Climate and Health Impacts of Scaling Adoption of LPG for Clean Cooking through the Cameroon LPG Master Plan

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Cooking with 'biomass'

Cooking with LPG

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Executive Summary

To address health, environment, deforestation and energy security issues related to reliance on biomass for domestic energy, the government of Cameroon recently adopted a National LPG Master Plan (Master Plan) to increase liquefied petroleum gas (LPG) adoption to around 58% of the population by 2030. We modelled the health and climate impacts of this aspirational goal in the short (2030) and long (2100) term. By 2030, successful implementation of the **Master Plan was estimated to save 23,000 lives and avert 760,000 disability-adjusted-life-years** (DALYs) compared to the current trend in LPG adoption. For the same time period the **Master Plan reduces the emissions of short-lived climate pollutants by more than one third, which is estimated to have a net cooling effect.** The Global Warming Potential with a time horizon of 100 years (GWP(100)) of the reduction is -4.5 Mt CO_2-equivalent, assuming 90% renewable biomass (assuming 50% renewable biomass, the figure is -7.6 Mt CO_2-equivalent). Using a simple climate model we estimate a global cooling effect of -0.10 millidegree centigrade (milli ˚C) in 2030. For 2100, the cooling effect for a continued Master Plan leading to LPG saturation (73%) was estimated to be -0.70 milli ˚C assuming 90% renewable biomass, or -0.93 milli ˚C assuming 50% renewable biomass. Avoided emissions of black carbon (BC) dominate the impact of the Master Plan on global temperature. Meeting the government's aspirational target of 58% of the population using LPG through successful implementation of the Master Plan will have significant positive impacts on population health (mortality and morbidity) and on climate, through reductions in climate emissions and associated global cooling.

Introduction

In Cameroon, the majority of cooking is carried out using biomass fuels (such as wood and charcoal), which pose risks to health and the environment and contribute to holding back economic development. These risks include death and illness from respiratory conditions due to high levels of smoke inhalation, environmental harm from deforestation and air pollution, and the impacts on society from sub-optimal health, leading to reduced quality of life and a less economically active population. They also include the direct impact on individuals and households from time lost gathering fuel and inefficient cooking.

"In 2016 in Sub-Saharan Africa, exposure to household air pollution from cooking with solid fuel was estimated to result in 520,000 premature deaths (7% of all deaths)" [1]

Switching to clean cooking fuels such as LPG has the potential to deliver large health, social and environmental benefits, as well as short-term climate benefits. The International Energy Agency now includes LPG as a key fuel recommended to tackle energy-related air pollution emissions [2].

As part of its commitment to become an emerging economy by 2035, the Cameroon Government has set a target that, by 2030, around 58% of the population will be using LPG as a cooking fuel (compared to less than 20% in 2014). In 2015 an inter-ministerial, multi-stakeholder national LPG 'ad hoc' committee, co-chaired by The Global LPG Partnership, oversaw the development of a National LPG Master Plan for Cameroon. This includes policy and regulatory enhancements and all necessary investments and interventions along the LPG value chain to achieve this target. The Master Plan was submitted to the Cameroon Government in August 2016, and publicly announced by the Government in December 2016. Implementation is expected to start in early 2018.

The aims of this study are to describe the impacts of this planned LPG expansion on **population health** and **climate change mitigation** and to be a model for replication for other Sub-Saharan Africa countries.

[1] Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualization. Seattle, WA: IHME, University of Washington, 2016.
[2] IEA. Energy and Air Pollution: World Energy Outlook Special Report 2016. Paris: International Energy Agency.

Approach

Statistical models were developed to measure the health and climate impacts of expanding LPG adoption for household cooking in Cameroon over two time frames:

1. **SHORT-TERM (2017-2030) for both health and climate impacts:**
Comparing **"Business as usual,"** assuming LPG adoption increases over time in line with current trends to 32% in 2030 (i.e. without implementation of the Master Plan) **with "Master Plan implementation"**, assuming LPG adoption reaches Master Plan target of 58% in 2030.

2. **LONG-TERM (2031-2100) for climate impacts:**
Comparing **"Business as usual"** assuming LPG adoption increases over time in line with current trends to 41% by 2100 with three **Post Master Plan scenarios:**

Post-Master Plan – minimum: Based on returning to the pre-implementation rate of adoption after 2030 resulting in 51% LPG adoption by 2100.

Post-Master Plan – saturation: Assuming a mature and saturated LPG market by 2100 with 73% adoption.

Post-Master Plan – maximum: Where LPG adoption was set at a theoretical maximum of 100% by 2100.

To model the health impacts, data on exposure to household air pollution ($PM_{2.5}$) taken from 61 women (mean 94.2 µg/m^3) and 56 children (mean 41.4 µg/m^3) from households exclusively using biomass were compared to 67 women (mean 18.5 µg/m^3) and 60 children (mean 18.9 µg/m^3) from households using LPG as their primary fuel. This data was collected in South West Cameroon as part of the University of Liverpool led LPG Adoption in Cameroon Evaluation (LACE) studies.

Modelling Health Impacts

The differential household air pollution exposure data for women and children outlined in the previous section informed a comparative risk modelling approach. This was conducted using the HAPIT v3.1 computer model (https://householdenergy.shinyapps.io/hapit3/) for Cameroon estimating the proportion of deaths that can be attributed to PM2.5 exposure and the number of deaths and disability-adjusted life years (DALYs) that can be averted by reductions in household air pollution from switching to LPG. To assess the "counterfactual scenario" we repeated the HAPIT analysis for the **Business as usual scenario** and subtracted averted mortality and disability-adjusted life years (DALYs) estimates from the **Master Plan implementation scenario.**


Child near open fire


Woman cooking on open fire

Modelling Climate Impacts

Climate impacts for the four Master Plan implementation scenarios were compared to the Business as usual scenarios for global heating and cooling emission components (Table 1). Modelling was adjusted for the impacts of increased CO_2 from LPG usage (somewhat offset by decreases in deforestation from biomass harvesting). The impact on global temperature was estimated using "Absolute Global Temperature Change Potential (AGTP)," giving the temporal global temperature response of a pulse emission of a component. Emission metrics values can be normalized to CO_2 to give CO_2-equivalent emissions, such as AGTP normalized to GTP. In addition, the emission metric "Global Warming Potential (GWP)" was applied to estimate the accumulating radiative forcing of CO_2-equivalent emissions. The impacts on AGTP, GTP, and GWP of the Master Plan scenarios were estimated as differences from the *Business as usual scenarios* (actual and percentage).

Table 1: Modelled Emission Components

Component	Acronym	Description
Black Carbon	BC	Warming aerosol, main heating component of biomass fuel.
Carbon Dioxide	CO_2	Warming greenhouse gas and long-lived in atmosphere, main heating component of LPG fuel.
Carbon Monoxide	CO	Warming ozone precursor.
Methane	CH_4	Warming greenhouse gas and short-lived in atmosphere.
Nitrous Oxide	NO_x	Ozone precursor, which is warming in the short-term and cooling in the long-term due to short-term warming from added ozone and long-term cooling from reduced CH_4.
Organic Carbon	OC	Cooling aerosol.
Sulphur Dioxide	SO_2	Cooling aerosol.
Volatile Organic Compounds	VOC	Warming ozone precursor.

Four data sources were used including (i) population projections based on Cameroon census data and United Nations population projections, (ii) baseline emissions data for the domestic sector in Cameroon (taken from the ECLIPSE study and used to project emissions growth to 2050), (iii) fuel use data for total biomass consumption (97% wood; 3% charcoal) and percentage renewable biomass in Cameroon (90% as reported by Bailis et al. 2015), with 50% and 100% as an uncertainty interval), and (iv) total emissions for each combustion component by applying published emission factors. Estimates of the climate impacts of each component, as well as the temperature response variations over time, was made for the different Master Plan scenarios. The total CO_2 equivalent emission changes were estimated for the Master Plan being achieved in 2030. We calculate the GWP and GTP with a time horizon of 20 and 100 years, respectively.

Ambient air pollution from wood fuel burning

Results

Health Impacts

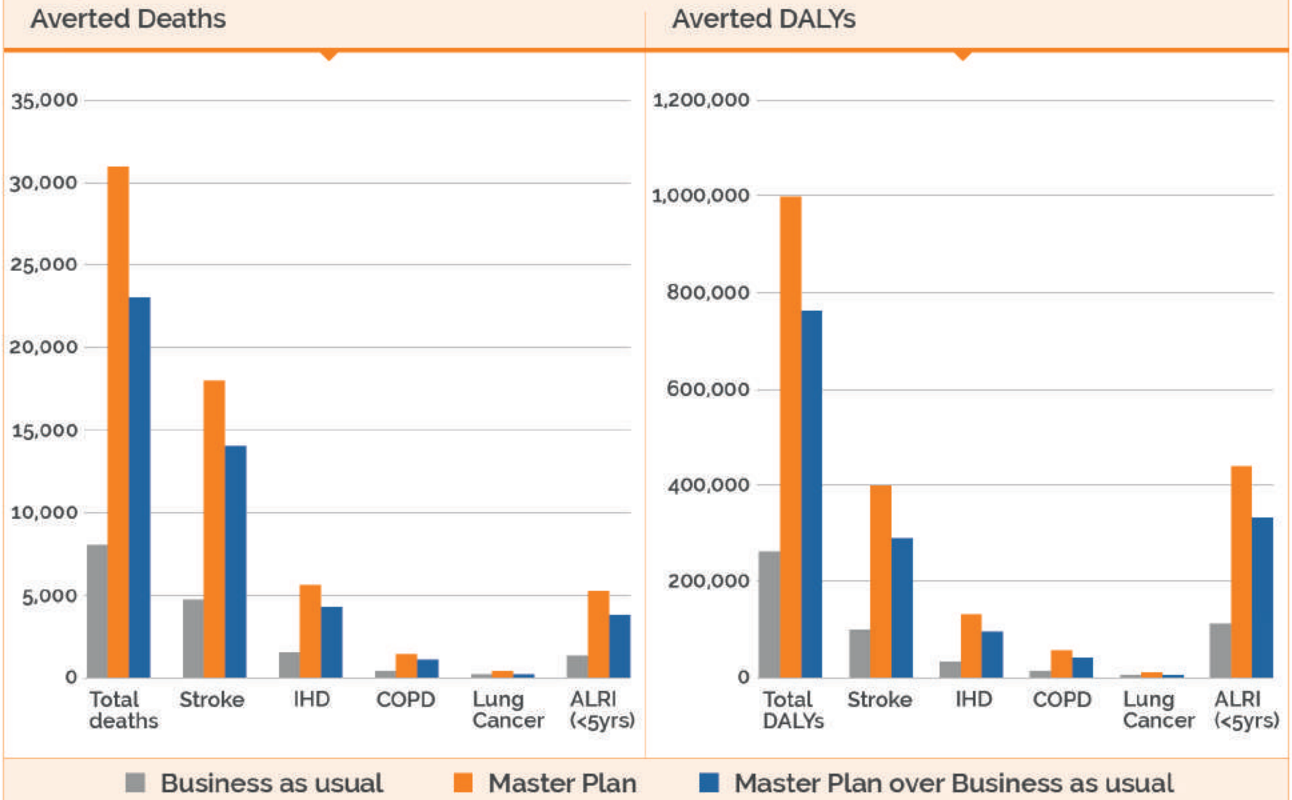
It was estimated that approximately **23,000 deaths** and **760,000 DALYs** could be averted if Cameroon achieves the Master Plan target of 58% for LPG penetration in 2030 and retains it for 5 years, compared to *Business as usual* (Table 2). This represents about 36% of all household air pollution related preventable deaths in Cameroon.

Based on the analysis for children alone it is estimated that those under five will expect to gain 19 days of life expectancy, on average, from every year they continue to live in a household that adopted LPG as a result of the Master Plan. Similar results were obtained when adjustments were made for population growth and disease trends over time.

Table 2: Health impacts from Master Plan implementation over Business as usual

Disease	Averted Deaths	Averted DALYs	Averted Years Lost To Disability	Averted Years of Life Lost
Acute Lower Respiratory Infection (ALRI) (age < 5 years old)	3,800 (2,700 to 4,500)	330,000 (230,000 to 390,000)	250 (180 to 290)	330,000 (230,000 to 390,000)
Chronic Obstructive Pulmonary Disease (COPD)	1,000 (620 to 1,400)	40,000 (24,000 to 52,000)	19,000 (11,000 to 25,000)	21,000 (12,000 to 27,000)
Ischemic Heart Disease (IHD)	4,200 (3,200 to 6,900)	94,000 (71,000 to 160,000)	2,800 (2,100 to 4,700)	92,000 (69,000 to 150,000)
Lung Cancer	230 (100 to 290)	5,700 (2,600 to 7,100)	58 (31 to 76)	5,600 (2,500 to 7,000)
Stroke	14,000 (4,700 to 17,000)	290,000 (100,000 to 360,000)	2,000 (680 to 2,400)	290,000 (100,000 to 360,000)
Totals	**23,000** (11,000 to 30,000)	**760,000** (430,000 to 960,000)	**24,000** (14,000 to 32,000)	**740,000** (420,000 to 930,000)

Figure 1: Health impacts of LPG adoption scenarios including the Master Plan target at 2030

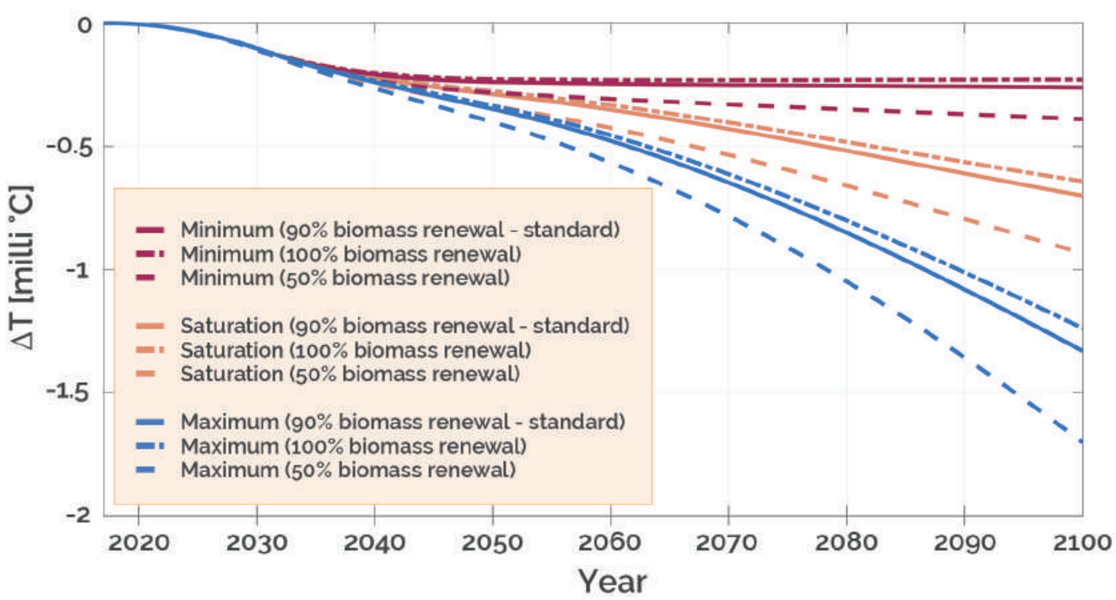


Climate Impacts

In 2030, a comparison between *Business as usual* and *Master Plan implementation scenario* found **total net reductions in emissions of around 37% for most emissions components** (BC: -37%, OC: -38%, SO2: -38%, NOx: -37%, CO: -37%, VOC: -26%, CH4: -38%). Conversion of emissions into CO_2-equivalent found a cooling effect of Global Warming Potential with a time horizon of 100 year (GWP(100)), equal to -4.5 Mt CO_2-equivalent. The cooling potential is greater the lower the percentage of renewable biomass and for a 50% renewable biomass, our upper uncertainty range level, the cooling effect of the Master Plan equals emissions of -7.6 Mt CO_2-equivalent. The Master Plan-implementation scenario lead to an estimated global cooling effect of -0.10 milli ˚C in 2030. CO_2 has minor importance on such short time scales.

Temperature responses resulting from changes in emissions under the three longer-term post-Master Plan scenarios to 2100 (minimum, saturation and maximum) are shown relative to *Business as usual* in Figure 2.

Figure 2: The net global temperature change for Master Plan scenarios



For 2100, under the Post-Master Plan-minimum scenario (51% adoption in 2100), the net cooling is estimated at -0.26 milli ˚C. The Post-Master Plan-saturation scenario (73% adoption in 2100) had a larger cooling impact, reaching -0.70 milli ˚C. The Post-Master Plan-maximum scenario (100% adoption) gave a net cooling of -1.33 milli ˚C. The results were sensitive to assumptions about how much deforestation is avoided through reductions in demand for wood as a cooking fuel. The reduction in global temperature under the Post-Master Plan-saturation scenario in 2100 is -0.64 milli ˚C using 100% renewable biomass, but increases to -0.93 milli ˚C with only 50% renewable biomass.

Highlights

- Supporting expansion of LPG adoption through the Master Plan to achieve target adoption of 58% by 2030 will have significant **positive impact on population health in terms of both mortality and morbidity.**

- The health impacts are substantially greater under the Master Plan than would be the case given the current rate of LPG adoption (unassisted by the Master Plan).

- Switching from biomass to LPG for domestic fuel in line with the Master Plan target has demonstrable impacts on emissions affecting climate and the estimated global temperature response.

- **A global cooling effect by 2100 is reported under all scenarios.**

- The 73% LPG adoption by 2100 under the post Master Plan saturation scenario (a similar level of adoption currently in Latin America) results in a global cooling effect of -0.70 milli ˚C. This will make an important contribution to the Paris climate agreement for controlling global warming.

- These climates benefits account for additional CO_2 from expanding LPG use and may be conservative, given the assumed 90% renewable biomass fraction.

Acknowledgements

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