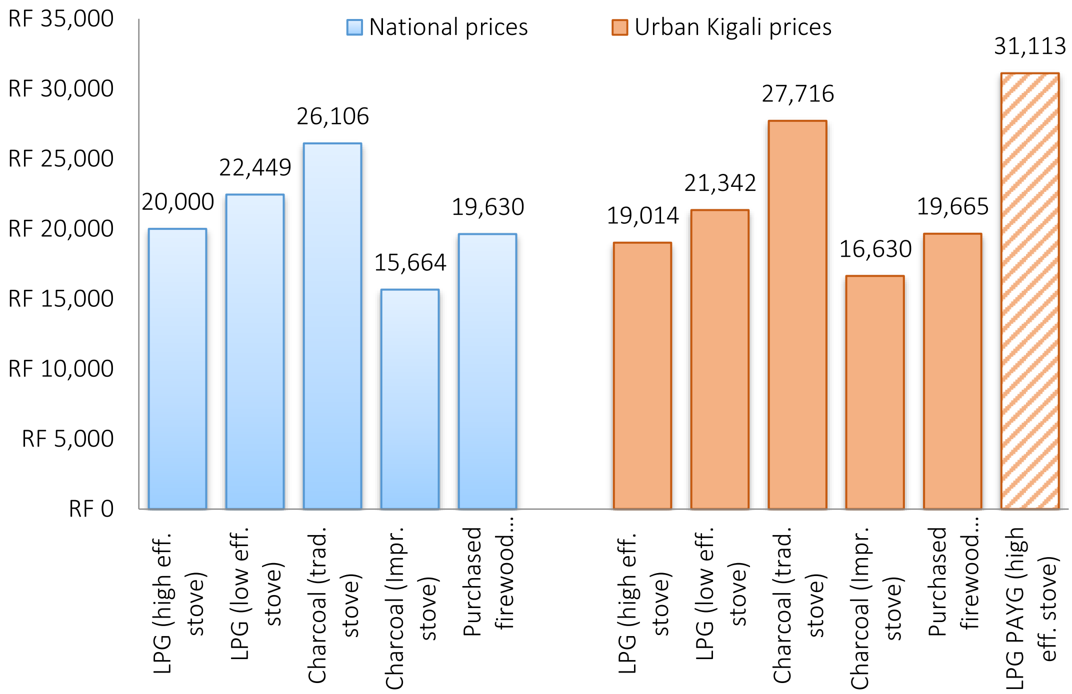
This economic impact does not consider the cost-savings to society from a reduced healthcare burden. However, it may overestimate the economic value of gained labor productivity, because not all working age adults affected by HAP are economically active. As previously reported these health impacts are based of five health outcomes only associated with HAP (i.e., ischemic heart disease, stroke, COPD, lung cancer in adults and ALRI in children) and underestimate the impacts associated with other known diseases and conditions that have now been proven to be causally related to HAP (e.g., diabetes, cataract in women and adverse pregnancy outcomes).

Finally, the estimates presented in this section relate to health impacts for households transtitioning to LPG only. Additional health gains are to be expected for people involved in catering in public institutions (e.g kitchen staff) and users of communal kitchen areas due to a transition to LPG.

64. Consumer Household Expenditure Impacts

The high cost of stoves and fuel are potential constraints to LPG initial adoption and sustained use, given the household incomes and liquidity levels of Rwandan households. Yet, LPG could create household savings over the long run compared to more expensive or less efficient fuel/stove alternatives. Figure 66 below shows the comparative cost of cooking a meal in Rwanda with LPG, charcoal and purchased firewood, based on different types of stove (see Volume 2, Chapter 21, for underlying assumptions).

Figure 66. Average monthly household cooking fuel costs by fuel/stove combination



LPG has a higher initial purchase price (in terms of the cost of the stove and cylinder) and larger, multi-week refill transactions relative to daily or weekly firewood or charcoal purchases (except for LPG distributed under PAYG). Over the lifecycle of the equipment, however, the cost of fuel dominates household cooking economics. Considering only the direct cash cost of cooking (what is paid for the equipment, amortized over its lifetime, plus the fuel; see Figure 22 in Volume 2, page 82), LPG delivers more cooked meals per Rwandan Franc compared with charcoal burned in traditional stoves and firewood burned in traditional or improved stoves.

However, consumers do not buy LPG on the basis of cost alone, but also on the basis of its benefits. Benefits of LPG not captured in a direct cost calculation include (i) preparation, cooking and clean-up time (essentially zero ignition time, zero warm-up time, zero dousing time, zero clean-up time), (ii) virtually no smoke/emissions, (iii) cleanliness, and in some cases (iv) an aspirational (SES) benefit. These mean that the cost-benefit comparison of LPG relative to firewood and charcoal is likely to be more favorable to LPG, as perceived on average by the consumer, than presented here.

In 2015, the World Bank estimated that 7% of a household's income in Africa was spent on energy, mostly on cooking, and additional incremental spending is often viewed as unaffordable given competing essential household expenses such as food and shelter.[124] Based on the CFET survey data, this figure in Rwanda is actually much higher: it is estimated that cooking fuel purchases comprised an average of 28.7% of the total household expenditure in 2020 in Rwanda[125].

Results

On average, the total expenditure on fuel varies by income, and similar-sized households from different income quintiles/*ubudehe* categories tend to spend different amounts of money on fuel. The fuel cost savings were calculated using the average cost of each fuel per household in 2020 according to different fuel groups to obtain the total fuel costs under each adoption scenario. No cost variations were assumed over time for charcoal or firewood for modeling purposes.[126] The LPG expenditure for households that gather firewood for free were excluded from this calculation. Results are summarized in Table 128.

In 2020, it was estimated that households in Rwanda spent approximately RWF 820 billion/ US $880 million on residential cooking fuels[127]. As shown in Table below, which summarizes annual savings levels in 2024 and 2030, LPG provides cost savings for households using biomass fuels on an annualized basis in 2030 (assuming relative stability of biomass fuel prices), with annual cost savings between RwF 161.4 – 260 billion (US $166–268 million), relative to the BAU projections. However, in 2024, the savings only became apparent for the NST-1 Target scenario (RWF 79.2 billion / USD 81.6 million), with losses in 2024 of RWF 447 million / USD 461,000 and RWF 121.5 million / USD 125,000 reported under the Low and High scenario, respectively.

Table 128. Incremental household cost savings with LPG cooking in 2024 and 2030 by scenario relative to BAU

Total annual household savings from cooking with LPG in place of biomass fuels		
Impact (relative to BAU)	Cost savings in 2024 (USD)	Cost savings 2030 (USD)
Low intervention scenario	Loss* of RWF 447 million / USD 461,000	Savings of RWF 161.4 billion / USD 166 million
High intervention scenario	Loss* of RWF 121.5 million / USD 125,000	Savings of RWF 193 billion / USD 199 million
NST-1 Target scenario	Savings of RWF 79.2 billion / USD 81.6 million	Savings of RWF 260 billion / USD 268 million
Total annual savings <u>per individual household</u> from cooking with LPG in place of biomass		
Impact (relative to BAU)	Cost savings in 2024 (USD)	Cost savings 2030 (USD)
Low intervention scenario	Loss* of RWF 115.4 / USD 0.12	Savings of RWF 161.4 / USD 33.9
High intervention scenario	Loss* of RWF 31.3 / USD 0.03	Savings of RWF 193 / USD 40.5

124 ESMAP (2015).

125 This finding is consistent with the experience of other geographically isolated countries which lack significant local primary energy resources, such as Caribbean island nations, as one class of example.

126 To calculate potential costs savings (or losses) from switching to LPG from charcoal and firewood, LPG costs were projected to rise over time, from 1,081 RwF/kg in 2020 to 1,381 RfW/kf in 2030. Because no reliable data sources were available for modelling how charcoal and firewood prices might change over time, in order to avoid overstating LPG savings, the costs of charcoal and firewood were kept constant over time, at their 2020 levels, for purposes of the analysis. The average 2020 costs of charcoal and firewood (pre-Covid-19) were computed from the CFET 2020 household survey. The values used are 254 RwF/kg for charcoal and 101 RwF/kg for purchased firewood.

127 Calculated using the total number of households by fuel category and the annual cost of using different fuels for cooking to obtain the total spent.

NST-1 Target scenario	Savings of RWF 15,400 / USD 15.8	Savings of RWF 35,200 / USD 36.2

**The reported minor economic loss in 2024 is due to a distortion in the assumptions used in the modelling which makes mixed use households pay a higher costs than the exclusive LPG households, because they would pay the same for their LPG plus the cost of the additional, non-LPG fuels.*

65. Macroeconomic Impacts

This analysis estimates the macroeconomic impacts of increasing LPG usage for cooking in Rwanda in terms of (1) tax revenue and (2) trade balance.

Rwanda's LPG is VAT zero-rated and is entirely imported. LPG import taxes include a 1.5% Infrastructure Development Tax and a 1.2% African Union Tax[128]. Charcoal and firewood are free from any tax/levy and they are not generally imported (although records show 9,800 kg of fuelwood[129] and 7,000 kg of charcoal[130] being imported into Rwanda in 2016 and 2018, respectively).

Tax revenue impact

The net effect of increased LPG consumption and decreased charcoal, and firewood use over time would be a likely increase in taxes collected in Rwanda as imported LPG is subject to import duties (1.5% plus 1.2% taxes) while charcoal and firewood are not. Therefore, the overall collected taxes are expected to increase unless an alternative way of local LPG production (such as from bioLPG[131]) can change this scenario. Further, the increasing domestic consumption of LPG will create formal economic activity (e.g., staff of bulk depots, staff of filling plants, truckers, retailers, etc.), which could positively affect the tax revenue from corporate tax in the country. However, this effect was not captured/modeled in the analysis.

To estimate the impact of fuel sales on the tax base, the total quantity of fuel consumed in-country was multiplied by (i) the domestic sales price per kg of fuel (see pricing information in Volume 1, Chapter 5)[132] and (ii) the various taxes or levies applicable to that fuel (which in the case of Rwanda applied only to LPG). Major changes to fuel prices and/or taxes and duties would change the tax revenues, but projecting how these might change for charcoal and firewood over time was beyond the scope of this work. Only changes to LPG pricing over time were factored into the model (see Figure 17 in Volume 1, page 44).

Results

In 2020, the national tax revenue due to cooking fuels was calculated to be RwF 562 million (US$ 578,500) based on the assumptions just described.[133] As shown in Table 129, the national tax revenue could increase cumulatively by RWF 6.7 to 28.8 billion (US$ 6.9 to 29.7 million) from 2021 to 2030 depending on the

---

128 There is also an additional 5% withholding tax applied to those who don't have a clearance certificate from RRA, however, this tax is deducted from the quarterly tax declaration and therefore it has not been considered as an expensed tax.

129 See http://data.un.org/Data.aspx?q=+wood&d=FAO&f=itemCode%3a1864%3bcountryCode%3a184%3byear%3a2016%2c2017%2c2018&c=2,4,5,6,7&s=countryName:asc,elementCode:asc,year:desc&v=1

130 See http://data.un.org/Data.aspx?q=charcoal&d=FAO&f=itemCode%3a1630%3bcountryCode%3a184%3byear%3a2018&c=2,4,5,6,7&s=countryName:asc,elementCode:asc,year:desc&v=1

131 See MECS and GLPGP 2020. https://mecs.org.uk/press-release-green-biolpg-for-clean-cooking-can-be-produced-at-scale-in-africa-from-renewable-resources/

132 This was held constant over time and calculated from domestic sales prices and applicable VAT (zero in the Rwanda case) and import duties.

133 As calculated from the CEFT Households/institutional level data.

scenario, relative to BAU projections. The annual tax revenue increase in 2024 would range between RwF 168 million to 2.7 billion (US$ 173,000 to 2.8 million) relative to BAU projections. In 2030, the range would be from RwF 1.7 billion to 4.4 billion (US$ 1.7 million to 4.5 million) relative to BAU.

Table 129. Incremental tax revenues by scenario relative to BAU

Tax revenue economic impacts			
Impact (relative to BAU scenario)	Annual economic increase in 2024 (RWF) / (USD)	Annual economic increase in 2030 (RWF) / (USD)	Cumulative economic increase in 2021-2030 (RWF) / (USD)
Low intervention scenario	RWF 168 million / USD 173,000	RWF 1.7 billion / USD 1.7 million	RWF 6.7 billion / USD 6.9 million
High intervention scenario	RWF 365 million / USD 376,000	RWF 3 billion / USD 3.1 million	RWF 12.3 billion / USD 12.8 million
NST-1 Target scenario	RWF 2.7 billion / USD 2.8 million	RWF 4.4 billion / USD 4.5 million	RWF 28.8 billion / USD 29.7 million

Trade balance impact

This study assumed that 100% importation of LPG and current production capacities of alternative fuels would remain constant over the projected time frame (up to 2030). Given Rwanda's high forest cover, it was assumed that production capacity would meet charcoal and firewood demand. Domestic charcoal demand and associated usage will decrease with consequent reduced production (assuming no increased exports to protect the environment).

To estimate impacts on the trade balance, we calculated the total impact of importing and exporting different cooking fuels on the national trade balance under the various adoption scenarios (Low, High, NST-1 as well as BAU projections).

The impact on the country's trade balance was calculated by determining exports of LPG (that is, zero) and competing fuels (small but non-zero) and subtracting these from Rwanda's imports of both. The values of future exports and imports were estimated by keeping the price per kg of fuel imported/exported constant over time (except for LPG). The difference between the BAU projections scenario and the three interventional scenarios shows the impact to the national trade balance, should greater LPG availability, accessibility and affordability be achieved.

Results

In 2016, cooking fuel represented RwF 6.2 billion (US$ 6.4 million) of the increase to the trade deficit in that year, equal to 4.5% of the cumulative trade deficit (assuming a cumulative deficit of US$ 142.80 million)[134]. The trade balance could decrease by between RwF 2.8 to 46.8 billion (US$ 2.9 to 48.2 million) in 2024 depending on the scenario, relative to the BAU projections (see Table 130). Similarly, in 2030, the trade deficit could decrease by RwF 43 to 134 billion (US$ 44.3 to 138.3 million), relative to BAU projections.

134 Source: https://tradingeconomics.com/rwanda/balance-of-trade

Table 130. Incremental trade balance impacts by scenario relative to BAU

Trade balance economic impacts		
Impact (relative to BAU scenario)	Annual expansion of national trade deficit in 2024 (RWF) / (USD)	Annual expansion of national trade deficit in 2030 (RWF) / (USD)
Low adoption scenario	RWF 2.8 billion / USD 2.9 million	RWF 43 billion / USD 44.3 million
High adoption scenario	RWF 6.3 billion / USD 6.5 million	RWF 87.7 billion / USD 90.3 million
NST-1 adoption scenario	RWF 46.8 billion / USD 48.2 million	RWF 134 billion / USD 138.3 million

Summary of macroeconomics impacts

Assuming that current tax rates and status regarding charcoal and firewood fuels remain unchanged over time, increased LPG consumption, combined with reduced consumption of firewood and charcoal will impact national tax revenue. Assuming no major increase in the export of woodfuels, the result will be a cumulative increase in the national tax base of between RwF 6.7 and 28.8 billion (US$ 6.9 and 29.7 million) from years 2021 to 2030 depending on the scenario, relative to BAU projections.

The projected increases in LPG importation could widen the national trade deficit by between RwF 43 and 134 billion (US$ 44.3 and 138.3 million) in 2030, relative to BAU projections, assuming 100% of the LPG consumed continues to be imported LPG. These estimates would change were Rwanda to develop any domestic source of LPG production (such as bioLPG plants, for which there is good evidence for feasibility)[135] as a substitute for or complement to LPG importation.

135 GLPGP (2020)

66. Impacts on Gender and Livelihoods

Gender equality is important for Rwanda's national strategy (Ministry of Gender, 2020), and Rwanda is leading in advancing gender equality in the African continent. Yet gender gaps in access to energy remain a key challenge. According to the 2020 ESMAP report, it is estimated that women spend an average of 6 hours a day performing cooking-related tasks resulting in an estimated US $0.8 trillion of national productivity lost per year[136]. For all of SSA, this figure is US $186.2 billion per year. Reducing the number of hours per day spent by women on unpaid work involving acquisition of fuel, and inefficient cooking, could have numerous benefits, both financial and social, including allowing women to find more paid work, pursue education, or have more time for themselves and their families and their wellbeing.

According to the CFET 2020 survey data, firewood is collected by 68.6% of households, with an additional 8% of households combining free collection and purchase. 42% of women are responsible for firewood collection tasks. Overall, only 26.2% of households have access to firewood collection below a 500m distance, with the majority (41.2%) having to cover a distance of 500m-1km. In the case of charcoal purchase, the CFET data indicate that 57.2% of women and 11.1% of women/children are responsible for securing the fuel supply. Concerning the distance covered to reach the charcoal selling point, the majority of households (58.9%) cover a distance that is less than 500m, while 32% buy charcoal at a distance varying between 500m and 1km.

LPG offers a significant time savings advantage relative to charcoal and firewood (and other collected biomass) because: (i) LPG provides a long-term means of energy storage in the home (i.e., fewer trips to purchase alternative fuels or fetch biomass); (ii) LPG saves cooking time from faster, more efficient cooking (including savings from not having to start and douse a fire), and (iii) LPG saves on time needed for cleaning pots, utensils and the household cooking space that become blackened by smoke and soot from the use ofbiomass fuels.[137] The LPG-related time savings from increased speed of cooking and the reduced requirement for cleaning has been documented in several contexts. In Peru, for example, rural women adopting LPG through participation in a research study spent on average 3.2 fewer hours cooking (rigorously measured through stove use monitors) and 1.9 fewer hours collecting fuel per week[138]. They also reported that the saved time was used in activities with income-generating potential such as caring for animals and working in the fields, in addition to having extra time for leisure activities and households chores. In Rwanda, data from the World Bank Multi-Tier Tracking Framework (MTF) collected in 2016 indicates that women spend substantially more time than men in acquiring fuels for cooking (73 minutes compared to 36 a day, respectively). The burden for women in rural areas is twice that of women in urban areas. In addition, women spend twice as long as men on firewood preparation tasks (e.g. chopping into smaller pieces) for their every day cooking.

---

136 ESMAP (2020)

137 Brooks et al. (2016); Nautiyal (2013)

138 Williams et al. (2020)

Concerning the energy supply sector, increased access to LPG may create an increased net negative effect on women from lost employment opportunities in the charcoal and firewood sectors, where they are often employed as part of the informal economy. At the same time, women could be employed as sales agents or in other roles in the LPG supply chain (as they currently are succesfully being employed in the clean lighting sector)[139]. According to a USAID and Power Africa 2020 survey of energy suppliers, representation of women in this sector is highest in high and middle-level staff functions[140].

139 Barron et al. (2020)

140 Gihana et al. (2020)

67. Conclusion

The results summarized above demonstrate that successful scale-up of LPG use has meaningful positive impacts on three of five socio-economic impacts assessed: environment, health, and consumer household expenditure, and a positive effect on women at the consumer and health levels but a likely net negative effect on women from lost employment opportunities in the charcoal and firewood sectors.

Final considerations

The assessment excluded some potential avenues for impact due to a lack of reliable data, which in turn may underestimate the total positive impacts of transitioning to LPG:

- With respect to environmental impacts, the assessment does not consider cooling effects.
- The health analysis is restricted to the historical five GBD health outcomes, not including the most recent additions of low birth weight and diabetes (2019), nor other impacts such as cataracts and adverse pregnancy outcomes for which there is definitive evidence of an association with HAP. In addition, burns and scalds in adults and children were not included in the quantification of health impacts, yet they carry substantial disability. A transition to LPG is likely to result in fewer of these accidents and injuries, particularly in children, who would have less contact with open flames.
- Under macro-economic analysis, it was not possible to quantify the employment impacts (in terms of jobs created in the LPG supply chain and their likely increase as LPG adoption increases and job losses in the charcoal/firewood supply chains as LPG displaces the use of biomass).

The results presented in this Chapter demonstrate that successful scaling up of LPG use has meaningful positive impacts on environment, climate, health, and consumer household expenditure, as well as multiple positive impacts for millions of women in their roles as cooks, family caretakers and consumers.

Altough unquantified, some potential negative effects for women employed (formally and informally) in the charcoal and firewood supply chains should be expected, due to reduced demand for these alternative fuels as LPG becomes more widely adopted and used. Assessment of such negative effects would require the development of detailed data about the charcoal and firewood industry that do not presently exist.

Rwanda National LPG Master Plan

Volume 7

Annexes

Contents

List of Tables

List of Figures

XX. Monitoring and Evaluation Framework

This Part is intended to set the basis for the creation of a monitoring and evaluation (M&E) framework to measure progress and impacts of increased LPG access and use in Rwanda over time. This is a guidance document intended to be further developed through working closely with relevant national stakeholders and partner organizations responsible for programme monitoring and evaluation at the country level, and subsequently implemented upon identification of appropriate resources.

In this Part, a set of indicators - the **Indicators of Sustainable LPG Expansion (ISLE)** – is described in order to help the GoR and other stakeholders evaluate and report on progress in safely scaling up LPG adoption and sustained use at the household level. For the GoR, it may specifically be used to monitor progress towards its NST-1 goals and its Sustainable Development Goal 7 targets.

➲ It is recommended that the ISLE indicators be formalized and institutionalized in Rwanda as part of the efforts of GoR, industry, funding sources, and other stakeholders to monitor progress and to create a feedback mechanism to make adjustments to Plan execution and the investment programme in future years.

68. M&E Goals and Context

M&E of LPG in an impacts context

LPG has been highlighted by several international organizations, including the World Health Organization (WHO) and the International Energy Agency (IEA), as one of the key fuels to be scaled up rapidly throughout the developing world. This is because LPG is a clean burning and easily transportable fuel that consistently achieves the best performing tier level for indoor emissions (Tier 4) under the International Organization for Standardization, International Workshop Agreement 11 (ISO/IWA-11)[141], in both laboratory and field conditions. Its performance in the field does not normally vary with user operation and equipment condition (which means that it burns cleanly not only initially but also over time). Nevertheless, there may be variations in the levels of personal exposure reductions due to local circumstances (e.g. ambient (outdoor) air pollution, fuel stacking etc.). For example, the benefits of LPG adoption in terms of reduced household air pollution (HAP) might be reduced due to cross-contamination from neighbouring households' continued use of polluting fuels/stoves, or LPG households not fully switching to using LPG for a sufficient portion of cooking tasks.

Types of evaluations

This proposed M&E framework covers two aspects of an evaluation: process and impact.

1. The *Process/outcome evaluation* is intended to understand better the effectiveness of policies and programs and to assess why particular interventions work or do not work. It measures programme effects on the target population by assessing the progress towards the programme's outcome objectives and how the programme has been implemented.

2. The *Impact evaluation* focuses on the results and ultimate effects of the intervention programme/policy in regard to achieving its goals for the target population.

The two types of evaluation go hand in hand. They draw from a mix of regularly collected data on key aspects of an LPG national market, such as consumption, sales, distribution and safety, national population surveys with questions on household energy use, and ad hoc data collection efforts and research activities. The combination of different data gathering efforts is needed in order to quantify impacts in a more robust way. Specifically, without very accurate information on LPG household consumption and sustained use (i.e., primary and secondary fuel use), it is not possible to evaluate and accurately quantify the health, environmental, climate and other impacts of LPG uptake over time.

Population-based household surveys, conducted as part of ad hoc data collection efforts (e.g. research projects or programs), will be a key component in complementing and enhancing the proposed set of

141 Shen, et al. (2018). Evaluating the performance of household liquefied petroleum gas cookstoves. Environmental Science & Technology, 52(2), 904–915.

monitoring indicators that track LPG scale-up (see Chapter 69). Surveys and qualitative methods (e.g., in-depth interviews and focus groups discussions) are, indeed, needed to capture the complexity of cooking behavior, including fuel usage patterns and decreased use of traditional cookstoves and fuels. Such surveys and methods will also be necessary in capturing gender-related impacts of adoption and sustained use of LPG, which are currently difficult to quantify.

Household energy questions in existing national representative surveys

A number of nationally representative surveys are conducted in Rwanda at regular intervals (e.g., Integrated Household Living Conditions (EIVC) by the National Institute of Statistics of Rwanda and the Demographic and Health Survey by USAID). While these can contribute to tracking national estimates of household energy use, they only include a small set of household energy questions, in most cases only a single question on the main fuel used for household cooking. Surveys like the World Bank multi-tier tracking framework (MTF) or the National Survey on Cooking Fuel Energy and Technologies (CFET) in Households, Commercial and Public Institutions in Rwanda provide unique data but they may not be repeated at the necessary frequency to track progress on a yearly/bi-yearly basis (particularly given the NST-1 Target for 2024). Also, use of different survey questions makes comparisons across different surveys difficult.

Given the importance of tracking progress towards SDG7 and, specifically, SDG 7.1.2: *Proportion of population with primary reliance on clean fuels and technologies*, it is recommended that the GoR and its implementing agencies adopt the 'harmonized' household energy survey questions developed by the World Health Organization (WHO) and partners as part of their routine national data collection efforts. The set of questions are available from the WHO website[142]. With endorsement by statistical offices and major national surveys in Rwanda and other countries, it will be possible to track household fuel use, including modern and clean energy uptake over time, much more accurately.

Particularly, it will be important to ask about primary and secondary fuel use to assess the concurrent use of multiple stoves and fuels, known as stove/fuel stacking, in order to better quantify impacts from energy transitions.

Finally, LPG tracking at the household level would benefit by having better formulated LPG-specific survey questions included in both bespoke and routinely collected national surveys administered to both existing LPG users and non- users. This will facilitate capturing more accurate information on currently used cylinder size (and associated refill costs) as well as monitoring availability of LPG to be able to track increased retail density over time.

Why is an M&E plan needed?

This work is embedded in GoR's efforts to scale up clean cooking to meet its NST-1 and SDG7 targets for access to clean household energy and forest protection through reduced biomass use. LPG is one of the clean fuels specifically promoted by the Government for household and institutional cooking.

[142] See https://www.who.int/airpollution/household/survey-harmonization/en/

A properly designed and implemented M&E framework for LPG scaling up will allow national/international stakeholders to:

i. Monitor progress with the implementation of agreed policy against programme goals;

ii. Apply evidence-based adjustments to improve programme performance and reach;

iii. Contribute (using harmonized household energy survey questions) to SDG7 and SEforAll global tracking; and

iv. Understand, quantify, and interpret the wider societal impacts (on the environment, health, climate, gender empowerment and economic development) of scaling up LPG uptake.

Steps in developing and implementing the LPG scale-up M&E plan in Rwanda

The process of developing a national M&E plan for LPG scale up should begin during the initial stages of programme planning and implementation, in consultation with local stakeholders responsible for programme implementation, ministries and agencies with M&E expertise. The framework presented in this document and developed under the EU/KfW-sponsored Clean Cooking for Africa Program should, therefore, be considered as one of the initial steps in the process to help Rwandan authorities develop and implement a full M&E plan with respect to LPG, for which additional funding may need to be sought.

The proposed framework should be discussed and refined through stakeholder consultation and participation by local implementers and M&E authorities, according to the following steps:

i. Conduct stakeholder consultation(s) convened by Rwandan authorities;

ii. Define processes for stakeholder involvement: identify the key local stakeholder(s) responsible for overseeing and implementing the M&E plan, determine which local capacity is available (and can also be strengthened), and identify which partners can support the process;

iii. Discuss and revise the proposed M&E framework and the ISLE indicators developed under the Clean Cooking for Africa Program to determine elements to be monitored and evaluated;

iv. Identify available resources to implement the M&E plan, including over which timeframe; this is a key limiting factor that may influence how the M&E plan is finalized and implemented;

v. Determine M&E methods for data and information collection: (a) develop a data collection plan (including indicators to be collected, timing for data collection and analysis, tools, resources, training provision for staff, etc.); (b) determine M&E responsibilities (data collection, supervision, analysis, reporting, etc.);

vi. Set M&E targets; and

vii. Define a reporting system for dissemination and utilization of results.

69. ISLE Indicators for Monitoring and Evaluation

Indicators for Monitoring and Evaluation of LPG adoption, sustained use and infrastructure expansion over time

The **Indicators of Sustainable LPG Expansion (ISLE)** developed by Clean Cooking for Africa/GLPGP consist of a set of indicators to be routinely collected at the national level in order to inform the monitoring and evaluation of scaling safe adoption and sustained use of LPG as a clean household cooking fuel and the resulting social, environmental, health and economic impacts.

These indicators are the first step to conducting further, more detailed evaluation on different impact categories with metrics presented in the final section of this Chapter. These impact metrics measure the extent and rate of the existing and projected social, health, environmental and economic impacts from increased LPG adoption and use and associated economic activity, including number of jobs created and lost across different fuel value chains. Quantifying impacts would require bespoke expertise and data collection efforts, including monitoring concentrations of and personal exposure to health damaging air pollutants such as fine particulate matter ($PM_{2.5}$), in order to reliably project the health impacts of scaling adoption and sustaining use of LPG over time.

Execution of this M&E plan aims to provide representative data which is sufficiently valid and precise for the purposes of review efforts to achieve desired LPG scale and subsequent improvements to related policies and actions. It is recommended to track the ISLE indicators on an annual basis (or as practical, based on availability of national representative surveys), depending on available resources and survey data already being collected.

As described in the section below, the proposed set of M&E indicators can be grouped into distinct categories according to different aspects of LPG scale-up they intend to cover, for which bespoke data collection efforts are required in most cases.

Categories of indicators

There are three main categories of ISLE indicators:

Category 1: LPG adoption and use (ISLE Table 1). This category measures the extent and rate of expansion of LPG adoption and consumption through national consumption data and nationally representative surveys

Category 2: LPG supply chain expansion and indicators of the safety of the LPG market (ISLE Table 2). This category measures the extent and rate of build-out of the LPG supply chain and associated investment, as well as the safety performance of the LPG sector

Category 3: LPG safety for households and occupational settings (ISLE Table 3. This category measures injuries and burn incidents related to LPG fuel use in the population

While RURA, RRA, RSB, REG/EDCL and other agencies already collect information on key LPG metrics on an annual basis, such as LPG national consumption, national LPG imports, and several others, additional important indicators are not currently tracked. These untracked indicators include, for example, LPG cylinder refill sales by cylinder size, the number of cylinders in circulation, the number of scrapped cylinders, and number of jobs in the LPG supply chain (short-term and long-term), among others. In addition, key indicators such as the number of LPG-related accidents at the occupational and household level are not currently tracked. Such tracking would support planning and implementing improved safety measures and improved consumer education.

The ability to track all the proposed ISLE indicators depends on a number of factors: (i) endorsement by national stakeholders following discussion and adaptation, (ii) availability of resources, and (iii) staff capacity of the relevant agency/ies involved in the implementation and monitoring of LPG-related progress. For example, in order to collect and track the ISLE safety indicators, it may be necessary to establish a national surveillance system to record accidents from LPG and other fuels in both occupational and household settings by involving the Health Sector.

Methodology used to develop the ISLE indicators

The proposed ISLE indicators were developed between June 2016 and July 2018 through a stakeholder consultation process with LPG industry experts (LPG policy and regulatory advisors, LPG business developers and industry technical experts, GLPGP country managers in Kenya, Ghana and Cameroon among others, financial experts (planning and investment) and public health experts (academics with expertise in M&E and HAP/household energy use)). Starting with the review of existing literature on indicators to track under SDG 7.1 ('Ensure universal access to affordable, reliable and modern energy services by 2030') and indicators of household energy adoption[143], two rounds of international expert consultations have been conducted. The first consultation was hosted in 2016 in Frankfurt with the Clean Cooking for Africa Program scientific advisory board, comprising leading public health and climate experts. This initial set of indicators was then revisited, expanded and discussed during a consultation hosted with the KfW Clean Cooking for Africa Program appointed technical experts and University of Liverpool public health experts in February 2018.

Following the consultations, the indicators were piloted in Kenya, Ghana and Cameroon to test the feasibility and practicality of collecting the required data, to adjust and refine the indicator set. The list of indicators presented in this document is therefore the result of extensive piloting and consists of 'essential' and 'desirable' indicators that may need local adaptation. The list is thus presented for consideration by the Rwandan authorities with respect to such local adaptation.

Guiding principles

The development of the ISLE Indicators was guided by three key principles: (i) identifying and making the best use of existing routine and annual data collection systems, (ii) collecting new data at minimal or no extra cost and (iii) not excluding metrics that would require full cooperation in data sharing from private sector players, which may result in added costs to conduct stakeholders interviews/surveys.

Category 1: ISLE Indicators of LPG market expansion and household adoption and use

The Indicators proposed in ISLE Table 1 include some of the key performance indicators (KPIs) used by the worldwide LPG industry, and indicators of population access to LPG that can be compiled through existing data collection systems. These indicators should be collected on an annual basis (or as frequently as survey

143 See cleancookstoves.org/binary-data/RESOURCE/file/000/000/379-1.pdf

information from nationally representative surveys is available, estimated as every 2-3 years). They would serve to track progress towards the Rwanda Government's policy goals regarding LPG and the reduction of biomass use, regarding the progress of LPG scale-up generally, and the developmental, social and environmental impacts of that progress.

Selected highlights on the proposed indicators:

- Indicator 1.1 – *Total LPG kg per capita consumption per year* – is the 'gold standard' or preferred LPG industry KPI to track LPG market expansion and uptake. It also allows international comparisons of LPG penetration to be made (see Box 1 at right)[144]. However, this indicator would over-estimate household use of LPG if other sectors (e.g., industrial uses, such as in the case of Kenya) also make up a substantial proportion of total LPG consumption. For this reason, Indicator 1.2 on residential LPG consumption should also be jointly tracked.

- Indicator 1.2 – *Residential LPG kg per capita consumption per year* – is specific to the residential sector and is based on consumption of LPG in cylinders of 3-15 kg sizes (as compared to larger cylinders, typically of 35-50 kg that are used in institutional and commercial settings), divided by the total population.

  In Rwanda, the main household cylinder sizes are primarily 6kg and 12kg. Small personal businesses such as roadside food-street vendors can also make use of cylinders of these sizes, and their consumption would be captured as part of the total residential consumption (unless a digitized system is put in place for a more accurate tracking and monitoring; see later section in this Chapter titled *The potential role of a digital recording system for LPG tracking*. Note that in most SSA markets, the residential use of LPG is for cooking and not for heating (with LPG portable heaters), so the kg/capita of LPG residential consumption would effectively correspond to the amount of LPG used for cooking. In addition, it is helpful to note that if the national LPG market is primarily for residential use, the correspondent kg/capita value will be close to the total LPG kg/capita consumption.

- Indicator 2.1 – *Percentage of population cooking primarily with LPG in a given year* – and its sub indicators (urban / rural primary usage), rely on nationally representative population-based surveys that are used to monitor household energy use, including for SDG 7 reporting. Large-scale nationally

Box 1 – LPG market stage according to international industry standards

- **Early stage/growth markets:** Defined as <10 kg per capita per year.
- **Transitioning stage markets**: Defined as around 15 kg and aspiring to increase (e.g., up to 40 kg capita per year or more).
- **Mature/advanced stage markets**: Usually >15 kg/capita but not necessarily defined by high LPG consumption (some are well below this). This market classification is based on sophistication and diversity of the LPG value chain as well as an excellent overall safety record.

144 Source: WLPGA (2014). Guidelines for the Development of Sustainable LPG Markets – Transitioning-Stage Markets. Paris: World LP Gas Association.

representative surveys (e.g., EICV, DHS and national census surveys) take place every 5 to 10 years. However, due to their different frequency, it may be possible to track primary LPG use in a range of 2-3 years. This interval is appropriate for tracking purposes, as extremely large changes in percentage of LPG use are unlikely to occur in periods of less than 2-3 years. These data, complemented by indicator 2.2 below, provide the best means of tracking progress on LPG uptake based on existing routine information. The suggested new question under the WHO-World Bank survey harmonization process is designed to capture primary, secondary and tertiary fuel/stove use as three answers are allowed. The proposed question is: '*What does this household use for cooking most of the time, including cooking food, making tea/coffee, boiling drinking water? Please tell me the cookstove or device that is used for the most time, followed by the other cookstove(s) or device(s) used most often, if applicable'.*

- Indicator 2.2 – *Percentage of population using LPG for cooking (any use) per year* – intends to capture primary and secondary use of LPG for household cooking and boiling water. Secondary use of LPG is common, particularly for households that have recently adopted LPG but do not yet use it for all their cooking/boiling water needs. Lack of such secondary use recording may underestimate total LPG household usage figures. By endorsing the full set of household energy questions, countries will be able to track this indicator.

- Indicator 2.3 – *LPG consumption per LPG user (kg/capita among LPG using households) per year* is calculated as the total LPG consumption in the residential sector in a giving year, divided by the percentage of households using LPG in the same year multiplied by the mean household average size for the country. The accuracy for tracking this number depends on the accuracy of the residential LPG consumption estimates (that may be a slight overestimate if it includes LPG use for cooking by small commercial entities) and the number of households using LPG (whether primary or secondary users, and the year the number of households is estimated for). Without a digitised system that would allow to exactly know how many households are making use of LPG (and their refilling patterns), national representative surveys should be used as an alternative source to estimate household LPG consumption.

Indicators of LPG supply chain expansion and safety of the LPG market

The set of indicators presented in ISLE Table 2 is a selection of key metrics for tracking and recording LPG infrastructure expansion, as well as detecting and responding to market dysfunctions (e.g. cross-filling of cylinders of different brands, interchangeability of cylinders etc., that are detrimental for LPG marketers). This set of indicators also contains a section on indicators for tracking economic development, including the quantity of direct jobs created as a result of LPG market expansion.

Obtaining the information needed to compile this set of indicators may present challenges as most of the data is not routinely collected and would need some bespoke data collection efforts. Challenges may include: (i) obtaining information on cylinders in circulation from each private sector player (e.g. LPG marketers operating under the BCRM) for pooling into national estimates, due to private firms' possible concerns about this information being proprietary (e.g. see indicators 3.2 and 3.3); (ii) procuring the data, if the information is scarce (e.g. on safety) and/or not currently compiled (e.g. indicator 5.2); and (iii) sourcing the number of LPG-related jobs created under the different categories without asking each individual company on a bespoke basis (e.g. indicators 5.3 and 5.4). It is anticipated that obtaining some of these data will be labour intensive and require special data collection efforts and resources along with good technical knowledge of the LPG sector. It is, therefore, strongly recommended that collection and compilation tasks are assigned, in the first instance, to technical experts with a thorough understanding of the LPG system and the private sector rules in the country.

The Government/RURA may need to consider legislation on mandatory data reporting from all LPG marketing companies and private sector players, especially on safety aspects.

Selected highlights:

- ISLE Table 2, Section 3 – LPG supply infrastructure development: cylinders and bulk infrastructure, includes a number of indicators and sub-indicators to track the number of cylinder assets added and taken out from circulation and bulk infrastructure expansion. All the information regarding cylinders is critical in terms of measuring both supply and demand (and safety). For example, with regards to indicators 3.2 - 3.4, the best way to collect the total numbers of cylinder deployed, scrapped and circulating into the market is to have numbers submitted by the individual LPG marketers to an appointed body (e.g. RURA or others) on a mandatory basis. Information about cylinders which are imported should also be made available from customs duties, as a cross-check.

- ISLE Table 2, Section 4 – LPG industry safety metrics: presents a recommended set of indicators for tracking safety in relation to LPG use at all nodes in the value chain. The indicators are tailored for countries operating under the BCRM, relevant to Rwanda as it seeks to strengthen its implementation of BCRM. Cylinder scrapping, testing and recertification are examples of standard industry practices for ensuring safety, but national level monitoring or compilation of information is rarely implemented in SSA settings. Stakeholder consultation will be key in this area to determine what is possible to monitor and consider for inclusion, as the data is currently very sparse. Strengthening safety monitoring and the use of good practices throughout the LPG value chain is vital to protecting both LPG consumers and LPG operators and can help address the root causes of LPG incidents and injuries.

- ISLE Table 2, Section 5 – Economic aspects in relation to LPG expansion, include a selection of indicators to capture the amount of investment in LPG infrastructure and the jobs created and lost as a consequence of market expansion. While these data are critical to monitor contributions to national economic growth and mobilization of international capital, these are not currently compiled and sourcing may pose challenges. Other indicators, such as the indirect jobs created by LPG infrastructure expansion, are useful to include in the list, recognizing that obtaining reliable information will be difficult; the wider impacts of LPG expansion on the macroeconomics should not be underestimated or ignored. Similarly, systems to track the number of jobs in the charcoal and firewood sectors over time should be put in place to monitor overall impacts on job loss/creation at the national level. This requires an expanded set of indicators and information sources, going beyond the focus of the ISLE indicators on LPG-related metrics.

The ISLE LPG supply chain expansion and safety indicators should be ideally compiled on an annual basis to measure progress over time. Tracking of this information is valuable and necessary also for making international comparisons about market expansion, especially for countries starting with similar LPG market conditions and LPG consumption rates to Rwanda.

Safety indicators in relation to LPG

ISLE Table 3 is specifically designed to track LPG-related explosions and accidents (burns and injuries) in both home and occupational/institutions settings. Being able to track, monitor and report on safety-related indicators is the first step to help prevent and intervene when such events occur.

Notwithstanding the importance of safety, recording, compiling and acting on the results of such data poses certain challenges. Often, these actions are not possible to implement unless a specific surveillance system coordinated by the health sector is put in place (e.g., at the hospital level). It is therefore recommended that national stakeholders in Rwanda consider establishing such a mechanism for data gathering and reporting in order to monitor safety accidents closely and put in place measures to address the root causes of LPG-related safety accidents. The Ministry of Health, working together with fire services, may lead this process.

Note also that WHO has made available a Global Burn Registry (GBR) for health facilities, which collects information on main risk factors, mechanisms, and risk groups for burn injuries requiring a hospital stay (see www.who.int/violence_injury_prevention/burns/gbr/en/). Participation in the GBR empowers standardized data collection from burn victims, helps prioritizing prevention programs, and allows global tracking of burn victims and their causes, including LPG-related burns and injuries.

The potential role of a digital recording system for LPG tracking

The advantages of setting up digital recording for LPG adopting households and businesses are multiple and are summarized below. A prerequisite for such recording at the retail and consumer level is a digitized LPG and/or payments system, such as already developed and in near-universal use in India, or such as are in pilot phases by pay-as-you-go LPG providers in certain SSA countries, including especially Kenya and Tanzania. Rwanda's growing penetration of mobile payments and mobile money systems creates a strong starting point for such digitalization.

Several high-income and middle-income countries have been making use of digital databases over the years for taxation and other purposes, and have been able to digitize LPG consumers' data successfully. India, Brazil, and El Salvador are just a few examples. This section presents the case of LPG data tracking in India, one of the countries that most recently have embraced such digitalization (see https://socialcops.com/case-studies/tracking-pmuy-beneficiaries-using-data-intelligence/).

Under Indian law, LPG distributors must maintain an electronic register with names and addresses of persons registered to obtain their first LPG cylinder and equipment (LPG connection) and subsequent refills. Each household is registered with a unique identification number.

The advantages of such a digital recording system of LPG customers are multifold, and include:

i. Accurately tracking LPG household consumption as compared to LPG use by other sectors (e.g. autogas, power generation, etc.) and by small and medium enterprises (e.g. food street vendors). Monitoring refill patterns across consumers and over time is needed to understand factors influencing refill rates and contribute to better delivery planning;

ii. Recording precisely the number and location of households using LPG – which is important for both creating new distribution centres (sales outlets under BCRM) and creating potential for booking of cylinder refills online or through mobile phone apps for home delivery;

iii. Tracking seasonal and other cyclical demand variations (e.g. tied to agricultural production) for planning of distribution;

iv. Identifying gaps between refill requests and actual refills to identify bottlenecks in supply or under-performing distributors;

v. Providing a tracking system for cylinders that LPG marketers and distributors can rely on to control their cylinder assets;

vi. Tracking households that receive subsidized equipment/fuel as part of pro-poor initiatives (e.g. PMUY programme in India that provides free initial LPG equipment to below-poverty line women; and

vii. Avoiding abuse of LPG subsidies as registered households are tracked and only one household member is allowed to receive the subsidized equipment and LPG refills.

Overall, such a digital system provides a platform for benefit transfer to the right people at the right time, and identify where processes are failing to deliver and need to be improved.

Regardless of specific hardware/software specifications, which go beyond the scope of this document, a number of principles would need to be considered:

- Security of the system for ensuring confidentiality of records;
- Creation of unique ID systems tied to individual customers;
- Ensuring standardization in data entry – for example, having village names spelled differently, or addresses entered using more than one convention (e.g. village name + district name in one field versus in two separate fields) would create problems later in ensuring households are assigned to the right village in analysis;
- Ability to easily export data into one or more widely used file formats and ability to select subsets of data for export; and
- Data fields to distinguish different classes of customers (e.g. those benefiting from LPG subsidy / subsidized equipment versus those who do not).

Role for mobile banking services for LPG purchasing and indicator tracking

Mobile banking is an important future mode of financial transactions in Rwanda for middle and upper income groups who already have bank accounts, as well as for unbanked population segments.

Apart from cash transactions, mobile phones can also be used for tracking cylinders. Through an app, a sales person would record the serial number of the cylinder, and the customer would be compelled to return the same cylinder when empty to the designated retailer for exchange for a full cylinder. The serial number of the customer's replacement cylinder would be recorded with each exchange, in a cyclic fashion. This approach would allow the company to know the interval between refills for each customer, and therefore plan more precisely for having the right number of filled cylinders on hand in each retail outlet. LPG purchase patterns can also be monitored for seasonality.

This sort of tracking is done automatically for PAYG cylinders equipped with smartmeters.

Potential for additional indicators based on digital LPG records

Additional key indicators could be added to the current ISLE list if a certain condition, such as a unified system for digital recording of LPG adopting households and businesses, is put in place. Two such examples are as follows:

- *Average number of LPG (kg-equivalent) cylinder refills per year by household using LPG*. This indicator and potential sub-indicators (urban, rural and regional averages) would help to measure primary and secondary LPG usage accurately across the national territory. This value could then be compared to the number of refills that is needed as an indicator of primary use in the country to ensure that the public health and other benefits from transition to LPG are achieved.
- *Percentage of calls to emergency service helpline for LPG incident complaints per year.* This indicator would contribute to safety and prompt intervention tracking and could assist LPG companies in improving their services. It could be considered only if LPG marketing companies operate an emergency service helpline as most middle and high-income countries do.

Final considerations

The proposed ISLE indicators are intended as a resource to be used in all countries that promote LPG as a household fuel. They are particularly important to be adopted in low and middle-income settings that are trying to create a robust monitoring system for LPG sustainable scale-up.

The recommended set of ISLE indicators for Rwanda should be considered provisional until endorsed by the relevant authorities following appropriate national stakeholder consultation. As much as they have been designed as a flexible tool to incorporate in-country variations, their added value is also as a harmonized set of indicators for international comparison, and for reviewing trends over time at the country level.

Among the whole set of proposed indicators, an 'essential' set of indicators could be also prioritized for regular annual updating and public reporting. The essential set should include a mix of indicators from the three listed categories (including safety, if a national surveillance system can be successfully established).

ISLE TABLE 1: ISLE indicators of LPG adoption and use

Domain	Indicator	***Sub-indicator* / Component needed for main indicator**	Comment on indicator and sources	Frequency of collection
1. National LPG consumption				
1.1	**Total** LPG kg/capita consumption per year	To be measured using: (i) The total national LPG consumption in a given year divided by (ii) the population amount in the same year	This indicator is the standard and universally accepted key performance indicator (kpi) to describe the degree of development of the LPG market in a country (all sectors). *Source:* If multiple consumption sources exist, identify the most reliable source to assess baseline	Yearly

Domain	Indicator	*Sub-indicator* / Component needed for main indicator	Comment on indicator and sources	Frequency of collection
			consumption or use an average among different LPG consumption sources.	
1.2	LPG kg/capita consumption for the **residential sector** per year	To be measured using: (i) the total LPG consumption in the Residential sector in a given year (as compared to other sectors such as Industry; Transport; Refinery; Chemical and Agriculture), divided by (ii) the population amount in the same year	This is a specific indicator to measure the degree of development of the residential LPG sector. *Source*: Use an average among different sources, or understand the most accurate source to use for baseline estimates. If the national LPG market is primarily domestic, this value will be similar to the national LPG kg/capita consumption.	Yearly
2. Population cooking with LPG				
2.1	Percentage of population cooking **primarily** on LPG in a given year	Sub-indicators: 69.1.1 Percentage of URBAN population cooking primarily on LPG in a given year 69.1.2 Percentage of RURAL population cooking primarily on LPG in a given year	*Source*: national census surveys, DHS, MICS and other surveys with nationally representative data (e.g. the World Bank Multi-Tier Tracking Framework.). Note that CFET does not currently distinguish between primary and secondary fuel use.	Bi-yearly (with updates depending on when national representative surveys or census surveys are conducted)
2.2	Percentage of population using LPG for cooking (**any use**) in a given year	Sub-indicators: 2.2.1 Percentage of URBAN population using LPG for cooking (any use) in a given year 2.2.2 Percentage of URBAN population using LPG for cooking (any use) in a given year	*Source:* The source for this indicator and its sub-indicators would be nationally representative surveys that include question on secondary cookfuels	Bi-yearly if possible (depending on when the data is available)
2.3	LPG consumption per LPG user (kg/capita) per year	To be measured using: (i) the total LPG consumption in the Residential sector in a giving year, divided by the (ii)	This is the recommended indicator to be used to monitor LPG adoption and sustained use at the household level.	Yearly

Domain	Indicator	*Sub-indicator* / Component needed for main indicator	Comment on indicator and sources	Frequency of collection
		percentage of households using LPG in the same year multiplied by the (iii) mean household average size for the country.		

ISLE TABLE 2: ISLE indicators of LPG value chain expansion and safety

Domain	Indicator	Sub-indicator / component needed for main indicator	Comment on indicator and sources	Frequency of collection
3. LPG infrastructure development				
3.1	Amount and percentage of LPG produced and/or imported per year	*Sub-indicators*: 3.1.1 LPG production 3.1.2 LPG Imports	*Sources*: National imports/ production (if applicable) sources	Yearly
3.2	Number of new cylinders deployed into the market per year (by cylinder size)	This indicator (for cylinders sizes up to 15kg) is a rough proxy measure of new LPG users and market expansion	Households making use of LPG should have at least one cylinder and exchange it regularly given that Rwanda operates under the BCRM *Sources*: To be obtained by each individual marketer and pooled in a final figure (no disclosure of individual marketer cylinder figures).	Yearly
3.3	Total number and percentage of cylinders being scrapped per year (by cylinder size)	To be measured using cylinder scrapping data	Indicator for the conditions of cylinders and valves. *Sources*: cylinder scrapping data from LPG marketers (pooled data)	Yearly
3.4	Total number of 12 kg[145]	To be measured using (i) the total number cylinder	This is an indicator used by the worldwide LPG industry	Yearly

[145] The chosen cylinder size to calculate the kg-equivalents can be adapted depending on what the most popular cylinder size in a given country at different time points.

Domain	Indicator	Sub-indicator / component needed for main indicator	Comment on indicator and sources	Frequency of collection
	cylinders-equivalent in circulation per capita	imported/manufactured , less (ii) those scrapped and (iii) those exported to other affiliates, all in in 12kg-eq, divided by (iv) the total national population	to measure and compare LPG market development[146].	
3.5	Cylinder rotation rate per year	To be measured using (i) number of refills over (ii) size of cylinder park (both measured in 12kg-eq)	This indicator is an indirect measure of LPG sustained use (the higher is the rotation rate, the more households are refilling their cylinders and using LPG for most of their cooking).	Yearly
3.6	Total national LPG infrastructure capacity by type per year	3.6.1 Bulk transport – Bulk Road Vehicle (BRV)	*Sources*: LPG Marketers and licenced transporters	Yearly
		3.6.2 Bulk storage capacity in MT	*Sources*: LPG Marketers	Yearly
		3.6.3 Refilling capacity and number of operational bottling plants (or refilling stations) over the national territory	The number of operational filling plants should be tracked to check progress against the country's plant for LPG expansions. However, it is the refilling capacity represented by the bottling plants that is key to measure.	Yearly

[146] In mature/developed LPG markets this measure falls in the range of 3-4 cylinders every 10 people. In Morocco, one of the most developed LPG household markets, the ratio is almost 1 to 1.

Domain	Indicator	Sub-indicator / component needed for main indicator	Comment on indicator and sources	Frequency of collection
			In addition, the number of operational 'filling scales'[147] could be used to cross-check the filling capacity.	
		3.6.4 Cylinder manufacturing capacity (if applicable)	*Sources*: data from local cylinders manufacturing companies	Yearly (if applicable)
		3.6.5 Number of construction permits for building filling plants / or plant built per year	*Sources*: LPG Marketers and official ministerial recordings	Yearly
		3.6.6 Number of construction permits for building or expanding import terminals (including storage capacity) per year	*Sources*: LPG Marketers and official ministerial recordings	Yearly
3.7	Number of licensed marketers / cylinder brand owners per year		This indicator is a proxy for LPG industry consolidation/ fragmentation.	Yearly
3.8	Total number of authorized retail outlets per year	*Sub-indicator* 3.8.1 Total number of authorized retail outlets by region/province in a given year	This indicator and its sub-indicator is an important measure to track LPG market expansion over the national territory and harder to reach regions. The more retail outlets are available, the more households can access	Yearly

[147] Estimates assume that 1 filling scale per plant will be equivalent to 1,000 MT/year based on a single 8 hour shift. This is based on 1 filling scale filling 40 cylinders of 12kg/hour x 8 hours per day (1 shift), for 260 days per year. For example, a 12 scales filling plant would be able to fill approximately 12,000 MT of LPG in one year working 8 hours per day for 260 days per year.

Domain	Indicator	Sub-indicator / component needed for main indicator	Comment on indicator and sources	Frequency of collection
			LPG at relatively short distances.	
4. LPG industry safety metrics				
4.1	Percentage of LPG facilities (by type) audited by year	Sub-indicators: 4.1.1 Percentage of LPG facilities (by type) in non-compliance 4.1.2 Percentage of LPG facilities (by type) in full compliance	This indicator and its sub-indicators measure the level of compliance of the LPG system with safety norms and regulations (note: most major LPG Marketets conduct internal safty audits of their own facilities)	Yearly
4.2	Percentage of total cylinders being hydro tested per year	Measured by (i) total number of cylinders hydrotested and (ii) total number of cylinders in circulation	This is a measure for LPG safety in a market and regulatory compliance with safety norms. During hydro-testing a cylinder is examined to ensure it can safely hold its rated pressure.	Yearly
4.3	Percentage of total cylinders being refurbished/ recertified per year	Measured by (i) total number of cylinders recertified and (ii) total number of cylinders in circulation	This is a measure for LPG safety in a market and regulatory compliance with safety norms.	Yearly
4.4	Percentage of total cylinders whose valve is replaced per year	Measured by (i) total number of cylinders with valve replaced and (ii) total number of cylinders in circulation	This is a measure for LPG safety in a market and regulatory compliance with safety norms.	
4.5	Percentage of trucks presented for loading turned away (rejected) for non-compliance with Safety, Health, Environmental and Quality requirements		This is an indicator of compliance with safety rules and practices. To be collected by individual filling plants where trucks discharge empty cylinders and upload filled cylinders.	Yearly
4.6	Percentage of drivers that have attended refresher courses in defensive driving / LPG		This is an indicator of compliance with safety rules and practices.	Yearly

Domain	Indicator	Sub-indicator / component needed for main indicator	Comment on indicator and sources	Frequency of collection
	truck driving within the stipulated refresher training requirement.			
5. Economic aspects in relation to LPG				
5.1	Amount and percentage of LPG price volatility in a given year	Measured considering maximum and minimum LPG retail price across the national territory and impact on LPG cylinder refill sales.	This indicator is useful in a market where there are no price controls in the LPG market allowing for full cost pass through to the end user	Yearly
5.2	Net amount of new investment in LPG infrastructure, per capita, per year	This is an indicator of impact on society and macroeconomics.	*Sources*: require a bespoke data collection effort	Yearly / bi-yearly
5.3	Direct number of new short-term jobs created during construction of LPG-infrastructure per year	This is an indicator of impact on society and macroeconomics.	*Sources*: requires a bespoke data collection effort	Yearly / bi-yearly
5.4	Direct number of new long-term jobs created in the LPG sector during operations per year	To be calculated using the following sub-categories: 5.4.1 Importation operations 5.4.2 LPG Bulk Transporters 5.4.3 LPG Storage Companies 5.4.4 Cylinder manufacturing companies 5.4.5 Filling plant operators 5.4.6 Safety inspectors 5.4.7 Cylinder revalidation/ recertification personnel 5.4.8 LPG Distribution companies	This is an indicator of impact on society and macroeconomics. Sources: Bespoke data collection effort with data obtained by recording the number of employees after a new facility becomes operational, and/or in connection with renewals of registrations and license renewals of existing companies and facilities	Yearly / bi-yearly

Domain	Indicator	Sub-indicator / component needed for main indicator	Comment on indicator and sources	Frequency of collection
		5.4.9 LPG retailers 5.4.10 Consumer education / marketing		

ISLE TABLE 3: ISLE safety indicators (occupational and household settings)

Domain	Indicator	Sub-indicator / component needed for main indicator	Comment on indicator and sources	Frequency of collection
6. LPG-related Incidents and burns				
6.1	Number of LPG-related incidents (fires or explosions) in **occupational** and **institutional settings** per year	*Sub-indicators* (i) Occupation settings: 6.1.1 LPG Primary Distribution operations (bulk importation and bulk transportation to bottling plants) incidents. 6.1.2 LPG Secondary Distribution Operations (bulk delivery to bulk consumers for primary storage and transportation / distribution of bottled LPG) incidents. (ii) Institutional and commercial settings: 6.1.3 Hotel, restaurants, health facilities, schools, prisons, etc. LPG-related incidents.	*Sources:* This will likely need a special data collection effort starting from government data on LPG accidents and incident investigation reports	Yearly / bespoke
6.2	Number of LPG-related incidents (fires of explosions) **in homes** per year		As above	Yearly / bespoke
6.3	Number of LPG-related fatalities (both		As above	Yearly / bespoke

<table>
<tr><th>Domain</th><th>Indicator</th><th>Sub-indicator / component needed for main indicator</th><th>Comment on indicator and sources</th><th>Frequency of collection</th></tr>
<tr><td></td><td>occupational and residential) per year</td><td></td><td></td><td></td></tr>
<tr><td>6.4</td><td>Number of non-fatal LPG-related burns per year</td><td></td><td rowspan="2">This will likely need a special data collection effort and standardization process across all hospitals in the country.

Sources: burns registry for severe burns, scalds and fatalities (if recorded in hospitals/health facilities).</td><td>Yearly / bespoke</td></tr>
<tr><td>6.5</td><td>Number of fatal LPG-related burns per year</td><td></td><td>Yearly / bespoke</td></tr>
</table>

XXI. Project Annexes

70. Methodology and Common Elements in the Infrastructure Plan

Methodology

Scenario per scenario, the main methdological steps for developing the infrastructure plan are:

1. Estimate the infrastructure starting conditions (capacities and utilization rates) for 2020, based on the information actually available (survey data, selected industry interviews, government reports, SSA industry benchmarks and assumptions, etc.)
2. Allocate demand scenario volumes for each market segment across regions and container type (cylinder and bulk) for each year
3. Calculate the filling and storage capacity requirements nationally and regionally (consistent with the regionalized infrastructure strategy of the Plan) for each year
4. Calculate the number and timing of new filling plants region by region
5. Calculate the strategic storage requirement in accordance with governmental policy objectives, divided into a national strategic storage infrastructure and a private sector strategic storage (reserve storage) infrastructure
    - A first variation excludes all LPG in the operating and logistical assets of the supply chain
    - A second, recommended variation includes 50% of the LPG in the operating and logistical assets of the supply chain
    - In both cases, calculate the cost of the fuel to be added to and held in the reserve
6. Calculate the required number of circulating cylinders to serve the demand for each region in each year, taking into account regional cylinder rotation rate assumptions, the existing inventory of cylinders in circulation, comprising the cylinders in the logistic chain (on trucks, in depots, in the retail network) and the cylinders in the hands of end-users
7. Determine the number, sizing, and potential location of new filling plants and main depots, in terms of:
    - Number of weighing scales and filling elements
    - Associated storage capacity at the plants
    - The timing of constructing plants vs. establishing depots, based on the volume and growth rate in each region to support economnically the presence of filling plants vs. depots
8. Calculate the primary bulk transport and primary cylinder transport requirements for each region in each year
9. Perform a cost estimation of the investment required for all of the mentioned assets, year by year

Bulk LPG segments

Institutional

On top of household demand for LPG, which will vary depending on the scenarios, the institutional demand (including hotel-restaurant demand) will be consistent across all the scenarios. It comprises the following tonnage:

Table 131. Projected public institution LPG tonnage by region by year

	TOTAL All Institutional demand (non commercial and commercial)					
	RWANDA	Kigali	Southern	Western	Northern	Eastern
2020	4 972 T	1 832	281	515	369	1 975
2021	7 352 T	1 825	809	1 037	1 015	2 666
2022	12 419 T	2 479	1 963	2 161	1 849	3 968
2023	22 302 T	3 661	4 254	4 373	3 489	6 524
2024	29 673 T	4 550	5 972	6 038	4 708	8 404
2025	30 467 T	4 746	6 117	6 200	4 823	8 581
2026	31 278 T	4 951	6 262	6 365	4 940	8 761
2027	32 111 T	5 166	6 409	6 533	5 060	8 944
2028	32 971 T	5 392	6 559	6 705	5 182	9 132
2029	33 850 T	5 629	6 711	6 881	5 307	9 323
2030	34 760 T	5 881	6 864	7 061	5 435	9 520

This regional repartition has been calculated considering the location of the institution (boarding school, police, prison, refugee camp, military barracks) when the location was known, and calculated on a pro-rata basis of the population when the location was not known (health facilities, nursery schools, primary schools, secondary schools).

Having insufficient data for the hotel-restaurant segment, locations were also calculated on a pro-rata basis of the population.

Table 132. Projected commercial institution LPG tonnage by region by year

	TOTAL HOTEL RESTAURANT (MT)					
	RWANDA	Kigali	Southern	Western	Northern	Eastern
2020	2 697 T	1 397	179	406	276	439
2021	2 915 T	1 510	193	439	299	474
2022	3 155 T	1 634	209	475	323	513
2023	3 407 T	1 765	226	513	349	554
2024	3 662 T	1 897	243	552	375	596
2025	3 937 T	2 040	261	593	403	640
2026	4 232 T	2 192	281	638	433	688
2027	4 546 T	2 354	302	685	466	739
2028	4 877 T	2 525	324	735	500	793
2029	5 229 T	2 707	347	788	536	851
2030	5 605 T	2 904	371	844	574	912

These two segments, public institutional and commercial institutional, will consume LPG in cylinders or bulk in small tanks depending on how much will be used in each institution each year. The consumption is assumed to prefer cylinders when the yearly consumption is less than 1,820 Kg (2x35Kg cylinders/week), and small domestic tanks above 1,820Kg/year.

Having no information on the reticulation (gas piping) among these institutions, the hypothesis is made that small institutions (< approx 200 persons) such as police will use cylinders, and large ones will use domestic bulk tanks. Commercial institutions having respectively an average yearly consumption of 6-12 tonnes will use preferably LPG bulk tanks. Therefore, a ratio of 15.5/84.5 cylinder versus bulk was assumed for the partition of these LPG tonnages.

Table 133. Projected institutional LPG tonnage in tanks vs. cylinders by region by year

Cylinder ratio	TOTAL All Institutional demand (non commercial and commercial)(MT)- CYLINDERS					
15,5%	**RWANDA**	Kigali	Southern	Western	Northern	Eastern
2020	771 T	284 T	44 T	80 T	57 T	306 T
2021	1 139 T	283 T	125 T	161 T	157 T	413 T
2022	1 925 T	384 T	304 T	335 T	287 T	615 T
2023	3 457 T	567 T	659 T	678 T	541 T	1 011 T
2024	4 599 T	705 T	926 T	936 T	730 T	1 303 T
2025	4 722 T	736 T	948 T	961 T	748 T	1 330 T
2026	4 849 T	768 T	971 T	987 T	766 T	1 358 T
2027	4 978 T	801 T	994 T	1 013 T	784 T	1 386 T
2028	5 111 T	836 T	1 017 T	1 039 T	803 T	1 415 T
2029	5 248 T	873 T	1 040 T	1 067 T	823 T	1 445 T
2030	5 388 T	911 T	1 064 T	1 094 T	842 T	1 476 T

Bulk ratio	TOTAL All Institutional demand (non commercial and commercial)(MT) - BULKS					
84,5%	**RWANDA**	Kigali	Southern	Western	Northern	Eastern
2020	3 680 T	1 356 T	208 T	381 T	273 T	1 462 T
2021	6 212 T	1 542 T	683 T	876 T	857 T	2 253 T
2022	10 494 T	2 094 T	1 658 T	1 826 T	1 562 T	3 353 T
2023	18 845 T	3 093 T	3 595 T	3 695 T	2 949 T	5 513 T
2024	25 073 T	3 845 T	5 047 T	5 102 T	3 978 T	7 102 T
2025	25 745 T	4 011 T	5 169 T	5 239 T	4 076 T	7 251 T
2026	26 433 T	4 184 T	5 292 T	5 379 T	4 175 T	7 403 T
2027	27 137 T	4 367 T	5 416 T	5 521 T	4 276 T	7 557 T
2028	27 864 T	4 557 T	5 543 T	5 667 T	4 380 T	7 716 T
2029	28 608 T	4 757 T	5 671 T	5 815 T	4 485 T	7 879 T
2030	29 373 T	4 969 T	5 800 T	5 967 T	4 592 T	8 044 T

This leads to an estimated bulk volume of approximately 3,000 T in 2020, growing to 28,000 T in 2030.

Industrial

Industrial bulk volumes are projected as follows, depending on the scenario as deteiled in Volume 2, Part XII.

Table 134. Projected industrial LPG tonnage by year

	NATIONAL INDUSTRIAL VOLUMES		
	2020	2024	2030
BAU	3 600 T/y	4 889 T/y	7 482 T/y
BAU +LI	3 600 T/y	7 251 T/y	12 794 T/y
BAU +HI	3 600 T/y	7 835 T/y	15 584 T/y
NST-1	3 600 T/y	10 293 T/y	17 364 T/y

Starting cylinder inventory

In all cases, for purposes of computations, cylinder sizes are normalized to a 12kg equivalent (12kg-eq) cylinder size. For example, two cylinders of 6kg are equivalent to one 12kg cylinder (one 12kg-eq); one cylinder of 35kg is equivalent to 2.90 cylinders of 12 Kg (2.90 12kg-eq).

Once cylinder inventories are calcualted on the basis of 12kg-eq, it is straightfoward to convert the 12kg-eq quantities into the equivalent quantities 6, 12, and 35kg cylinders (the recommended standard sizes under this Plan), using the prevailing market ratio.

Cylinder Rotation rate par year

To define the need of cylinders related to the annual consumption, the LPG industry defines a cylinder rotation rate, which is the average number of refillings of the cylinder in a year. This rate is referred to as the "cylinder rotation rate per year." It is, ideally, measured both regionally and per segment.

This rate is the $\frac{Annual\ LPG\ consumption\ of\ LPG\ in\ cylinders}{Number\ of\ existing\ cylinders\ in\ Marketers'\ assets}$

If one of these parameters is not available, an assumption must be used, based on rates seen in other East African and SSA markets at similar stages of market development. (The rate evolves over time based on stregthening BCRM, scale-based efficiencies in the distribution network, on increasing population density using LPG, and where applicable on increased per-user consumption over time. In Rwanda, the per-user consumption is not forecast to increase, so, therefore, it is the first three factors which will result in increases in the assumed rates for each region.

Having only the data on cylinder imports in Rwanda for the period 2015 to 2019 to work with, it was necessary to estimate the existing cylinder park entering the year 2015 by applying a theoretical turnover rate of 2.9 (corresponding to rotation rate values of comparable markets) to the LPG volume of 2014. It is important to note that the number of 2014 cylinders has a very small influence on the estimate of the 2024 and 2030 cylinders required. The volume of LPG in 2014 being 4,240 tons, the estimated cylinder inventory for the same year is 4,240,080 kg / (12 kg x 2.9) = about 122,000 cylinders of 12 Kg-eq.

Table 135. Historical LPG cylinder imports and rotation rates 2015-2019

Cylinder imports by size		**Year imported**						
Cylinder Size	2014	2015	2016	2017	2018	2019	**Total by size**	*%age*
3 Kg	(*)	378	5 126	4 263	-	400	**10 167**	*2,4*
6 Kg	(*)	2 007	11 689	28 956	33 409	69 752	**145 813**	*34,8*
9 Kg	(*)	-	-	20	-	1 597	**1 617**	*0,4*
12 Kg	(*)	17 748	15 495	35 069	25 504	71 077	**164 893**	*39,4*
13 Kg	(*)	-	-	1 178	-	-	**1 178**	*0,3*
13 Kg	(*)	-	19 911	8 929	28 142	3 679	**60 661**	*14,5*
15 Kg	(*)	-	-	-	23	-	**23**	*0,0*
20 Kg	(*)	3	2 714	10 363	6 199	800	**20 079**	*4,8*
25 Kg	(*)	718	937	2 881	2 331	936	**7 803**	*1,9*
35 Kg	(*)	200	100	550	1	-	**851**	*0,2*
38 Kg	(*)	226	50	779	702	1 056	**2 813**	*0,7*
45 Kg	(*)	-	-	1 200	100	1 290	**2 590**	*0,6*
50 Kg	(*)	19	1	-	35	30	**85**	*0,0*
50 Kg	(*)	28	-	-	-	4	**32**	*0,0*
Total by year		**21 327**	**56 023**	**94 188**	**96 446**	**150 621**	**418 605**	***100,0***
Percentage		*5,1*	*13,4*	*22,5*	*23,0*	*36,0*	***100,0***	

B12 Equ	no data	**21 842**	**51 121**	**93 373**	**90 659**	**122 843**	**379 837**
B12Equ (cumulative) (*)	*121 841*	143 683	194 804	288 177	378 836	501 678	**501 678**

Annual Tonnage (Kg) (**)	4 240 080 Kg	4 270 560 Kg	5 531 948 Kg	10 543 642 Kg	16 745 251 Kg	19 270 000 Kg	**<== Cylinders**
Cylinder Rotation rate (***)	2,90	2,48	2,37	3,05	3,68	3,20	**activity volume**

(*) : calculation of existing cylinders park by applying the 2015 toonage/average rotation rate of 2

(**) : Annual tonnage could includes some tonnage in LPG bulk activties

(***): rotation rate =annual tonnage year N/cylinders park N-1

Experiences of other comparable LPG markets demonstrate that the rotation rate in urban areas, where the availability of the product is higher and there is a higher density of retail points, is greater than in rural areas, where availability of cylinders is less and where the relative scarcity of LPG supply obliges some customers to own more than one cylinder as a back-up.

Accordingly, two rotation rates were assumed for the year 2020:

- **2.70 for the urban areas**
- **2.30 for the rural areas**

The increase in the rate to 2030, based on the factors mentioned above, is assumed to be 0.5 based on industry experiences from comparable markets.

Table 136. Cylinder rotation rate assumptions by region by year

	Cylinder rotation rate					
High interv	**Rwanda average**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	2.68	2.70	2.59	2.62	2.65	2.58
2021	2.73	2.75	2.67	2.69	2.72	2.66
2022	2.78	2.80	2.74	2.76	2.78	2.73
2023	2.84	2.85	2.80	2.82	2.83	2.80
2024	2.89	2.90	2.86	2.87	2.88	2.85
2025	2.93	2.95	2.91	2.92	2.93	2.90
2026	2.98	3.00	2.95	2.97	2.98	2.94
2027	3.02	3.05	2.99	3.01	3.03	2.98
2028	3.06	3.10	3.01	3.04	3.07	3.01
2029	3.09	3.15	3.04	3.07	3.11	3.03
2030	3.11	3.19	3.06	3.10	3.15	3.04

Storage and filling facilities locations

Table 48 in Volume 4 (page 251) sets forth the recommended locations and rationales for the siting of new filling plants and depots, based on an assessment of ease of transportation (road network) and optimal placement to minimize transport distances on average. For ease of reference, the locations are:

Province	District	Town/ Area
Kigali City	Gasabo	Kabuga/Rusororo
		Jabana
	Kicukiro	Gahanga
Northern	Musanze	Musanze
Southern	Muhanga	Muhanga
Eastern	Kayonza	Kayonza
Western	Rusizi	Kamembe

71. Infrastructure Details and Costing: BAU Case

The following tables restate and expand upon the regional volumes to be served and associated asset requirements (see Volume 4, Chapter 42 for details):

Table 137. Regional LPG volume projections by year, BAU

BAU	TOTAL VOLUMES CYLINDER + BULK					
	RWANDA	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	27,297 T	16,256 T	2,182 T	2,674 T	2,345 T	3,838 T
2021	33,551 T	18,152 T	3,119 T	3,723 T	3,524 T	5,033 T
2022	43,784 T	21,561 T	4,786 T	5,518 T	5,077 T	6,841 T
2023	59,520 T	25,568 T	7,723 T	8,576 T	7,621 T	10,032 T
2024	73,086 T	28,693 T	10,285 T	11,344 T	10,021 T	12,743 T
2025	81,935 T	31,106 T	11,669 T	13,135 T	11,886 T	14,139 T
2026	92,070 T	33,474 T	13,346 T	15,295 T	14,128 T	15,828 T
2027	103,482 T	35,747 T	15,331 T	17,831 T	16,741 T	17,832 T
2028	116,248 T	37,947 T	17,648 T	20,756 T	19,722 T	20,176 T
2029	130,381 T	40,088 T	20,302 T	24,068 T	23,052 T	22,871 T
2030	145,770 T	42,134 T	23,292 T	27,742 T	26,681 T	25,921 T

Table 138. Annual regional LPG cylinder inventory increases, BAU

BAU	Estimated number of 12kg-eq cylinders to be added annually					
	Rwanda	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	122,152 cyl	83,986 cyl	8,239 cyl	10,045 cyl	9,610 cyl	10,271 cyl
2021	92,563 cyl	44,643 cyl	9,877 cyl	12,876 cyl	15,059 cyl	10,108 cyl
2022	155,371 cyl	75,263 cyl	17,666 cyl	22,024 cyl	22,652 cyl	17,765 cyl
2023	191,929 cyl	76,956 cyl	26,112 cyl	31,250 cyl	30,901 cyl	26,711 cyl
2024	184,064 cyl	56,098 cyl	28,376 cyl	35,222 cyl	35,949 cyl	28,419 cyl
2025	200,954 cyl	50,581 cyl	31,563 cyl	42,147 cyl	45,865 cyl	30,798 cyl
2026	229,745 cyl	47,298 cyl	38,706 cyl	50,979 cyl	54,763 cyl	37,999 cyl
2027	257,369 cyl	42,927 cyl	46,085 cyl	59,709 cyl	63,106 cyl	45,541 cyl
2028	285,667 cyl	39,271 cyl	53,700 cyl	68,352 cyl	70,925 cyl	53,419 cyl
2029	313,187 cyl	36,195 cyl	61,218 cyl	76,555 cyl	77,935 cyl	61,283 cyl
2030	336,615 cyl	32,248 cyl	68,387 cyl	83,752 cyl	83,268 cyl	68,960 cyl
TOTAL	**2,369,615 cyl**	**585,467 cyl**	**389,930 cyl**	**492,911 cyl**	**510,033 cyl**	**391,275 cyl**

Table 139. Annual regional LPG cylinder inventory increases by cylinder size, BAU

	Estimated number of new cylinders/year																	
	Rwanda			Kigali city			Southern Province			Western Province			Northern Province			Eastern Province		
BAU	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg
2020	38,870	81,665	1,617	26,725	56,149	1,112	2,622	5,508	109	3,196	6,716	133	3,058	6,425	127	3,268	6,867	136
2021	29,454	61,883	1,225	14,206	29,846	591	3,143	6,603	131	4,097	8,608	170	4,792	10,067	199	3,217	6,758	134
2022	49,440	103,874	2,057	23,949	50,317	996	5,622	11,811	234	7,008	14,724	292	7,208	15,144	300	5,653	11,877	235
2023	61,073	128,315	2,541	24,488	51,449	1,019	8,309	17,457	346	9,944	20,892	414	9,833	20,659	409	8,500	17,857	354
2024	58,570	123,056	2,437	17,851	37,504	743	9,029	18,971	376	11,208	23,548	466	11,439	24,034	476	9,043	18,999	376
2025	63,945	134,349	2,660	16,095	33,816	670	10,044	21,102	418	13,411	28,177	558	14,595	30,663	607	9,800	20,590	408
2026	73,107	153,597	3,042	15,051	31,621	626	12,317	25,877	512	16,222	34,082	675	17,426	36,612	725	12,091	25,404	503
2027	81,897	172,065	3,407	13,660	28,699	568	14,665	30,810	610	19,000	39,919	790	20,081	42,189	835	14,492	30,447	603
2028	90,902	190,984	3,782	12,496	26,255	520	17,088	35,901	711	21,750	45,697	905	22,569	47,417	939	16,998	35,714	707
2029	99,658	209,382	4,146	11,518	24,199	479	19,480	40,927	810	24,360	51,181	1,014	24,800	52,104	1,032	19,501	40,971	811
2030	107,114	225,045	4,456	10,262	21,560	427	21,761	45,721	905	26,650	55,992	1,109	26,496	55,669	1,102	21,944	46,104	913
TOTAL	754,030	1,584,214	31,371	186,300	391,416	7,751	124,079	260,689	5,162	156,848	329,537	6,526	162,296	340,984	6,752	124,507	261,588	5,180

Table 140. Regional LPG filling plant quantities, capacities and scale counts, BAU

	ESTIMATED YEARLY FILLING CAPACITY					
BAU	**Rwanda**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	0 Filling Plant	Maintaining the existing filling plant capacity				
2021	0 Filling Plant	Maintaining the existing filling plant capacity				
2022	1 Filling Plant	1 Filling Plant	depot	depot	depot	depot
2023	1 Filling Plant	1 Filling Plant	depot	depot	depot	depot
2024	2 Filling Plant	1 Filling Plant	depot	depot	depot	1 Filling Plant
2025	3 Filling Plant	1 Filling Plant	depot	1 Filling Plant	depot	1 Filling Plant
2026	3 Filling Plant	1 Filling Plant	depot	1 Filling Plant	depot	1 Filling Plant
2027	3 Filling Plant	1 Filling Plant	depot	1 Filling Plant	depot	1 Filling Plant
2028	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2029	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2030	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant

	ESTIMATED YEARLY FILLING CAPACITY (MT)					
BAU	**Rwanda**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	20,016 T/y	Maintaining the existing filling plant capacity				
2021	23,447 T/y	Maintaining the existing filling plant capacity				
2022	29,079 T/y	29,079 T/y				
2023	36,127 T/y	36,127 T/y				
2024	43,124 T/y	33,499 T/y				9,625 T/y
2025	50,935 T/y	26,542 T/y		11,908 T/y		12,485 T/y
2026	59,986 T/y	28,693 T/y		15,294 T/y		15,999 T/y
2027	70,276 T/y	30,741 T/y		19,352 T/y		8,708 T/y
2028	81,873 T/y	32,703 T/y	10,542 T/y	13,569 T/y	14,280 T/y	10,778 T/y
2029	94,792 T/y	34,595 T/y	12,956 T/y	16,623 T/y	17,429 T/y	13,189 T/y
2030	108,916 T/y	36,377 T/y	15,698 T/y	20,028 T/y	20,869 T/y	15,945 T/y

	ESTIMATED YEARLY FILLING CAPACITY (FILLING SCALES)					
BAU	**Rwanda**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	20 scales	Maintaining the existing filling plant capacity				
2021	23 scales	Maintaining the existing filling plant capacity				
2022	29 scales	29 scales	depot	depot	depot	depot
2023	36 scales	36 scales	depot	depot	depot	depot
2024	43 scales	33 scales	depot	depot	depot	10 scales
2025	51 scales	27 scales	depot	12 scales	depot	12 scales
2026	60 scales	29 scales	depot	15 scales	depot	16 scales
2027	59 scales	31 scales	depot	19 scales	depot	9 scales
2028	82 scales	33 scales	11 scales	14 scales	14 scales	11 scales
2029	95 scales	35 scales	13 scales	17 scales	17 scales	13 scales
2030	109 scales	36 scales	16 scales	20 scales	21 scales	16 scales

Table 141. Governmental strategic storage capacity requirement by year, at 60 days, BAU prior to offsets from private sector logistical and operational storage

BAU	ESTIMATED GOVERNMENT STRATEGIC STORAGE (Tons)
2020	4 636 T
2021	5 592 T
2022	7 297 T
2023	9 920 T
2024	12 181 T
2025	13 656 T
2026	15 344 T
2027	17 246 T
2028	19 374 T
2029	21 729 T
2030	24 295 T

Table 142. Pivate sector strategic storatge offsets in volumes and months

		Estimated yearly stock MT		
		Low interv	High interv	NST1
2024	1/2 Cylinders	9 260 MT	10 210 MT	23 652 MT
	1/2 FP storage	770 MT	830 MT	1 605 MT
	1/2 Bulk trucks	637 MT	713 MT	1 753 MT
	TOTAL	**10 667 MT**	**11 753 MT**	**27 010 MT**
2030	1/2 Cylinders	23 032 MT	28 427 MT	34 912 MT
	1/2 FP storage	1 743 MT	2 080 MT	2 533 MT
	1/2 Bulk trucks	1 854 MT	2 285 MT	2 889 MT
	TOTAL	**26 629 MT**	**32 792 MT**	**40 334 MT**

	Estimated yearly stock in months		
	Low interv	High interv	NST1
2024	1.6 Months	1.6 Months	1.9 Months
2030	1.8 Months	1.8 Months	1.8 Months

	Estimated new strategic storage		
	Low interv	High interv	NST1
2024	9,400 MT	9,800 MT	14,700 MT
2030	18,700 MT	21,300 MT	25,500 MT

Table 143. Regional private sector operational and logistical storage capacities by year, BAU

	ESTIMATED THEORETICAL PRIVATE SECTOR OPERATION STORAGE					
BAU	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	1 605 Tons	1 605 Tons				
2021	1 936 Tons	1 936 Tons				
2022	2 526 Tons	2 526 Tons	depot	depot	depot	depot
2023	3 434 Tons	3 434 Tons	depot	depot	depot	depot
2024	4 216 Tons	2 903 Tons	depot	depot	depot	1 313 Tons
2025	4 727 Tons	1 795 Tons	depot	1 431 Tons	depot	1 501 Tons
2026	5 311 Tons	1 931 Tons	depot	1 652 Tons	depot	1 728 Tons
2027	5 970 Tons	2 062 Tons	depot	1 913 Tons	depot	1 995 Tons
2028	6 706 Tons	2 189 Tons	1 018 Tons	1 197 Tons	1 138 Tons	1 164 Tons
2029	7 522 Tons	2 313 Tons	1 171 Tons	1 388 Tons	1 330 Tons	1 319 Tons
2030	8 410 Tons	2 431 Tons	1 344 Tons	1 600 Tons	1 539 Tons	1 495 Tons

	ESTIMATED THEORETICAL LOGISTIC STORAGE CAPACITY FOR CYLINDER ACTIVITY					
BAU	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	385 Tons	385 Tons				
2021	451 Tons	451 Tons				
2022	559 Tons	559 Tons	depot	depot	depot	depot
2023	695 Tons	695 Tons	depot	depot	depot	depot
2024	829 Tons	644 Tons	depot	depot	depot	185 Tons
2025	980 Tons	510 Tons	depot	229 Tons	depot	240 Tons
2026	1 154 Tons	552 Tons	depot	294 Tons	depot	308 Tons
2027	1 351 Tons	591 Tons	depot	372 Tons	depot	388 Tons
2028	1 574 Tons	629 Tons	203 Tons	261 Tons	275 Tons	207 Tons
2029	1 823 Tons	665 Tons	249 Tons	320 Tons	335 Tons	254 Tons
2030	2 095 Tons	700 Tons	302 Tons	385 Tons	401 Tons	307 Tons

L=logistic S=Strategic	LOGISTIC STORAGE + PRIVATE SECTOR STRATEGIC STORAGE (MT)																					
	2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030	
BAU	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S
KIGALI					1 100		1 100	3 300	1 100	3 300	1 100	3 300	1 100	3 300	1 100	3 300	1 100	3 300	1 100	3 300	1 100	3 300
SOUTHERN																	450	1 350	450	1 350	450	1 350
WESTERN											650	1 950	650	1 950	650	1 950	650	1 950	650	1 950	650	1 950
NORTHERN																	550	1 550	550	1 550	550	1 550
EASTERN									650	1 900	650	1 900	650	1 900	650	1 900	650	1 900	650	1 900	650	1 900
TOTAL					1 100	0	1 100	3 300	1 750	5 200	2 400	7 150	2 400	7 150	2 400	7 150	3 400	10 050	3 400	10 050	3 400	10 050

Table 144. Transportation asset requirements by region and year, BAU

A) Bulk trucks

BAU	ESTIMATED NUMBER OF BULK PRIMARY TRANSPORT TRUCKS/Year					
	Rwanda	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	0 bulk trucks					
2021	0 bulk trucks					
2022	32 bulk trucks	32 bulk trucks				
2023	40 bulk trucks	40 bulk trucks				
2024	48 bulk trucks	37 bulk trucks			11 bulk trucks	
2025	57 bulk trucks	29 bulk trucks	13 bulk trucks		14 bulk trucks	
2026	67 bulk trucks	32 bulk trucks	17 bulk trucks		18 bulk trucks	
2027	78 bulk trucks	34 bulk trucks	22 bulk trucks		22 bulk trucks	
2028	91 bulk trucks	36 bulk trucks	12 bulk trucks	15 bulk trucks	16 bulk trucks	12 bulk trucks
2029	105 bulk trucks	38 bulk trucks	14 bulk trucks	18 bulk trucks	19 bulk trucks	15 bulk trucks
2030	121 bulk trucks	40 bulk trucks	17 bulk trucks	22 bulk trucks	23 bulk trucks	18 bulk trucks

B) Cylinder trucks

BAU	ESTIMATED NUMBER OF CYLINDER PRIMARY TRANSPORT TRUCKS/Year					
	Rwanda	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	0 cyl trucks	Maintaining the existing filling plant capacity				
2021	0 cyl trucks	Maintaining the existing filling plant capacity				
2022	4 cyl trucks		1,1 cyl trucks	1,0 cyl trucks	0,9 cyl trucks	0,8 cyl trucks
2023	5 cyl trucks		1,5 cyl trucks	1,4 cyl trucks	1,3 cyl trucks	1,1 cyl trucks
2024	8 cyl trucks		2,0 cyl trucks	2,6 cyl trucks	3,5 cyl trucks	
2025	8 cyl trucks		3,5 cyl trucks		4,6 cyl trucks	
2026	10 cyl trucks		4,5 cyl trucks		6,0 cyl trucks	
2027	13 cyl trucks		5,6 cyl trucks		7,7 cyl trucks	
2028						
2029						
2030						

C) Bulk institutional volumes

Bulk ratio	TOTAL All Institutional demand (non commercial and commercial)(MT) - BULKS					
84,5%	RWANDA	Kigali	Southern	Western	Northern	Eastern
2020	4 201 T	1 548 T	238 T	435 T	312 T	1 669 T
2021	6 212 T	1 542 T	683 T	876 T	857 T	2 253 T
2022	10 494 T	2 094 T	1 658 T	1 826 T	1 562 T	3 353 T
2023	18 845 T	3 093 T	3 595 T	3 695 T	2 949 T	5 513 T
2024	25 073 T	3 845 T	5 047 T	5 102 T	3 978 T	7 102 T
2025	25 745 T	4 011 T	5 169 T	5 239 T	4 076 T	7 251 T
2026	26 430 T	4 183 T	5 291 T	5 378 T	4 175 T	7 403 T
2027	27 134 T	4 365 T	5 415 T	5 520 T	4 275 T	7 557 T
2028	27 860 T	4 557 T	5 542 T	5 666 T	4 379 T	7 716 T
2029	28 604 T	4 756 T	5 670 T	5 814 T	4 484 T	7 878 T
2030	29 373 T	4 969 T	5 800 T	5 967 T	4 592 T	8 044 T

D) Bulk industrial volumes

	BULK INDUSTRIAL (MT)					
BAU	RWANDA	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2020	3 600 T	379 T	864 T	841 T	587 T	930 T
2021	3 892 T	410 T	933 T	909 T	634 T	1 005 T
2022	4 211 T	444 T	1 010 T	983 T	686 T	1 087 T
2023	4 548 T	479 T	1 091 T	1 062 T	741 T	1 174 T
2024	4 889 T	515 T	1 173 T	1 142 T	797 T	1 262 T
2025	5 255 T	554 T	1 261 T	1 227 T	857 T	1 357 T
2026	5 649 T	595 T	1 355 T	1 319 T	921 T	1 459 T
2027	6 067 T	639 T	1 455 T	1 417 T	989 T	1 567 T
2028	6 510 T	686 T	1 562 T	1 521 T	1 061 T	1 681 T
2029	6 979 T	735 T	1 674 T	1 630 T	1 138 T	1 802 T
2030	7 482 T	788 T	1 795 T	1 747 T	1 220 T	1 932 T

E) Total bulk volumes

Bulk ratio	TOTAL ALL Institutional (non commercial and commercial)+INDUSTRIAL (MT) - BULKS					
84,5%	RWANDA	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2020	7 801 T	1 927 T	1 101 T	1 276 T	899 T	2 598 T
2021	10 104 T	1 952 T	1 617 T	1 785 T	1 492 T	3 257 T
2022	14 705 T	2 538 T	2 668 T	2 809 T	2 249 T	4 440 T
2023	23 393 T	3 572 T	4 686 T	4 758 T	3 690 T	6 687 T
2024	29 962 T	4 360 T	6 219 T	6 244 T	4 775 T	8 364 T
2025	31 000 T	4 564 T	6 429 T	6 467 T	4 932 T	8 608 T
2026	32 079 T	4 779 T	6 647 T	6 698 T	5 095 T	8 861 T
2027	33 201 T	5 005 T	6 871 T	6 937 T	5 264 T	9 124 T
2028	34 371 T	5 243 T	7 104 T	7 186 T	5 440 T	9 397 T
2029	35 583 T	5 492 T	7 345 T	7 444 T	5 622 T	9 680 T
2030	36 854 T	5 757 T	7 595 T	7 714 T	5 812 T	9 976 T

Table 145. Summary investment requirements by asset category, region and year, BAU

COSTS ESTIMATION- INVESTMENT- BAU		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	TOTAL
CYLINDERS	**NATIONAL**	**0 $**	**1 707 260 $**	**2 865 719 $**	**3 540 022 $**	**3 394 944 $**	**3 706 481 $**	**4 237 509 $**	**4 747 009 $**	**5 268 962 $**	**5 776 542 $**	**6 208 667 $**	**41 453 116 $**
FILLING PLANTS	**KIGALI**	0 $		9 777 900 $	61 600 $	0 $							9 839 500 $
	SOUTHERN									8 393 000 $	21 000 $	23 100 $	8 437 100 $
	WESTERN							8 790 100 $	14 000 $	28 000 $			8 832 100 $
	NORTHERN									0 $	8 597 600 $	49 000 $	8 646 600 $
	EASTERN						8 591 000 $		30 800 $				8 621 800 $
	TOTAL	**0 $**		**9 777 900 $**	**61 600 $**	**0 $**	**8 591 000 $**	**8 790 100 $**	**44 800 $**	**8 421 000 $**	**8 618 600 $**	**72 100 $**	**44 377 100 $**
PALETTIZATION	**Palettization in Filling plant**	0 $	0 $	1 454 000 $	0 $	895 000 $	895 000 $	0 $	0 $	1 831 000 $	0 $	26 000 $	5 101 000 $
	Palets in the logistic network	0 $	0 $	103 792 $	129 896 $	128 947 $	143 946 $	166 807 $	189 649 $	213 715 $	238 096 $	260 298 $	1 575 147 $
	TOTAL	**0 $**	**0 $**	**1 557 792 $**	**129 896 $**	**1 023 947 $**	**1 038 946 $**	**166 807 $**	**189 649 $**	**2 044 715 $**	**238 096 $**	**286 298 $**	**6 676 147 $**
STRATEGIC STORAGE	**PRIVATE SECTOR**	0 $	0 $	0 $	4 950 000 $	2 850 000 $	2 925 000 $	0 $	0 $	4 350 000 $	0 $	0 $	**15 075 000 $**
BULK PRIMARY TRANSPORT	**NATIONAL**	**0 $**	**0 $**	**1 403 273 $**	**1 756 197 $**	**1 743 361 $**	**1 946 147 $**	**2 255 227 $**	**2 564 060 $**	**2 889 427 $**	**3 219 059 $**	**3 519 231 $**	**21 295 981 $**
CYLINDER PRIMARY TRANSPORT	**NATIONAL**	**0 $**	**0 $**	**680 800 $**	**340 400 $**	**510 600 $**	**0 $**	**340 400 $**	**0 $**	**0 $**	**0 $**	**0 $**	**1 872 200 $**
CAGES	**NATIONAL**	**0 $**	**0 $**	**110 321 $**	**128 841 $**	**142 111 $**	**186 432 $**	**216 486 $**	**242 139 $**	**264 181 $**	**282 266 $**	**296 072 $**	**1 868 848 $**
													132 618 392 $
NATIONAL STRATEGIC STORAGE				**$ 22 742 000**		**$ 9 828 000**						**$ 27 520 000**	**60 090 000 $**
TOTAL			1 707 260 $	39 137 806 $	10 906 957 $	19 492 963 $	18 394 005 $	16 006 529 $	7 787 658 $	23 238 284 $	18 134 562 $	37 902 369 $	**192 708 392 $**
													117 543 392 $
OPTION2 : STRATEGIC STORAGE				**22 742 000 $**		**15 881 000 $**						**3 865 000 $**	**42 488 000 $**
OPTION 2 GRAND TOTAL			**1 707 260 $**	**39 137 806 $**	**5 956 957 $**	**22 695 963 $**	**15 469 005 $**	**16 006 529 $**	**7 787 658 $**	**18 888 284 $**	**18 134 562 $**	**14 247 369 $**	**160 031 392 $**

Table 146. Cylinder investment requirements by size, region and year, BAU

		Estimated cylinder costs by size, region and year											
		2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**TOTAL**
Rwanda	6 Kg	0 $	385,849 $	647,666 $	800,062 $	767,273 $	837,682 $	957,697 $	1,072,847 $	1,190,810 $	1,305,526 $	1,403,188 $	9,368,600 $
	12 Kg	0 $	1,261,794 $	2,117,982 $	2,616,343 $	2,509,119 $	2,739,368 $	3,131,838 $	3,508,397 $	3,894,159 $	4,269,299 $	4,588,672 $	30,636,972 $
	35 Kg	0 $	59,618 $	100,071 $	123,618 $	118,552 $	129,430 $	147,974 $	165,766 $	183,992 $	201,717 $	216,807 $	1,447,544 $
Kigali City	6 Kg	0 $	186,094 $	313,737 $	320,791 $	233,845 $	210,848 $	197,163 $	178,942 $	163,702 $	150,881 $	134,429 $	2,090,431 $
	12 Kg	0 $	608,561 $	1,025,974 $	1,049,043 $	764,713 $	689,511 $	644,756 $	585,172 $	535,334 $	493,408 $	439,605 $	6,836,077 $
	35 Kg	0 $	28,753 $	48,475 $	49,565 $	36,131 $	32,578 $	30,464 $	27,648 $	25,294 $	23,313 $	20,771 $	322,993 $
Southern Province	6 Kg	0 $	41,171 $	73,642 $	108,849 $	118,286 $	131,573 $	161,348 $	192,107 $	223,851 $	255,187 $	285,074 $	1,591,087 $
	12 Kg	0 $	134,637 $	240,823 $	355,956 $	386,815 $	430,266 $	527,637 $	628,224 $	732,031 $	834,506 $	932,242 $	5,203,135 $
	35 Kg	0 $	6,361 $	11,378 $	16,818 $	18,276 $	20,329 $	24,930 $	29,682 $	34,587 $	39,429 $	44,047 $	245,839 $
Western Province	6 Kg	0 $	53,675 $	91,807 $	130,268 $	146,823 $	175,689 $	212,506 $	248,900 $	284,926 $	319,121 $	349,120 $	2,012,837 $
	12 Kg	0 $	175,527 $	300,226 $	425,998 $	480,138 $	574,535 $	694,933 $	813,947 $	931,759 $	1,043,583 $	1,141,684 $	6,582,331 $
	35 Kg	0 $	8,293 $	14,185 $	20,128 $	22,686 $	27,146 $	32,834 $	38,458 $	44,024 $	49,307 $	53,943 $	311,004 $
Northern Province	6 Kg	0 $	62,772 $	94,427 $	128,810 $	149,856 $	191,189 $	228,282 $	263,057 $	295,652 $	324,876 $	347,103 $	2,086,024 $
	12 Kg	0 $	205,275 $	308,793 $	421,232 $	490,055 $	625,223 $	746,522 $	860,243 $	966,834 $	1,062,400 $	1,135,087 $	6,821,664 $
	35 Kg	0 $	9,699 $	14,590 $	19,903 $	23,154 $	29,541 $	35,272 $	40,645 $	45,681 $	50,197 $	53,631 $	322,312 $
Eastern Province	6 Kg	0 $	42,136 $	74,053 $	111,344 $	118,464 $	128,382 $	158,398 $	189,841 $	222,680 $	255,461 $	287,463 $	1,588,222 $
	12 Kg	0 $	137,794 $	242,166 $	364,113 $	387,398 $	419,833 $	517,990 $	620,812 $	728,201 $	835,403 $	940,055 $	5,193,764 $
	35 Kg	0 $	6,511 $	11,442 $	17,204 $	18,304 $	19,836 $	24,474 $	29,332 $	34,406 $	39,471 $	44,416 $	245,396 $
GRAND TOTAL		**0 $**	**1,707,260 $**	**2,865,719 $**	**3,540,022 $**	**3,394,944 $**	**3,706,481 $**	**4,237,509 $**	**4,747,009 $**	**5,268,962 $**	**5,776,542 $**	**6,208,667 $**	**41,453,116 $**

Table 147. Filling plant investment requirements by region and year, BAU

KIGALI (MAX CAPACITY 40KT/Y) - BAU		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE		Maintaining	Maintainin	29079 T/y	36127 T/y	33499 T/y	26542 T/y	28693 T/y	30741 T/y	32703 T/y	34595 T/y	36377 T/y
LOGISTIQUE STORAGE		535 Tons	645 Tons	842 Tons	1 145 Tons	968 Tons	598 Tons	644 Tons	687 Tons	730 Tons	771 Tons	810 Tons
Total Nber of filling scales	taining the	existing fillir	existing filli	29 scales	36 scales	33 scales	27 scales	29 scales	31 scales	33 scales	35 scales	36 scales
12 Kg line carousel 24 stages - 12 scales	scales			18 scales	24 scales	24 scales	24 scales	24 scales	24 scales	24 scales	24 scales	24 scales
6 Kg line carousel 12 stages - 8 scales	scales			10 scales	12 scales	12 scales	12 scales	12 scales	12 scales	12 scales	12 scales	12 scales
35kg line 2 scales	scales			2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Real storage				1 100 Tons								
KIGALI FILLING PLANT COST	**ITEMS**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
1°) SITTING AND PREPARATION				665 K$								
2°) ROAD, SEWERAGE AND NETWORKS				1467 K$								
3°) CIVIL WORKS				183 K$								
4°) BUILDINGS				504 K$								
5°) LOGISTIC STORAGE				2029 K$								
6°) LOCKSMITHING (SERRURERIE)				59 K$								
7°) VALVES for piping				401 K$								
8°) PIPING				767 K$								
9°) ELECTRICITY				713 K$								
10°) EQUIPMENTS				0 K$								
10-1°) GAS EQUIPMENT				148 K$								
10-2°) FIRE FIGHTING EQUIPMENT				623 K$								
10-3°) COMPRESSED AIR EQUIPMENT				80 K$								
10-4°) FILLING HALL				1250 K$	56 K$							12 K$
TOTAL WITHOUT ENGINEERING AND & VARIOUS AND FORESSEEN				8889 K$	56 K$	0 K$						
11°) ENGINEERING				444 K$	3 K$	0 K$						
12°) VARIOUS AND FORESSEEN				444 K$	3 K$	0 K$						
SOUS TOTAL WITHOUT PALETTIZATION				**9778 K$**	**62 K$**	**0 K$**	**0 K$**	**0 K$**	**0 K$**	**0 K$**	**0 K$**	**0 K$**
13° PALETTIZATION including FP Palets and truck trasformation				**1454 K$**								26 K$
GRAND TOTAL				**11 232 K$**	**62 K$**	**0 K$**	**0 K$**	**0 K$**	**0 K$**	**0 K$**	**0 K$**	**26 K$**

OUTHERN PROVINCE (MAX CAPACITY 20KT/Y) BAU		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE										10542 T/y	12956 T/y	15698 T/y
STORAGE CAPACITY										339 Tons	390 Tons	448 Tons
Total Nber of filling scales										11 scales	13 scales	16 scales
12 Kg line carrousel 12 stages-12 scales	scales									6 scales	9 scales	10 scales
6 Kg : 4 scales in line	scales									4 scales	4 scales	5 scales
35kg line 1 scale	scales									1 scales	1 scales	1 scales
Maintenance: retesting, painting, cold repair										Yes	Yes	Yes

Real storage 450 Tons

SOUTHERN PROVINCE FILLING PLANT COSTS- USD		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1°) SITTING AND PREPARATION										665 K$		
2°) ROAD, SEWERAGE AND NETWORKS										1 467 K$		
3°) CIVIL WORKS										183 K$		
4°) BUILDINGS										504 K$		
5°) LOGISTIC STORAGE										928 K$		
6°) LOCKSMITHING (SERRURERIE)										59 K$		
7°) VALVES for piping										401 K$		
8°) PIPING										767 K$		
9°) ELECTRICITY										713 K$		
10°) EQUIPMENTS												
10-1°) GAS EQUIPMENT										148 K$		
10-2°) FIRE FIGHTING EQUIPMENT										623 K$		
10-3°) COMPRESSED AIR EQUIPMENT										80 K$		
10-4°) FILLING HALL										1 092 K$	21 K$	21 K$
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN										7 630 K$	21 K$	21 K$
11°) ENGINEERING										382 K$		1 K$
12°) VARIOUS AND FORESSEEN										382 K$		1 K$
SOUS TOTAL WITHOUT PALETTIZATION										**8393 K$**	**21 K$**	**23 K$**
13° PALETTIZATION including Palets and truck trasformation										**936 K$**		
GRAND TOTAL										**9 329 K$**	**21 K$**	**23 K$**

NORTHERN PROVINCE (MAX CAPACITY 30KT/Y) BA		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE									14895 T/y	18844 T/y	23285 T/y	28134 T/y
LOGISTIQUE STORAGE									399 Tons	480 Tons	571 Tons	669 Tons
Total Nber of filling scales									15 scales	19 scales	23 scales	28 scales
12 Kg line carrousel 24 stages-12 scales	scales								10 scales	12 scales	15 scales	19 scales
6 Kg line carousel 12 stages - 8 scales	scales								4 scales	6 scales	8 scales	8 scales
35kg line 2 scales	scales								1 scales	1 scales	1 scales	2 scales
Maintenance: retesting, painting, cold repair									Yes	Yes	Yes	Yes
									500 Tons		200 Tons	

NORTHERN PROVINCE FILLING PLANT COSTS-USD		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1°) SITTING AND PREPARATION									665 K$			
2°) ROAD, SEWERAGE AND NETWORKS									1467 K$			
3°) CIVIL WORKS									183 K$			
4°) BUILDINGS									504 K$			
5°) STOCKAGE									1027 K$		350 K$	
6°) LOCKSMITHING (SERRURERIE)									59 K$			
7°) VALVES for piping									401 K$			
8°) PIPING									767 K$			
9°) ELECTRICITY									713 K$			
10°) EQUIPMENTS									0 K$			
10-1°) GAS EQUIPMENT									148 K$			
10-2°) FIRE FIGHTING EQUIPMENT									623 K$			
10-3°) COMPRESSED AIR EQUIPMENT									80 K$			
10-4°) FILLING HALL									1233 K$	28 K$	35 K$	35 K$
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN									7870 K$	28 K$	385 K$	35 K$
11°) ENGINEERING									394 K$		19 K$	
12°) VARIOUS AND FORESSEEN									394 K$		19 K$	
SOUS TOTAL WITHOUT PALETTIZATION									**8657 K$**	**28 K$**	**424 K$**	**35 K$**
13° PALETTIZATION including Palets and truck trasformation									895 K$			
GRAND TOTAL									**9 552 K$**	**28 K$**	**424 K$**	**35 K$**

NORTHERN PROVINCE (MAX CAPACITY 30KT/Y) BAU		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE										14280 T/y	17429 T/y	20869 T/y
STORAGE CAPACITY										379 Tons	443 Tons	513 Tons
Total Nber of filling scales										14 scales	17 scales	21 scales
12 Kg line carrousel 12 stages-8 scales	scales									8 scales	10 scales	12 scales
6 Kg line carousel 8 stages - 5 scales	scales									6 scales	6 scales	8 scales
35kg line 1 scale	scales									1 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair										Yes	Yes	Yes
Real storage										550 Tons		

NORTHERN PROVINCE FILLING PLANT COSTS-USD		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1°) SITTING AND PREPARATION										665 K$		
2°) ROAD, SEWERAGE AND NETWORKS										1 467 K$		
3°) CIVIL WORKS										183 K$		
4°) BUILDINGS										504 K$		
5°) LOGISTIC STORAGE										1 114 K$		
6°) LOCKSMITHING (SERRURERIE)										59 K$		
7°) VALVES for piping										401 K$		
8°) PIPING										767 K$		
9°) ELECTRICITY										713 K$		
10°) EQUIPMENTS												
10-1°) GAS EQUIPMENT										148 K$		
10-2°) FIRE FIGHTING EQUIPMENT										623 K$		
10-3°) COMPRESSED AIR EQUIPMENT										80 K$	28 K$	
10-4°) FILLING HALL										1 092 K$	21 K$	28 K$
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN										7816 K$	49 K$	28 K$
11°) ENGINEERING										391 K$		
12°) VARIOUS AND FORESSEEN										391 K$		
SOUS TOTAL WITHOUT PALETTIZATION										**8598 K$**	**49 K$**	**28 K$**
13° PALETTIZATION including Palets and truck trasformation										**895 K$**		
GRAND TOTAL										**9 493 K$**	**49 K$**	**28 K$**

EASTERN PROVINCE (MAX CAPACITY 20KT/Y) BAU		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE						9625 T/y	12485 T/y	15999 T/y	8708 T/y	10778 T/y	13189 T/y	15945 T/y
STORAGE CAPACITY						438 Tons	500 Tons	576 Tons	665 Tons	388 Tons	440 Tons	498 Tons
Total Nber of filling scales						10 scales	12 scales	16 scales	9 scales	11 scales	13 scales	13 scales
12 Kg line carrousel 12 stages-6 scales	scales					6 scales	7 scales	10 scales	9 scales	9 scales	9 scales	9 scales
6 Kg 4 scales in line	scales					4 scales	4 scales	4 scales	4 scales	4 scales	4 scales	4 scales
35kg line 1 scale	scales					1 scales	1 scales	2 scales	2 scales	2 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair						Yes	Yes	Yes	Yes	Yes	Yes	Yes
Real storage						650 Tons						

EASTERN PROVINCE FILLING PLANT COSTS- USD		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1°) SITTING AND PREPARATION						665 K$						
2°) ROAD, SEWERAGE AND NETWORKS						1 467 K$						
3°) CIVIL WORKS						183 K$						
4°) BUILDINGS						504 K$						
5°) LOGISTIC STORAGE						1 289 K$						
6°) LOCKSMITHING (SERRURERIE)						59 K$						
7°) VALVES for piping						401 K$						
8°) PIPING						767 K$						
9°) ELECTRICITY						713 K$						
10°) EQUIPMENTS												
10-1°) GAS EQUIPMENT						148 K$						
10-2°) FIRE FIGHTING EQUIPMENT						623 K$						
10-3°) COMPRESSED AIR EQUIPMENT						80 K$						
10-4°) FILLING HALL						911 K$	14 K$	28 K$				
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN						7810 K$	14 K$	28 K$	0 K$	0 K$	0 K$	0 K€
11°) ENGINEERING						391 K$		1 K$	0 K$			0 K€
12°) VARIOUS AND FORESSEEN						391 K$		1 K$	0 K$			0 K€
SOUS TOTAL WITHOUT PALETTIZATION						**8591 K$**	**14 K$**	**31 K$**	**0 K$**	**0 K$**	**0 K$**	**0 K$**
13° PALETTIZATION including Palets and truck trasformation						**895 K$**						
GRAND TOTAL						**9 486 K$**	**14 K$**	**31 K$**	**0 K$**	**0 K$**	**0 K$**	**0 K$**

Table 148. Pallet and cage investment requirements by region and year, BAU

BAU	ESTIMATED NUMBER OF PALLETS/YEAR										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Numbers of Pallets		1,074 palets	258 palets	323 palets	320 palets	358 palets	414 palets	471 palets	531 palets	592 palets	647 palets
Cost			**$ 103,792**	**$ 129,896**	**$ 128,947**	**$ 143,946**	**$ 166,807**	**$ 189,649**	**$ 213,715**	**$ 238,096**	**$ 260,298**
										TOTAL	**$ 1,575,147**

BAU	ESTIMATED NUMBER OF PALLETS/YEAR										
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Numbers of cages	1,235	291	345	403	444	583	677	757	826	882	925
Cost			$ 110,321	$ 128,841	$ 142,111	$ 186,432	$ 216,486	$ 242,139	$ 264,181	$ 282,266	$ 296,072
										TOTAL	**$ 1,868,848**

Table 149. Transport investment requirements by truck type, region and year, BAU

	ESTIMATED BULK PRIMARY TRANSPORT COST										
	2 020	2 021	2 022	2 023	2 024	2 025	2 026	2 027	2 028	2 029	2 030
Number of trucks (Tractor + bulk tank	21 trucks	4 trucks	6 trucks	8 trucks	8 trucks	9 trucks	10 trucks	11 trucks	13 trucks	14 trucks	16 trucks
Cost	**$ -**	**$ -**	**$ 1 403 273**	**$ 1 756 197**	**$ 1 743 361**	**$ 1 946 147**	**$ 2 255 227**	**$ 2 564 060**	**$ 2 889 427**	**$ 3 219 059**	**$ 3 519 231**
										TOTAL	**$ 21 295 981**

BAU	ESTIMATED CYLINDER PRIMARY TRANSPORT TRUCKS COST/year										
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
ESTIMATED NUMBER OF CYLINDER PRIMARY TRANSPORT TRUCKS/Year	0 trucks	0 trucks	4 trucks	2 trucks	3 trucks	0 trucks	2 trucks				
ESTIMATED CYLINDER PRIMARY TRANSPORT TRUCKS COST/year	$ -	$ -	$ 680 800	$ 340 400	$ 510 600	$ -	$ 340 400				
										TOTAL	**$ 1 872 200**

72. Infrastructure Details and Costing: Low Intervention Scenario

The following tables restate and expand upon the regional volumes to be served and associated asset requirements (see Volume 4, Chapter 42 for details):

Table 150. Regional LPG volume projections by year, Low case

BAU-LI	TOTAL VOLUMES CYLINDER + BULK PER YEAR					
	RWANDA	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	27,296 T	16,256 T	2,182 T	2,674 T	2,345 T	3,838 T
2021	34,514 T	18,515 T	3,259 T	3,887 T	3,678 T	5,176 T
2022	46,271 T	22,370 T	5,177 T	5,976 T	5,509 T	7,240 T
2023	64,174 T	26,884 T	8,500 T	9,485 T	8,478 T	10,827 T
2024	80,086 T	30,465 T	11,487 T	12,773 T	11,395 T	13,966 T
2025	91,699 T	33,280 T	13,382 T	15,220 T	13,948 T	15,869 T
2026	105,302 T	36,012 T	15,741 T	18,239 T	17,071 T	18,239 T
2027	120,963 T	38,622 T	18,610 T	21,849 T	20,746 T	21,135 T
2028	138,885 T	41,131 T	22,061 T	26,093 T	24,956 T	24,643 T
2029	158,927 T	43,226 T	26,170 T	31,005 T	29,673 T	28,852 T
2030	181,254 T	44,991 T	31,004 T	36,594 T	34,812 T	33,854 T

Table 151. Annual regional LPG cylinder inventory increases, Low case

	Estimated number of 12kg-eq cylinders to be added annually					
Low interv	**Rwanda**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	122,152 cyl	65,025 cyl	8,516 cyl	15,720 cyl	13,222 cyl	19,669 cyl
2021	112,411 cyl	54,677 cyl	11,861 cyl	15,652 cyl	18,224 cyl	11,998 cyl
2022	183,791 cyl	86,591 cyl	21,123 cyl	26,854 cyl	28,149 cyl	21,075 cyl
2023	229,449 cyl	88,809 cyl	31,328 cyl	38,492 cyl	39,093 cyl	31,727 cyl
2024	231,546 cyl	66,656 cyl	35,976 cyl	45,603 cyl	47,525 cyl	35,784 cyl
2025	267,394 cyl	60,124 cyl	43,477 cyl	58,073 cyl	63,276 cyl	42,444 cyl
2026	312,853 cyl	55,383 cyl	54,841 cyl	71,840 cyl	76,820 cyl	53,969 cyl
2027	359,014 cyl	49,797 cyl	67,250 cyl	85,809 cyl	89,320 cyl	66,838 cyl
2028	409,319 cyl	45,110 cyl	81,255 cyl	100,391 cyl	100,883 cyl	81,679 cyl
2029	454,810 cyl	32,327 cyl	97,003 cyl	115,553 cyl	111,228 cyl	98,699 cyl
2030	503,907 cyl	22,296 cyl	114,251 cyl	130,526 cyl	119,045 cyl	117,789 cyl
TOTAL	**3,186,646 cyl**	**626,795 cyl**	**566,882 cyl**	**704,513 cyl**	**706,784 cyl**	**581,671 cyl**

Table 152. Annual regional LPG cylinder inventory increases by cylinder size, Low case

	Estimated number of new cylinders/year																	
	Rwanda			Kigali City			Southern Province			Western Province			Northern Province			Eastern Province		
Low interv	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg
2019																		
2020	38,870	81,665	1,617	20,692	43,473	861	2,710	5,693	113	5,002	10,510	208	4,207	8,839	175	6,259	13,150	260
2021	35,770	75,153	1,488	17,399	36,555	724	3,774	7,929	157	4,981	10,464	207	5,799	12,183	241	3,818	8,021	159
2022	58,484	122,874	2,433	27,554	57,890	1,146	6,722	14,122	280	8,545	17,953	356	8,957	18,819	373	6,706	14,090	279
2023	73,012	153,399	3,038	28,260	59,374	1,176	9,969	20,944	415	12,248	25,734	510	12,440	26,136	518	10,096	21,211	420
2024	73,680	154,801	3,065	21,211	44,563	882	11,448	24,052	476	14,511	30,488	604	15,123	31,773	629	11,387	23,924	474
2025	85,087	178,767	3,540	19,132	40,196	796	13,835	29,066	576	18,479	38,825	769	20,135	42,303	838	13,506	28,376	562
2026	99,552	209,159	4,142	17,623	37,026	733	17,451	36,664	726	22,860	48,029	951	24,445	51,358	1,017	17,173	36,081	714
2027	114,241	240,020	4,753	15,846	33,292	659	21,399	44,960	890	27,305	57,368	1,136	28,422	59,715	1,183	21,268	44,685	885
2028	130,248	273,652	5,419	14,354	30,158	597	25,856	54,324	1,076	31,945	67,117	1,329	32,102	67,446	1,336	25,991	54,607	1,081
2029	144,724	304,065	6,021	10,287	21,612	428	30,867	64,852	1,284	36,770	77,253	1,530	35,394	74,362	1,473	31,407	65,986	1,307
2030	160,347	336,889	6,671	7,095	14,906	295	36,356	76,383	1,513	41,534	87,263	1,728	37,881	79,588	1,576	37,481	78,748	1,559
TOTAL	1,014,015	2,130,442	42,188	199,451	419,046	8,298	180,386	378,991	7,505	224,182	471,005	9,327	224,904	472,523	9,357	185,092	388,878	7,701

Table 153. Regional LPG filling plant quantities, capacities and scale counts, Low case

Low interv	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	0 Filling Plant	Maintaining the mini- filling plant activity				
2021	0 Filling Plant	Maintaining the mini- filling plant activity				
2022	1 Filling Plant	1 Filling Plant	Maintaining the mini- filling plant activity			
2023	1 Filling Plant	1 Filling Plant	Maintaining the mini- filling plant activity			
2024	3 Filling Plant	1 FP 2 shift	depot	1 Filling Plant	depot	1 Filling Plant
2025	3 Filling Plant	1 FP 2 shift	depot	1 Filling Plant	depot	1 Filling Plant
2026	3 Filling Plant	1 FP 2 shift	depot	1 Filling Plant	depot	1 Filling Plant
2027	4 Filling Plant	1 FP 2 shift	depot	1 Filling Plant	1 Filling Plant	1 Filling Plant
2028	5 Filling Plant	1 FP 2 shift	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2029	5 Filling Plant	1 FP 2 shift	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2030	5 Filling Plant	1 FP 2 shift	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant

	ESTIMATED YEARLY FILLING CAPACITY (MT)					
Low interv	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	20016 T/y			20016 T/y		
2021	24104 T/y			24104 T/y		
2022	30704 T/y	19741 T/y			10963 T/y	
2023	108121 T/y	23131 T/y			15936 T/y	
2024	58440 T/y	36535 T/y		10679 T/y		11227 T/y
2025	57981 T/y	28429 T/y		14420 T/y		15132 T/y
2026	70090 T/y	30903 T/y		19152 T/y		20035 T/y
2027	84162 T/y	33237 T/y		24947 T/y	14895 T/y	11083 T/y
2028	100393 T/y	35454 T/y	13969 T/y	17944 T/y	18844 T/y	14182 T/y
2029	118646 T/y	37239 T/y	17699 T/y	22464 T/y	23285 T/y	17959 T/y
2030	139087 T/y	38674 T/y	22135 T/y	27639 T/y	28134 T/y	22506 T/y

	ESTIMATED YEARLY FILLING CAPACITY (FILLING SCALES)					
Low interv	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	20 Filling scales	20 Filling scales				
2021	24 Filling scales	24 Filling scales				
2022	31 Filling scales	20 Filling scales	11 Filling Plant			
2023	39 Filling scales	23 Filling scales	16 Filling Plant			
2024	58 Filling scales	37 Filling scales	depot	11 Filling scales	depot	11 Filling scales
2025	58 Filling scales	28 Filling scales	depot	14 Filling scales	depot	15 Filling scales
2026	70 Filling scales	31 Filling scales	depot	19 Filling scales	depot	20 Filling scales
2027	84 Filling scales	33 Filling scales	depot	25 Filling scales	15 Filling scales	11 Filling scales
2028	100 Filling scales	35 Filling scales	14 Filling scales	18 Filling scales	19 Filling scales	14 Filling scales
2029	119 Filling scales	37 Filling scales	18 Filling scales	22 Filling scales	23 Filling scales	18 Filling scales
2030	139 Filling scales	39 Filling scales	22 Filling scales	28 Filling scales	28 Filling scales	23 Filling scales

Table 154. Governmental strategic storage capacity requirement by year, at 60 days, Low case prior to offsets from private sector logistical and operational storage

Low interv	ESTIMATED THEORETICAL GOVERNMENT STRATEGIC STORAGE (Tons)
2020	4 636 T
2021	5 752 T
2022	7 712 T
2023	10 696 T
2024	13 348 T
2025	15 283 T
2026	17 550 T
2027	20 160 T
2028	23 147 T
2029	26 487 T
2030	30 209 T

Table 155. Pivate sector strategic storage offsets in volumes and months

		Estimated yearly stock MT		
		Low interv	High interv	NST1
2024	1/2 Cylinders	9 260 MT	10 210 MT	23 652 MT
	1/2 FP storage	770 MT	830 MT	1 605 MT
	1/2 Bulk trucks	637 MT	713 MT	1 753 MT
	TOTAL	**10 667 MT**	**11 753 MT**	**27 010 MT**
2030	1/2 Cylinders	23 032 MT	28 427 MT	34 912 MT
	1/2 FP storage	1 743 MT	2 080 MT	2 533 MT
	1/2 Bulk trucks	1 854 MT	2 285 MT	2 889 MT
	TOTAL	**26 629 MT**	**32 792 MT**	**40 334 MT**

	Estimated yearly stock in months		
	Low interv	High interv	NST1
2024	1,6 Months	1,6 Months	1,9 Months
2030	1,8 Months	1,8 Months	1,8 Months

	Estimated New strategic storage		
	Low interv	High interv	NST1
2024	9 400 MT	9 800 MT	14 700 MT
2030	18 700 MT	21 300 MT	25 500 MT

Table 156. Regional private sector operational and logistical storage capacities by year, Low case

	ESTIMATED THEORETICAL PRIVATE SECTOR OPERATION STORAGE					
Low interv	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	1 605 Tons	1 605 Tons				
2021	1 991 Tons	1 991 Tons				
2022	1 291 Tons	1 291 Tons				
2023	3 702 Tons	3 702 Tons				
2024	6 835 Tons	3 973 Tons	depot	1 400 Tons	depot	1 463 Tons
2025	6 956 Tons	3 585 Tons	depot	1 650 Tons	depot	1 720 Tons
2026	7 811 Tons	3 814 Tons	depot	1 960 Tons	depot	2 037 Tons
2027	8 791 Tons	4 040 Tons	depot	2 334 Tons	1 197 Tons	1 219 Tons
2028	9 905 Tons	4 266 Tons	1 273 Tons	1 505 Tons	1 440 Tons	1 422 Tons
2029	11 147 Tons	4 472 Tons	1 510 Tons	1 789 Tons	1 712 Tons	1 664 Tons
2030	12 525 Tons	4 664 Tons	1 789 Tons	2 111 Tons	2 008 Tons	1 953 Tons

	ESTIMATED THEORETICAL LOGISTIC CYLINDER+BULK STORAGE CAPACITY					
Low interv	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	535 Tons	535 Tons				
2021	664 Tons	664 Tons				
2022	860 Tons	430 Tons	430 Tons			
2023	2 468 Tons	1 234 Tons	1 234 Tons			
2024	2 278 Tons	1 324 Tons	depot	467 Tons	depot	488 Tons
2025	2 319 Tons	1 195 Tons	depot	550 Tons	depot	573 Tons
2026	2 604 Tons	1 271 Tons	depot	653 Tons	depot	679 Tons
2027	2 930 Tons	1 347 Tons	depot	778 Tons	399 Tons	406 Tons
2028	3 302 Tons	1 422 Tons	424 Tons	502 Tons	480 Tons	474 Tons
2029	3 716 Tons	1 491 Tons	503 Tons	596 Tons	571 Tons	555 Tons
2030	4 175 Tons	1 555 Tons	596 Tons	704 Tons	669 Tons	651 Tons

L=logistic S=Strategic	LOGISTIC STORAGE + PRIVATE SECTOR STRATEGIC STORAGE (MT)																					
	2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030	
LOW INT	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S
KIGALI					1300	4000	1300	4000	1300	4000	1300	4000	1300	4000	1300	4000	1500	4700	1500	4700	1500	4700
SOUTHERN																	600	1800	600	1800	600	1800
WESTERN									600	2000	600	2000	850	2000	850	2400	850	2400	850	2400	850	2400
NORTHERN															500	2000	500	2000	700	2000	700	2000
EASTERN									600	2000	600	2000	700	2000	700	2000	700	2000	700	2000	700	2000
TOTAL	0	0	0	0	1300	4000	1300	4000	2500	8000	2500	8000	2850	8000	3350	10400	4150	12900	4350	12900	4350	12900

Table 157. Transportation asset requirements by region and year, Low case

A) Bulk trucks

	ESTIMATED NUMBER OF BULK PRIMARY TRANSPORT TRUCKS/Year					
Low interv	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	22 bulk trucks	22 bulk trucks				
2021	27 bulk trucks	27 bulk trucks				
2022	34 bulk trucks	22 bulk trucks	12 bulk trucks			
2023	61 bulk trucks	43 bulk trucks	18 bulk trucks			
2024	58 bulk trucks	34 bulk trucks		12 bulk trucks		12 bulk trucks
2025	64 bulk trucks	32 bulk trucks		16 bulk trucks		17 bulk trucks
2026	78 bulk trucks	34 bulk trucks		21 bulk trucks		22 bulk trucks
2027	94 bulk trucks	37 bulk trucks		28 bulk trucks	17 bulk trucks	12 bulk trucks
2028	112 bulk trucks	39 bulk trucks	16 bulk trucks	20 bulk trucks	21 bulk trucks	16 bulk trucks
2029	132 bulk trucks	41 bulk trucks	20 bulk trucks	25 bulk trucks	26 bulk trucks	20 bulk trucks
2030	155 bulk trucks	43 bulk trucks	25 bulk trucks	31 bulk trucks	31 bulk trucks	25 bulk trucks

B) Cylinder trucks

	ESTIMATED NUMBER OF CYLINDER PRIMARY TRANSPORT TRUCKS/Year					
Low interv	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	2 cyl trucks		0,6 cyl trucks	0,0 cyl trucks	0,5 cyl trucks	0,5 cyl trucks
2021	3 cyl trucks		0,8 cyl trucks	0,7 cyl trucks	0,7 cyl trucks	0,6 cyl trucks
2022	4 cyl trucks		1,2 cyl trucks	1,0 cyl trucks	1,0 cyl trucks	0,9 cyl trucks
2023	6 cyl trucks		1,7 cyl trucks	1,5 cyl trucks	1,5 cyl trucks	1,2 cyl trucks
2024	7 cyl trucks		3,1 cyl trucks		4,2 cyl trucks	
2025	10 cyl trucks		4,2 cyl trucks		5,7 cyl trucks	
2026	13 cyl trucks		5,6 cyl trucks		7,6 cyl trucks	
2027	7 cyl trucks		7,3 cyl trucks			
2028						
2029						
2030						

Table 158. Summary investment requirements by asset category, region and year, Low case

COSTS ESTIMATION- INVESTMENT BAU+LI		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	TOTAL
CYLINDERS	NATIONAL		2,073,358 $	3,389,922 $	4,232,046 $	4,270,724 $	4,931,916 $	5,770,384 $	6,621,798 $	7,549,644 $	8,388,707 $	9,294,262 $	56,522,761 $
FILLING PLANTS	KIGALI	0 $	0 $	9,075,000 $	0 $	0 $	0 $	0 $	0 $	385,000 $	0 $	0 $	9,460,000 $
	SOUTHERN	0 $	0 $	0 $	0 $	0 $	0 $	0 $	0 $	8,694,400 $	28,000 $	28,000 $	8,750,400 $
	WESTERN	0 $	0 $	0 $	0 $	8,849,500 $	0 $	496,650 $	42,000 $	0 $	0 $	38,500 $	9,426,650 $
	NORTHERN	0 $	0 $	0 $	0 $	0 $	0 $	0 $	0 $	8,657,000 $	28,000 $	423,500 $	9,108,500 $
	EASTERN	0 $	0 $	0 $	0 $	0 $	8,694,400 $	0 $	210,000 $	0 $	0 $	0 $	8,904,400 $
	TOTAL	0 $	0 $	9,075,000 $	0 $	8,849,500 $	8,694,400 $	496,650 $	252,000 $	17,736,400 $	56,000 $	490,000 $	45,649,950 $
PALLETIZATION	Palletization in Filling Plant	0 $	0 $	1,454,000 $	120,000 $	1,790,000 $	0 $	0 $	895,000 $	936,000 $	0 $	0 $	5,195,000 $
	Pallets in the logistic network	0 $	0 $	121,650 $	154,113 $	160,245 $	188,329 $	223,161 $	259,347 $	299,133 $	336,395 $	376,719 $	2,119,093 $
	TOTAL	0 $	0 $	1,575,650 $	274,113 $	1,950,245 $	188,329 $	223,161 $	1,154,347 $	1,235,133 $	336,395 $	376,719 $	7,314,093 $
STRATEGIC STORAGE	PRIVATE SECTOR PORTION	0 $	0 $	6,000,000 $	0 $	6,000,000 $	0 $	0 $	3,600,000 $	3,750,000 $	0 $	0 $	19,350,000 $
BULK PRIMARY TRANSPORT	NATIONAL	0 $	0 $	1,644,704 $	2,083,611 $	2,166,511 $	2,546,214 $	3,017,142 $	3,506,374 $	4,044,275 $	4,548,063 $	5,093,241 $	28,650,135 $
CYLINDER PRIMARY TRANSPORT	NATIONAL	0 $	0 $	170,200 $	340,400 $	170,200 $	510,600 $	510,600 $	0 $	0 $	0 $	0 $	1,702,000 $
CAGES	NATIONAL	0 $	0 $	117,760 $	146,880 $	148,160 $	171,200 $	200,320 $	229,760 $	261,760 $	291,200 $	322,560 $	1,889,600 $
													161,078,539 $
NATIONAL STRATEGIC STORAGE				$ 22,742,000		$ 11,126,000						$ 34,010,000	67,878,000 $
GRAND TOTAL			$ 2,073,358	$ 44,715,235	$ 7,077,051	$ 34,681,340	$ 17,042,659	$ 10,218,258	$ 15,364,280	$ 34,577,212	$ 13,620,365	$ 49,586,782	228,956,539 $
													141,728,539 $
OPTION 2: STRAGETIC STORAGE				22,742,000 $		15,881,000 $					10,869,000 $		49,492,000 $
OPTION2 : GRAND TOTAL			$ 2,073,358	$ 38,715,235	$ 7,077,051	$ 33,436,340	$ 17,042,659	$ 10,218,258	$ 11,764,280	$ 30,827,212	$ 24,489,365	$ 15,576,782	191,220,539 $

Table 159. Cylinder investment requirements by size, region and year, Low case

		Estimated cylinder costs by size, region and year											
		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	TOTAL
Rwanda	6 Kg		468,589 $	766,138 $	956,463 $	965,204 $	1,114,636 $	1,304,134 $	1,496,558 $	1,706,255 $	1,895,887 $	2,100,547 $	12,774,412 $
	12 Kg		1,532,368 $	2,505,407 $	3,127,801 $	3,156,386 $	3,645,057 $	4,264,748 $	4,894,007 $	5,579,755 $	6,199,886 $	6,869,159 $	41,774,574 $
	35 Kg		72,402 $	118,376 $	147,783 $	149,134 $	172,223 $	201,502 $	231,233 $	263,634 $	292,934 $	324,556 $	1,973,776 $
Kigali City	6 Kg		227,923 $	360,955 $	370,204 $	277,859 $	250,628 $	230,864 $	207,581 $	188,042 $	134,756 $	92,940 $	2,341,751 $
	12 Kg		745,349 $	1,180,385 $	1,210,631 $	908,648 $	819,596 $	754,967 $	678,825 $	614,930 $	440,675 $	303,930 $	7,657,936 $
	35 Kg		35,216 $	55,771 $	57,200 $	42,932 $	38,724 $	35,671 $	32,073 $	29,054 $	20,821 $	14,360 $	361,824 $
Southern Province	6 Kg		49,441 $	88,052 $	130,590 $	149,969 $	181,233 $	228,608 $	280,333 $	338,715 $	404,360 $	476,260 $	2,327,562 $
	12 Kg		161,682 $	287,945 $	427,054 $	490,424 $	592,663 $	747,587 $	916,740 $	1,107,659 $	1,322,329 $	1,557,453 $	7,611,536 $
	35 Kg		7,639 $	13,605 $	20,178 $	23,172 $	28,002 $	35,322 $	43,314 $	52,335 $	62,478 $	73,587 $	359,632 $
Western Province	6 Kg		65,247 $	111,940 $	160,454 $	190,099 $	242,080 $	299,467 $	357,696 $	418,483 $	481,684 $	544,100 $	2,871,249 $
	12 Kg		213,368 $	366,063 $	524,714 $	621,657 $	791,643 $	979,308 $	1,169,729 $	1,368,514 $	1,575,191 $	1,779,302 $	9,389,489 $
	35 Kg		10,081 $	17,296 $	24,792 $	29,372 $	37,404 $	46,271 $	55,268 $	64,660 $	74,425 $	84,069 $	443,637 $
Northern Province	6 Kg		75,965 $	117,339 $	162,960 $	198,110 $	263,768 $	320,226 $	372,331 $	420,534 $	463,658 $	496,241 $	2,891,132 $
	12 Kg		248,420 $	383,720 $	532,908 $	647,853 $	862,567 $	1,047,196 $	1,217,588 $	1,375,219 $	1,516,244 $	1,622,796 $	9,454,511 $
	35 Kg		11,737 $	18,130 $	25,179 $	30,610 $	40,755 $	49,478 $	57,529 $	64,977 $	71,640 $	76,674 $	446,709 $
Eastern Province	6 Kg		50,012 $	87,853 $	132,254 $	149,168 $	176,929 $	224,969 $	278,617 $	340,481 $	411,429 $	491,006 $	2,342,719 $
	12 Kg		163,549 $	287,294 $	432,494 $	487,805 $	578,587 $	735,690 $	911,126 $	1,113,433 $	1,345,447 $	1,605,677 $	7,661,102 $
	35 Kg	12,668 $	7,727 $	13,574 $	20,435 $	23,048 $	27,337 $	34,760 $	43,049 $	52,608 $	63,570 $	75,865 $	374,642 $
GRAND TOTAL		**12,668 $**	**2,073,358 $**	**3,389,922 $**	**4,232,046 $**	**4,270,724 $**	**4,931,916 $**	**5,770,384 $**	**6,621,798 $**	**7,549,644 $**	**8,388,707 $**	**9,294,262 $**	**56,535,429 $**

Table 160. Filling plant investment requirements by region and year, Low case

KIGALI (MAX CAPACITY 40KT/Y) BAU+LI		**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
ANNUAL TONNAGE				19741 T/y	23131 T/y	36535 T/y	28429 T/y	30903 T/y	33237 T/y	35454 T/y	37239 T/y	38674 T/y
LOGISTIQUE STORAGE				430 Tons	1 234 Tons	1 324 Tons	1 195 Tons	1 271 Tons	1 347 Tons	1 422 Tons	1 491 Tons	1 555 Tons
Total Nber of filling scales				20 scales	23 scales	37 scales	28 scales	31 scales	33 scales	35 scales	36 scales	36 scales
12 Kg line carousel 24 stages - 12 scales	scales			12 scales	14 scales	23 scales	23 scales	23 scales	23 scales	23 scales	23 scales	23 scales
6 Kg line carousel 12 stages - 8 scales	scales			8 scales	8 scales	12 scales	12 scales	12 scales	12 scales	12 scales	12 scales	12 scales
35kg line 2 scales	scales			1 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Real storage				1 300 Tons					2 shifts	200T-2 shift	2 shifts	2 shifts
KIGALI FILLING PLANT COST	**ITEMS**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
1°) SITTING AND PREPARATION				665 K$								
2°) ROAD, SEWERAGE AND NETWORKS				1467 K$								
3°) CIVIL WORKS				183 K$								
4°) BUILDINGS				504 K$								
5°) STOCKAGE				1407 K$						350 K$		
6°) LOCKSMITHING (SERRURERIE)				59 K$								
7°) VALVES for piping				401 K$								
8°) PIPING				767 K$								
9°) ELECTRICITY				713 K$								
10°) EQUIPMENTS				0 K$								
10-1°) GAS EQUIPMENT				148 K$								
10-2°) FIRE FIGHTING EQUIPMENT				623 K$								
10-3°) COMPRESSED AIR EQUIPMENT				80 K$								
10-4°) FILLING HALL				1233 K$	21 K$	91 K$						
TOTAL WITHOUT ENGINEERING AND & VARIOUS AND FORESSEEN				8250 K$						350 K$	0 K$	
11°) ENGINEERING				413 K$	0 K$					18 K$		
12°) VARIOUS AND FORESSEEN				413 K$	0 K$					18 K$		
SOUS TOTAL WITHOUT PALETTIZATION				**9075 K$**	**0 K$**	**0 K$**				**385 K$**	**0 K$**	
13° PALETTIZATION including FP Palets and truck trasformation				**1454 K$**	**120 K$**							
GRAND TOTAL				**10 529 K$**	**120 K$**	**0 K$**				**385 K$**	**0 K$**	

UTHERN PROVINCE (MAX CAPACITY 20KT/Y) BAU+LI		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE										13969 T/y	17699 T/y	22135 T/y
LOGISTIQUE STORAGE										424 Tons	503 Tons	596 Tons
Total Nber of filling scales										14 scales	18 scales	22 scales
12 Kg line carrousel 12 stages-12 scales	scales									8 scales	10 scales	13 scales
6 Kg line carousel 8 stages - 8 scales	scales									6 scales	7 scales	8 scale
35kg line 2 scales	scales									1 scales	2 scales	2 scale
Maintenance: retesting, painting, cold repair										Yes	Yes	Yes

600 Tons

SOUTHERN PROVINCE FILLING PLANT COSTS- USD		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1°) SITTING AND PREPARATION										665 K$		
2°) ROAD, SEWERAGE AND NETWORKS										1 642 K$		
3°) CIVIL WORKS										183 K$		
4°) BUILDINGS										504 K$		
5°) STOCKAGE										1 027 K$		
6°) LOCKSMITHING (SERRURERIE)										59 K$		
7°) VALVES for piping										401 K$		
8°) PIPING										767 K$		
9°) ELECTRICITY										713 K$		
10°) EQUIPMENTS												
10-1°) GAS EQUIPMENT										148 K$		
10-2°) FIRE FIGHTING EQUIPMENT										623 K$		
10-3°) COMPRESSED AIR EQUIPMENT										80 K$		
10-4°) FILLING HALL										1 092 K$	28 K$	28 K$
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN										7904 K$	28 K$	28 K$
11°) ENGINEERING										395 K$		
12°) VARIOUS AND FORESSEEN										395 K$		
SOUS TOTAL WITHOUT PALETTIZATION										**8694 K$**	**28 K$**	**28 K$**
13° PALETTIZATION including Palets and truck trasformation										**936 K$**		
GRAND TOTAL										**9 630 K$**	**28 K$**	**28 K$**

WESTERN PROVINCE (MAX CAPACITY 30KT/Y) BAU+I		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE						10679 T/y	14420 T/y	19152 T/y	24947 T/y	17944 T/y	22464 T/y	27639 T/y
LOGISTIQUE STORAGE						467 Tons	550 Tons	653 Tons	778 Tons	502 Tons	596 Tons	704 Tons
Total Nber of filling scales						11 scales	14 scales	19 scales	25 scales	18 scales	22 scales	28 scales
12 Kg line carrousel 24 stages-12 scales	scales					10 scales	10 scales	12 scales	15 scales	15 scales	15 scales	16 scales
6 Kg line carousel 12 stages - 8 scales	scales					6 scales	6 scales	6 scales	8 scales	8 scales	8 scales	10 scales
35kg line 2 scales	scales					1 scales	1 scales	1 scales	2 scales	2 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair						Yes	Yes	Yes	Yes	Yes	Yes	Yes
						600 Tons		250 Tons				
WESTERN PROVINCE FILLING PLANT COSTS-USD		**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
1°) SITTING AND PREPARATION						665 K$						
2°) ROAD, SEWERAGE AND NETWORKS						1467 K$						
3°) CIVIL WORKS						183 K$						
4°) BUILDINGS						504 K$						
5°) STOCKAGE						1202 K$		438 K$				
6°) LOCKSMITHING (SERRURERIE)						59 K$						
7°) VALVES for piping						401 K$						
8°) PIPING						767 K$						
9°) ELECTRICITY						713 K$						
10°) EQUIPMENTS						0 K$						
10-1°) GAS EQUIPMENT						148 K$						
10-2°) FIRE FIGHTING EQUIPMENT						623 K$						
10-3°) COMPRESSED AIR EQUIPMENT						80 K$						
10-4°) FILLING HALL						1233 K$		14 K$	42 K$			35 K$
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN						8045 K$		452 K$	42 K$			35 K$
11°) ENGINEERING						402 K$		23 K$				2 K$
12°) VARIOUS AND FORESSEEN						402 K$		23 K$				2 K$
SOUS TOTAL WITHOUT PALETTIZATION						**8850 K$**		**497 K$**	**42 K$**			**39 K$**
13° PALETTIZATION including Palets and truck trasformation						895 K$						
GRAND TOTAL						**9 745 K$**	**0 K$**	**497 K$**	**42 K$**	**0 K$**	**0 K$**	**39 K$**

NORTHERN PROVINCE (MAX CAPACITY 30KT/Y) BA		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE									14895 T/y	18844 T/y	23285 T/y	28134 T/y
LOGISTIQUE STORAGE									399 Tons	480 Tons	571 Tons	669 Tons
Total Nber of filling scales									15 scales	19 scales	23 scales	28 scales
12 Kg line carrousel 24 stages-12 scales	scales								10 scales	12 scales	15 scales	19 scales
6 Kg line carousel 12 stages - 8 scales	scales								4 scales	6 scales	8 scales	8 scales
35kg line 2 scales	scales								1 scales	1 scales	1 scales	2 scales
Maintenance: retesting, painting, cold repair									Yes	Yes	Yes	Yes
									500 Tons		200 Tons	

NORTHERN PROVINCE FILLING PLANT COSTS-USD		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1°) SITTING AND PREPARATION									665 K$			
2°) ROAD, SEWERAGE AND NETWORKS									1467 K$			
3°) CIVIL WORKS									183 K$			
4°) BUILDINGS									504 K$			
5°) STOCKAGE									1027 K$		350 K$	
6°) LOCKSMITHING (SERRURERIE)									59 K$			
7°) VALVES for piping									401 K$			
8°) PIPING									767 K$			
9°) ELECTRICITY									713 K$			
10°) EQUIPMENTS									0 K$			
10-1°) GAS EQUIPMENT									148 K$			
10-2°) FIRE FIGHTING EQUIPMENT									623 K$			
10-3°) COMPRESSED AIR EQUIPMENT									80 K$			
10-4°) FILLING HALL									1233 K$	28 K$	35 K$	35 K$
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN									7870 K$	28 K$	385 K$	35 K$
11°) ENGINEERING									394 K$		19 K$	
12°) VARIOUS AND FORESSEEN									394 K$		19 K$	
SOUS TOTAL WITHOUT PALETTIZATION									**8657 K$**	**28 K$**	**424 K$**	**35 K$**
13° PALETTIZATION including Palets and truck trasformation									895 K$			
GRAND TOTAL									**9 552 K$**	**28 K$**	**424 K$**	**35 K$**

EASTERN PROVINCE (MAX CAPACITY 20KT/Y) BAU+LI		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE						11227 T/y	15132 T/y	20035 T/y	11083 T/y	14182 T/y	17959 T/y	22506 T/y
LOGISTIQUE STORAGE						488 Tons	573 Tons	679 Tons	406 Tons	474 Tons	555 Tons	651 Tons
Total Nber of filling scales						11 scales	15 scales	20 scales	11 scales	14 scales	18 scales	23 scales
12 Kg line carrousel 12 stages-12 scales	scales					8 scales	8 scales	12 scales	12 scales	12 scales	12 scales	12 scales
6 Kg line carousel 8 stages - 8 scales	scales					6 scales	6 scales	6 scales	6 scales	6 scales	6 scales	6 scales
35kg line 2 scales	scales					1 scales	1 scales	2 scales	2 scales	2 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair						Yes	Yes	Yes	Yes	Yes	Yes	Yes
						600 Tons		100 Tons				

EASTERN PROVINCE FILLING PLANT COSTS- USD		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1°) SITTING AND PREPARATION						665 K$						
2°) ROAD, SEWERAGE AND NETWORKS						1 467 K$						
3°) CIVIL WORKS						183 K$						
4°) BUILDINGS						504 K$						
5°) STOCKAGE						1 202 K$		175 K$				
6°) LOCKSMITHING (SERRURERIE)						59 K$						
7°) VALVES for piping						401 K$						
8°) PIPING						767 K$						
9°) ELECTRICITY						713 K$						
10°) EQUIPMENTS												
10-1°) GAS EQUIPMENT						148 K$						
10-2°) FIRE FIGHTING EQUIPMENT						623 K$						
10-3°) COMPRESSED AIR EQUIPMENT						80 K$						
10-4°) FILLING HALL						1 092 K$		35 K$				
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN						7904 K$		210 K$				0 K€
11°) ENGINEERING						395 K$						0 K€
12°) VARIOUS AND FORESSEEN						395 K$						0 K€
SOUS TOTAL WITHOUT PALETTIZATION						**8694 K$**		**210 K$**				**0 K$**
13° PALETTIZATION including Palets and truck trasformation						**895 K$**						
GRAND TOTAL						**9 589 K$**						**0 K$**

Table 161. Pallet and cage investment requirements by region and year, Low case

Low case	ESTIMATED NUMBER OF PALLETS/YEAR										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Numbers of Pallets		1,104 palets	302 palets	383 palets	398 palets	468 palets	554 palets	644 palets	743 palets	836 palets	936 palets
Cost			**$ 121,650**	**$ 154,113**	**$ 160,245**	**$ 188,329**	**$ 223,161**	**$ 259,347**	**$ 299,133**	**$ 336,395**	**$ 376,719**
										Total	**$ 2,119,093**

Low case	ESTIMATED NUMBER OF CAGES/YEAR										
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Numbers of cages	1,248	224	368	459	463	535	626	718	818	910	1,008
Cost			$ 117,760	$ 146,880	$ 148,160	$ 171,200	$ 200,320	$ 229,760	$ 261,760	$ 291,200	$ 322,560
										Total	**$ 1,889,600**

Table 162. Transport investment requirements by truck type, region and year, Low case

Low case	ESTIMATED BULK PRIMARY TRANSPORT COST										
	2,020	2,021	2,022	2,023	2,024	2,025	2,026	2,027	2,028	2,029	2,030
Number of trucks (Tractor + bulk tank	21 trucks	5 trucks	7 trucks	9 trucks	10 trucks	11 trucks	13 trucks	16 trucks	18 trucks	20 trucks	23 trucks
Cost	**$ -**	**$ -**	**$ 1,644,704**	**$ 2,083,611**	**$ 2,166,511**	**$ 2,546,214**	**$ 3,017,272**	**$ 3,506,411**	**$ 4,044,252**	**$ 4,548,124**	**$ 5,093,036**
										Total	**$ 28,650,135**

Low case	ESTIMATED CYLINDER PRIMARY TRANSPORT TRUCKS COST/year										
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
ESTIMATED NUMBER OF CYLINDER PRIMARY TRANSPORT TRUCKS/Year	2 trucks	1 trucks	1 trucks	2 trucks	1 trucks	3 trucks	3 trucks				
ESTIMATED CYLINDER PRIMARY TRANSPORT TRUCKS COST/year	$ -	$ -	$ 170 200	$ 340 400	$ 170 200	$ 510 600	$ 510 600				
										Total	**$ 1 702 000**

73. Infrastructure Details and Costing: High Intervention Scenario

The following tables restate and expand upon the regional volumes to be served and associated asset requirements (see Volume 4, Chapter 42 for details):

Table 163. Regional LPG volume projections by year, High case

BAU+HI	TOTAL VOLUMES CYLINDER + BULK					
	RWANDA	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	27,297 T	16,257 T	2,182 T	2,674 T	2,345 T	3,838 T
2021	35,394 T	18,955 T	3,354 T	4,009 T	3,806 T	5,270 T
2022	48,475 T	23,335 T	5,442 T	6,321 T	5,875 T	7,502 T
2023	68,167 T	28,413 T	9,024 T	10,172 T	9,216 T	11,342 T
2024	86,347 T	32,493 T	12,384 T	13,955 T	12,666 T	14,848 T
2025	101,074 T	35,749 T	14,853 T	17,146 T	16,010 T	17,317 T
2026	118,464 T	38,852 T	17,967 T	21,108 T	20,096 T	20,442 T
2027	137,927 T	41,102 T	21,801 T	25,853 T	24,846 T	24,325 T
2028	160,458 T	43,055 T	26,536 T	31,479 T	30,210 T	29,178 T
2029	186,844 T	45,021 T	32,387 T	38,079 T	36,091 T	35,267 T
2030	216,325 T	46,650 T	39,406 T	45,496 T	42,072 T	42,701 T

Table 164. Annual regional LPG cylinder inventory increases, High case

	Estimated number of 12kg-eq cylinders to be added annually					
High interv	**Rwanda**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	122,152 cyl	83,986 cyl	8,239 cyl	10,045 cyl	9,610 cyl	10,271 cyl
2021	135,751 cyl	67,672 cyl	13,953 cyl	18,577 cyl	21,555 cyl	13,993 cyl
2022	218,598 cyl	101,552 cyl	25,141 cyl	32,458 cyl	34,518 cyl	24,929 cyl
2023	276,231 cyl	104,314 cyl	37,692 cyl	47,312 cyl	49,057 cyl	37,856 cyl
2024	289,897 cyl	79,705 cyl	45,316 cyl	58,335 cyl	61,697 cyl	44,844 cyl
2025	346,255 cyl	70,867 cyl	57,808 cyl	77,119 cyl	83,976 cyl	56,485 cyl
2026	407,768 cyl	63,699 cyl	73,782 cyl	95,817 cyl	101,614 cyl	72,856 cyl
2027	453,444 cyl	37,903 cyl	91,994 cyl	114,763 cyl	116,617 cyl	92,166 cyl
2028	525,598 cyl	28,180 cyl	114,778 cyl	135,848 cyl	129,764 cyl	117,027 cyl
2029	618,370 cyl	27,171 cyl	143,166 cyl	159,260 cyl	139,997 cyl	148,777 cyl
2030	691,962 cyl	17,143 cyl	173,122 cyl	178,632 cyl	139,325 cyl	183,740 cyl
TOTAL	**4,086,025 cyl**	**682,193 cyl**	**784,992 cyl**	**928,167 cyl**	**887,731 cyl**	**802,943 cyl**

Table 165. Annual regional LPG cylinder inventory increases by cylinder size, High case

	Estimated number of new cylinders/year																	
	Rwanda			Kigali City			Southern Province			Western Province			Northern Province			Eastern Province		
High interv	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg
2020	38,870	81,665	1,617	26,725	56,149	1,112	2,622	5,508	109	3,196	6,716	133	3,058	6,425	127	3,268	6,867	136
2021	43,197	90,757	1,797	21,534	45,242	896	4,440	9,329	185	5,911	12,420	246	6,859	14,411	285	4,453	9,355	185
2022	69,560	146,145	2,894	32,315	67,893	1,344	8,000	16,808	333	10,328	21,700	430	10,984	23,077	457	7,933	16,666	330
2023	87,899	184,675	3,657	33,194	69,740	1,381	11,994	25,199	499	15,055	31,631	626	15,610	32,797	649	12,046	25,308	501
2024	92,247	193,812	3,838	25,363	53,287	1,055	14,420	30,296	600	18,563	39,000	772	19,633	41,248	817	14,270	29,980	594
2025	110,181	231,490	4,584	22,550	47,378	938	18,395	38,648	765	24,540	51,558	1,021	26,722	56,143	1,112	17,974	37,763	748
2026	129,755	272,614	5,398	20,270	42,586	843	23,478	49,327	977	30,490	64,059	1,269	32,334	67,934	1,345	23,183	48,708	965
2027	144,289	303,151	6,003	12,061	25,340	502	29,273	61,503	1,218	36,519	76,725	1,519	37,109	77,965	1,544	29,328	61,618	1,220
2028	167,249	351,390	6,958	8,967	18,840	373	36,523	76,735	1,520	43,228	90,822	1,799	41,292	86,754	1,718	37,239	78,239	1,549
2029	196,770	413,413	8,187	8,646	18,165	360	45,557	95,714	1,895	50,678	106,474	2,108	44,548	93,595	1,853	47,342	99,465	1,970
2030	220,188	462,613	9,161	5,455	11,461	227	55,089	115,742	2,292	56,842	119,425	2,365	44,334	93,146	1,845	58,467	122,840	2,433
TOTAL	1,300,205	2,731,725	54,095	217,079	456,082	9,032	249,790	524,809	10,393	295,350	620,529	12,288	282,483	593,495	11,753	255,503	536,810	10,630

Table 166. Regional LPG filling plant quantities, capacities and scale counts, High case

	ESTIMATED YEARLY FILLING CAPACITY					
High interv	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020		Maintaining the existing- filling plant activity				
2021		Maintaining the existing- filling plant activity				
2022	1 Filling Plant	1 Filling Plant	Maintaining the existing- filling plant activity			
2023	1 Filling Plant	1 Filling Plant	Maintaining the existing- filling plant activity			
2024	3 Filling Plant	1 Filling Plant	depot	1 Filling Plant	1 Filling Plant	depot
2025	3 Filling Plant	1 Filling Plant	depot	1 Filling Plant	1 Filling Plant	depot
2026	4 Filling Plant	1 Filling Plant	depot	1 Filling Plant	1 Filling Plant	1 Filling Plant
2027	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2028	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2029	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2030	5 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant

	ESTIMATED YEARLY FILLING CAPACITY (MT)					
High interv	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	20016 T/y	20016 T/y				
2021	24875 T/y	24875 T/y				
2022	32661 T/y	20680 T/y	11981 T/y			
2023	42659 T/y	24618 T/y	18041 T/y			
2024	53439 T/y	27822 T/y		12481 T/y	13135 T/y	
2025	66515 T/y	30809 T/y		17418 T/y	18288 T/y	
2026	82107 T/y	33622 T/y		23705 T/y	14304 T/y	10477 T/y
2027	99663 T/y	35563 T/y	13716 T/y	17734 T/y	18756 T/y	13894 T/y
2028	120133 T/y	37184 T/y	18004 T/y	22901 T/y	23799 T/y	18244 T/y
2029	144278 T/y	38793 T/y	23368 T/y	29004 T/y	29331 T/y	23782 T/y
2030	171369 T/y	40039 T/y	29868 T/y	35889 T/y	34939 T/y	30633 T/y

	ESTIMATED YEARLY FILLING CAPACITY (FILLING SCALES)					
High interv	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	20 Filling scales	20 Filling scales				
2021	25 Filling scales	25 Filling scales				
2022	33 Filling scales	21 Filling scales	12 Filling scales			
2023	43 Filling scales	25 Filling scales	18 Filling scales			
2024	53 Filling scales	28 Filling scales	depot	12 Filling scales	13 Filling scales	depot
2025	67 Filling scales	31 Filling scales	depot	17 Filling scales	18 Filling scales	depot
2026	82 Filling scales	34 Filling scales	depot	24 Filling scales	14 Filling scales	10 Filling scales
2027	100 Filling scales	36 Filling scales	14 Filling scales	18 Filling scales	19 Filling scales	14 Filling scales
2028	120 Filling scales	37 Filling scales	18 Filling scales	23 Filling scales	24 Filling scales	18 Filling scales
2029	144 Filling scales	39 Filling scales	23 Filling scales	29 Filling scales	29 Filling scales	24 Filling scales
2030	171 Filling scales	40 Filling scales	30 Filling scales	36 Filling scales	35 Filling scales	31 Filling scales

Table 167. Governmental strategic storage capacity requirement by year, at 60 days, High case prior to offsets from private sector logistical and operational storage

High inter	ESTIMATED GOVERNMENT STRATEGIC STORAGE (Tons)
2020	4 636 T
2021	5 899 T
2022	8 079 T
2023	11 361 T
2024	14 391 T
2025	16 846 T
2026	19 743 T
2027	22 987 T
2028	26 742 T
2029	31 140 T
2030	36 054 T

Table 168. Pivate sector strategic storatge offsets in volumes and months

		Estimated yearly stock MT		
		Low interv	High interv	NST1
2024	1/2 Cylinders	9 260 MT	10 210 MT	23 652 MT
	1/2 FP storage	770 MT	830 MT	1 605 MT
	1/2 Bulk trucks	637 MT	713 MT	1 753 MT
	TOTAL	**10 667 MT**	**11 753 MT**	**27 010 MT**
2030	1/2 Cylinders	23 032 MT	28 427 MT	34 912 MT
	1/2 FP storage	1 743 MT	2 080 MT	2 533 MT
	1/2 Bulk trucks	1 854 MT	2 285 MT	2 889 MT
	TOTAL	**26 629 MT**	**32 792 MT**	**40 334 MT**

	Estimated yearly stock in months		
	Low interv	High interv	NST1
2024	1.5 Months	1.6 Months	1.9 Months
2030	1.7 Months	1.8 Months	1.9 Months

	Estimated new strategic storage		
	Low interv	High interv	NST1
2024	10,300 MT	9,800 MT	14,700 MT
2030	19,600 MT	21,300 MT	25,100 MT

Table 169, Regional private sector operational and logistical storage capacities by year, High case

	ESTIMATED THEORETICAL PRIVATE SECTOR OPERATION STORAGE					
Low interv	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	1 605 Tons	1 605 Tons				
2021	2 042 Tons	2 042 Tons				
2022	1 346 Tons	1 346 Tons				
2023	1 639 Tons	1 639 Tons				
2024	4 885 Tons	1 875 Tons	depot	1 423 Tons	1 587 Tons	depot
2025	5 729 Tons	2 062 Tons	depot	1 744 Tons	1 923 Tons	depot
2026	6 967 Tons	2 241 Tons	depot	2 146 Tons	1 400 Tons	1 179 Tons
2027	8 090 Tons	2 371 Tons	1 258 Tons	1 374 Tons	1 684 Tons	1 403 Tons
2028	9 393 Tons	2 484 Tons	1 531 Tons	1 691 Tons	2 004 Tons	1 683 Tons
2029	10 918 Tons	2 597 Tons	1 868 Tons	2 063 Tons	2 355 Tons	2 034 Tons
2030	12 622 Tons	2 691 Tons	2 273 Tons	2 482 Tons	2 712 Tons	2 464 Tons

High interv	ESTIMATED THEORETICAL LOGISTIC CYLINDER+BULK STORAGE CAPACITY					
	Rwanda	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019	0 Tons					
2020	535 Tons	535 Tons				
2021	681 Tons	681 Tons				
2022	932 Tons	449 Tons	483 Tons			
2023	1 193 Tons	546 Tons	647 Tons			
2024	1 628 Tons	625 Tons	depot	474 Tons	529 Tons	depot
2025	1 910 Tons	687 Tons	depot	581 Tons	641 Tons	depot
2026	2 322 Tons	747 Tons	depot	715 Tons	467 Tons	393 Tons
2027	2 697 Tons	790 Tons	419 Tons	458 Tons	561 Tons	468 Tons
2028	3 131 Tons	828 Tons	510 Tons	564 Tons	668 Tons	561 Tons
2029	3 639 Tons	866 Tons	623 Tons	688 Tons	785 Tons	678 Tons
2030	4 207 Tons	897 Tons	758 Tons	827 Tons	904 Tons	821 Tons

L=logistic S=Strategic	LOGISTIC STORAGE + PRIVATE SECTOR STRATEGIC STORAGE (MT)																					
	2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030	
HIGH INT	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S
KIGALI					700	2000	700	2000	800	2000	800	2000	800	2800	800	2800	1000	2800	1000	2800	1000	2800
SOUTHERN															600	1600	600	1600	800	2300	800	2300
WESTERN									700	2200	700	2000	700	2000	700	3400	700	4200	900	4200	900	4200
NORTHERN									700	1800	700	1800	700	1800	700	1800	1000	2700	1000	2700	1000	2700
EASTERN													600	1500	600	1500	600	1500	900	2750	900	2750
TOTAL					700	2000	700	2000	2200	6000	2200	5800	2800	8100	3400	11100	3900	12800	4600	14750	4600	14750

Table 170. Transportation asset requirements by region and year, High case

A) Bulk trucks

High interv	ESTIMATED NUMBER OF BULK PRIMARY TRANSPORT TRUCKS/Year					
	Rwanda	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	22 bulk trucks	22 bulk trucks				
2021	28 bulk trucks	28 bulk trucks				
2022	36 bulk trucks	23 bulk trucks	13 bulk trucks			
2023	47 bulk trucks	27 bulk trucks	20 bulk trucks			
2024	59 bulk trucks	31 bulk trucks		14 bulk trucks	15 bulk trucks	
2025	74 bulk trucks	34 bulk trucks		19 bulk trucks	20 bulk trucks	
2026	91 bulk trucks	37 bulk trucks		26 bulk trucks	16 bulk trucks	12 bulk trucks
2027	111 bulk trucks	40 bulk trucks		35 bulk trucks	21 bulk trucks	15 bulk trucks
2028	133 bulk trucks	41 bulk trucks	20 bulk trucks	25 bulk trucks	26 bulk trucks	20 bulk trucks
2029	160 bulk trucks	43 bulk trucks	26 bulk trucks	32 bulk trucks	33 bulk trucks	26 bulk trucks
2030	190 bulk trucks	44 bulk trucks	33 bulk trucks	40 bulk trucks	39 bulk trucks	34 bulk trucks

B) Cylinder trucks

	ESTIMATED NUMBER OF CYLINDER PRIMARY TRANSPORT TRUCKS/Year					
High interv	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	2 cyl trucks		0,6 cyl trucks	0,0 cyl trucks	0,5 cyl trucks	0,5 cyl trucks
2021	3 cyl trucks		0,8 cyl trucks	0,7 cyl trucks	0,7 cyl trucks	0,6 cyl trucks
2022	4 cyl trucks		1,3 cyl trucks	1,1 cyl trucks	1,1 cyl trucks	0,9 cyl trucks
2023	7 cyl trucks		1,9 cyl trucks	1,6 cyl trucks	1,7 cyl trucks	1,4 cyl trucks
2024	6 cyl trucks		3,6 cyl trucks			1,9 cyl trucks
2025	8 cyl trucks		5,0 cyl trucks			2,6 cyl trucks
2026	7 cyl trucks		6,9 cyl trucks			
2027	9 cyl trucks		9,1 cyl trucks			
2028						
2029						
2030						

Table 171. Summary investment requirements by asset category, region and year, High case

COSTS ESTIMATION- INVESTMENT High interv		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	TOTAL
CYLINDERS	NATIONAL	0 $	2,503,839 $	4,031,912 $	5,094,919 $	5,346,975 $	6,386,463 $	7,521,032 $	8,363,495 $	9,694,341 $	11,405,469 $	12,762,817 $	73,111,264 $
FILLING PLANTS	KIGALI	0 $	0 $	9,046,400 $	28,000 $	498,300 $	28,000 $	21,000 $	14,000 $	282,700 $	0 $	0 $	9,918,400 $
	SOUTHERN	0 $	0 $	0 $	0 $	0 $	0 $	0 $	8,849,500 $	0 $	432,000 $	49,000 $	9,330,500 $
	WESTERN	0 $	0 $	0 $	0 $	9,046,400 $	0 $	42,000 $	53,900 $	0 $	475,000 $	35,000 $	9,652,300 $
	NORTHERN	0 $	0 $	0 $	0 $	0 $	9,236,700 $	0 $	0 $	0 $	614,000 $	38,500 $	9,889,200 $
	EASTERN	0 $	0 $	0 $	0 $	0 $	0 $	0 $	8,849,500 $	0 $	0 $	711,700 $	9,561,200 $
	TOTAL	0 $	0 $	9,046,400 $	28,000 $	9,544,700 $	9,264,700 $	63,000 $	17,766,900 $	282,700 $	1,521,000 $	834,200 $	48,351,600 $
PALLETIZATION	Palletization in Filling Plants	0 $	0 $	1,454,000 $	120,000 $	2,108,000 $	0 $	1,054,000 $	1,054,000 $	0 $	0 $	0 $	5,790,000 $
	Pallets in the logistic network	0 $	0 $	143,490 $	184,252 $	198,667 $	240,994 $	287,352 $	323,548 $	377,242 $	444,980 $	499,280 $	2,699,805 $
	TOTAL	0 $	0 $	1,597,490 $	304,252 $	2,306,667 $	240,994 $	1,341,352 $	1,377,548 $	377,242 $	444,980 $	499,280 $	8,489,805 $
STRATEGIC STORAGE	PRIVATE SECTOR PORTION	0 $	0 $	3,000,000 $	0 $	6,000,000 $	0 $	3,450,000 $	4,200,000 $	2,550,000 $	2,925,000 $	0 $	22,125,000 $
BULK PRIMARY TRANSPORT	NATIONAL	0 $	0 $	1,939,992 $	2,491,081 $	2,685,973 $	3,258,245 $	3,884,994 $	4,374,370 $	5,100,306 $	6,016,127 $	6,750,267 $	36,501,357 $
CYLINDER PRIMARY TRANSPORT	NATIONAL	0 $	0 $	170,200 $	510,600 $	0 $	170,200 $	0 $		0 $	0 $	0 $	851,000 $
CAGES	NATIONAL	0 $	0 $	139,840 $	176,960 $	185,600 $	221,440 $	261,120 $	290,240 $	336,320 $	395,520 $	442,880 $	2,449,920 $
													191,879,946 $
NATIONAL STRATEGIC STORAGE				$ 22,742,000		$ 12,742,000						$ 45,325,000	80,809,000 $
													169,754,946 $
OPTION2 : STRATEGIC STORAGE				22,742,000 $		15,881,000 $				14,267,000 $			52,890,000 $
OPTION 2 GRAND TOTAL			2,503,839 $	39,667,834 $	8,605,812 $	35,950,915 $	19,542,043 $	13,071,498 $	32,172,554 $	30,057,909 $	19,783,097 $	21,289,445 $	222,644,946 $

Table 172. Cylinder investment requirements by size, region and year, High case

		ESTIMATED cylinders costs per capacity, year and region										
		2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**TOTAL**
Rwanda	6 Kg	565,880 $	911,231 $	1,151,476 $	1,208,442 $	1,443,371 $	1,699,789 $	1,890,190 $	2,190,967 $	2,577,690 $	2,884,457 $	16,523,492 $
	12 Kg	1,850,526 $	2,979,887 $	3,765,529 $	3,951,817 $	4,720,076 $	5,558,609 $	6,181,252 $	7,164,848 $	8,429,500 $	9,432,682 $	54,034,725 $
	35 Kg	87,434 $	140,794 $	177,915 $	186,716 $	223,015 $	262,635 $	292,053 $	338,527 $	398,279 $	445,678 $	2,553,047 $
Kigali City	6 Kg	282,092 $	423,320 $	434,836 $	332,253 $	295,409 $	265,532 $	157,999 $	117,469 $	113,263 $	71,463 $	2,493,637 $
	12 Kg	922,490 $	1,384,332 $	1,421,991 $	1,086,526 $	966,041 $	868,335 $	516,685 $	384,145 $	370,391 $	233,695 $	8,154,630 $
	35 Kg	43,586 $	65,407 $	67,187 $	51,336 $	45,644 $	41,027 $	24,412 $	18,150 $	17,500 $	11,042 $	385,292 $
Southern Province	6 Kg	58,165 $	104,801 $	157,120 $	188,900 $	240,973 $	307,561 $	383,480 $	478,455 $	596,791 $	721,665 $	3,237,911 $
	12 Kg	190,210 $	342,717 $	513,809 $	617,738 $	788,025 $	1,005,780 $	1,254,046 $	1,564,633 $	1,951,612 $	2,359,971 $	10,588,539 $
	35 Kg	8,987 $	16,193 $	24,277 $	29,187 $	37,233 $	47,521 $	59,251 $	73,926 $	92,210 $	111,505 $	500,290 $
Western Province	6 Kg	77,439 $	135,303 $	197,222 $	243,170 $	321,471 $	399,417 $	478,393 $	566,287 $	663,878 $	744,630 $	3,827,210 $
	12 Kg	253,240 $	442,464 $	644,950 $	795,209 $	1,051,267 $	1,306,162 $	1,564,430 $	1,851,858 $	2,170,999 $	2,435,070 $	12,515,649 $
	35 Kg	11,965 $	20,906 $	30,473 $	37,572 $	49,671 $	61,714 $	73,917 $	87,497 $	102,576 $	115,053 $	591,343 $
Northern Province	6 Kg	89,853 $	143,891 $	204,497 $	257,187 $	350,058 $	423,579 $	486,122 $	540,924 $	583,579 $	580,778 $	3,660,467 $
	12 Kg	293,836 $	470,549 $	668,740 $	841,045 $	1,144,751 $	1,385,177 $	1,589,705 $	1,768,917 $	1,908,406 $	1,899,246 $	11,970,371 $
	35 Kg	13,883 $	22,233 $	31,597 $	39,738 $	54,087 $	65,447 $	75,111 $	83,578 $	90,169 $	89,736 $	565,579 $
Eastern Province	6 Kg	58,330 $	103,916 $	157,802 $	186,932 $	235,459 $	303,701 $	384,196 $	487,832 $	620,178 $	765,923 $	3,304,268 $
	12 Kg	190,750 $	339,824 $	516,039 $	611,299 $	769,993 $	993,154 $	1,256,387 $	1,595,295 $	2,028,092 $	2,504,701 $	10,805,537 $
	35 Kg	9,013 $	16,056 $	24,382 $	28,883 $	36,381 $	46,925 $	59,362 $	75,375 $	95,824 $	118,343 $	510,543 $
GRAND TOTAL		**2,503,839 $**	**4,031,912 $**	**5,094,919 $**	**5,346,975 $**	**6,386,463 $**	**7,521,032 $**	**8,363,495 $**	**9,694,341 $**	**11,405,469 $**	**12,762,817 $**	**73,111,264 $**

Table 173. Filling plant investment requirements by region and year, High case

KIGALI (MAX CAPACITY 40KT/Y) BAU+HI		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE				20680 T/y	24618 T/y	27822 T/y	30809 T/y	33622 T/y	35563 T/y	37184 T/y	38793 T/y	40039 T/y
STORAGE				449 Tons	546 Tons	625 Tons	687 Tons	747 Tons	790 Tons	828 Tons	866 Tons	897 Tons
Total Nber of filling scales				21 scales	25 scales	28 scales	31 scales	34 scales	36 scales	37 scales	39 scales	40 scales
12 Kg line carousel 24 stages - 12 scales	scales			12 scales	16 scales	17 scales	18 scales	21 scales	23 scales	24 scales	24 scales	24 scales
6 Kg line carousel 12 stages - 8 scales	scales			8 scales	8 scales	10 scales	12 scales	12 scales	12 scales	12 scales	12 scales	12 scales
35kg line 2 scales	scales			2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Real storage				700 Tons		100 Tons				100T 2 shifts plants=========>		
KIGALI FILLING PLANT COST	**ITEMS**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
1°) SITTING AND PREPARATION				665 K$								
2°) ROAD, SEWERAGE AND NETWORKS				1467 K$								
3°) CIVIL WORKS				183 K$								
4°) BUILDINGS				504 K$								
5°) STOCKAGE				1381 K$		350 K$				175 K$		
6°) LOCKSMITHING (SERRURERIE)				59 K$								
7°) VALVES for piping				401 K$		75 K$				75 K$		
8°) PIPING				767 K$								
9°) ELECTRICITY				713 K$								
10°) EQUIPMENTS												
10-1°) GAS EQUIPMENT				148 K$								
10-2°) FIRE FIGHTING EQUIPMENT				623 K$								
10-3°) COMPRESSED AIR EQUIPMENT				80 K$								
10-4°) FILLING HALL				1233 K$	28 K$	28 K$	28 K$	21 K$	14 K$	7 K$		
TOTAL WITHOUT ENGINEERING AND & VARIOUS AND FORESSEEN				8224 K$	28 K$	453 K$	28 K$	21 K$	14 K$	257 K$	0 K$	
11°) ENGINEERING				411 K$		23 K$				13 K$		
12°) VARIOUS AND FORESSEEN				411 K$		23 K$				13 K$		
SOUS TOTAL WITHOUT PALETTIZATION				**9046 K$**	**28 K$**	**498 K$**	**28 K$**	**21 K$**	**14 K$**	**283 K$**	**0 K$**	
13° PALETTIZATION including FP Palets and truck trasformation				**1454 K$**	**120 K$**							
GRAND TOTAL		**0 K$**	**0 K$**	**10 500 K$**	**148 K$**	**498 K$**	**28 K$**	**21 K$**	**14 K$**	**283 K$**	**0 K$**	

SOUTHERN PROVINCE (MAX CAPACITY 30KT/Y) BAU+HI		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE									13716 T/y	18004 T/y	23368 T/y	29868 T/y
STORAGE CAPACITY									419 Tons	510 Tons	623 Tons	758 Tons
Total Nber of filling scales									14 scales	18 scales	23 scales	30 scales
12 Kg line carrousel 24 stages-12 scales	scales								12 scales	12 scales	13 scales	16 scales
6 Kg line carousel 12 stages - 8 scales	scales								8 scales	8 scales	8 scales	12 scales
35kg line 2 scales	scales								2 scales	2 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair										Yes	Yes	Yes
Real storage									600 tons		200 tons	

SOUTHERN PROVINCE FILLING PLANT COSTS- USD		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1°) SITTING AND PREPARATION									665 K$			
2°) ROAD, SEWERAGE AND NETWORKS									1467 K$			
3°) CIVIL WORKS									183 K$			
4°) BUILDINGS									504 K$			
5°) STOCKAGE									1202 K$		350 K$	
6°) LOCKSMITHING (SERRURERIE)									59 K$			
7°) VALVES for piping									401 K$		75 K$	
8°) PIPING									767 K$			
9°) ELECTRICITY									713 K$			
10°) EQUIPMENTS												
10-1°) GAS EQUIPMENT									148 K$			
10-2°) FIRE FIGHTING EQUIPMENT									623 K$			
10-3°) COMPRESSED AIR EQUIPMENT									80 K$			
10-4°) FILLING HALL									1233 K$		7 K$	49 K$
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN									8045 K$	0 K$	432 K$	49 K$
11°) ENGINEERING									402 K$	0 K$		
12°) VARIOUS AND FORESSEEN									402 K$	0 K$		
SOUS TOTAL WITHOUT PALETTIZATION									**8850 K$**	**0 K$**	**432 K$**	**49 K$**
13° PALETTIZATION including Palets and truck trasformation									**1 054 K$**			
GRAND TOTAL									**9 904 K$**	**0 K$**	**432 K$**	**49 K$**

WESTERN PROVINCE (MAX CAPACITY 40KT/Y) BAU+HI		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE						12481 T/y	17418 T/y	23705 T/y	17734 T/y	22901 T/y	29004 T/y	35889 T/y
STORAGE CAPACITY						474 Tons	581 Tons	715 Tons	458 Tons	564 Tons	688 Tons	827 Tons
Total Nber of filling scales						12 scales	17 scales	24 scales	18 scales	23 scales	29 scales	36 scales
12 Kg line carrousel 24 stages-12 scales	scales					12 scales	12 scales	14 scales	21 scales	21 scales	21 scales	22 scales
6 Kg line carousel 12 stages - 8 scales	scales					8 scales	8 scales	8 scales	8 scales	8 scales	8 scales	12 scales
35kg line 2 scales	scales					2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair						Yes	Yes	Yes	Yes	Yes	Yes	Yes
Real storage						700 Tons					200 Tons	

WESTERN PROVINCE FILLING PLANT COSTS-USD		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1°) SITTING AND PREPARATION						665 K$						
2°) ROAD, SEWERAGE AND NETWORKS						1467 K$						
3°) CIVIL WORKS						183 K$						
4°) BUILDINGS						504 K$						
5°) STOCKAGE						1381 K$					350 K$	
6°) LOCKSMITHING (SERRURERIE)						59 K$						
7°) VALVES for piping						401 K$					75 K$	
8°) PIPING						767 K$					50 K$	
9°) ELECTRICITY						713 K$						
10°) EQUIPMENTS												
10-1°) GAS EQUIPMENT						148 K$						
10-2°) FIRE FIGHTING EQUIPMENT						623 K$						
10-3°) COMPRESSED AIR EQUIPMENT						80 K$						
10-4°) FILLING HALL						1233 K$		42 K$	49 K$			35 K$
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN						8224 K$	0 K$	42 K$	49 K$	0 K$	475 K$	35 K$
11°) ENGINEERING						411 K$			2 K$			
12°) VARIOUS AND FORESSEEN						411 K$			2 K$			
SOUS TOTAL WITHOUT PALETTIZATION						**9046 K$**	**0 K$**	**42 K$**	**54 K$**	**0 K$**	**475 K$**	**35 K$**
13° PALETTIZATION including Palets and truck trasformation						1 054 K$						
GRAND TOTAL						**10 100 K$**	**0 K$**	**42 K$**	**54 K$**	**0 K$**	**475 K$**	**35 K$**

NORTHERN PROVINCE (MAX CAPACITY 40KT/Y) BAU+HI		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE						13135 T/y	18288 T/y	14304 T/y	18756 T/y	23799 T/y	29331 T/y	34939 T/y
STORAGE CAPACITY						529 Tons	641 Tons	467 Tons	561 Tons	668 Tons	785 Tons	904 Tons
Total Nber of filling scales						13 scales	18 scales	14 scales	19 scales	24 scales	29 scales	35 scales
12 Kg line carrousel 24 stages-12 scales	scales					12 scales	12 scales	12 scales	12 scales	14 scales	17 scales	21 scales
6 Kg line carousel 12 stages - 8 scales	scales					8 scales	8 scales	8 scales	8 scales	8 scales	10 scales	12 scales
35kg line 2 scales	scales					2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair						Yes	Yes	Yes	Yes	Yes	Yes	Yes
Real storage						700 Tons				300 Tons		
NORTHERN PROVINCE FILLING PLANT COSTS-USD		**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
1°) SITTING AND PREPARATION						665 K$						
2°) ROAD, SEWERAGE AND NETWORKS						1467 K$						
3°) CIVIL WORKS						183 K$						
4°) BUILDINGS						504 K$						
5°) STOCKAGE						1554 K$				525 K$		
6°) LOCKSMITHING (SERRURERIE)						59 K$						
7°) VALVES for piping						401 K$				75 K$		
8°) PIPING						767 K$						
9°) ELECTRICITY						713 K$						
10°) EQUIPMENTS												
10-1°) GAS EQUIPMENT						148 K$						
10-2°) FIRE FIGHTING EQUIPMENT						623 K$						
10-3°) COMPRESSED AIR EQUIPMENT						80 K$						
10-4°) FILLING HALL						1233 K$				14 K$	35 K$	42 K$
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN						8397 K$	0 K$	0 K$	0 K$	614 K$	35 K$	42 K$
11°) ENGINEERING						420 K$			0 K$		2 K$	
12°) VARIOUS AND FORESSEEN						420 K$			0 K$		2 K$	
SOUS TOTAL WITHOUT PALETTIZATION						**9237 K$**	**0 K$**	**0 K$**	**0 K$**	**614 K$**	**39 K$**	**42 K$**
13° PALETTIZATION including Palets and truck trasformation						1 054 K$						
GRAND TOTAL						**10 291 K$**	**0 K$**	**0 K$**	**0 K$**	**614 K$**	**39 K$**	**42 K$**

EASTERN PROVINCE (MAX CAPACITY 30KT/Y) BAU+HI		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE								10477 T/y	13894 T/y	18244 T/y	23782 T/y	30633 T/y
STORAGE CAPACITY								393 Tons	468 Tons	561 Tons	678 Tons	821 Tons
Total Nber of filling scales								10 scales	14 scales	18 scales	24 scales	31 scales
12 Kg line carrousel 24 stages-12 scales	scales							10 scales	10 scales	12 scales	14 scales	18 scales
6 Kg line carousel 12 stages - 8 scales	scales							6 scales	6 scales	6 scales	8 scales	10 scales
35kg line 2 scales	scales							2 scales	2 scales	2 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair								Yes	Yes	Yes	Yes	Yes
Real storage								600			300	

EASTERN PROVINCE FILLING PLANT COSTS- USD		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1°) SITTING AND PREPARATION								665 K$				
2°) ROAD, SEWERAGE AND NETWORKS								1 467 K$				
3°) CIVIL WORKS								183 K$				
4°) BUILDINGS								504 K$				
5°) STOCKAGE								1 202 K$			544 K$	
6°) LOCKSMITHING (SERRURERIE)								59 K$				
7°) VALVES for piping								401 K$			75 K$	
8°) PIPING								767 K$				
9°) ELECTRICITY								713 K$				
10°) EQUIPMENTS												
10-1°) GAS EQUIPMENT								148 K$				
10-2°) FIRE FIGHTING EQUIPMENT								623 K$				
10-3°) COMPRESSED AIR EQUIPMENT								80 K$				
10-4°) FILLING HALL								1 233 K$			28 K$	42 K$
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN								8045 K$	0 K$	0 K$	647 K$	42 K€
11°) ENGINEERING								402 K$		0 K$	32 K$	
12°) VARIOUS AND FORESSEEN								402 K$		0 K$	32 K$	
SOUS TOTAL WITHOUT PALETTIZATION								**8850 K$**	**0 K$**	**0 K$**	**712 K$**	**42 K$**
13° PALETTIZATION including Palets and truck trasformation								**1 054 K$**				
GRAND TOTAL								**9 904 K$**	**0 K$**	**0 K$**	**712 K$**	**42 K$**

Table 174. Pallet and cage investment requirements by region and year, High case

High Case	ESTIMATED NUMBER OF PALLETS/YEAR									
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Numbers of Pallets	1,139 palets	356 palets	458 palets	494 palets	599 palets	714 palets	804 palets	937 palets	1,106 palets	1,240 palets
Cost		**$ 143,490.50**	**$ 184,251.59**	**$ 198,666.67**	**$ 240,994.49**	**$ 287,351.62**	**$ 323,548.10**	**$ 377,241.59**	**$ 444,979.84**	**$ 499,280.14**
									Total	**$ 2,699,804.54**

High case	ESTIMATED NUMBER OF CAGES /YEAR										
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Numbers of cages	1 248	271	437	553	580	692	816	907	1 051	1 236	1 384
Cost			**$ 139 840**	**$ 176 960**	**$ 185 600**	**$ 221 440**	**$ 261 120**	**$ 290 240**	**$ 336 320**	**$ 395 520**	**$ 442 880**
										Total	**$ 2 449 920**

Table 175. Transport investment requirements by truck type, region and year, High case

High Case	ESTIMATED BULK PRIMARY TRANSPORT COST										
	2 020	2 021	2 022	2 023	2 024	2 025	2 026	2 027	2 028	2 029	2 030
Number of trucks (Tractor + bulk tank	21 trucks	5 trucks	9 trucks	11 trucks	12 trucks	15 trucks	17 trucks	20 trucks	23 trucks	27 trucks	30 trucks
Cost	$ -	$ -	**$ 1 939 992**	**$ 2 491 081**	**$ 2 685 973**	**$ 3 258 245**	**$ 3 884 994**	**$ 4 374 370**	**$ 5 100 306**	**$ 6 016 127**	**$ 6 750 267**
										Total	**$ 36 501 357**

High Case	ESTIMATED CYLINDER PRIMARY TRANSPORT TRUCKS COST/year										
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
ESTIMATED NUMBER OF CYLINDER PRIMARY TRANSPORT TRUCKS/Year	2 trucks	1 trucks	1 trucks	3 trucks	0 trucks	1 trucks	0 trucks	0 trucks			
ESTIMATED CYLINDER PRIMARY TRANSPORT TRUCKS COST/year	**$ -**	**$ -**	**$ 170 200**	**$ 510 600**	**$ -**	**$ 170 200**	**$ -**	**$ -**			
										Total	**$ 851 000**

74. Infrastructure Details and Costing: NST-1 Target Scenario

The following tables restate and expand upon the regional volumes to be served and associated asset requirements (see Volume 4 for details):

Table 176. Regional LPG volume projections by year, NST-1

NST1 Target	TOTAL VOLUMES CYLINDER + BULK					
	RWANDA	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2020	27,296 T	15,920 T	2,225 T	2,728 T	2,366 T	4,057 T
2021	45,385 T	16,421 T	6,422 T	7,304 T	6,546 T	8,692 T
2022	76,307 T	22,873 T	12,429 T	13,822 T	12,123 T	15,060 T
2023	123,350 T	32,744 T	21,611 T	23,684 T	20,486 T	24,825 T
2024	166,872 T	41,580 T	30,154 T	32,936 T	28,381 T	33,821 T
2025	180,770 T	42,341 T	33,265 T	36,500 T	31,612 T	37,051 T
2026	192,499 T	42,631 T	35,973 T	39,607 T	34,425 T	39,864 T
2027	209,251 T	44,166 T	39,583 T	43,730 T	38,151 T	43,622 T
2028	224,168 T	45,266 T	42,860 T	47,476 T	41,531 T	47,035 T
2029	243,889 T	47,357 T	47,044 T	52,252 T	45,839 T	51,397 T
2030	263,436 T	49,342 T	51,213 T	57,010 T	50,129 T	55,743 T

Table 177. Annual regional LPG cylinder inventory increases, NST-1

	Estimated number of 12kg-eq cylinders to be added annually					
NST1 Target	**Rwanda**	Kigali City	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	122,731 cyl	82,845 cyl	8,219 cyl	10,118 cyl	9,448 cyl	12,101 cyl
2021	442,468 cyl	1,999 cyl	107,812 cyl	117,696 cyl	103,796 cyl	111,164 cyl
2022	738,901 cyl	158,587 cyl	140,935 cyl	155,572 cyl	136,238 cyl	147,570 cyl
2023	1,068,351 cyl	242,604 cyl	201,159 cyl	220,807 cyl	192,280 cyl	211,502 cyl
2024	1,074,747 cyl	213,958 cyl	212,246 cyl	230,437 cyl	195,120 cyl	222,985 cyl
2025	300,326 cyl	4,525 cyl	69,718 cyl	80,460 cyl	74,239 cyl	71,385 cyl
2026	228,509 cyl	302 cyl	53,303 cyl	62,221 cyl	58,445 cyl	54,237 cyl
2027	341,540 cyl	5,941 cyl	79,484 cyl	91,108 cyl	83,168 cyl	81,839 cyl
2028	285,571 cyl	7,518 cyl	65,495 cyl	75,593 cyl	69,760 cyl	67,205 cyl
2029	391,266 cyl	11,886 cyl	90,068 cyl	102,912 cyl	93,427 cyl	92,973 cyl
2030	387,298 cyl	25,671 cyl	85,709 cyl	98,143 cyl	89,362 cyl	88,413 cyl
TOTAL	**5,381,707 cyl**	**755,835 cyl**	**1,114,147 cyl**	**1,245,068 cyl**	**1,105,283 cyl**	**1,161,374 cyl**

Table 178. Annual regional LPG cylinder inventory increases by cylinder size, NST-1

	Estimated number of new cylinders/year																	
	Rwanda			Kigali City			Southern Province			Western Province			Northern Province			Eastern Province		
NST1 Target	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg	6 Kg	12 Kg	35 Kg
2020	39,054	82,052	1,625	26,362	55,387	1,097	2,615	5,495	109	3,220	6,765	134	3,006	6,316	125	3,851	8,090	160
2021	140,797	295,813	5,858	636	1,337	26	34,307	72,078	1,427	37,452	78,686	1,558	33,029	69,393	1,374	35,373	74,319	1,472
2022	235,124	493,995	9,782	50,463	106,024	2,100	44,846	94,222	1,866	49,504	104,008	2,060	43,352	91,083	1,804	46,958	98,658	1,954
2023	339,958	714,249	14,144	77,198	162,193	3,212	64,010	134,486	2,663	70,262	147,621	2,923	61,185	128,549	2,546	67,301	141,400	2,800
2024	341,993	718,525	14,229	68,083	143,042	2,833	67,538	141,898	2,810	73,327	154,060	3,051	62,089	130,448	2,583	70,955	149,077	2,952
2025	95,566	200,784	3,976	1,440	3,025	60	22,185	46,610	923	25,603	53,792	1,065	23,623	49,632	983	22,715	47,725	945
2026	72,713	152,770	3,025	96	202	4	16,961	35,636	706	19,799	41,598	824	18,598	39,074	774	17,259	36,261	718
2027	108,681	228,337	4,522	1,891	3,972	79	25,292	53,139	1,052	28,991	60,911	1,206	26,465	55,602	1,101	26,042	54,714	1,083
2028	90,871	190,919	3,781	2,392	5,026	100	20,841	43,787	867	24,054	50,538	1,001	22,198	46,638	924	21,385	44,930	890
2029	124,504	261,582	5,180	3,782	7,946	157	28,660	60,215	1,192	32,747	68,802	1,362	29,729	62,461	1,237	29,585	62,157	1,231
2030	123,241	258,930	5,127	8,169	17,163	340	27,273	57,301	1,135	31,230	65,614	1,299	28,436	59,744	1,183	28,134	59,109	1,171
TOTAL	1,712,501	3,597,957	71,249	240,513	505,316	10,007	354,530	744,866	14,750	396,190	832,394	16,483	351,710	738,941	14,633	369,558	776,440	15,375

Table 179. Regional LPG filling plant quantities, capacities and scale counts, NST-1

	ESTIMATED YEARLY FILLING CAPACITY					
NST1	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020		Maintaining the existing- filling plant activity				
2021		Maintaining the existing- filling plant activity				
2022	4 Filling Plant	2 Filling Plant	depot	1 Filling Plant	1 Filling Plant	depot
2023	4 Filling Plant	2 Filling Plant	depot	1 Filling Plant	1 Filling Plant	depot
2024	5 Filling Plant	2 Filling Plant	depot	1 Filling Plant	1 Filling Plant	1 Filling Plant
2025	7 Filling Plant	3 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2026	7 Filling Plant	3 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2027	7 Filling Plant	3 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2028	7 Filling Plant	3 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2029	7 Filling Plant	3 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant
2030	8 Filling Plant	4 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant	1 Filling Plant

	ESTIMATED YEARLY FILLING CAPACITY (MT)					
NST1	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	20016 T/y	20016 T/y				
2021	34384 T/y	34384 T/y				
2022	59367 T/y	38315 T/y	depot	10209 T/y	10843 T/y	depot
2023	95962 T/y	57319 T/y	depot	18832 T/y	19811 T/y	depot
2024	131506 T/y	71168 T/y	depot	29457 T/y	18091 T/y	12791 T/y
2025	143763 T/y	77936 T/y	13853 T/y	18290 T/y	19769 T/y	13916 T/y
2026	153813 T/y	83477 T/y	14796 T/y	19552 T/y	21145 T/y	14843 T/y
2027	168709 T/y	91710 T/y	16190 T/y	21419 T/y	23183 T/y	16208 T/y
2028	181724 T/y	98897 T/y	17408 T/y	23051 T/y	24964 T/y	17403 T/y
2029	199340 T/y	108639 T/y	19054 T/y	25257 T/y	27375 T/y	19015 T/y
2030	216700 T/y	118239 T/y	20676 T/y	27431 T/y	29751 T/y	20604 T/y

NST1	ESTIMATED YEARLY FILLING CAPACITY (FILLING SCALES)					
	Rwanda	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	20 Filling scales	20 Filling scales				
2021	34 Filling scales	34 Filling scales				
2022	59 Filling scales	38 Filling scales	depot	10 Filling scales	11 Filling scales	depot
2023	96 Filling scales	57 Filling scales	depot	19 Filling scales	20 Filling scales	depot
2024	132 Filling scales	71 Filling scales	depot	29 Filling scales	18 Filling scales	13 Filling scales
2025	144 Filling scales	78 Filling scales	14 Filling scales	18 Filling scales	20 Filling scales	14 Filling scales
2026	154 Filling scales	83 Filling scales	15 Filling scales	20 Filling scales	21 Filling scales	15 Filling scales
2027	169 Filling scales	92 Filling scales	16 Filling scales	21 Filling scales	23 Filling scales	16 Filling scales
2028	182 Filling scales	99 Filling scales	17 Filling scales	23 Filling scales	25 Filling scales	17 Filling scales
2029	199 Filling scales	109 Filling scales	19 Filling scales	25 Filling scales	27 Filling scales	19 Filling scales
2030	217 Filling scales	118 Filling scales	21 Filling scales	27 Filling scales	30 Filling scales	21 Filling scales

Table 180. Governmental strategic storage capacity requirement by year, at 60 days, NST-1 prior to offsets from private sector logistical and operational storage

NST1	ESTIMATED GOVERNMENT STRATEGIC STORAGE (Tons)
2020	4 636 T
2021	7 564 T
2022	12 718 T
2023	20 558 T
2024	27 812 T
2025	30 128 T
2026	32 083 T
2027	34 874 T
2028	37 361 T
2029	40 647 T
2030	43 906 T

Table 181. Pivate sector strategic storatge offsets in volumes and months

		Estimated yearly stock MT		
		Low interv	High interv	NST1
2024	1/2 Cylinders	9 260 MT	10 210 MT	23 652 MT
	1/2 FP storage	770 MT	830 MT	1 605 MT
	1/2 Bulk trucks	637 MT	713 MT	1 753 MT
	TOTAL	**10 667 MT**	**11 753 MT**	**27 010 MT**
2030	1/2 Cylinders	23 032 MT	28 427 MT	34 912 MT
	1/2 FP storage	1 743 MT	2 080 MT	2 533 MT
	1/2 Bulk trucks	1 854 MT	2 285 MT	2 889 MT
	TOTAL	**26 629 MT**	**32 792 MT**	**40 334 MT**

	Estimated yearly stock in months		
	Low interv	High interv	NST1
2024	1,6 Months	1,6 Months	1,9 Months
2030	1,8 Months	1,8 Months	1,8 Months

	Estimated New strategic storage		
	Low interv	High interv	NST1
2024	9 400 MT	9 800 MT	14 700 MT
2030	18 700 MT	21 300 MT	25 500 MT

Table 182. Regional private sector operational and logistical storage capacities by year, NST-1

	ESTIMATED THEORETICAL LOGISTIC STORAGE CAPACITY FOR CYLINDER ACTIVITY					
NST1	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	385 Tons	385 Tons				
2021	661 Tons	661 Tons				
2022	1 142 Tons	737 Tons		196 Tons	209 Tons	
2023	1 845 Tons	1 102 Tons		362 Tons	381 Tons	
2024	2 529 Tons	1 369 Tons		566 Tons	348 Tons	246 Tons
2025	2 765 Tons	1 499 Tons	266 Tons	352 Tons	380 Tons	268 Tons
2026	2 958 Tons	1 605 Tons	285 Tons	376 Tons	407 Tons	285 Tons
2027	3 244 Tons	1 764 Tons	311 Tons	412 Tons	446 Tons	312 Tons
2028	3 495 Tons	1 902 Tons	335 Tons	443 Tons	480 Tons	335 Tons
2029	3 833 Tons	2 089 Tons	366 Tons	486 Tons	526 Tons	366 Tons
2030	4 167 Tons	2 274 Tons	398 Tons	528 Tons	572 Tons	396 Tons

NST1	ESTIMATED THEORETICAL LOGISTIC CYLINDER+BULK STORAGE CAPACITY					
	Rwanda	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	535 Tons	535 Tons				
2021	873 Tons	873 Tons				
2022	1 456 Tons	790 Tons		311 Tons	355 Tons	
2023	2 347 Tons	1 179 Tons		555 Tons	613 Tons	
2024	3 173 Tons	1 463 Tons		820 Tons	457 Tons	434 Tons
2025	3 476 Tons	1 599 Tons	418 Tons	503 Tons	494 Tons	463 Tons
2026	3 702 Tons	1 711 Tons	443 Tons	534 Tons	525 Tons	489 Tons
2027	4 024 Tons	1 875 Tons	477 Tons	578 Tons	570 Tons	524 Tons
2028	4 311 Tons	2 019 Tons	509 Tons	618 Tons	610 Tons	555 Tons
2029	4 690 Tons	2 213 Tons	549 Tons	669 Tons	663 Tons	596 Tons
2030	5 066 Tons	2 405 Tons	589 Tons	720 Tons	715 Tons	637 Tons

L=logistic S=Strategic	LOGISTIC STORAGE + PRIVATE SECTOR STRATEGIC STORAGE (MT)																					
	2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030	
NST1	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S
KIGALI					1400	4500	1400	4500	1400	4500	2100	6000	2100	6000	2100	6000	2100	7200	2100	7200	3100	7200
SOUTHERN											500	1500	500	1500	500	1500	600	1800	600	1800	600	1800
WESTERN					800	2500	800	2500	800	2500	800	2500	800	2500	800	2500	800	2500	800	2500	800	2500
NORTHERN					700	1900	700	1900	700	1900	700	1900	700	1900	700	1900	700	1900	700	2200	700	2200
EASTERN									500	1500	500	1500	500	1500	500	2000	700	2000	700	2000	700	2000
TOTAL	0	0	0	0	2900	8900	2900	8900	3400	10400	4600	13400	4600	13400	4600	13900	4900	15400	4900	15700	5900	15700

Table 183. Transportation asset requirements by region and year, NST-1

A) Bulk trucks

High interv	ESTIMATED NUMBER OF CYLINDER PRIMARY TRANSPORT TRUCKS/Year					
	Rwanda	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	2 cyl trucks		0,6 cyl trucks	0,0 cyl trucks	0,5 cyl trucks	0,5 cyl trucks
2021	3 cyl trucks		0,8 cyl trucks	0,7 cyl trucks	0,7 cyl trucks	0,6 cyl trucks
2022	4 cyl trucks		1,3 cyl trucks	1,1 cyl trucks	1,1 cyl trucks	0,9 cyl trucks
2023	7 cyl trucks		1,9 cyl trucks	1,6 cyl trucks	1,7 cyl trucks	1,4 cyl trucks
2024	6 cyl trucks		3,6 cyl trucks			1,9 cyl trucks
2025	8 cyl trucks		5,0 cyl trucks			2,6 cyl trucks
2026	7 cyl trucks		6,9 cyl trucks			
2027	9 cyl trucks		9,1 cyl trucks			
2028						
2029						
2030						

B) Cylinder trucks

	ESTIMATED NUMBER OF CYLINDER PRIMARY TRANSPORT TRUCKS/Year					
NST1	**Rwanda**	Kigali city	Southern Province	Western Province	Northern Province	Eastern Province
2019						
2020	0 cyl trucks					
2021	0 cyl trucks					
2022	4 cyl trucks		2,2 cyl trucks			1,6 cyl trucks
2023	7 cyl trucks		4,1 cyl trucks			2,8 cyl trucks
2024	6 cyl trucks		6,4 cyl trucks			
2025	0 cyl trucks					
2026	0 cyl trucks					
2027	0 cyl trucks					
2028	0 cyl trucks					
2029	0 cyl trucks					
2030	0 cyl trucks					

Table 184. Summary investment requirements by asset category, region and year, NST-1 case

COSTS ESTIMATION- INVESTMENT-NST1 TARGET		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	TOTAL
CYLINDERS	**NATIONAL**	**0 $**	**8,161,050 $**	**13,628,584 $**	**19,705,090 $**	**19,823,055 $**	**5,539,337 $**	**4,214,706 $**	**6,299,493 $**	**5,267,185 $**	**7,216,668 $**	**7,143,486 $**	**96,998,654 $**
FILLING PLANTS	**KIGALI**	0 $	0 $	9,046,400 $	0 $	603,900 $	7,000 $	0 $	0 $	275,000 $	0 $	0 $	9,932,300 $
	SOUTHERN	0 $	0 $	9,046,400 $	0 $	0 $	23,100 $	14,000 $	738,100 $	21,000 $	28,000 $	0 $	9,870,600 $
	WESTERN	0 $	0 $	9,046,400 $	0 $	21,000 $	573,100 $	21,000 $	30,800 $	573,100 $	0 $	0 $	10,265,400 $
	NORTHERN	0 $	0 $	8,851,700 $	0 $	7,000 $	1,123,100 $	14,000 $	28,000 $	21,000 $	21,000 $	0 $	10,065,800 $
	EASTERN	0 $	0 $	9,046,400 $	0 $	14,000 $	840,400 $	14,000 $	28,000 $	14,000 $	305,800 $	0 $	10,262,600 $
	TOTAL	**0 $**		**45,037,300 $**	**0 $**	**645,900 $**	**2,566,700 $**	**63,000 $**	**824,900 $**	**904,100 $**	**354,800 $**	**0 $**	**50,396,700 $**
PALLETIZATION	**Palletization in Filling plant**	0 $	0 $	5,670,000 $	120,000 $	0 $	0 $	120,000 $	360,000 $	0 $	0 $	0 $	6,270,000 $
	Pallets in the logistic network	0 $	0 $	460,427 $	674,430 $	655,065 $	225,890 $	185,200 $	274,540 $	239,847 $	324,668 $	319,928 $	3,359,994 $
	TOTAL	**0 $**	**0 $**	**6,130,427 $**	**794,430 $**	**655,065 $**	**225,890 $**	**305,200 $**	**634,540 $**	**239,847 $**	**324,668 $**	**319,928 $**	**9,629,994 $**
STRATEGIC STORAGE	**PRIVATE SECTOR PORTION**	0 $	0 $	15,300,000 $	0 $	750,000 $	2,400,000 $	750,000 $	2,250,000 $	1,500,000 $	0 $	0 $	**22,950,000 $**
BULK PRIMARY TRANSPORT	**NATIONAL**	**0 $**	**0 $**	**6,225,057 $**	**9,118,198 $**	**8,856,502 $**	**3,054,068 $**	**2,503,804 $**	**3,711,849 $**	**3,242,737 $**	**4,389,650 $**	**4,325,296 $**	**45,427,163 $**
CYLINDER PRIMARY TRANSPORT	**NATIONAL**	**0 $**	**0 $**	**0 $**	**0 $**	**0 $**	**0 $**	**0 $**	**0 $**	**0 $**	**0 $**	**0 $**	**0 $**
CAGES	**NATIONAL**	**0 $**	**0 $**	**474,560 $**	**680,000 $**	**689,280 $**	**186,560 $**	**134,080 $**	**225,920 $**	**180,800 $**	**262,720 $**	**248,640 $**	**3,082,560 $**
													228,485,071 $
NATIONAL STRATEGIC STORAGE (GO				**$ 22,742,000**		**$ 32,302,000**						**$ 44,848,000**	**99,892,000 $**
													205,535,071 $
OPTION 2 : STRATEGIC STORAGE				**22,742,000 $**	**15,881,000 $**	**10,869,000 $**			**22,786,000 $**				**72,278,000 $**
OPTION 2 : GRAND TOTAL			**$ 8,161,050**	**$ 94,237,928**	**$ 46,178,718**	**$ 41,538,802**	**$ 11,572,555**	**$ 7,220,790**	**$ 34,482,702**	**$ 9,834,669**	**$ 12,548,506**	**$ 12,037,350**	**277,813,071 $**

Table 185. Cylinder investment requirements by size, region and year, NST-1 case

		Estimated cylinder costs by size, region and year										
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	TOTAL
Rwanda	6 Kg	565,880 $	911,231 $	1,151,476 $	1,208,442 $	1,443,371 $	1,699,789 $	1,890,190 $	2,190,967 $	2,577,690 $	2,884,457 $	16,523,492 $
	12 Kg	1,850,526 $	2,979,887 $	3,765,529 $	3,951,817 $	4,720,076 $	5,558,609 $	6,181,252 $	7,164,848 $	8,429,500 $	9,432,682 $	54,034,725 $
	35 Kg	87,434 $	140,794 $	177,915 $	186,716 $	223,015 $	262,635 $	292,053 $	338,527 $	398,279 $	445,678 $	2,553,047 $
Kigali City	6 Kg	282,092 $	423,320 $	434,836 $	332,253 $	295,409 $	265,532 $	157,999 $	117,469 $	113,263 $	71,463 $	2,493,637 $
	12 Kg	922,490 $	1,384,332 $	1,421,991 $	1,086,526 $	966,041 $	868,335 $	516,685 $	384,145 $	370,391 $	233,695 $	8,154,630 $
	35 Kg	43,586 $	65,407 $	67,187 $	51,336 $	45,644 $	41,027 $	24,412 $	18,150 $	17,500 $	11,042 $	385,292 $
Southern Province	6 Kg	58,165 $	104,801 $	157,120 $	188,900 $	240,973 $	307,561 $	383,480 $	478,455 $	596,791 $	721,665 $	3,237,911 $
	12 Kg	190,210 $	342,717 $	513,809 $	617,738 $	788,025 $	1,005,780 $	1,254,046 $	1,564,633 $	1,951,612 $	2,359,971 $	10,588,539 $
	35 Kg	8,987 $	16,193 $	24,277 $	29,187 $	37,233 $	47,521 $	59,251 $	73,926 $	92,210 $	111,505 $	500,290 $
Western Province	6 Kg	77,439 $	135,303 $	197,222 $	243,170 $	321,471 $	399,417 $	478,393 $	566,287 $	663,878 $	744,630 $	3,827,210 $
	12 Kg	253,240 $	442,464 $	644,950 $	795,209 $	1,051,267 $	1,306,162 $	1,564,430 $	1,851,858 $	2,170,999 $	2,435,070 $	12,515,649 $
	35 Kg	11,965 $	20,906 $	30,473 $	37,572 $	49,671 $	61,714 $	73,917 $	87,497 $	102,576 $	115,053 $	591,343 $
Northern Province	6 Kg	89,853 $	143,891 $	204,497 $	257,187 $	350,058 $	423,579 $	486,122 $	540,924 $	583,579 $	580,778 $	3,660,467 $
	12 Kg	293,836 $	470,549 $	668,740 $	841,045 $	1,144,751 $	1,385,177 $	1,589,705 $	1,768,917 $	1,908,406 $	1,899,246 $	11,970,371 $
	35 Kg	13,883 $	22,233 $	31,597 $	39,738 $	54,087 $	65,447 $	75,111 $	83,578 $	90,169 $	89,736 $	565,579 $
Eastern Province	6 Kg	58,330 $	103,916 $	157,802 $	186,932 $	235,459 $	303,701 $	384,196 $	487,832 $	620,178 $	765,923 $	3,304,268 $
	12 Kg	190,750 $	339,824 $	516,039 $	611,299 $	769,993 $	993,154 $	1,256,387 $	1,595,295 $	2,028,092 $	2,504,701 $	10,805,537 $
	35 Kg	9,013 $	16,056 $	24,382 $	28,883 $	36,381 $	46,925 $	59,362 $	75,375 $	95,824 $	118,343 $	510,543 $
GRAND TOTAL		**2,503,839 $**	**4,031,912 $**	**5,094,919 $**	**5,346,975 $**	**6,386,463 $**	**7,521,032 $**	**8,363,495 $**	**9,694,341 $**	**11,405,469 $**	**12,762,817 $**	**73,111,264 $**

Table 186. Filling plant investment requirements by region and year, NST-1 case

KIGALI (MAX CAPACITY 40KT/Y) NST1		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE				38315 T/y	57319 T/y	71168 T/y	77936 T/y	83477 T/y	91710 T/y	98897 T/y	108639 T/y	118239 T/y
STORAGE				790 Tons	1 179 Tons	1 463 Tons	1 599 Tons	1 711 Tons	1 875 Tons	2 019 Tons	2 213 Tons	2 405 Tons
Total Nber of filling scales				38 scales	57 scales	71 scales	78 scales	83 scales	92 scales	99 scales	109 scales	118 scales
12 Kg line carousel 24 stages - 12 scales	scales			24 scales	24 scales	24 scales	24 scales	24 scales	24 scales	24 scales	24 scales	24 scales
6 Kg line carousel 12 stages - 8 scales	scales			12 scales	12 scales	12 scales	12 scales	12 scales	12 scales	12 scales	12 scales	12 scales
35kg line 2 scales	scales			2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Real storage				700 Tons			700 Tons					1 000 Tons
KIGALI FILLING PLANT COST	**ITEMS**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
1°) SITTING AND PREPARATION				1330 K$			665 K$					665 K$
2°) ROAD, SEWERAGE AND NETWORKS				2934 K$			1467 K$					1467 K$
3°) CIVIL WORKS				366 K$			183 K$					183 K$
4°) BUILDINGS				1008 K$			504 K$					504 K$
5°) STOCKAGE				2762 K$			1381 K$					1902 K$
6°) LOCKSMITHING (SERRURERIE)				118 K$			59 K$					59 K$
7°) VALVES for piping				802 K$			401 K$					401 K$
8°) PIPING				1534 K$			767 K$					767 K$
9°) ELECTRICITY				1426 K$			713 K$					713 K$
10°) EQUIPMENTS												0 K$
10-1°) GAS EQUIPMENT				296 K$			148 K$					148 K$
10-2°) FIRE FIGHTING EQUIPMENT				1246 K$			623 K$					623 K$
10-3°) COMPRESSED AIR EQUIPMENT				160 K$			80 K$					80 K$
10-4°) FILLING HALL				160 K$			80 K$					80 K$
TOTAL WITHOUT ENGINEERING AND & VARIOUS AND FORESSEEN				14142 K$			7071 K$					7592 K$
11°) ENGINEERING				707 K$			354 K$					380 K$
12°) VARIOUS AND FORESSEEN				707 K$			354 K$					380 K$
SOUS TOTAL WITHOUT PALETTIZATION				**15556 K$**			**7778 K$**					**8351 K$**
13° PALETTIZATION including FP Palets and truck trasformation				**2908 K$**	**240 K$**		**1454 K$**		**120 K$**			**1454 K$**
GRAND TOTAL				**18 464 K$**	**240 K$**		**9 232 K$**		**120 K$**			**9805 K$**
PRIVATE SECTOR STRATEGIC STORAGE				**6 750 K$**			**2 250 K$**	**0 K$**		**1 800 K$**		

SOUTHERN PROVINCE (MAX CAPACITY 20KT/Y) NST1		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE							13853 T/y	14796 T/y	16190 T/y	17408 T/y	19054 T/y	20676 T/y
STORAGE CAPACITY							418 Tons	443 Tons	477 Tons	509 Tons	549 Tons	589 Tons
Total Nber of filling scales							14 scales	15 scales	16 scales	17 scales	19 scales	21 scales
12 Kg line carrousel 12 stages-8 scales	scales											
6 Kg line carousel 8 stages - 6 scales	scales											
35kg line 2 scales	scales						2 scales	2 scales	2 scales	2 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair							Yes	Yes	Yes	Yes	Yes	Yes
Real storage							500 tons			100 tons		
SOUTHERN PROVINCE FILLING PLANT COSTS- USD		**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
1°) SITTING AND PREPARATION							665 K$					
2°) ROAD, SEWERAGE AND NETWORKS							1467 K$					
3°) CIVIL WORKS							183 K$					
4°) BUILDINGS							504 K$					
5°) STOCKAGE							1027 K$			175 K$		
6°) LOCKSMITHING (SERRURERIE)							59 K$					
7°) VALVES for piping							401 K$			75 K$		
8°) PIPING							767 K$					
9°) ELECTRICITY							713 K$					
10°) EQUIPMENTS												
10-1°) GAS EQUIPMENT							148 K$					
10-2°) FIRE FIGHTING EQUIPMENT							623 K$					
10-3°) COMPRESSED AIR EQUIPMENT							80 K$					
10-4°) FILLING HALL							1092 K$				7 K$	49 K$
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN							7729 K$		0 K$	250 K$	7 K$	49 K$
11°) ENGINEERING							386 K$		0 K$	13 K$		
12°) VARIOUS AND FORESSEEN							386 K$		0 K$	13 K$		
SOUS TOTAL WITHOUT PALETTIZATION							**8502 K$**		**0 K$**	**275 K$**	**7 K$**	**49 K$**
13° PALETTIZATION including Palets and truck trasformation							**1 054 K$**		**1 054 K$**			
GRAND TOTAL							**9 556 K$**		**1 054 K$**	**275 K$**	**7 K$**	**49 K$**
PRIVATE SECTOR STRATEGIC STORAGE							**2 250 K$**			**450 K$**		

WESTERN PROVINCE (MAX CAPACITY 30KT/Y) NST1		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE				10209 T/y	18832 T/y	29457 T/y	18290 T/y	19552 T/y	21419 T/y	23051 T/y	25257 T/y	27431 T/y
STORAGE CAPACITY				311 Tons	555 Tons	820 Tons	503 Tons	534 Tons	578 Tons	618 Tons	669 Tons	720 Tons
Total Nber of filling scales				10 scales	19 scales	29 scales	18 scales	20 scales	21 scales	23 scales	25 scales	27 scales
12 Kg line carrousel 24 stages-12 scales	scales			12 scales	12 scales	16 scales	16 scales	16 scales	16 scales	16 scales	16 scales	16 scales
6 Kg line carousel 12 stages - 8 scales	scales			8 scales	8 scales	11 scales	11 scales	11 scales	11 scales	11 scales	11 scales	11 scales
35kg line 2 scales	scales			2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Real storage				800 Tons								
WESTERN PROVINCE FILLING PLANT COSTS-USD		**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
1°) SITTING AND PREPARATION				665 K$								
2°) ROAD, SEWERAGE AND NETWORKS				1467 K$								
3°) CIVIL WORKS				183 K$								
4°) BUILDINGS				504 K$								
5°) STOCKAGE				1558 K$								
6°) LOCKSMITHING (SERRURERIE)				59 K$								
7°) VALVES for piping				401 K$								
8°) PIPING				767 K$								
9°) ELECTRICITY				713 K$								
10°) EQUIPMENTS												
10-1°) GAS EQUIPMENT				148 K$								
10-2°) FIRE FIGHTING EQUIPMENT				623 K$								
10-3°) COMPRESSED AIR EQUIPMENT				80 K$								
10-4°) FILLING HALL				1233 K$		54 K$						
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN				8401 K$		54 K$	0 K$	0 K$	0 K$	0 K$	0 K$	0 K$
11°) ENGINEERING				420 K$		3 K$			0 K$			
12°) VARIOUS AND FORESSEEN				420 K$		3 K$			0 K$			
SOUS TOTAL WITHOUT PALETTIZATION				**9241 K$**		**59 K$**	**0 K$**	**0 K$**	**0 K$**	**0 K$**	**0 K$**	**0 K$**
13° PALETTIZATION including Palets and truck trasformation				1 054 K$								
GRAND TOTAL				**10 295 K$**		**59 K$**	**0 K$**	**0 K$**	**0 K$**	**0 K$**	**0 K$**	**0 K$**

PRIVATE SECTOR STRATEGIC STORAGE				**3 750 K$**		**0 K$**			**0 K$**	**0 K$**		

NORTHERN PROVINCE (MAX CAPACITY 30KT/Y) NST1		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE				10843 T/y	19811 T/y	18091 T/y	19769 T/y	21145 T/y	23183 T/y	24964 T/y	27375 T/y	29751 T/y
STORAGE CAPACITY				355 Tons	613 Tons	457 Tons	494 Tons	525 Tons	570 Tons	610 Tons	663 Tons	715 Tons
Total Nber of filling scales				11 scales	20 scales	18 scales	20 scales	21 scales	23 scales	25 scales	27 scales	30 scales
12 Kg line carrousel 24 stages-12 scales	scales			12 scales	12 scales	12 scales	12 scales	12 scales	13 scales	14 scales	15 scales	18 scales
6 Kg line carousel 12 stages - 8 scales	scales			8 scales	8 scales	8 scales	8 scales	8 scales	8 scales	9 scales	10 scales	10 scales
35kg line 2 scales	scales			2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Real storage				700 Tons								
NORTHERN PROVINCE FILLING PLANT COSTS-USD		**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
1°) SITTING AND PREPARATION				665 K$								
2°) ROAD, SEWERAGE AND NETWORKS				1467 K$								
3°) CIVIL WORKS				183 K$								
4°) BUILDINGS				504 K$								
5°) STOCKAGE				1381 K$								
6°) LOCKSMITHING (SERRURERIE)				59 K$								
7°) VALVES for piping				401 K$								
8°) PIPING				767 K$								
9°) ELECTRICITY				713 K$								
10°) EQUIPMENTS												
10-1°) GAS EQUIPMENT				148 K$								
10-2°) FIRE FIGHTING EQUIPMENT				623 K$								
10-3°) COMPRESSED AIR EQUIPMENT				80 K$								
10-4°) FILLING HALL				1233 K$					7 K$	7 K$	14 K$	21 K$
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN				8224 K$		0 K$	0 K$	0 K$	7 K$	7 K$	14 K$	21 K$
11°) ENGINEERING				411 K$		0 K$			0 K$		1 K$	
12°) VARIOUS AND FORESSEEN				411 K$		0 K$			0 K$		1 K$	
SOUS TOTAL WITHOUT PALETTIZATION				**9046 K$**		**0 K$**	**0 K$**	**0 K$**	**8 K$**	**7 K$**	**15 K$**	**21 K$**
13° PALETTIZATION including Palets and truck trasformation				1 054 K$								
GRAND TOTAL				**10 100 K$**		**0 K$**	**0 K$**	**0 K$**	**8 K$**	**7 K$**	**15 K$**	**21 K$**

PRIVATE SECTOR STRATEGIC STORAGE				**2 850 K$**							**450 K$**	

EASTERN PROVINCE (MAX CAPACITY 20KT/Y) NST1		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ANNUAL TONNAGE						12791 T/y	13916 T/y	14843 T/y	16208 T/y	17403 T/y	19015 T/y	20604 T/y
STORAGE CAPACITY						434 Tons	463 Tons	489 Tons	524 Tons	555 Tons	596 Tons	637 Tons
Total Nber of filling scales						13 scales	14 scales	15 scales	16 scales	17 scales	19 scales	21 scales
12 Kg line carrousel 12 stages-12 scales	scales					12 scales	12 scales	12 scales	12 scales	12 scales	12 scales	12 scales
6 Kg line carousel 8 stages - 8 scales	scales					8 scales	8 scales	8 scales	8 scales	8 scales	8 scales	8 scales
35kg line 2 scales	scales					2 scales	2 scales	2 scales	2 scales	2 scales	2 scales	2 scales
Maintenance: retesting, painting, cold repair						Yes	Yes	Yes	Yes	Yes	Yes	Yes
Real storage						500 tons				200 tons		
EASTERN PROVINCE FILLING PLANT COSTS- USD		**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
1°) SITTING AND PREPARATION						665 K$						
2°) ROAD, SEWERAGE AND NETWORKS						1 467 K$						
3°) CIVIL WORKS						183 K$						
4°) BUILDINGS						504 K$						
5°) STOCKAGE						1 027 K$				350 K$		
6°) LOCKSMITHING (SERRURERIE)						59 K$						
7°) VALVES for piping						401 K$				75 K$		
8°) PIPING						767 K$						
9°) ELECTRICITY						713 K$						
10°) EQUIPMENTS												
10-1°) GAS EQUIPMENT						148 K$						
10-2°) FIRE FIGHTING EQUIPMENT						623 K$						
10-3°) COMPRESSED AIR EQUIPMENT						80 K$						
10-4°) FILLING HALL						1 092 K$						
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN						7729 K$		0 K$	0 K$	425 K$	0 K$	0 K€
11°) ENGINEERING						386 K$		0 K$		21 K$	0 K$	
12°) VARIOUS AND FORESSEEN						386 K$		0 K$		21 K$	0 K$	
SOUS TOTAL WITHOUT PALETTIZATION						**8502 K$**		**0 K$**	**0 K$**	**468 K$**	**0 K$**	**0 K$**
13° PALETTIZATION including Palets and truck trasformation						**1 054 K$**						
GRAND TOTAL						**9 556 K$**		**0 K$**	**0 K$**	**468 K$**	**0 K$**	**0 K$**
PRIVATE SECTOR STRATEGIC STORAGE						**2 250 K$**			**750 K$**			

Table 187. Pallet and cage investment requirements by region and year, NST-1 case

NST1 Target	ESTIMATED NUMBER OF PALLETS/YEAR										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Numbers of Pallets		1,574 palets	1,144 palets	1,676 palets	1,627 palets	561 palets	460 palets	682 palets	596 palets	807 palets	795 palets
Cost			**$ 460,427**	**$ 674,430**	**$ 655,065**	**$ 225,890**	**$ 185,200**	**$ 274,540**	**$ 239,847**	**$ 324,668**	**$ 319,928**
										Total	**$ 3,359,994**

NST1 Target	ESTIMATED NUMBER OF CAGES/YEAR										
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Numbers of cages	1,249	885	1,478	2,136	2,150	600	457	683	572	782	775
Cost			$ 472,960	$ 683,520	$ 688,000	$ 192,000	$ 146,240	$ 218,560	$ 183,040	$ 250,240	$ 248,000
										Total	**$ 3,082,560**

Table 188. Transport investment requirements by truck type, region and year, NST-1 case

NST1 Target	ESTIMATED BULK PRIMARY TRANSPORT COST										
	2,020	2,021	2,022	2,023	2,024	2,025	2,026	2,027	2,028	2,029	2,030
Number of trucks (Tractor + bulk tank	21 trucks	16 trucks	28 trucks	41 trucks	39 trucks	14 trucks	11 trucks	17 trucks	14 trucks	20 trucks	19 trucks
Cost	**$ -**	**$ -**	**$ 6,224,976**	**$ 9,118,287**	**$ 8,856,481**	**$ 3,054,034**	**$ 2,503,898**	**$ 3,711,780**	**$ 3,242,729**	**$ 4,389,514**	**$ 4,325,425**
										Total	**$ 45,427,124**

NST1 Target	ESTIMATED CYLINDER PRIMARY TRANSPORT TRUCKS COST/year										
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
ESTIMATED NUMBER OF CYLINDER PRIMARY TRANSPORT TRUCKS/Year	0 trucks	0 trucks	0 trucks	0 trucks	0 trucks	0 trucks	0 trucks				
ESTIMATED CYLINDER PRIMARY TRANSPORT TRUCKS COST/year	$ -	$ -	$ -	$ -	$ -		$ -				
										Total	**$ -**

75. Filling Plant and Storage Sizing, Costing and Technical Data

Sizing a filling plant

To maximize safety, industry experience in SSA and worldwide has demonstrated that industrial-grade filling facilities provide a far greater level of safety performance of the filling and storage equipment and operations, and a profoundly superior safety track record with respect to inspection and maintenance of cylinders. In addition, there are significant economies of scale associated with filing facilities. The capex per tonne of a medium to large-sized plant can be as little as half that of a small sized plant, and there are opex advantages as well.

This means that it is better to have a large filling plant with well-designed facilities and highly trained and supervised staff, in accordance with applicable standards, safety requirements, rigorous maintenance programs and the skills of operators than several small, less well-equipped and less-managed filling facilities.

The filling plant must be constructed or transformed for at least 4 years' projected volume. A filling plant with a nominal filling capacity of X tpa could perform a filling capacity of 2X tpa by working in two labor shifts. It could be pushed to 2.5X tpa working in 3 shifts, but this is not practical or prudent to do on a sustained basis.

When the regional market served by a plant reaches sufficient volume, or when the existing filling capacity is saturated, then a second filling plant must be added, or the first plant expanded. The world's largest filling plants (in Asia) serve over one million customers each.

The key investment strategy question is: what volume justifies a new filling plant vs. a distributed cylinder depot (warehouse)?

Two categories of criteria lead to the decision for put up a new filling plant:

- Maximizing safety
- Cost effectiveness for the volume to be served

The safety criteria

This safety criteria require certain minimum investments and costs in the filling plant, in cylinder maintenance, and in management and staff and their training. These are semi-fixed costs, which means that only at a certain size of plant or above can these essential costs be financially covered by the plant's income.

Investing in a filling facility without worrying about safety and cylinder maintenance, taking into account only profit creiteria, leads to the risk of serious accidents that may increase public distrust of LPG and encourage illegal cross-filling by competitors who never invest in safety at all.

As example, countries such as Ghana[148] and Cameroon that have allowed cylinder filling facilities without strong safety environments, cylinder maintenance and safety management have had to revise their national

---

148 See http://www.npa.gov.gh/news/gas-explosion-and-fire-incident-at-the-louis-gas

filling and cylinder models (to adopt or strengthen BCRM), their rules and and their standards and requirements following numerous serious accidents.

The cost-effectiveness criteria

The decision to put a filling plant in a geographic area must weigh the cost of bulk transport to the plant on the one hand, against the massive transport of cylinders[149] into the area on the other hand, to which must be added warehouse costs.

Cost comparison of a filling plant versus massive cylinders transport

Filling costs are made up of fixed and variable costs associated with the production volume.

An estimated filling cost is in a range of US $35 to 77 USD/MT[150] depending on the volume. Filling costs decrease with incresing volumes. The relative share of staff costs in the overall cost is about 1/6, 1/3 is for depreciation costs, and 1/2 for other fixed costs.

For example, an increase in production of 20,000 to 25,000 MT/year for a filling plant designed for this range will have a small impact on costs. The cost of staff, depreciation and other fixed costs are not particularly affected by changes in volume if the filling plant is able to absorb the production increase.

The impact of all staff (management, filling, safety) are synthesized in this table. The details of this calculation is given later in the Annxes.

Table 189. Filling plant staff costs by plant size

Staff cost	Annual tonnage			
	Approx 7 KT/y	Approx 18 KT/y	Approx 24 KT/y	Approx 35 KT/y
Typical Filling plant	7,08 $/Tons	3,12 $/Tons	3,01 $/Tons	2,49 $/Tons
Typical Filling plant with palleztization	7,08 $/Tons	2,93 $/Tons	2,72 $/Tons	2,13 $/Tons

Massive cylinder transport (in place of an in-region filling plant) costs approximately double the cost of bulk primary transport of the same LPG volume. The difference between cylinder transport and bulk primary transport cost is approximately as follows[151]:

[149] The mass transport of cylinders is done with semi-trailers capable of loading 900 cylinders or about 10 to 11 tons of product compared to the bulk primary transport of product that is done with 20-24T semi-trailers.

[150] Benchmarks include: Congo GPLSA = 40€/T; Morocco SalamGaz = 32 to 55€/T; Morocco TOTAL = 30 to 60€/T

[151] Refer to the Section titled *Transport cost recovery* at the end of this Chapter.

Table 190. Filling plant vs. cylinder transport cost tradeoffs by distance

In USD- Delta Cylinder transport cost- bulk primary transport cost Transport go and back 900 cyl 12Kg Equ	Distance Filling plant -Cylinder wharehouse	$/ton
	100 km	8,228 $/Ton
	200 km	16,456 $/Ton
	300 km	24,684 $/Ton

based on 1,15 =1€

The installation of a delocalized warehouse for 5-10 KT/y volume would cost some US $3-5/MT.

Based on the foregoing information, in a new catchment region, if the volumes are less than 10,000-15 000 MT/year, it will cost more to build a small filling plant than make a cylinder transport to a regional warehouse if the distance is below 300km.

Note: This is true when the filling plant can absorb the added production for the new area without an expansion investment.

Filling plant design

The filling plant layout

Main areas constituting the LPG filling plant

The Filling Plant layout must contain the following identified main areas and zones:

- The industrial fence of the filling plant, defining the area in which all the safety and security rules apply under the supervision of the Filling Plant manager. The fence must be more than 2.5m high, with preferably only one entry/exit gate for any persons or vehicles. Another gate should be dedicated for safety evacuation.
- The vehicle parking and roadways for LPG bulk trucks, for cylinder delivery trucks, and for personal vehicles. These areas must be located outside the immediate industrial fence of the filling plant.
- The LPG storage tanks area
- The bulk LPG truck unloading area
- The weighbridge for reception of LPG from the bulk trucks
- The LPG pumps and the LPG compressors for discharging the trucks
- The LPG cylinders filling hall and maintenance area
- The storage areas for refilled and empty LPG cylinders in pallets
- Identified LPG hazardous areas or risk zones (Z0-Z1-Z2)
- The water fire-fighting system: piping, storage, water pumps, sprinklers, hydrants, monitors, hoses
- The flame detectors, the gas detectors, and the alarm button network connected to the safety management system
- The emergency power generator, control and lighting distribution
- The compressed air pipe network
- The lightning protection system
- The freshwater pipe network
- The wastewater evacuation network

- The buildings: offices; guard house; utility building

Rules applicable for land selection and siting of any filling plant

LPG being highly flammable, filling plants must be located at a safe remove from the public and from property that could be damaged by a fire or explosion.

The appropriate conditions for siting are be as follows:

i. The most-preferred area to locate such a facility is an Industrial Area. Even when located in an Industrial Area, a risk assessment survey describing the impact of any accident or event in the Filling Plant on the environment could be required, to adjust the technical and safety features of the layout in order to minimize the impact by reducing the risk zones.

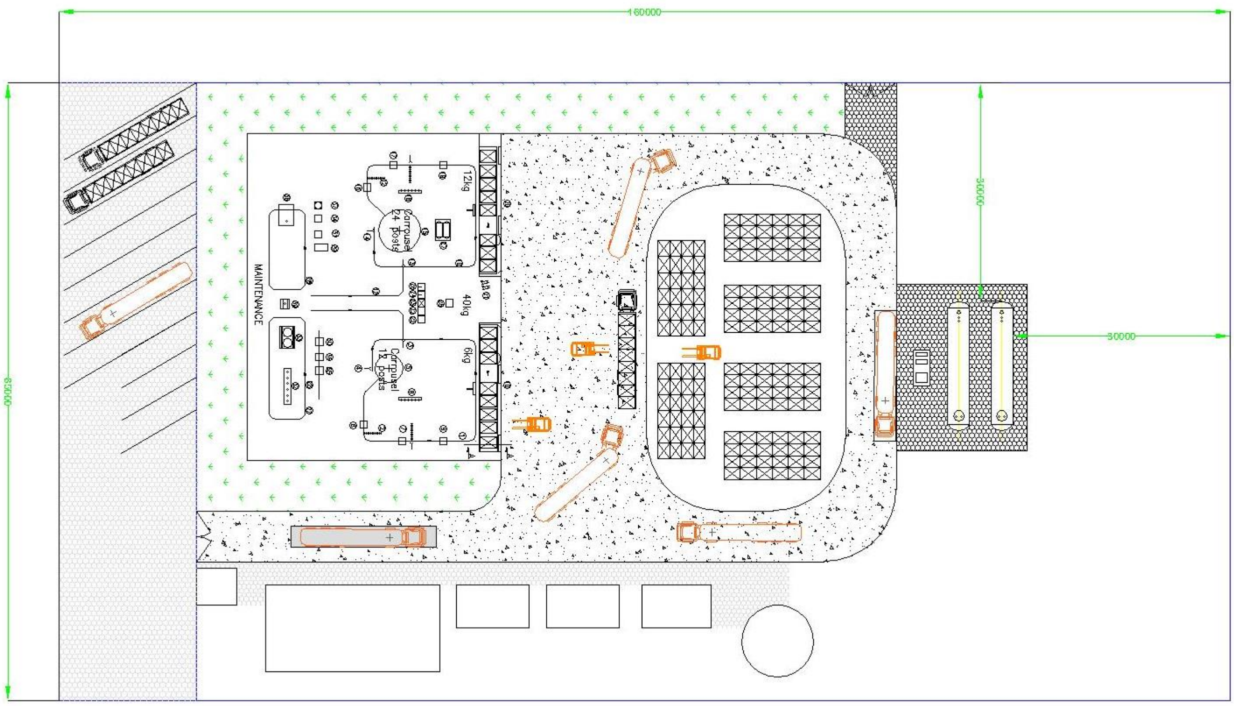
ii. The second preferred location is a Virgin Area where there is no habitation close by, within 500m from the fence of the plot. After the filling plant is constructed and the permit of operation is awarded, the owning Marketer should have the legal right to oppose any permit of construction at a distance less than 500m from the fence.

iii. The permit to construct a Filling Plant must not be given for sites located:
   a. In a Residential Area
   b. In a Mixed-Use Area or Commercial Area
   c. Close to ecologically sensitive areas and public places, such as dumpsites, landfills, hospitals, shopping malls, markets, schools, houses of worship, etc.
   d. With any ditches in the surrounding areas within 15m of the storage area, to avoid settling of LPG vapour

iv. Regulatory agencies shall play a key role in Site Recognizance Surveying and Selection (SRSS) prior to site acquisition by the project developer

v. Health, Safety, Security and Environmental (HSSE) considerations for determining plot size appropriate for locating a Filling Plant shall be as follows:
   a. The quantity in tonnes of LPG to be stored in the Bulk Tanks
   b. The filling capacity in tonnes per year (assuming one shift), expressing the flow of liquid transfer (both for the filling and for the truck offloads) and taking into account the risks associated with the flow of LPG
   c. Layout of the facility, which should be in accordance with separation distances specified in the LPG Safety Book
   d. Provision of land necessary for any future expansion of the cylinder filling capacity and of the storage capacity
   e. A description of the Safety Management System and risk avoidances/mitigations
   f. The determination of the 3 risk zones, Z0, Z1, Z2
   g. A description of the fire-fighting system and water flow capability. The site should have access to water either naturally at the site or at a reasonable distance, to refill the water storage quickly for firefighting
   h. The risk assessment survey, include assessment of the impacts of an accident on the environment, as necessary
   i. Future expansion of the facility

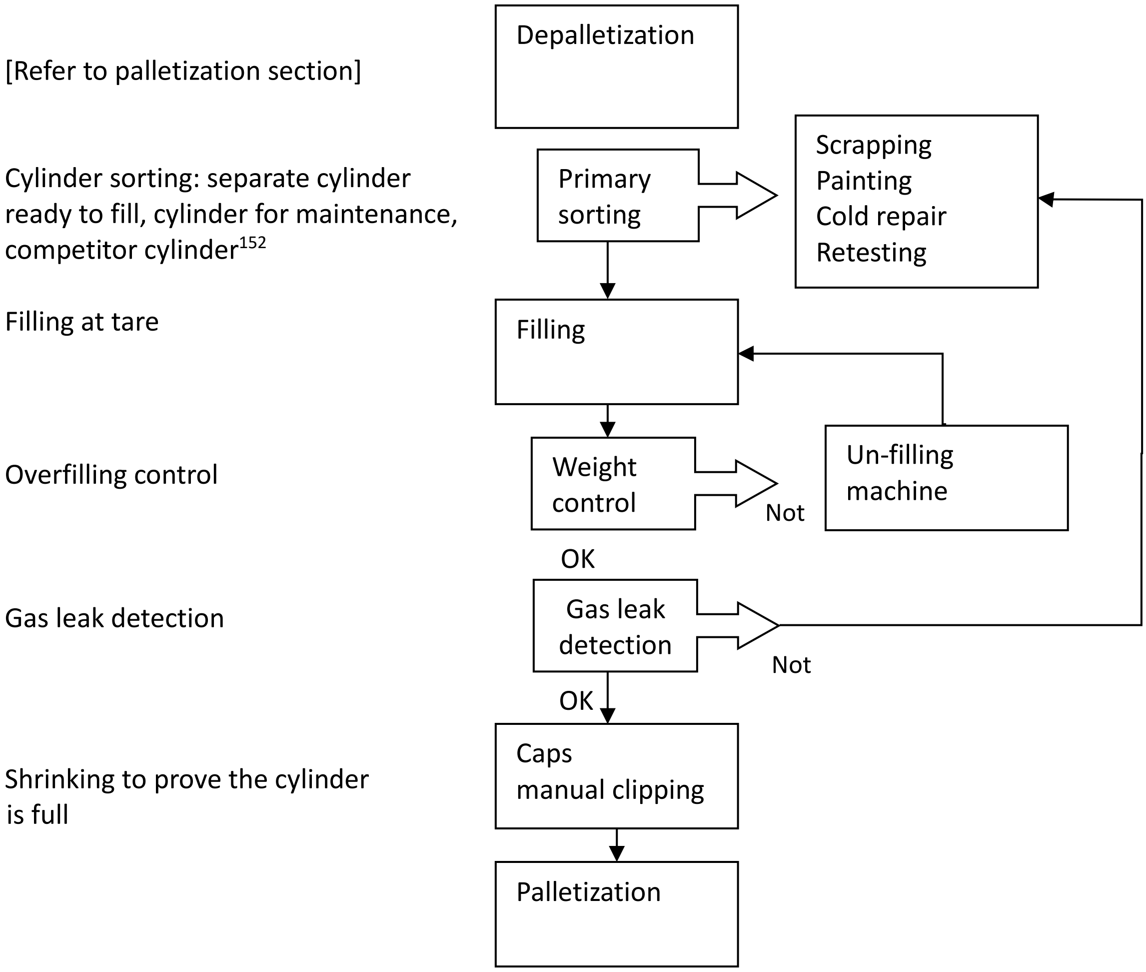
Figure 67. Representative filing plant site layout



Process in filling hall

Two processes have to be considered in the filling hall: the cylinder filling and the cylinder maintenance. These processes cannot be dissociated, because filling without maintenance may cause defective cylinders to be released to users and in addition may worsen the condition of the cylinder, which can lead to accidents in the wost case, and to a reduction in the cylinder’s lifespan in any case.

The typical cylinder filling process schema os:



Cylinder maintenance process

When cylinder arrives in the maintenance zone, depending on the type of repair, the cylinder will be degassed.

- Maintenance of the body of the cylinder

  The cylinder to be repaired would be processed in accordance with maintenance criteria

  Foot or collar deformation ➔ machine to straighten feet and collars (cold repair)

  Body deformation ➔ following criteria, go to scrap or hot repair

---

152 Competitors' cylinders would be present either (1) under a contract for hosted refilling, or (2) due to a mistake (or an illegal act) by the Distributor. In the first case, the cylinder would be refilled in the plant per the contract terms, regulations and LPG Safety Book. In the second case, it would be reported to the authorities, the Distributor sanctioned, and the cylinder made available to its rightful owner for return or collection.

- Maintenance of the valve
  Valve change after degassing
- Cylinder to be retested
- Cylinder to be repainted (commercial painting)

Cylinder filling performance

The following are examples of filling performance per machine:

Table 191. Cylinder filling equipment types and performance

6 Kg cylinders	Performances in cyl/h
Stationnary scales	120 cyl/h
4 scales in line	440 cyl/h
Carousel 8 stages-8 scales	800 cyl/h
Carousel 12 stages-12 scales	1200 cyl/h

12 Kg cylinders	Performances in cyl/h
Stationnary scales	60 cyl/h
4 scales in line	200 cyl/h
Carousel 12 stages-12 scales	600 cyl/h
Carousel 18 stages- 18 scales	900 cyl/h
Carousel 24 stages- 24 scales	1200 cyl/h

40 Kg cylinders	Performances in cyl/h
Stationnary scales	15 cyl/h
4 scales in line	80 cyl/h

Palletization

Palletization refers to loading, unloading and transporting cylinders in pallets (or lockers) specially designed for handling by forklifts.

The pallets

The design of cylinder transport pallets was created by BUTAGAZ in the 1960s. At that time, the company was called the Union Rational des Gaz, and a number of international patents were filed under the name URG. At the global level, there are no longer any companies that have been totally or partly inspired by the design of these pallets.

In domestic cylinders with a diameter of 300/310 mm, the outer dimensions of the base of 2200 mm x 1600 mm have become a standard. The capacity is 7 rows of 5 cylinders (i.e., 35 cylinders).

A steel or composite fiber closure bar with different locking modes closes each of the two open faces.

Benefits of palletization:

Transportation: It can be said without reservation that pallet transport is the safest available. The transport of standing cylinders protects the latter from damage to the valve during transport, especially for cylinders transported without a protective cap or collar. The cylinders are thus protected until delivery to the retailer. In a traffic accident, falling cylinders and cutting the valve can be catastrophic.

Cylinder handling: Cylinders are no longer handled by operators but by forklifts and under the filling hall, by the palletizer. This significantly reduces the loading and unloading time of trucks. A single forklift operator with trolley is sufficient to handle the pallets for a line at 1,200 cylinders/h.

Storage in filling plants and distributors: The ability of pallets to be germinated allows storage of up to 8 heights of empty cylinders or 5 heights of full cylinders, or more than 79 cylinders per square meter.

Stock tool: A stock tool of palletized cylinders allows the operator to be able to prevent any momentary shutdown of production and the sudden influx of trucks, and to avoid load failures during frequent changes of Marketers. In Marketers' warehouses, cylinders can be handled either by hand or with forklifts.

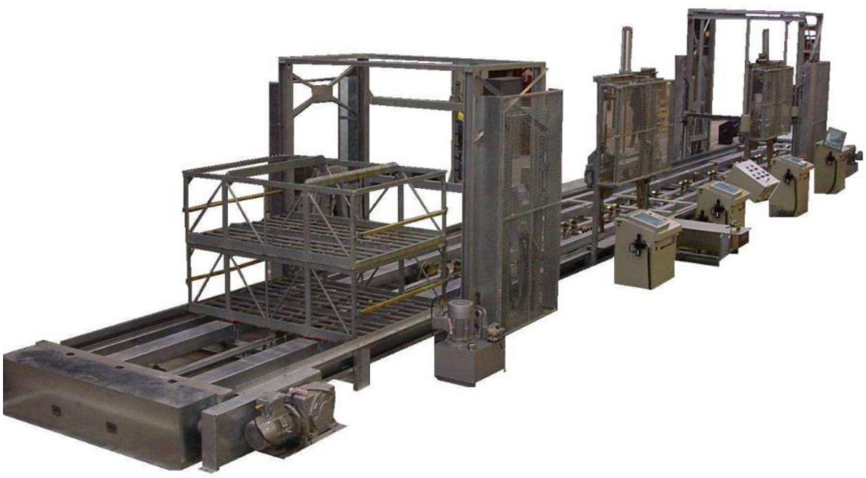
Specialized trucks: Pallet trucks receive specific equipment that virtually no longer allows them to transport other goods; this is a guarantee of safety that allows the operator better control of the truck fleet that circulates in its facilities. (Note that trucks and forklifts are subject to very specific regulations.)

Economics: There are many savings from palletization:

1. Economy of personnel for handling, 1 operator easily replaces 4 handlers.
2. Economy on cylinder maintenance: less shocks on the whole cylinder, no valve deterioration, so fewer cylinders requiring maintenance.
3. Economy due to better productivity of the filling line: No truck waiting, no loss of production during truck manoeuvres, so a steady supply of cylinders to the line.

The palletizer's technique

This is the first and last machine in the filling chain. It can be equipped with various accessories making the loading/unloading operation fully automatic when the pallets are equipped with cable bars. Complemented by a stacker/un-stacker (gerbeuse-dégerbeuse in French), it is able to produce 2400 bt/h with one or two forklifts depending on the



distances to be travelled between the filling hall and the storage areas.

The machine above is fully automatic. A stack of 4 pallets is deposited by the operator at the farthest end on this view. The pallets are transferred by two parallel chains to different stations or perform the following operations:

- Battery de-icing
- Automatic lift of the closing bar
- Unloading empty cylinders and lowering the bar
- Automatic lift of the closing bar
- Loading full cylinders and lowering the bar
- Stacking of 2 or 3 pallets
- Removal of the stack by the busman.

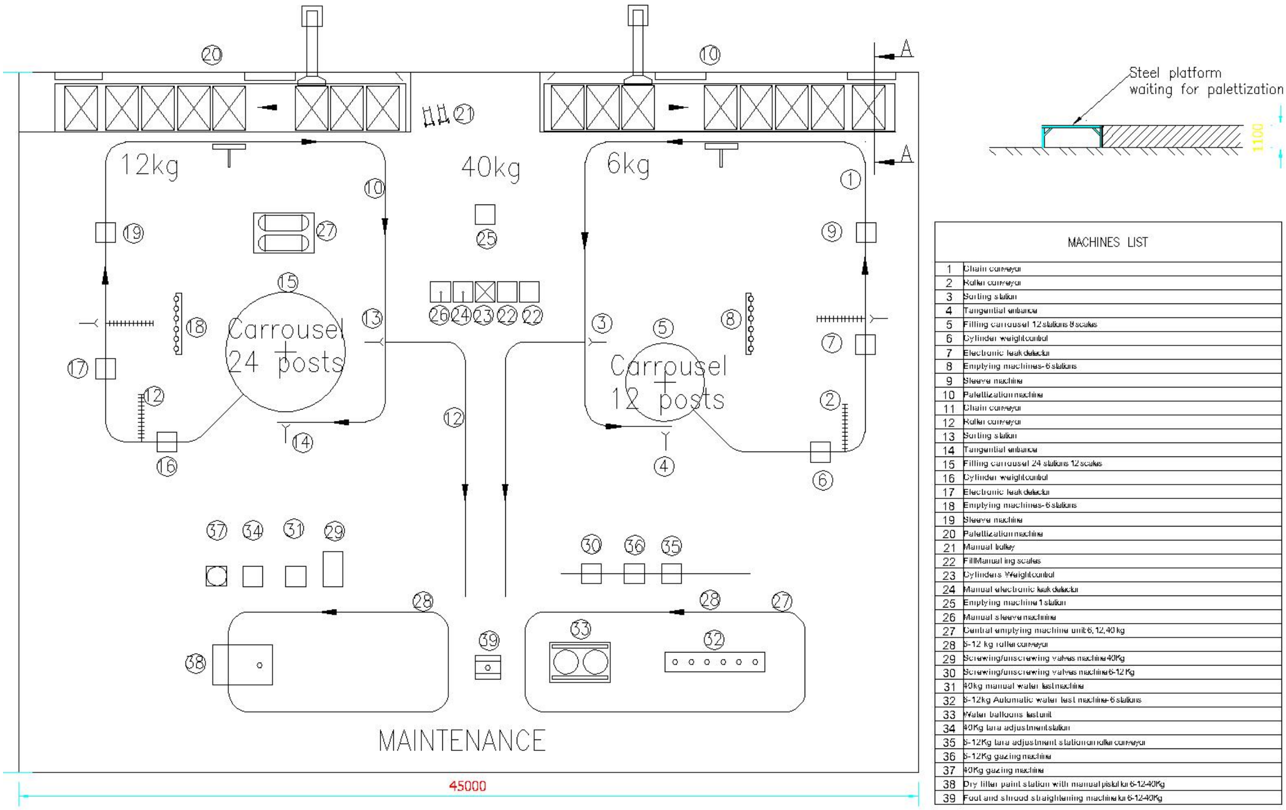
Financial considerations

Table 192. Costs and economic benefits of palletization

	PALLETIZATION	Unit Price	Total price
CAPEX	Cost of investment palletizer 11 lockers		165 000 €
	Cost of investment palletizer 5 lockers		70 000 €
	Pallets:		
	· Stock tool plant filler: 115 pallets x 350	350,00 €	40 250 €
	· Stock tool warehouse marketer and rolling: 115 pallets x 350	350,00 €	40 250 €
	Forklift		50 000 €
	Gain on the quality of the cylinder: it can easily be said that the gain on the life of the cylinder is multiplied by 2: Life of a cylinder 10 years: 2 years gain over the life to be pessimistic. A palletizer processes 20,000 tons per year, the equivalent of 670,000 cylinders processed with a rotation of 2 Or a CAPEX saving of 670,000 cylinders x 25 € / 0.2		- 3 350 000 €
OPEX /Day	Productivity gain per day filling hall: avoids load breaks (30 minutes/charge break x 8/day)- 4 hours of filling: 4 x 11.25Tx24		- 1 080 €
	Truck load productivity gain:		
	· 1h x 8 people x 8h- 1.4 x8-11.2	1,40 €	- 11 €
	· Truck immobilization: 1hx100	100,00 €	- 100 €
	Cartist's extra cost: $14/d	14,00 €	14 €
		TOTAL OPEX/day	- 1 177 €

OPEX/Y		TOTAL OPEX/Y	- 353 160 €

Figure 68. Representative filling hall layout



Filling plant costing

Key assumptions

The following costs are not included:

- The cost of land
- The extra cost in relation with bad condition of the soil
- The access road

Utilities (fresh water, electricity) need to be in proximity of the site.

Main characteristics:

- International standard
- 2x50T cigar tanks (propane capable)
- 1 truck loading/unloading bay
- 1 filling hall equipped with
  - 6 kg : 1 carousel 12 stages - 8 scales
  - 12 kg : 1 carousel 24 stages - 12 scales
  - 40 kg : 2 manual scales
  - Maintenance, painting and retesting
- Automatic valves on all storage liquid valves, on loading bay, at the entrance of hall
- Fire water network at 10.2l/m²/min.

Estimated costs

Table 193. Rwanda standard LPG filling plant cost estimate
(for approximately 22 KT/year of throughput)

RWANDA-STANDARD FILLING PLANT-ESTIMATED COST FOR 22KT/year Excluded land, access road- geotechnical conditions are standard		
ITEMS	ITEMS	COSTS
1°) SITTING AND PREPARATION		648 K$
2°) ROAD, SEWERAGE AND NETWORKS		1 430 K$
3°) CIVIL WORKS		178 K$
4°) BUILDINGS		491 K$
5°) STOCKAGE (aerial type)	400 MT	966 K$
6°) LOCKSMITHING (SERRURERIE)		58 K$
7°) VALVES for piping		391 K$
8°) PIPING		748 K$
9°) ELECTRICITY		699 K$
10°) EQUIPMENTS		0 K$
10-1°) GAS EQUIPMENT		144 K$
10-2°) FIRE FIGHTING EQUIPMENT		607 K$
10-3°) COMPRESSED AIR EQUIPMENT		78 K$
10-4°) FILLING HALL		1 064 K$
TOTAL WITHOUT ENGINEERING AND et VARIOUS AND FORESSEEN		**7 501 K$**
11°) ENGINEERING		375 K$
12°) VARIOUS AND FORESSEEN		375 K$
SOUS TOTAL		**8 251 K$**
13°) PALETS (calculated for approx 80 000 cyl)		1 417 K$
GRAND TOTAL		**9 668 K$**

Costing of filling plant staff (based on filling plant size)

The following is an estimate of the standard staff requested to operate a filling plant in safe operational conditions:

Based on staff cost:

	USD/y
Annual cost: manager	$ 10 000,00
Annual cost :middle management	$ 3 700,00
Annual cost :Accountant	$ 3 700,00

Management staff	Annual tonnage			
	5-10KT/y	10-25KT/y	25-35KT/y	35-50KT/y
Manager	1	1	1	1
Manager assistant	1	1	1	1
Accounting	2	2	3	3
Safety management	1	1	1	1
Miscellaneous	1	1	2	2
Maintenance	2	2	3	4
Guards	4	4	4	6
Total number	12	12	15	18
Estimated cost	$ 38 700,00	$ 38 700,00	$ 49 800,00	$ 54 900,00

Cylinder filling hall staff	12kg cylinders with clip—on valve						
	4 scales online	Carrousel		Carrousel		Carrousel	
	200 cyl/h	12 scales-600cyl/h		18 scales-900cyl/h		24 scales-1200cyl/h	
	4032 Tons/Year	12096 Tons/Year		18144 Tons/Year		24192 Tons/Year	
Palletization	No	Yes	No	Yes	No	Yes	No
Unloading cyl	2	1	4	1	6	1	8
Sorting cyl		1	1	1	1	1	1
Carrousel entrance		1	1	1	1	1	1
Carrousel outlet		0	0	1	1	1	1
Scales on line	1						
Weight control+elec leak detector test	1	1	1	1	1	1	1
Thermo sleeve	1	1	1	1	1	1	1
Loading cyl	2	1	4	1	6	1	8
Leaking (Cyl + valve)	1	1	2	2	2	2	2
Forklift	0	2	0	2	0	2	0
TOTAL	8	9	14	11	19	11	23

Cylinder filling hall staff	6kg cylinders with clip—on valve						
	Single scale	2single scales	4 scales online	Carrousel		Carrousel	
	120	240	440	8 scales- 800cyl/h		12 scales- 1200cyl/h	
	1210 Tons/Year	2419 Tons/Year	4435 Tons/Year	800 Tons/Year		12096 Tons/Year	
Palletization			No	Yes	No	Yes	No
Unloading cyl	1	1	2	1	4	2	8
Sorting cyl				1	1	1	1
Carrousel entrance				1	1	1	1
Carrousel outlet				0	0	1	1
Scales on line	1	1	1				
Weight control+elec leak detector test	1	1	1	1	1	1	1
Thermo sleeve			1	1	1	1	1
Loading cyl		1	2	1	4	2	8
Leaking (Cyl + valve)	0	0	1	1	2	2	2
Forklift	0	0	0	2	0	2	0
TOTAL	3	4	8	9	14	13	23
Estimated cost	$ 2 100,00	$ 2 800,00	$ 5 600,00	$ 6 300,00	$ 9 800,00	$ 9 100,00	$ 16 100,00

Cylinder filling hall staff	Large capacity cylinders		
	1single scale	2single scales	4 scales online
	15 cyl/h	30 cyl/h	80 cyl/h
	1008 Tons/Year	2016 Tons/Year	5376 Tons/Year
Filling cycle	1	2	2
Leaking (Cyl + valve)	0.5	1	2
TOTAL	1,5	3	4
Estimated cost	$ 1 050,00	$ 2 100,00	$ 2 800,00

Typical Filling plant Without palletization	Annual tonnage			
	Approx 7 KT/y	Approx 18 KT/y	Approx 24 KT/y	Approx 35 KT/y
12 kg	4 scales on line	Carrousel 12 scales	Carrousel 12 scales	Carrousel 18 scales
6 Kg	2 single scales	4 scales on line	Carrousel 8 scales	Carrousel 12 scales
40Kg	1 single scale	2 single scales	4 scales on line	4 scales on line
Managment cost	$ 38 700,00	$ 38 700,00	$ 49 800,00	$ 54 900,00
Filling cost without palettization	$ 10 850,00	$ 17 500,00	$ 22 400,00	$ 32 200,00
TOTAL STAFF COST	$ 49 550,00	$ 56 200,00	$ 72 200,00	$ 87 100,00
$/Tons	7,08 $/Tons	3,12 $/Tons	3,01 $/Tons	2,49 $/Tons

Typical Filling plant With palleztization	Annual tonnage			
	Approx 7 KT/y	Approx 18 KT/y	Approx 24 KT/y	Approx 34 KT/y
12 kg	4 scales on line	Carrousel 12 scales	Carrousel 12 scales	Carrousel 18 scales
6 Kg	1 single scales	4 scales on line	Carrousel 8 scales	Carrousel 12 scales
40Kg	1 single scale	2 single scales	4 scales on line	4 scales on line
Managment cost	$ 38 700,00	$ 38 700,00	$ 49 800,00	$ 54 900,00
Filling cost with palettization	$ 10 850,00	$ 14 000,00	$ 15 400,00	$ 19 600,00
TOTAL STAFF COST	$ 49 550,00	$ 52 700,00	$ 65 200,00	$ 74 500,00
$/Tons	7,08 $/Tons	2,93 $/Tons	2,72 $/Tons	2,13 $/Tons

Transport cost recovery

	Décomposition of primary transport cost	Bulk primary transport Europe	Bulk primary transport West Africa	Cylinder primary transport Europe	Cylinder primary transport West Africa
Hypothèses Hypothesis	Kilométrage annuel par véhicule Annual mileage per vehicle	110 000 km/year	110 000 km/year	110 000 km/year	110 000 km/year
	Nombre de jours d'exploitation par an Number of operating days per year	250 days	250 days	250 days	250 days
	Durée de conservation du véhicule moteur Motor vehicle shelf life	10 years	10 years	10 years	10 years
	Prix tracteur Tractor price	120 000 €	140 000 €	120 000 €	140 000 €
	prix remorque 57m3 Trailer price	55 000 €	55 000 €	28 000 €	35 000 €

Carburant / km (30l/100km) Fuel /km (30l/100km)	0,300 €/km	0,300 €/km	0,300 €/km	0,300 €/km
Pneumatiques / km Pneumatics / km	0,026 €/km	0,026 €/km	0,026 €/km	0,026 €/km
Entretien-réparations / km Maintenance-repairs/km	0,160 €/km	0,160 €/km	0,160 €/km	0,160 €/km
Terme kilométrique (hors péages) Mileage term (excluding tolls)	0,486 €/km	0,486 €/km	0,486 €/km	0,486 €/km
Terme horaire (CC) Hourly term (CC)	23,170 €/h	5,000 €/h	23,170 €/h	2,000 €/h
Coût de détention du véhicule tracteur / jour Cost of holding tractor vehicle per day	48,000 €/j	56,000 €/j	48,000 €/j	56,000 €/j
Coût de détention remorque/ jour (28T gpl) Cost of detention trailer/day (28T LPG)	22,000 €/j	22,000 €/j	11,200 €/j	14,000 €/j
Assurances / jour Insurance per day	10,900 €/j	10,900 €/j	10,900 €/j	10,900 €/j
Taxes / jour Taxes per day	3,020 €/j	3,020 €/j	3,020 €/j	3,020 €/j
Charges de structure et autres charges indirectes / jour (CS) Structural and other indirect charges per day (CS)	104,380 €/j	104,380 €/j	104,380 €/j	104,380 €/j
Cost per day based on 10h	420,000 €/j	246,300 €/j	409,200 €/j	208,300 €/j

basIs 400km/j on 10h	614,400 €/j	440,700 €/j	603,600 €/j	402,700 €/j
Prix de revient au kilometrique Cost per kilometer	1,54 €	1,10 €	1,51 €	1,01 €

Cost go and back 20 T LPG TRUCK	0,154 €/km.Ton	0,110 €/km.Ton
Cost go and back 24 T LPG TRUCK	0,128 €/km.Ton	0,092 €/km.Ton
Cost go and back 28 T LPG TRUCK	0,110 €/km.Ton	0,079 €/km.Ton

Cost go and back 900 cyl trucks			0,279 €/km.Ton	0,186 €/km.Ton

Delta (Cylinders - Bulk 24T)	0,151 €/km.Ton	0,095 €/km.Ton
100 km	15,144 €/Ton	9,462 €/Ton
200 km	30,289 €/Ton	18,925 €/Ton
300 km	45,433 €/Ton	28,387 €/Ton

	Distance Filling plant -Cylinder wharehouse	$/ton
In USD- Delta Cylinder transport cost- bulk primary transport cost Transport go and back 900 cyl 12Kg Equ	100 km	8,228 $/Ton
	200 km	16,456 $/Ton
	300 km	24,684 $/Ton

based on 1,15 =1€

XXII. Informational Annexes

76. LPG as a Main Solution to Universal Clean, Modern Cooking

The clean, modern cooking challenge

The global community has recognized the central role of access to clean, modern energy for development with the adoption of the 2030 Agenda for Sustainable Development by the United Nations in 2015. The Government of Rwanda has done likewise, in particular in its National Strategy for Transformation 2017-2024.

In 2020, nearly 3 billion people still suffer the harmful and often fatal effects of cooking with solid fuels. Household air pollution (HAP) caused by burning these fuels far exceeds the safe levels defined in the World Health Organization (WHO) Indoor Air Quality Guidelines (IAQG). According to WHO[153], close to 4 million people die prematurely each year from these HAP effects; many more suffer from chronically worsened health. The accumulated evidence indicates that levels of household particulate matter must be reduced close to the WHO guidelines levels if a large portion of this health burden is to be averted.

A major portion of the woodfuels and charcoal used for cooking come from unsustainably harvested biomass. This adds to already significant pressure on forests, via increased deforestation and forest degradation. Loss and degradation of forest cover may, in turn, weaken agricultural productivity in adjacent land areas.

The pollutants from cooking with solid fuels also contribute to shorter-term climate warming through black carbon and methane.

Obtaining and cooking with solid fuels is also more time consuming than obtaining and cooking with fuels such as LPG, which are commercially obtainable (or are delivered to the home), provide "instant-on, instant-off" heat energy for cooking, and require little maintenance and cleaning of cooking appliances and areas.

In Sub-Saharan Africa (SSA), four of five people use wood fuel or charcoal as their main source of cooking energy. In view of the rapid population growth in Africa (projected to more than double to 2.5 billion by 2050)[154], the total number of solid fuel users will increase, together with all the associated negative health, environmental and development consequences, unless urgent and effective action is taken.

In this context, the Government of Rwanda and a growing number of governments of other countries in SSA and other regions have set policy goals and plans for scaling up the use of liquefied petroleum gas (LPG) as a cooking fuel. The reasons include meeting the Sustainable Energy for All (SEforAll) goals and Sustainable Development Goal (SDG) 7 of universal access to modern energy; forest protection; improvements in public

---

153 WHO (2016). Burning Opportunity: Clean Household Energy for Health, Sustainable Development, and Wellbeing of Women and Children Report. Geneva: World Health Organization.

154 United Nations, Department of Economic and Social Affairs, Population Division (2015). World Population Prospects: 2015 Revision, Key Findings and Advance Tables. Working Paper No. ESA/P/WP.241.

health from reduction of the health burden from HAP caused by cooking with biomass and kerosene; improvements in quality of life for their people; and economic development.

Clean Cooking for Africa Program overview

Government ministries and agencies and other relevant stakeholders in Rwanda and in a number of other countries have sought expert support for the development of policies, plans and investments required for the expansion of an effective, safe, and sustainable national market for LPG as a cooking fuel and for other uses.

For four in Sub-Saharan Africa, namely Rwanda, Kenya, Ghana and Cameroon, this support is being delivered through the Clean Cooking for Africa Program of KfW, funded through the European Union–Infrastructure Trust Fund and implemented by the Global LPG Partnership.

Countries seeking to achieve major transitions in household energy must respond to the needs, resources and circumstances of their populations, which will vary markedly across urban and rural settings, by socio-economic status, and over time. A variety of fuels and technologies may be required, with roles for both modern fuels such as LPG and electricity, as well as improved biomass cooking technologies.

In recent years, LPG has been selected by a growing number of LMIC governments to be the primary cooking fuel for expanded access to clean and modern energy for their populations.

Rwanda has made significant strides to expand its LPG sector during the last five years, with per capita consumption rising ninefold. The steps already taken position Rwanda to achieve major scale-up of LPG adoption and use by its people, including a portion of its rural population, by 2024 and through to 2030 as part of a steady, well-planned national transition to clean and modern energy for cooking for its people.

The **Clean Cooking for Africa Program** assists selected African partner countries in planning, financing and executing national-scale transitions from the use of solid fuels and kerosene for cooking to clean, safe, modern cooking using LPG. This assistance includes:

- National planning processes, conducted in partnership with the partner-country governments and relevant stakeholders, to create or enhance the enabling environment for successful, sustainable LPG scale-up, and to plan and financially structure the required corresponding investments in LPG infrastructure and distribution systems; and
- Relevant studies to define and justify the proper role and scale for LPG as a national clean cooking solution, whose findings may guide the planning of LPG transition.

This Plan reflects the results, through the date of its writing, of such activities in Rwanda.

The role of LPG

What is LPG?

According to the World LPG Association, LPG stands for “Liquefied Petroleum Gas”, whose acronym is widely used to describe two prominent members of a family of light hydrocarbons called “Natural Gas Liquids” (NGLs): propane (C_3H_8) and butane (C_4H_{10}), either individually or in a blend. While “liquefied gas” may seem a self-contradiction, liquidity is the unique character of LPG that makes it a widely-used fuel. At normal temperatures and pressure, LPG is gaseous. It changes to a liquid when subjected to modest pressure or cooling. In liquid form, the tank pressure is about twice the pressure in a normal truck tire. This makes LPG very safe when properly handled. LPG is a by-product of two large energy industries: the processing of natural gas liquids and the refining of crude oil.

Thus, LPG is a supply-driven commodity. It must always be disposed of by its producers. Globally, the market is cleared of surpluses by the petrochemical and plastics sector, which can use LPG as a feedstock. Currently, a global surplus of LPG supply over demand, accessible to Rwanda, is expected to persist to at least 2040.

In 2018, the first commercial quantities of bio-LPG were introduced into the global market at prices competitive to NGL-sourced or refinery-sourced LPG.

LPG has a number of qualities which make it an effective, large-scale off-grid gas energy solution in complement to the other large-scale clean energies, electricity and natural gas. This is summarized in the following table:

Figure 69. Key characteristics of LPG, natural gas and electricity solutions[155]

Household Energy Source	Key Characteristics	Primary Uses in Developing Stage Energy Market	Primary Uses in Mature Energy Market
LPG	• Low capital intensity • Infrastructure quick to deploy • Affordable, especially in urban/peri-urban areas • Portable • Salable in small units • Safe (with proper systems and handling) • High heat delivery	• Cooking/heating	• Non-urban cooking/heating • Industrial • Occasionally, transport
Grid Electricity	• High capital intensity • Time-consuming to deploy • Occasionally affordable • Safe (with proper systems) • Low-to-medium heat delivery	• Urban lighting, cell phones, electrical appliances including cooking, mechanical work	• Lighting, cell phones, electrical appliances including cooking/heating, mechanical work
Off-grid Electricity: Minigrids	• High capital intensity per kw • Usually more costly than grid-based • Potentially rapid deployment	• Small business use, cell phones, household lighting and low-power (non-cooking) electrical appliances	• Small business use, cell phones, household electrical appliances, sometimes including cooking (with larger-scale systems)

155 GLPGP: World Gas Conference (2015)

Household Energy Source	Key Characteristics	Primary Uses in Developing Stage Energy Market	Primary Uses in Mature Energy Market
Off-grid Electricity: Solar PV	• Rapid deployment • Low to medium capital intensity per kw • Pay-as-you-go can be an option	• Cell phones, household lighting and low-power (non-cooking) electrical appliances and productivity devices (e.g., sewing machines)	• Cell phones, household lighting and low-power (non-cooking) electrical appliances and productivity devices (e.g., sewing machines)
Natural Gas	• Very high capital intensity • Time-consuming to deploy • Very affordable • Primarily grid-based • Safe (with proper systems and handling) • High heat delivery	• Power generation	• Urban household cooking/heating • Power generation • Industrial and transport

LPG is an essential solution to reduce pressure on forests and achieve WHO emissions guidelines

To achieve WHO guideline levels of particulate matter requires community-wide use of clean fuels. In the transition towards universal use of clean fuels, countries will evaluate and execute on strategies that address the energy needs of their varied populations over time, involving a portfolio of energy carriers and technologies to meet cooking and other household needs.

In its *Special Report: Health and Climate Change*[156], WHO states: "It is not necessarily straightforward to choose the optimal household energy, and it may sometimes involve trade-offs. For example, while [LPG] is a fossil fuel, it emits almost no particulate air pollution and emits less climate pollutants than many other household energy sources. There may therefore be rapid health gains and sustainability if it replaces more polluting fuels and technologies, as opposed to crowding out investment in renewable energy." It is therefore important for Rwanda, and other LMICs, to define an optimal portfolio of energy carriers and technologies for the household sector, which portfolio will require adjustment over time as relative technological capabilities, scalability, and costs evolve.

Over the next one to two decades in SSA, this energy and technology mix is expected to include LPG and, where feasible, reliable electricity capable of delivering the wattage necessary to cook and to boil water. For those unable to transition quickly to clean liquid or gaseous fuels or to adequate electricity supply, improved (e.g., rocket-type) and advanced (e.g., fan-assisted, pellet-fueled) biomass stoves are expected to have a transitional role, even though in daily use they do not deliver the reduced emissions levels called for by the WHO guidelines.

[156] WHO (2018). www.who.int/iris/handle/10665/276405

Among existing liquid and gaseous fuel options, LPG can make an important contribution. It has the potential to deliver substantial benefits for health, climate, the environment, and development. As with biomass fuels and stoves, building the enabling environment and developing an effective and cost-efficient market and value-chain are required for success with LPG. Correct and safe handling and use of LPG is also a key requirement.

A number of national governments, including Rwanda, India, Ghana, Kenya, and Cameroon, have made it a priority to serve a majority of their populations with LPG for reasons including (i) forest preservation, (ii) addressing energy-related air pollution, and (iii) development.

LPG is benign for the climate

At a global level, however, the fact that LPG is created as a by-product of the production and refining of fossil fuels requires evaluation of its environmental impacts.

Issues around the overall affordability and accessibility for poorer and more rural populations also need to be addressed.

The findings described in this report indicate that the use of LPG instead of traditional biomass fuels and kerosene in Rwanda would contribute little or no net climate warming effect and would protect forest resources. Lifecycle assessments (performed by others) have found that LPG as a cooking fuel performs similarly to advanced biomass stoves for net CO_2 emissions in settings where biomass fuel harvesting is partially renewable, and better than these technologies for black carbon and other short-lived pollutants.

This is because (i) LPG has a lower Carbon-to-Hydrogen ratio (C:H of about 1 to 3) than any other hydrocarbon fuel except for natural gas (e.g., coal has a C:H ratio of about 2 to 1); (ii) LPG combusts very efficiently compared with other fuels, thereby keeping emissions lower; (iii) LPG has high completeness of combustion, which results in black carbon and other climate-active pollutant emissions being much lower than from biomass-burning stoves and open fires; (iv) LPG stove emissions performance generally remains the same over time and is relatively independent of user-operating factors; and (v) LPG fuel supply places no burden on forest resources.

Affordability of LPG

Where all or most cooking fuel is purchased, which occurs mainly in urban and peri-urban settings, LPG is price competitive with wood fuel, biomass pellets and charcoal on a cost-per-meal or cost-per-month basis.

These alternative fuels to LPG are typically bought in small daily quantities. While overall costs of LPG may be similar or superior over time, the transaction size for refilling an LPG cylinder may be a barrier for some low-income households. A number of options are available to address LPG refill transaction size. One that is well-established is use of smaller (e.g., 6 kg) cylinders. Newer initiatives involving pay-as-you-go LPG use and microfinance of, and/or mobile payment for, LPG refills are in early commercial operation in some SSA countries. Some households may also need financial assistance or tools to cover the initial acquisition cost of an LPG stove, cylinder and associated equipment, because traditional stoves are in general less costly than the equipment required for cooking with LPG.

For poorer and more rural populations currently gathering all or most of their fuel, the initial and ongoing costs for LPG refills can be barriers. Targeted subsidies or other forms of financial support, which preferentially assist poorer households, can play a role in facilitating acquisition and use of LPG for such consumers. This type of targeted financial assistance is already a key component of policy on LPG access in several countries with large scale LPG use, such as India, Brazil and Peru.

Creating a universal LPG refill price through regulatory measures (that is, a price that, through transportation cross-subsidy, is the same for all consumers no matter where they are located in the country) also benefits rural consumers, who tend to be both poorer and more remote from LPG refilling facilities.

Proven technical and operational feasibility of LPG in LMICs

LPG is a well-established technology for cooking. The World LPG Association estimates that 2 billion people use LPG for cooking, heating, and other uses. LPG has already become a large-scale solution for clean cooking in a numerous low and middle income countries[157].

Challenges for scaling up LPG on a national basis are addressable through effective policy, regulation and enforcement of regulation, ensuring adequate supply, developing robust distribution networks (limited by where the road network makes distribution viable), and, optionally, developing and implementing sustainable fiscal policy to support more equitable access.

User benefits of LPG

For the user, the speed and controllability of LPG cooking, combined with the convenience of storage, result in substantial convenience and time savings. This has particular implications for women, children, and others currently engaged in collecting and cooking with biomass fuel and cleaning their cooking appliances and cooking areas after use. The added convenience and time savings offer the potential for making more of employment and education opportunities.

LPG may also be viewed culturally as an aspirational fuel that some households would use, if available, based on their association of LPG with modernity—the “modern” of SDG7—even when cost savings from LPG use do not arise for them. While it is not possible to quantify this factor from available data, and it is excluded from this report’s analytics, desire for LPG as an aspirational energy choice frequently arises anecdotally in interviews with Rwandan consumers, policymakers, industry veterans and other stakeholders. (Many of which policymakers, industry veterans and other stakeholders being LPG consumers as well.)

[157] A non-exhaustive list of examples of LMICs which have achieved safe and sustained use of LPG for cooking by no less than 50% to upwards of 95% of their populations for cooking (and other uses) include Bolivia, Brazil, India, Indonesia, Malaysia, Morocco, Thailand and Vietnam. SSA countries which are approaching this range of LPG use include Cote d’Ivoire, Gabon and Senegal.

77. LPG Cylinder and Infrastructure Development 2015-2020

Cylinders

The following tables show details of Rwanda cylinder park development:

Figure 70. Cumulative Rwanda LPG cylinder imports 2015-2019

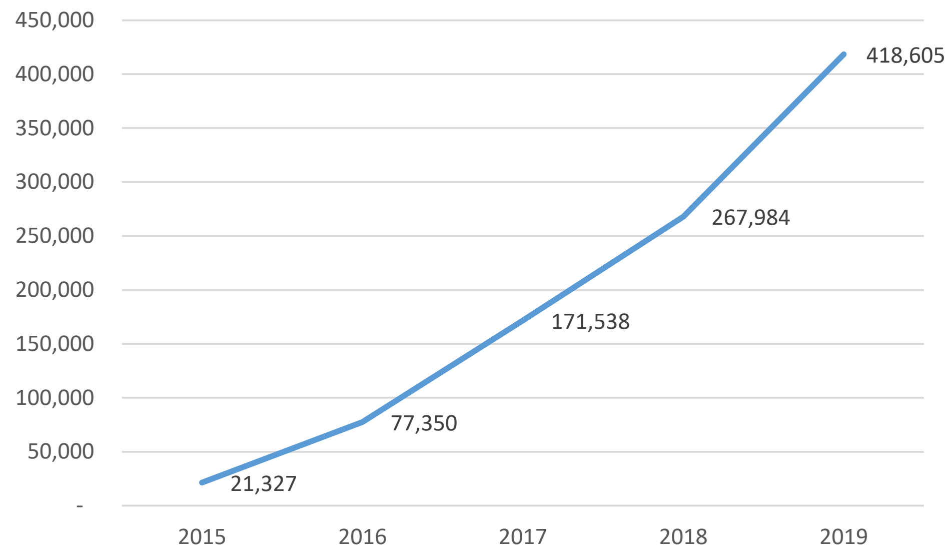


Figure 71. Annual cylinder imports by size 2015-2019

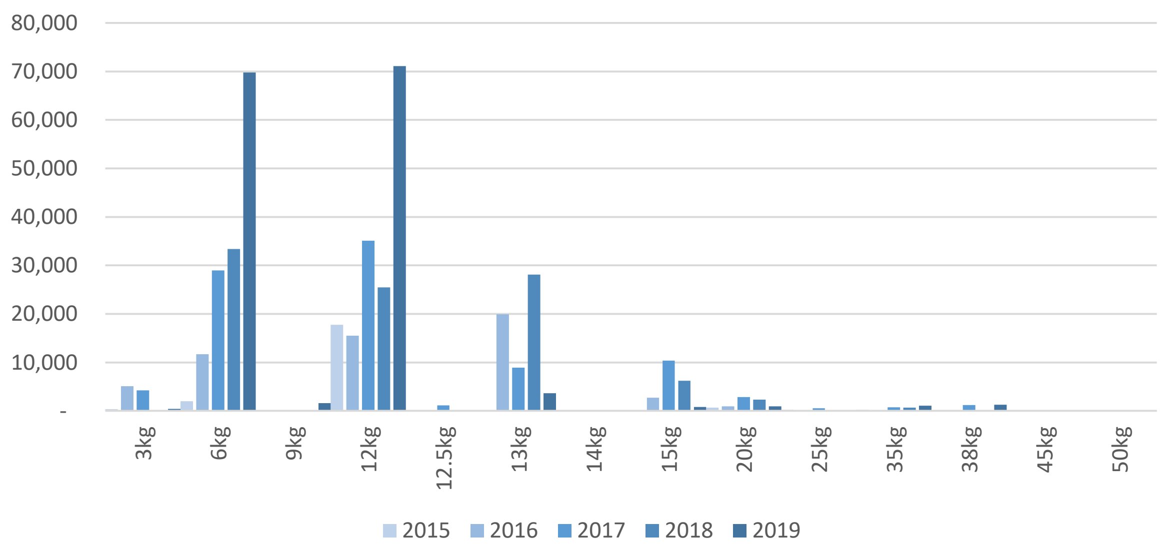
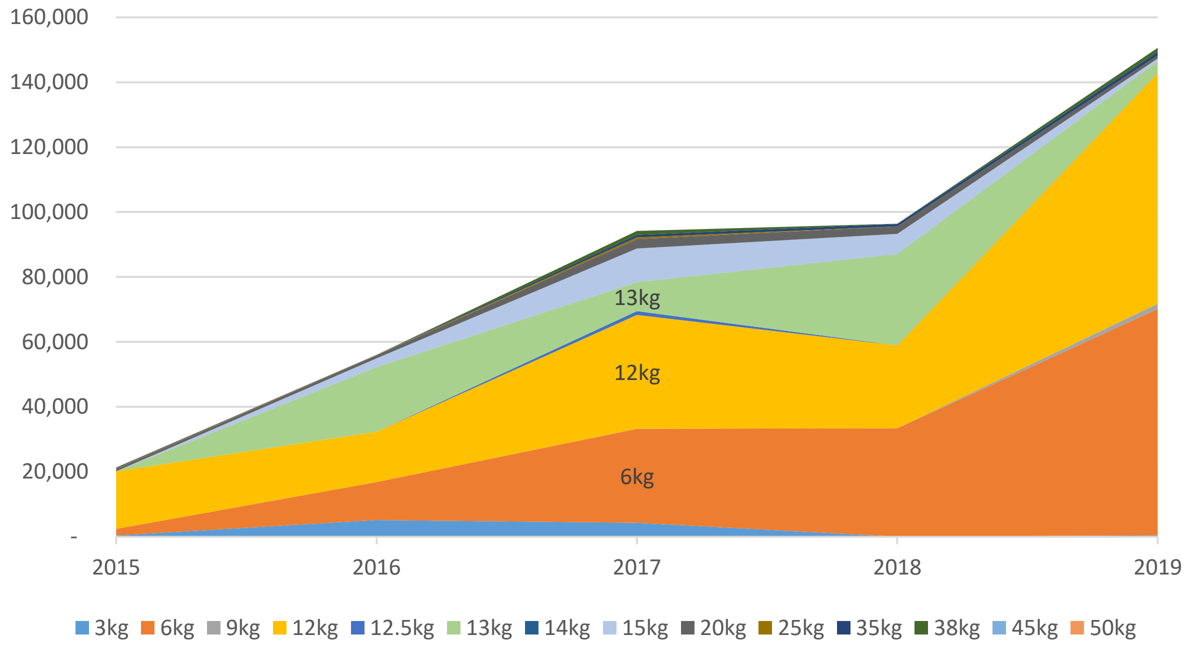


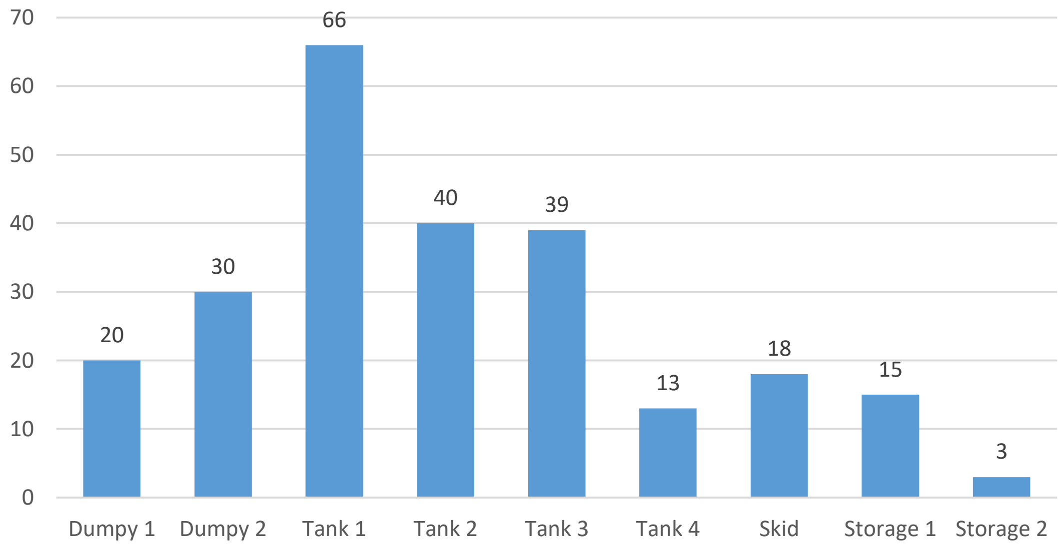
Figure 72. Cylinder import trends by size 2015-2019



Bulk tanks

The following chart and table show the breakdown of historical LPG bulk tanks by size.

Figure 73. Bulk LPG tank imports by size 2015-2019



Tanks are described in their water capacities, as shown in Table 194. The description given in the table is arbitrary and used for categorization only. Most of the tanks imported are below 20,000 litres of water capacity (LPG capacity below 10 MT), indicating they are directed to commercial, institutional and industrial uses.

Table 194. Summary of bulk LPG tanks imported 2015-2019

Description	Capacity (litres)	Total Units
Dumpy 1	≤ 500	20
Dumpy 2	>500, ≤1000	30
Tank 1	>1,001 - 2,000	66
Tank 2	>2,000-2,750	40
Tank 3	3,800-6,000	39
Tank 4	10,000-12,000	13
Skid	20,000-22,000	18
Storage 1	47,000-60,000	15
Storage 2	100,000+	3

78. Detailed Methodology—Demand Analysis

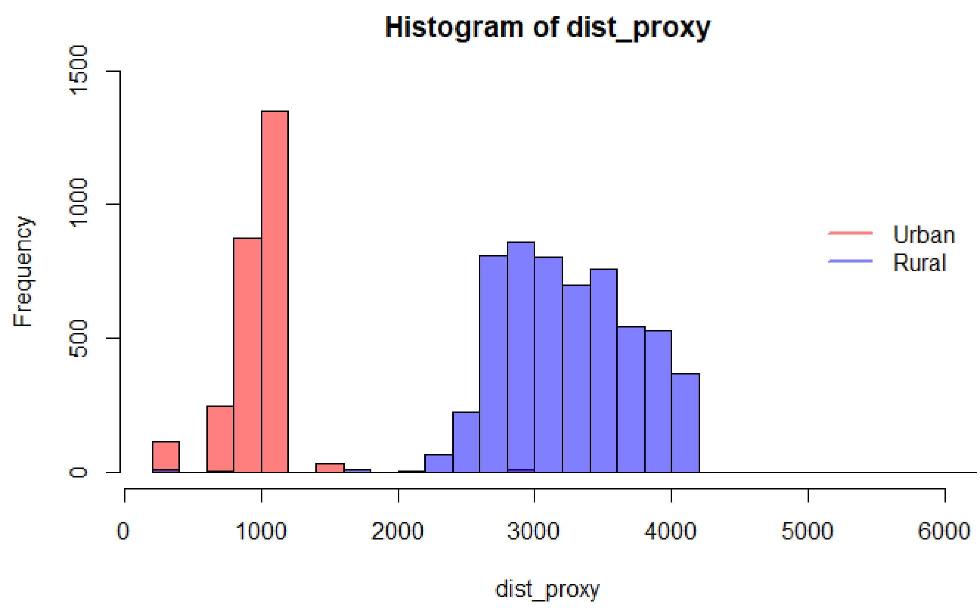
Household demand projections and assumptions

A probit cumulative link model with scale effects and flexible thresholds was the best fit to the data based on Akaike's Information Criterion (AIC) (and Bayesian Information Criterion). The model was built around a number of assumptions described in Volume 2, Chapter 26, and as further detailed below.

LPG accessibility and availability in urban and rural areas

Information on LPG accessibility was available in the CFET 2020 dataset, and reported in five categories (<500m; <500m-1km; 1km-2km; 2km-4km; 4km+) for households using LPG. The information on proximity of retail outlets for non-LPG using households needed to be imputed. The Gamma model had the best fit according to the AIC criterion. The categorical variable for distance was converted to a continuous one using the midpoint for each level of the categorical variable, and distance was imputed based on the proportion of households that use LPG. For this calculation, the "rule of three" was used and a unif(0, 3/n) for the proportion was assumed. Note that for rural areas the proxy distance ('dist_proxy') is probably an underestimation. The imputed distances for urban and rural areas are shown in Figure 74. As expected, retail outlets were much closer to households in urban areas than in rural areas (1km compared to 3.5km distance on average).

Figure 74. Imputed distances from LPG retail point in urban and rural areas
(CFET 2020)



Socio-economic status (SES) characteristics

Rwanda uses the 4-tier system called *Ubudehe* categories to classify household SES for purposes of identifying those in need for welfare support. The classification of each household is multi-faceted and involves factors such as household income, land ownership, assets, family size, whether children attend school, etc. The categories are absolute, not defined relative to one another. In 2020, the system began a transition from four to five categories, with more details to be publicized as of the time of the analysis. For modelling purposes, the current four SES levels were maintained up to 2030.

Methodology for household demand projection adjustments to account for in-school meals

In order to avoid double counting of children being fed at school via LPG instead of being fed at home with LPG, the following assumptions were used to adjust the household LPG demand projections accordingly.

In Rwanda, non-boarding schools are open an average of nine months a year and five days a week. Assuming a school meal (lunch) covers 40% of nutritional caloric need of school children, the amount of LPG displaced from LPG consumption in households due to children eating at school was estimated as 6.2 kg/pupil/year. Taking into account the proportion of children attending schools each year (assuming 100% of schools feeding their pupils from 2021 onward, in accordance with current policy plans), the following annual LPG household consumption rates were obtained and applied to offset the household demand projections:

Table 195. Consumption data for elimination of double-counting of schoolchildren usage

Year	Proportion of total population in school*	LPG consumption per school (kg/pupil/year)	LPG consumption in households (kg/year/capita)	Percentage of pupils fed in school	LPG consumption in households adjusted for school feeding (kg/capita/year)
2020	0.269	6.2	28.8	0%	28.8
2021	0.266	6.2	28.8	100%	27.159
2022	0.262	6.2	28.8	100%	27.185
2023	0.257	6.2	28.8	100%	27.215
2024	0.251	6.2	28.8	100%	27.249
2025	0.246	6.2	28.8	100%	27.284
2026	0.240	6.2	28.8	100%	27.319
2027	0.235	6.2	28.8	100%	27.349
2028	0.231	6.2	28.8	100%	27.377
2029	0.226	6.2	28.8	100%	27.403
2030	0.223	6.2	28.8	100%	27.425

**Proportion estimated for each school age group (4 – 6 nursery age group, 7-12 primary age group and 13-18 secondary age group), based on 2018 official MINEDUC data*

Fuel and stove retail survey sampling

Price data for cooking equipment with different fuels were collected through a representative field-based survey at outlet points conducted in September 2020 (n=89). The survey sampled stove and fuel prices in urban and peri-urban areas in all five provinces of Rwanda. The distribution of the sampled outlets per area and province for the three fuels/stove types is shown in the following table.

Table 196. Locations and number of fuel/stove outlets surveyed, 2020

Province	City	Number of surveyed outlets		
		LPG	Charcoal	Firewood
Kigali	Kigali city	6	6	6
Southern	Huye	3	3	3
	Muhanga	3	3	3

Province	City	Number of surveyed outlets		
		LPG	Charcoal	Firewood
North	Musanze	3	4	3
West	Gakenke	5	3	5
	Rubavu	3	5	3
	Karongi	3	4	3
East	Nyagatare	4	4	4
	Rwamagana	3	3	3

Additional references

Practical Action, 2020. Ensuring Refugee Camps in Rwanda have Access to Sustainable Energy. Rugby, UK: Practical Action Publishing.

79. Detailed Methodology—Impact Analysis

Averted deforestation

Averted deforestation was calculated as the difference between the number of trees used per year before and after households begin using LPG as their primary or secondary fuel (i.e. the difference between the baseline and an intervention scenario). This was calculated as the sum of the number of trees necessary for firewood use and the number of trees necessary for charcoal use.

The equivalent number of trees for firewood use and charcoal use was calculated using the equations below.

$$Trees(Firewood) = (Forest\ non\ renewability)\left(\frac{Firewood\ consumption}{Mass\ per\ tree}\right) = (82\%)\left(\frac{Firewood\ consumption}{100\ kg/tree}\right) \quad (1)$$

$$Trees(Charcoal) = (Forest\ non\ renewability)(Ratio\ charcoal{:}\ wood)\left(\frac{Charcoal\ consumption}{Mass\ per\ tree}\right) = (82\%)(7)\left(\frac{Charcoal\ consumption}{100\ kg/tree}\right) \quad (2)$$

The forest non-renewability factor indicates what proportion of wood for fuel was unsustainably harvested.

Carbon emissions

The mass method considers the grams of particles per kilograms of fuel and stove. The following equation was used to calculate the metric tonnes of carbon emissions per household.

$$CO_2(e) = 10^{-6}\left[\frac{Fuel\ consumption}{Number\ of\ households}\right][(CO_2\ emissions\ factor)(Non\ renewability) + (N_2O\ emissions\ factor)(GWPN_2O) + (CH_4\ emissions\ factor)(GWPCH_4)]$$

The emissions factors used vary depending on both fuel and stove, and the non-renewability factor was dependent on the fuel used.

The energy method considers the emissions rate of particles as grams per mega-Joule (MJ). In this method, the following equation was used to calculate the metric tonnes of carbon emissions per household.

$$CO_2(e) = 10^{-6}\left[\frac{Fuel\ consumption}{Number\ of\ households}\right][(CO_2\ emissions\ rate)(Non\ renewability) + (N_2O\ emissions\ rate)(GWPN_2O) + (CH_4\ emissions\ rate)(GWPCH_4)](NCV)(Thermal\ efficiency)$$

The net calorific value of the fuel (NCV) and thermal efficiency of the stove used in the impact calculations are summarized in Table 197. The emissions rates for carbon dioxide, nitrous oxide, and methane can be seen in Table 198. The GPW(100) values are summarized in Table 199.

The tonnage differential of black carbon (BC) emissions is calculated as the difference between the CO_2 equivalent tonnage emitted in the baseline analysis and both the upper and lower bound scenarios.

$$\begin{aligned} Black\ carbon = 10^{-6}(Fuel\ consumption)[&BC\ emissions\ factor \\ &- 0.1(OC\ emissions\ factor) + 0.002(CO\ emissions\ factor) \\ &+ 0.006(TNMOC\ emissions\ factor)] \end{aligned}$$

Table 197. Fuel calorific values and average stove thermal efficiencies

Fuel/stove combination	Net fuel calorific value (MJ/kg)	Average stove thermal efficiency
LPG (high eff. stove)	46.1	55%
LPG (low eff. stove)	46.1	49%
Average value used for LPG		**51%**
Charcoal (trad. stove)	29.5	15%
Charcoal (impr. stove)	29.5	25%
Average value used for charcoal		**20%**
Firewood (trad. stove)	15.6	15%
Average value used for firewood		**15%**

Table 198. Average stove emissions factors for laboratory or simulated kitchen measurements

Stove type (as in survey)	Emissions factor - CO_2 (g/kg)	Emissions factor - CH_4 (g/kg)	Emissions factor - N_2O (g/kg)[158]	CO_2 emissions rate (g/MJd)	CH_4 emissions rate (g/MJd)	N_2O emissions rate (g/MJd)[158]	Emissions factor - BC (g/kg)	Emissions factor - OC (g/kg)	Emissions factor - CO (g/kg)[158]	Emissions factor - TNMOC (g/kg)[158]
FIREWOOD										
Traditional stone fire	1610	8.9	0.28	577	3.4	0.0713	0.70[159]	0.44[158]	52.8	8.5
Improved stove (unvented)	1580	8.8	0.17	398	2.6	0.0391	1.5	0.55[158]	42.4	9
CHARCOAL										
Ordinary stove	2559	6.9	0.16	382	1.2	0.0609	0.24[158]	1.71[158]	162.3	10.3
Improved stove (unvented)	2622	6.6	0.24	245	0.8	0.0535	0.20[158]	1.43[158]	198.5	8.6
LPG										
Gas cooker	2532	0.04	0.15	121	0.025	0.006	0.011[160]	0.029[160]	14.2	3.7

Note: Except where specified otherwise, all the emissions factors for CO2, CO, CH4, BC and TNMOC are based on Water Boiling Tests results complied in Edwards et al. (2014). Review 2 in: WHO Indoor Air Quality Guidelines: Household fuel combustion. Geneva: World Health Organization.

Table 199. Global warming potential (GWP) values

Pollutant	GWP(100)	Source
BC	660	IPCC 2014 (Myhre et al. 2013, based on Bond et al. (2013))
CO_2	1	IPCC 2014 (Myhre et al. 2013)
CH_4	32	IPCC 2014 (Myhre et al. 2013 but increased by 14% based on Etminan et al. 2016)
N_2O	298	IPCC 2014 (Myhre et al. 2013)

158 Mercy Corps Database (2018) – IPCC data

159 Jeuland (2016)

160 Shen et al. (2018)

Health impacts data

To estimate the health impacts of transitioning from charcoal and firewood to LPG using the HAPIT tool as described in the Volume 6, Chapter 63, a set of assumptions was used for data on personal exposure to fine particulate matter ($PM_{2.5}$). These assumptions are summarized below.

Firewood and charcoal $PM_{2.5}$ personal exposure data

The data for personal exposure in homes using firewood in traditional or improved stoves was based on Rwanda data collected in a study by Kirby et al. 2019 that recorded $PM_{2.5}$ personal exposure before and after an improved stove intervention. The study included 231 primary cooks and 159 children providing valid measures of exposure across the various follow up phases - a large sample size for this type of impact assessment. The study was conducted in the Western Province of Rwanda between 2014 and 2016.

Data on personal exposure to $PM_{2.5}$ from charcoal use in traditional and improved charcoal stoves were conservatively estimated as one third of the personal exposure to $PM_{2.5}$ from firewood from the same Rwandan study due to the lack of objective exposure data on charcoal-derived $PM_{2.5}$ in the literature. This correction factor is made given that combustion of charcoal generally has low emissions of $PM_{2.5}$, although it also has higher carbon monoxide (CO) levels (CO is not currently included in projections of health impacts by the HAPIT tool).

The following assumptions were held constant at baseline and in 2030 for each scenario, using typical fuel/stoves combinations for Rwanda:

FIREWOOD	TRADITIONAL mean (SD), µg/m^3	IMPROVED STOVE mean (SD), µg/m^3
48-hour mean personal exposure to $PM_{2.5}$ – ADULTS (Cooks)	218 (204)	223 (200)
48-hour mean personal exposure to $PM_{2.5}$ – CHILDREN	224 (198)	231 (238)
CHARCOAL	TRADITIONAL mean (SD), µg/m^3	IMPROVED STOVE mean (SD), µg/m^3
48-hour mean personal exposure to $PM_{2.5}$ – ADULTS (Cooks)	72.7 (204)	74.3 (200)
48-hour mean personal exposure to $PM_{2.5}$ – CHILDREN	74.7 (198)	77.0 (238)

Personal exposure to PM2.5 from LPG

Whilst there is a paucity of data on personal exposure to $PM_{2.5}$ for homes using LPG fuel in SSA, data indicate that it is possible to achieve the WHO Interim Target 1 level for health (35 ug/m^3) when using the fuel in homes. We used personal exposure data from the recent HAPIN trial in Rwanda through personal communication (baseline assessment of personal exposure was found to be 45 (µg/m^3) ± 35 µg/m^3 and a publication on this analysis is currently under review (HAPIN/Berkeley Air Monitoring Group, 2020)).

LPG	TRADITIONAL mean (SD), µg/m^3	IMPROVED STOVE mean (SD), µg/m^3
48-hour mean personal exposure to $PM_{2.5}$ – ADULTS (Cooks)	35 (10)	45 (35)

Scenarios assumptions

According to CEFT data, 30% of biomass-using households in Rwanda used improved cookstoves (ICS), with about a third using an improved charcoal stove.

The following assumptions were used with respect to growth of improved access and adoption of improved firewood and charcoal stoves up to 2030 (with linear growth):

- Firewood
  - 2020 – 20% of households using improved stoves
  - 2030 – 80% of households using improved stoves (of the projected % of households under each scenario)
- Charcoal
  - 2020 – 10% of households using improved stoves (of the projected % of households under each scenario)
  - 2030 – 100% of households use improved stoves (of the projected % of households under each scenario)

In addition, as it was not possible to accurately predict how many biomass users will switch to LPG from traditional or improved firewood/charcoal stoves, an equal split was assumed:

- Firewood
  - 2020 – 50% of households that switch to LPG use improved stoves (of the projected % of households under each scenario)
- Charcoal
  - 2020 – 50% of households that switch to LPG use improved stoves (of the projected % of households under each scenario)

The ICS penetration rate did not emerge from the modelling as a major contributor to impacts. If starting at 50% (as shown above), and the penetration is either cut in half (to 25%), or increased by half (to 75%), the change in deaths averted and DALYs saved changes by only about 0.2% in either direction.

Bibliography

African Development Bank Group, (2018). Scaling Up Electricity Access Program Phase II (SEAP II), Rwanda Appraisal Report. September 2018

Bailis et al. (2017). Getting the numbers right: revisiting woodfuel sustainability in the developing world. Environ Res Letters, 12, 115002.

Barron et al. (2020). Gender and entrepreneurship in the renewable energy sector of Rwanda. IDS Bulletin, 51(1), 53-69.

Bond et. al. (2013). Bounding the role of black carbon in the climate system: A scientific assessment. J. Geophys. Res. Atmos , 118 (11), 5380-5552.

Brooks et. al. (2016). How much do alternative cookstoves reduce biomass fuel use? Evidence from North India. Resource and Energy Economics , 43, 153-171.

Chandar & Tandon. (2004). LPG: A Key to Empowerment of Hill Women. Availalbe at: http://www.jagritikullu.org/LPG%20-%20Mamta.pdf [Accessed 15 Nov 2020].

Edwards et al. 2014. Review 2: Emissions of Health-Damaging Pollutants from Household Stoves. In WHO Indoor Air Quality Guidelines: Household Fuel Combustion. Availalbe at: https://www.who.int/airpollution/guidelines/household-fuel-combustion/Review_2.pdf?ua=1 [Accessed 12 Oct 2020].

ESMAP. (2015). State of global clean and improved cooking sector. Washington, DC: Energy Sector Management Assistance Program

ESMAP. (2020). The state of access to modern energy cooking services. Washington, DC: Energy Sector Management Assistance Program

Etminan et al. (2016). Radiative forcing of carbon dioxide, methane, and nitrous oxide: A significant revision of the methane radiative forcing. Geophys Res Lett, 43(12).

Gihana, & Kooijman (2020). Gender and Energy Country Briefs.- Rwanda. ENERGIA

Global Forest Watch – Rwanda (2020). See: https://www.globalforestwatch.org/

Gold Standard Methodology. (2017). Technologies and Practices to Displace Decentralized Thermal Energy Consumption.

GLPGP (2020). Assessing Potential for BioLPG Production and Use within the Cooking Energy Sector in Africa. New York: The Global LPG Partnership.

Kirby et al. (2019). Effects of a large-scale distribution of water filters and natural draft rocket-style cookstoves on diarrhea and acute respiratory infection: A cluster-randomized controlled trial in Western Province, Rwanda. Plos Med, 16(6), e1002812.

Kypridemos et al. (2020). Health and climate impacts of scaling adoption of liquefied petroleum gas (LPG) for clean household cooking in Cameroon: a modelling study. Environmental Health Prespectives, 1288(4), 1-12.

MacCarty et. al. (2010). Fuel use and emissions performance of fifty cooking stoves in the laboratory and related benchmarks of performance. Energy for Sustainable Development, 14(3)161-171.

Morelli et al. (2017). Life cycle assessment of cookstoves and fuels in India, China, Kenya and Ghana. EPA/600/R 17/225.

Myhre, et al. (2013). Anthropogenic and natural radiative forcing. . In Climate Change 2013. The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, pp. 659-740.

Nautiyal, S et al. (2013). Transition from Wood Fuel to LPG and Its Impact on Energy Conservation and Health in the Central Himalayas, India. J. Mountain Science, 10.

Shen et. al. (2018). Evaluating the Performance of Household Liquefied Petroleum Gas Cookstoves. Environ Sci Technol , 16.

Smith et. al. (2015). Millions dead: how do we know and what does it mean? Methods used in the comparative risk assessment of household air pollution. Annu. Rev. Public Health , 185–206.

Smith, K et. al. (2000). Greenhouse implications of household stoves: an analysis for India. Annual Review of Energy and the Environment , 25, 741–763.

USAID. Greenhouse Gas Emissions in Rwanda (2018).

Williams, et al. (2020). Exploring the impact of a liquefied petroleum gas intervention on time use in rural Peru: A mixed methods study on perceptions, use, and implications of time savings. Ennvironment International, 145(105935).

Woolley et al. (2020). Biomass cooking carbon monoxide levels in commercial canteens in Kigali, Rwanda. Archives of Env and Occ Health. https://doi.org/10.1080/19338244.2020.1761279

World LP Gas Association. (2019). Statistical review of Global LPG 2018. Paris: WLPGA.

Zhang et. al. (2000). Greenhouse gases and other airborne pollutants from household stoves in China: a database for emission factors. Atmospheric Environment, 34, 4537-4549

80. Overview of Regulatory Agencies

Figure 75. Matrix of governmental agencies and current areas of LPG responsibility and influence

Institution	Policy/law development	Financing agents	Implementor	Regulator	Standards compliance	Taxation	Comments
MININFRA							Policy/laws on infrastructure, energy
RURA							Energy/LPG regulating agency
REG/EDCL							Energy/LPG implementing agencies
RSB							Standards
RRA							Revenue authority
MINICOM							Policy setter re strategic reserves
MINALOC/districts							Municipal engagement
RCS							Corrections population
Police							Includes police training academies
MINEDUC/schools							Includes boarding schools, TVETs, public tertiary institutions
MoH/health facilities							Health facilities engagement
MINECOFIN							Fiscal policies and budgets
BRD							Manages World Bank CCF in Rwanda
FONERWA							Rwanda green fund
MoE							Policy/laws on environment
REMA							Environmental implementing agency

Key: *Lead role (within its domain)* *Suporting role*

81. Conditions and Consequences of the CCCM LPG Market Model

In developing country contexts, this model has been shown to create a temporary surge in cylinder inventory and LPG consumption followed eventually by debilitating market dysfunction, the cessation of investment in new LPG cylinders, a rapid decline in cylinder safety, a corresponding rapid increase in fires and explosions, a surge in black market LPG activity, and eventual market stagnation or implosion. At the heart of CCCM is consumer ownership of, and control over, the LPG cylinder. This works well in America and Canada because:

- The consumer is very conscious of liability for cylinder safety, and will accept liability and the responsibility that goes with it;
- The consumer is well educated;
- The consumer has a vehicle and is easily able to transport his/her cylinder for periodic inspection and, when necessary, repair and recertification;
- The consumer is universally willing to pay to replace a damaged, unsafe cylinder that requires scrapping;
- The potential penalties (governmental, from civil lawsuit, and in terms of access to and of insurance) related to an LPG accident for which the consumer bears responsibility are very large, and are very likely to be experienced in practice;
- Corporations and SMEs in the U.S. and Canadian LPG sector are likewise very conscious of liability, and they are almost always unwilling to take non-compliant actions or to make non-compliant omissions in their activities, whether for the purpose of satisfying a consumer who does not want to pay to replace his/her unsafe cylinder, or for the purpose of avoiding business costs related to required safety practices;
- Corporations and SMEs are also conscious of, and comply with, generally strong and well-enforced consumer protection laws and competition laws that prohibit bad and unethical business practices;
- Corporations and SMEs are conscious of, and comply with, strict and well-enforced licensing requirements. One will almost never find an unlicensed or uncertified LPG business operating in the U.S. and Canada, or a licensed operator acting in intentional violation of its license terms.

Most developing countries do not have the above preconditions for success with CCCM.

The cost of regulation under CCCM model is high, because hundreds (as in Ghana, for example) or thousands (in America) of points of LPG cylinder refilling and exchange must be monitored for compliance.

When tried for the first time in a market where cylinders were previously not consumer-owned and -controlled, CCCM has been shown to unlock pent-up demand for the first few years, but the seeds of the LPG market's stagnation or demise will have been planted.

The following are main reasons why CCCM has not worked over the long term in the other countries that have tried it:

- Consumers will shop around for a refill point that does not require the consumer to replace or repair an unsafe cylinder or valve at the consumer's cost; this "shopping around" favors black marketers, who as a group will disregard safety if it means getting paid to refill a given cylinder vs. not refilling one.

- Consumer control of cylinders makes it very easy for black market operators (who do not spend any resources on cylinder safety) to interpose themselves in the supply chain to take business away from legitimate market players. They do this by locating closer to the consumer than the nearest legitimate player, charging a lower price, and thus stealing profits from the legitimate player who used to serve that customer. This leads to the black marketeers driving out the good players, and unsafe cylinders driving out the good cylinders. This in turn leads to market stagnation, higher infrastructure investment risk, and increasing numbers of safety incidents—including fatalities.

- Without strong institutions to inspect and enforce pro-safety market rules, these factors eventually halt market growth.

- Businesses seeking LPG customers in a new geographic area require as a precondition a critical mass of initial customers to have cylinders to be refilled. Consumers in such an area who may wish to become LPG users require as a precondition to purchasing LPG equipment the presence of a reliable and trustworthy supplier who can refill their cylinders. Therefore, there is minimal incentive for either the supplier or the consumer to start the process of buying and selling.

82. Note Regarding LPG Accounting Treatments

In the presentation of financial models for the LPG sector and firms operating in the LPG sector, for the sake of both conservatism and simplification, the following three financial statement/cashflow items have been omitted, with certain implications:

1. *LPG passthrough costs and arbitrage*. The financial performance of an LPG company, by industry convention, does not typically consider the asset value of the LPG fuel which it acquires and sells. In this report, the portion of turnover (revenue) and the cost of goods sold (COGS) associated with the LPG commodity itself are treated as equivalent and are effectively disregarded. That is, the LPG company creates gross profit from the unit margins applicable to its LPG volumes. Accordingly, what is presented in this report as "turnover" (or revenue) is in actuality the aggregate unit margins, and the cost to acquire the LPG commodity is disregarded. While it is possible in principle for an LPG company to "buy low and sell high", by having sufficient storage to exploit time-based arbitrage, that has not been considered in the economic and financial analysis of the LPG firms.

2. *LPG gain*. LPG gain is an LPG industry term for the small quantity of LPG that remains in returned cylinders when customers return their "empty" cylinders to the cylinder recirculation system. This amount may run to 1-3%. It is normative in the LPG industry that the LPG Marketer does not provide a credit to the consumer for this leftover LPG quantity. This is a practical matter: it is not operationally or economically feasible to measure the leftover quantity accurately and efficiently across thousands of retail cylinder exchange points. Thus, the LPG Marketer gets a small head-start on the refill of every cylinder that passes safety inspection at the filing plant. This head-start is a potentially significant contributor to the profit stream of the Marketer, because it is effectively "free LPG" to the Marketer, the value of which passes directly through to the Marketer's pretax net income. The notional value of the LPG gain has not been included in the financial modelling presented in this report, in part because it is not practical to assign a specific, reliable value, and in part in order to err on the side of conservative forecasting of firms' financial performance. Therefore, the financial rate of return generated by an expansion investment in an LPG Marketer will, in practice, be somewhat higher than presented in this report's financial models, and the cash flow and debt service risk will be slightly lower than suggested by those models. For PAYG LPG companies, the LPG gain is de minimis, because only gas that is actually used is paid for by the user.

3. *Treatment of cylinder deposits.* It is not known if Rwanda companies practice a uniform accounting treatment with respect to cylinder deposits. Under BCRM, the branded cylinder is deemed to be owned by the Marketer throughout the cylinder's lifecycle. Numerous leading Marketers elsewhere in East Africa provide receipts to their new customers for the cylinder deposit amount as documentation the customer can use to reclaim the deposit upon cancelling service and returning the cylinder that is in his/her possession at the time. The financial modelling in this document reflects the legal framework underpinning cylinder ownership: the cylinder is a long-term, depreciating asset of the Marketer, and the deposit payment from the consumer is a liability (in effect, an interest-free demand note). That liability is matched on the balance sheet by an equal increase in cash. The modelling does not attempt to address reserving against deposit claims.

83. Note Regarding LPG Pricing and Availability After 2030

LPG pricing trends beyond 10 years are not feasible to predict with high confidence. Historically, global and regional LPG prices tracked directionally with the long-term movements in global and regionally-applicable crude oil price indices. Thus, price spikes of intermediate durations are possible. (The governments of some LPG-using countries protect their populations from such spikes through price-stabilization mechanisms.)

From the 2010s, LPG has increasingly tracked directionally with regional natural gas and LNG prices as natural gas / LNG pricing decoupled from crude oil pricing in international markets.

It should be noted that the LPG market clearing function performed by the petrochemical / plastics sector currently represents approximately 30% of total LPG global consumption. This segment is the most price-sensitive of all consuming segments. Therefore, petrochemicals/plastics consumption may provide a buffer that insulates LPG pricing to some degree for the other consuming sectors (residential, industrial, etc.), if global LPG supply tightens after 2030.

It was also beyond the practical scope of the Plan's analytical process to attempt to assess how *relative* price changes among LPG and the main Rwandan cooking energy and technology alternatives might affect adoption and consumption beyond 2030.

84. Comments on Proposed Rusororo Strategic Storage Project

A project has been proposed by a leading LPG Marketer in Rwanda for a Rusororo facility comprising (i) 15,000 m^3 of LPG strategic storage for the country and (ii) 2,100 m^3 of private storage and a filling plant.

A copy of the main body of a feasibility study, comprising technical details (November 2020), was provided to the Master Plan expert team, omitting the proposed financial, ownership, and other details contained in separate appendices.

Below is a briecf commentary on the main body of the study. The comments do not speak directly to the private sector filling plant and storage aspects, which are addressed in other Parts of this Plan, nor the topic of balancing of public sector and private sector economic and ownership interests and investments in the facility over time, given the lack of information provided regarding that aspect of the project.

One important financial element is noted here, and in Chapters 45 (Volume 4) and 51 (Volume 5): the cost of the LPG fuel to be stored in the strategic storage is a material element of the total investment need, and must be included in the GoR procurement and funding plans.

Environmental impact assessment comments

1. Add in the negative effects; traffic movement of the trucks.
2. In mitigation, there is a need for a safety management system.
3. In the "emergency plan", involve the fire brigade and / or police, as appropriate to the area.
4. In the absence of a Quantitative Risk Assessment, considering the volume of LPG and the probability of major accidents, it is recommended to freeze all the habitation buildings (ensuring no residential buildings) within a minimum of 500 m radius.

Technical and safety comments

1. In making the design, environmental risks should be taken into consideration, as applicable (flood, seismic, climatic conditions, soil conditions, etc.).
2. It is recommended that the storage accommodate 250 psi pressure for the possibility to store propane in the future.
3. 7,300 MT pf strategic storage will be needed to comply with the projected LPG consumption demand up to 2022, depending on the scenario. Future demand is expected to require a total of 30,000-44,000MT of strategic storage in 2030. Therefore, it is recommended to have enough space remaning within the same site to install additional storage tanks in future as the market grows.
4. The depot will be used for both receiving imported product and for loading for local Marketers. The loading/unloading bays should be adequate for those activities; more should be provided.
5. The firefighting flow rate (10.2 litres/min.m^2) on the two 7500m^3 and one 2100m^3 spheres, two loading bays, pump rooms and hydrants requires approximately 2,800m^3/hr total flow rate and 11,200 m^3 water storage. The designed firefighting system of the project therefore seems insufficient. As an alternative, a mounded storage would provide passive fire-protection, reduce safety distances, and reduce the required scale of the water-based firefighting system.

6. The legs of the spheres would need fire protection concrete or fire retardant.
7. The control command system is managed by a programmable logic controller (PLC); it is recommended to have a redundant safety-PLC, in case of a problem with the main PLC.

85. About the Global LPG Partnership

The Global LPG Partnership (GLPGP) is a United Nations (UN)-backed, non-profit Public-Private Partnership formed in 2012, under the UN Sustainable Energy for All initiative, to aggregate and deploy needed global resources to help developing countries transition large populations rapidly and sustainably to liquefied petroleum gas (LPG), including renewable bioLPG where feasible, for cooking.

GLPGP is evidenced-based and competition-neutral in its work.

GLPGP partners with host country governments at their invitation, and other relevant stakeholders, to create national plans for rapid, sustainable scale-up of LPG infrastructure, distribution and demand. GLPGP then assists with the mobilizing of financing for, and the implementation of, key plan elements to transition the maximum viable population to LPG for cooking.

Developing countries request GLPGP's assistance to achieve the three main prerequisites for making LPG widely available and affordable:

- Plan and implement enhancements to government policies, regulations and regulatory enforcement to create the enabling environment for a viable, scalable, sustainable LPG sector;
- Provide knowledge and expansion capital to achieve critical mass of LPG supply, infrastructure and distribution systems quickly and sustainably; and
- Empower consumers, who can otherwise afford LPG fuel, to pay the upfront cost of appliances to use LPG and thereby unlock additional demand.

More information is available at www.glpgp.org.

86. Safe-Harbor Statement

This document is not an investment prospectus nor a solicitation to buy or sell securities.

Certain portions of this document contain forward-looking statements that are based on expectations, estimates, projections and assumptions. Words such as “expect,” “anticipate,” “plan,” “believe,” “scheduled,” “estimate” and variations of these words and similar expressions are intended to identify forward-looking statements, which include, but are not limited to, projections of supply, demand, consumption, prices, policies, regulations, investment activity, economic and financial performance, business performance, cash flows, contracts and tenders, and other projections. These statements are not guarantees of future performance with respect to the parties associated with, or referred to in, such statements. These statements involve certain risks and uncertainties, which are difficult to predict. Therefore, actual future results and trends may differ materially from what is forecast in forward-looking statements due to a variety of factors, which include, but are not limited to, changes in (i) government policies and regulations, (ii) pricing, (iii) business strategies, (iv) the national and/or global economy, (v) exchange rates, (vi) project costs, (vii) consumer demand or preferences for energy products and services, (viii) competition conditions, (ix) market structures, (x) outcomes of litigations, (xi) outcomes of political and legislative processes, and others.

All forward-looking statements speak only as of the date shown on the front page of this document, or, in the case of any document incorporated by reference, the date of that document. The Clean Cooking for African Programme and GLPGP do not undertake any obligation to update or publicly release any revisions to forward-looking statements to reflect events, circumstances or changes in expectations after the date of this document.

This document does not necessarily reflect the policy views of the Government of Rwanda, except where so noted.