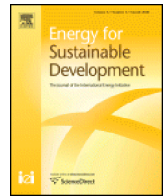




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Ghana's rural liquefied petroleum gas program scale up: A case study

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ABSTRACT

Background: The Government of Ghana launched the Rural LPG (RLP) promotion program in 2013 as part of its efforts to reduce fuelwood consumption. The aim of the RLP is to contribute to Ghana's overarching goal to provide LPG access to 50% of Ghana's population by 2020. The RLP has not announced long-term program objectives. However, in the interim the RLP targeted a cumulative total of 170,000 LPG cookstoves to rural households by the end of 2017. As of November 2017, 149,500 rural households had received the LPG cook stoves. Our case study documents Ghana's experiences to date with LPG scale up.

Methods: We carried out a desktop review/document analysis of literature on the RLP. Each document was reviewed for information related to the elements of the Reach, Effectiveness, Adoption, Implementation and Maintenance (RE-AIM) framework as it pertained to LPG promotion and adoption. In-depth interviews were held among key stakeholders in Ghana. Previously collected data from a field evaluation of the RLP was also assessed.

Findings: Generally, our evaluation suggests that the current form of the RLP is not achieving its stated goal. Our evaluation of the RLP in five rural communities showed that about 58% of households had never refilled their LPG cylinders nine months after the initial delivery of a filled cylinder. Only 8% still used their LPG at 18 months post distribution. Cost and distance to LPG filling stations were the main reasons for low LPG use. Beneficiaries did not exclusively use their LPG even at the initial stages when all of them had LPG in their cylinders. Ghana is currently undergoing transitions in the LPG sector including a change from the current private cylinder ownership model to a cylinder recirculation model for the distribution of LPG. There was no evidence of a well-documented implementation framework for the RLP.

Conclusion: Fuel cost, poor LPG access, and an inadequate implementation framework hinder the RLP implementation.

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Background

Air pollution from the use of solid fuels for household cooking is a top priority global risk factor for respiratory, cardio-vascular and ocular diseases (WHO, 2017). In Ghana, where biomass fuels are the primary cooking fuels for 70% of households, exposure to household air pollution is responsible for 16,600 deaths and the loss of 502,000 disability adjusted life-years annually (Ghana Statistical Service, 2012, 2014c; Inkoom & Crentsil, 2015). Biomass fuels also contribute to ambient air pollution (Fullerton, Bruce, & Gordon, 2008; Ghana Statistical Service,

2014b; WHO, 2011). Thus, there is a need to promote low emission fuels such as LPG (MacCarty, Still, & Ogle, 2010; WHO, 2011).

Ghana is a low middle-income country located in West Africa with a population of about 28 million as of 2016. About 50% of the population live in rural areas (Ghana-Web, 2013) where over 90% of households rely on either firewood or charcoal for cooking. The Gross Domestic Product (GDP) of Ghana was 42.7 billion US dollars in 2016 with a GDP growth rate of 3.6% (World-Bank, 2017).

In June 2012, Ghana became the first country to promulgate a Sustainable Energy for All Action Plan, as called for by the United Nation's Sustainable Energy for All (SEforALL) program (ENERGIA, 2015). Among other things, the plan emphasized the importance of clean energy for cooking. Ghana's SEforALL plan also called for LPG cylinder

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recirculation as a model for the distribution of LPG to accelerate the rate of uptake of LPG for cooking (Energy-Commission, 2012a).

The objective of this case study is to document Ghana's scale up of LPG. We focus on the Ghana Ministry of Energy's Rural Liquefied Petroleum Gas program, (RLP) a key element of Ghana's plan to expand LPG access to 50% of Ghana's population by 2020 (Pettersson, 2016). We also assess ongoing efforts to restructure the LPG sector around a cylinder recirculation model. This change is still in the planning stage, so its ramifications cannot yet be observed.

Ghana is both a producer and importer of LPG. In 2017, about 36% of Ghana's total LPG supply was produced in Ghana and around 64% was imported (Energy-Commission, 2017b). To achieve a 50% nationwide LPG use, Energy Commission of Ghana estimates at least 450,000 t of LPG will be required by 2020 based on an estimated population of 31–32 million (Energy-Commission, 2017a). LPG is distributed by about 42 LPG marketing companies to about 641 gas refilling stations across the country. These refilling stations serve customers who carry their empty cylinders to the gas refilling stations to get them refilled (IMANI, 2017).

Historical background of LPG promotion in Ghana

LPG Promotion program

LPG promotion has a long history in Ghana. The Government of Ghana, as part of its efforts to reduce deforestation, embarked on an LPG promotion program in 1989 under the Ministry of Energy (Morden-Ghana, 2011). The main objective of the program was to foster wider use of LPG as a substitute for charcoal and firewood for cooking; health was not a stated objective (Ahunu, 2015). The LPG promotion program also sought to improve LPG access via existing LPG distribution networks nationwide, to increase LPG safety awareness through educational campaigns, and to promote local manufacturing of LPG cylinders and accessories (Ahunu, 2015). The LPG promotion program targeted households, public catering facilities and small-scale food sellers, and worked to improve access, affordability and availability of LPG (UNDP, 2014).

As part of the 1989 LPG promotion strategy, 14.5 kg and 5 kg LPG cylinders were distributed freely to the public, especially in urban areas (Acharibasam & Aparinga, 2014). Consumers who requested an empty cylinder were given one free of cost but were required to pay for the cost of the gas. In order to consistently supply consumers with LPG, the Ministry of Energy devised an LPG delivery strategy by purchasing and assigning pick-up trucks to registered private individuals to retail LPG (Edjekumhene, Atta-Owusu, & Ampong, 2007; Energy-Commission, 2012b). The trucks operated a "door-to-door" LPG delivery service, mainly in Accra. The door-to-door services involved on-the-spot refilling of LPG cylinders to households from the haulage truck. However, the practice exposed both the end-users and the retailers to danger because there were no adequate safety measures in place as the haulage trucks served people in residential areas. This practice was therefore banned. (Edjekumhene et al., 2007). The fate of the haulage trucks after the ban is undocumented but they are likely to have been remodeled for other purposes. The LPG promotion program was extended to schools, hospitals and prisons. The Ministry of Energy installed free LPG cylinders and equipment for these institutions (Energy-Commission, 2012b).

To enhance LPG access in rural areas, financial incentives were provided through the Unified Petroleum Price Fund scheme to motivate transporters who traveled to rural locations outside a radius of 200 km from the LPG production center in the coastal area of Ghana (Ahunu, 2015). In spite of the Unified Petroleum Price Fund scheme, penetration of LPG in rural areas was not encouraging. Out of the 6% of households in 2004, and about 9% in 2005 using LPG as their primary source of fuel for cooking, 70% lived in the largest cities of Ghana-Greater Accra and

Ashanti regions (Kemausuor, Obeng, Brew-Hammond, & Duker, 2011). Only 3% of households in rural areas used LPG as of 2012 (Ahunu, 2015).

As part of its efforts to sustain LPG use, the Ministry of Energy created an LPG fund that was financed by levies from LPG purchases (Edjekumhene et al., 2007). The Fund was used to purchase and maintain cylinders, LPG tanks and kitchen equipment for Government of Ghana institutions (schools, hospitals and prisons). It was also used to finance the local component of the cost of constructing the Ghana Cylinder Manufacturing Company factory in Accra with additional support from the Government of the Republic of South Korea (Edjekumhene et al., 2007).

The LPG Levy was removed in 1998, and an LPG subsidy was introduced for domestic users to help households to meet their demand at an affordable price. However, the purpose of the LPG subsidy was defeated when taxis and other commercial vehicles switched to LPG fuel because of the price difference between LPG and other transport fuels such as petrol. The use of LPG as fuel for cars increased the demand leading to frequent shortages of LPG. This caused some households, schools and other public institutions to revert to the use of charcoal and firewood for cooking or at least as back-up fuels (Energy-Commission, 2012a).

The Ghana Cylinder Manufacturing Company Ltd. (GCMC) was established in 1998 to produce affordable LPG cylinders and accessories (Edjekumhene et al., 2007; GCMC, 2017). This also served to standardize cylinders, regulators and other LPG accessories (Ahunu, 2015; GCMC, 2014). Following this, a second cylinder manufacturing plant – Sigma Gas Ghana Ltd. was established in Accra. In 1995, three refilling stations were built in coastal and northern areas of Ghana to improve LPG access and distribution to various parts of the country (Acharibasam & Aparinga, 2014). Despite these advances, limited storage and distribution capacity throughout the country, combined with use of LPG as a vehicle fuel, led to intermittent severe nationwide shortages of LPG.

In 2010, the Ghana Energy Ministry's Energy Sector Strategy and Development Plan included a target of 50% LPG access by 2015. This was to be achieved through the development of LPG infrastructure, the injection of millions of new cylinders in the market, and pricing incentives to encourage distributors to expand their operations to rural and deprived areas. The following measures were earmarked for implementation (MoE, 2010):

- Speed up the establishment of a natural gas processing plant to produce LPG from the associated gas to be produced from the Jubilee Oil and Gas Field. It is estimated that 10,000 barrels (1340 t) a day of LPG could be produced from the gas from the Jubilee Field;
- Re-capitalise GCMC to expand production capacity. The production of cylinders will focus on relatively small size (4 kg and 6 kg) cylinders that will be affordable to households in rural communities;
- Construct LPG storage and supply infrastructure in all regional and district capitals in the long term. In the medium term, it is intended to develop district capital LPG infrastructure.

However, as of 2015, the goal of expanding LPG access to 50% of Ghana's population had not been achieved. LPG use for 2013, the most recent year for which we have data, was 22.3% (Energy-Commission, 2016). Of the measures outlined above, only one was implemented: the establishment of the Ghana National Gas Company to build and operate a Natural Gas Processing Plant in the Western Region (Energy-Commission, 2012a). The 2012 SEforALL Action Plan postponed the target of achieving 50% access by five years, to 2020. In February 2013, all subsidies on petroleum products, including LPG, were removed to help the Ghana government restore fiscal stability after exceeding its budget by nearly 100% in 2012 (Cooke, Hague, Tiberti, Cockburn, & El Lahga, 2016; Reuters, 2013). The focus of LPG promotion was turned to the free distribution of small size cylinders to rural communities – the Rural LPG Program.

The rural LPG promotion program

The Rural LPG Promotion Program (RLP) – the focus of this case study – is an expansion of Ghana's 1989 LPG Promotion Project. The LPG Promotion Project achieved some success in terms of increase in tonnage of LPG consumed nationwide – from a little over 5000 t per annum in 1989 to over 50,000 t in 2000 and 178,400 t by 2010. This notwithstanding, the program made little impact on the rural areas because of its focus on urban areas (Energy-Commission, 2012a). The RLP was launched in November 2013 (ENERGIA, 2015) in Garu-Tempana in the Upper East Region of Ghana to contribute to Ghana's overarching goal to expand LPG access to 50% of Ghana's population by 2020 (Pettersson, 2016). Under the RLP there is a heightened effort to promote LPG in rural areas where half of Ghanaians live and where the use of biomass fuel is nearly universal (IMANI, 2017).

The RLP is coordinated by the Ministry of Energy together with various stakeholders, including the Ghana National Petroleum Authority (NPA), the Energy Commission of Ghana, Bulk Oil Storage and Transporters Company (BOST), GCMC, and the Ghana National Fire Service.

According to the Ministry of Energy, selection of districts for RLP implementation is based on the presence of a local LPG refill station and district-specific levels of deforestation. Within each district, RLP coordinators meet with the District Assembly to identify rural communities for distribution. The Government of Ghana provides 6 kg LPG cylinders, single burner stoves and the rest of the equipment (hose and regulator) free of charge. The LPG cylinders and stoves are produced by GCMC. In each district, about 2000 to 4000 LPG cylinders and cookstove are expected to be distributed and households are expected to procure LPG from local vendors within the districts (Energy-Commission, 2012a).

The selection of LPG beneficiary households is a collaboration between the district assemblies and focal persons within the communities (district assembly nominated assemblymen, community volunteers, or opinion leaders in the communities). The focal person in each community is tasked by the district assembly to list potential beneficiaries who are interested in LPG use and are able to pay an initial amount of GHC 22.00 (USD 5) for the filling of the LPG cylinder.

The cylinder recirculation model

In October 2017, there was an explosion at an LPG refilling station in the Legon neighborhood of Accra, Ghana. The explosion left seven dead, and over 130 injured (myjoyonline, 2017; TheGuardian, 2017). After years of similar incidents, the Ghanaian government decided it was time to intervene. The President announced a series of initiatives to improve safety standards for LPG filling stations nationwide, led by the National Petroleum Authority (Arthur-Mensah, 2017; Mubarik, 2017). The primary focus is a shift to cylinder recirculation (Akoloh, 2017; Mubarik, 2017). In practice, this system means that consumers will no longer own their own cylinders, but instead will purchase LPG in pre-filled cylinders. The LPG cylinder recirculation model, along with planned improvements in LPG storage and distribution, has the potential to increase access to safe and cost-effective LPG use. Instead of a few hundred small filling stations, the policy will likely result in thousands of retailers served by a small number of industrial-scale filling stations. The full implementation of the cylinder recirculation policy was scheduled to start at the beginning of 2018 after the challenges encountered during the initial stages in 2017. During the sensitization, some stakeholders including the LPG marketing companies and LPG tanker drivers raised concerns that the implementation of the policy would put them out of business. The draft LPG policy was then recalled for further consultations with all relevant stakeholders, especially the LPG marketing companies and LPG tanker drivers (Akoloh, 2017).

Methods, sources and approach

We reviewed literature on the RLP and on Ghanaian LPG sector policies, drawing on peer reviewed papers, newspaper accounts, and official documents from the Government of Ghana and other institutions. In-depth interviews were held among key informants in Ghana. The interviewed stakeholders were purposively selected based on their role in the RLP. The interviewees included 2 personnel from the Ministry of Energy who are responsible for RLP implementation, 1 from Bulk Oil Storage and Transporters Company, a government owned company that is responsible for transporting LPG in bulk, and 1 from the Ghana Chamber of Bulk Oil Distributors, a representative body of Bulk Oil Distribution Companies. The documents and interviews were analyzed for information related to the elements of the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework (Glasgow, Vogt, & Boles, 1999) as it pertained to LPG promotion and adoption.

Previously-collected data from an evaluation of the RLP in five rural communities in the Nkoranza North District in the Brong Ahafo Region of Ghana was analyzed (Kintampo Health Research Centre, 2016). This evaluation used a cross-sectional mixed methods design to evaluate the RLP between November 2015 and October 2016. Focus Group Discussions (FGD) were conducted among women who were primary cooks (beneficiaries and non-beneficiaries of LPG), and male household heads from beneficiary households (Kintampo Health Research Centre, 2016). The study assessed the use of traditional three stone fire stoves and LPG stoves before and after the delivery of the LPG stoves among 200 randomly selected primary cooks. Data on carbon monoxide (CO) exposure of the primary cooks was collected using Lascar EL-USB-CO data loggers (Lascar Electronics, London, UK) in the same sample. Forty eight (48) hour CO exposure levels experienced by primary cooks were measured in four surveys: before LPG was distributed (baseline) and after the LPG was distributed (months three, six and nine post-distribution). The mean age of the 200 respondents was 39 (standard deviation 12.5) and over 91.5% of them were agricultural farmers. Over 60% (61%) of the respondents had large household sizes of between 5 and 9 household members (Kintampo Health Research Centre, 2016). Interactions with human subjects were approved by the Institutional Ethics Committee at Kintampo Health Research Centre in Ghana and Columbia University's Institutional Review Board in the US.

Results

Reach

Reach refers to the number of people and percentage of the target population affected by the RLP. It also includes the extent to which the individuals reached are representative and include those most at risk.

The total number of households in Ghana as at 2010 was 5,467,136 (Ghana Statistical Service, 2012). In 1990, use of LPG for household cooking was about 1% in the whole country and <1% in rural areas. According to the most recent national data, this has increased to about 22% and 6% in 2014 respectively (Fig. 1).

In 2014, wood (37%), charcoal (33%) and LPG/natural Gas/biogas (24%) were the most commonly used cooking fuels (Fig. 2). Urban households were much more likely to use LPG (37% vs 9%) or charcoal (42% vs 21%) compared to rural households. Overall, 70% of households use solid fuel for cooking, i.e., charcoal, wood, straw, shrubs, grass and agricultural crops, and animal dung. A higher proportion of rural households use wood for cooking compared with urban households (66% vs 13%) (Ghana Statistical Service, 2014b).

Beyond the overarching 50% national target, the rural LPG program has not made public long-term program objectives. As an interim goal, RLP targeted a cumulative total of 170,000 LPG cookstoves to rural households by the end of 2017. As at November 2017, 149,500 (87.6%) rural households had received the LPG cookstoves in 108

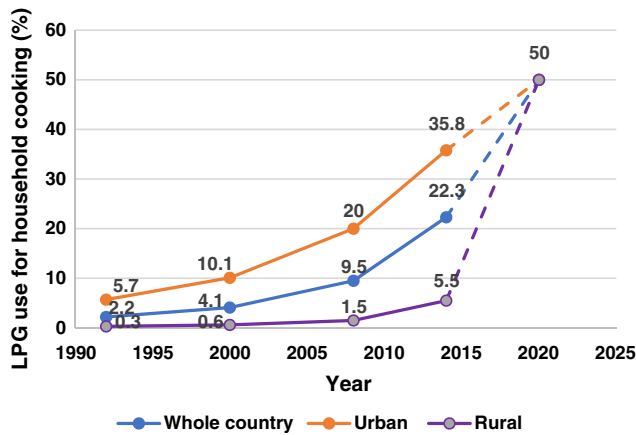


Fig. 1. Percentage of population using LPG for household cooking in Ghana over time, with the dotted line indicating the needed trajectory for a 50% target (Ghana Statistical Service, 1992, 2000, 2008, 2014c). Note: The historical data (1992–2014) is primary fuel use as reported in household surveys. We interpret the 50% target to mean that 50% of households regularly use LPG.

districts within the period. Only 2000 (14.4%) out of 13,882 households (Ghana Statistical Service, 2012, 2014a) received LPG cylinders and cookstoves in the Nkoranza North District where we evaluated the program. These numbers are small relative to district populations. The RLP aims to cover more than the 217 districts of Ghana. Though the population reached is rural, beneficiaries were selected in part based on their ability to pay 5 USD for the initial 6 kg LPG fill. This in effect selects against the poorest members of the beneficiary communities.

Effectiveness

Effectiveness refers to a measure of effects, including positive, negative, and unanticipated consequences of the RLP. The current form of the RLP is not promoting anything close to effective and sustained impact

based on our data on exclusive LPG use from the Nkoranza communities (Kintampo Health Research Centre, 2016). In a sample of 200 LPG recipients across these five communities, all 200 recipients continued to rely primarily on wood fuels for cooking nine months after LPG distribution.

In the five communities, the program did not demonstrate an effective change in personal CO exposures (Fig. 3). We did not evaluate effects on deforestation or other program objectives, but given the low rates of LPG use, meaningful impacts are unlikely. Our surveillance in the five Nkoranza communities did not reveal any unintended or adverse consequences of the program.

Adoption

Adoption refers to the number and percentage of people participating, the extent to which participants are representative of the broader population, and barriers to adoption. In the RLP, initial adoption is automatic for program participants. In evaluating the subject of adoption within the RE-AIM framework, however, we interpret adoption to mean sustained use of LPG.

The RLP is being rolled throughout the country in phases. Early phases of the program include districts that were selected based on poverty levels as per the Ghana Living and Livelihood Standards and Ghana’s Energy Commission report on access to LPG and increase depletion of forest (Ghana Statistical Service, 2014c; Kintampo Health Research Centre, 2016). In the review of data from the 5 Nkoranza communities, there was the perception of political influence in the selection of some of the beneficiary districts, and that political considerations worsened during the 2016 election year.

The LPG cookstoves were distributed based on political affiliation. My elder sister is a member of the ruling governments’ political party so she got one. When I asked her, she said it was true, I was told that, even if I was a party member who does not openly show my party affiliation [...]. That is why I did not to get one (FGD, LPG non-beneficiary).

Nine months after distribution, 58% of the 200 LPG beneficiary households had never refilled their 6 kg LPG cylinders after the initial

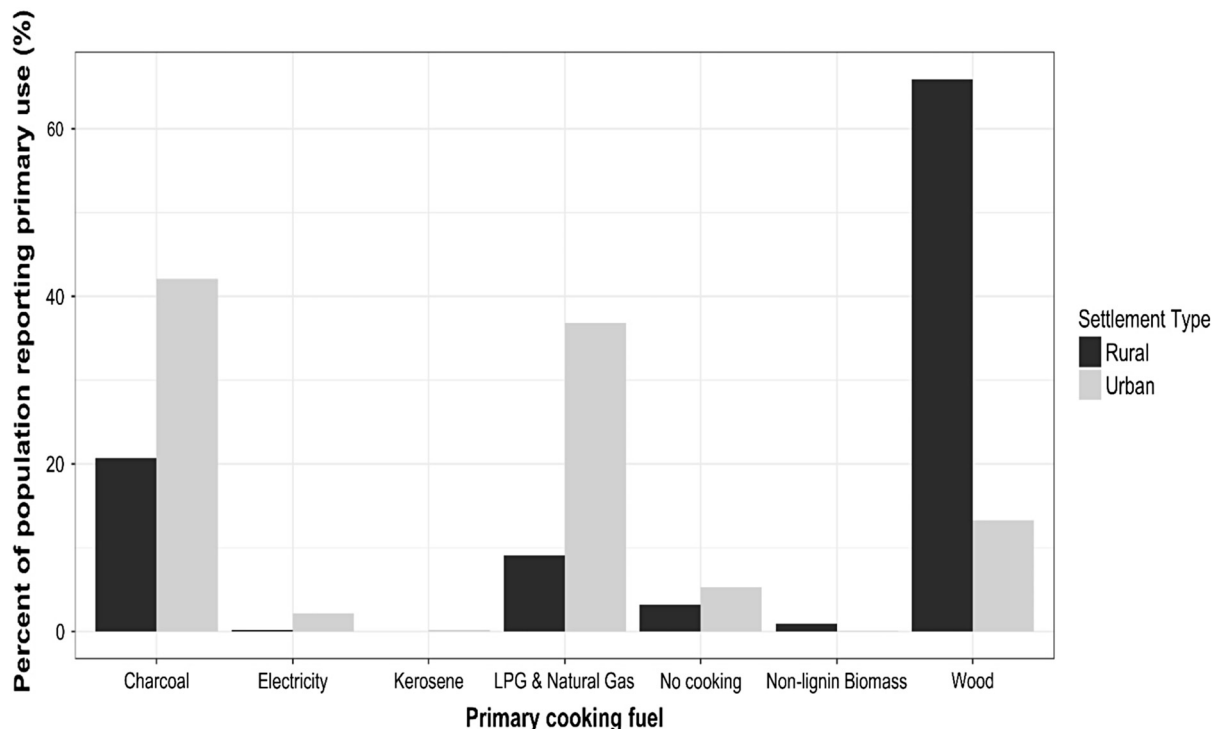


Fig. 2. Types of primary fuel use for cooking in rural and urban households in Ghana (Source: Ghana Statistical Service, 2014b). Note: Unlike Fig. 1, LPG is combined with natural gas in this figure.

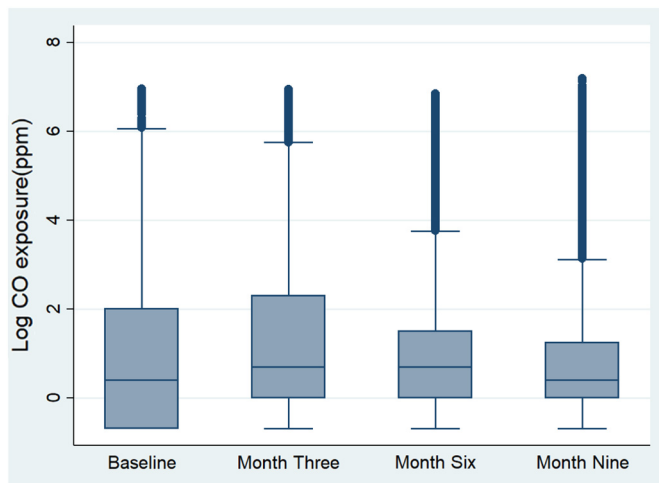


Fig. 3. A box plot showing the Log of means of CO exposure from baseline through to month 9 (Source: Data from Kintampo Health Research Centre, 2016).

fill; 24% of had refilled once, 10% had refilled twice, and about 9% had refilled three or more times. It is also important to note that the LPG beneficiaries did not exclusively use LPG for cooking even at the initial stage of the evaluation when they had LPG in their cylinders (Kintampo Health Research Centre, 2016). In follow up surveys in the Nkoranza communities, only 8% of respondents still used LPG 18 months after distribution of the cylinders. This finding was corroborated in focus groups, in which participants reported relying on traditional three stone fires and coal pots, and by low reported refill rates (as discussed above).

Poverty is the root cause of continued use of the traditional three stone fires (Karimu, Mensah, & Adu, 2016). It is therefore interesting to realize that the LPG subsidy was removed in 2013 when the RLP was launched. Targeted subsidy might be helpful. Fuel wood in our study area was almost exclusively gathered rather than purchased. LPG, in contrast, requires a substantial cash outlay. In rural households in Ghana, the average monthly expenditure on housing, water and household energy is about 15 USD (Ghana Statistical Service, 2014c). The cost of a month's supply of LPG (14.5 kg) is GHC 74.0 (approximately 16.80USD), and therefore competes keenly with other household needs. Price volatility is also high (Fig. 4). Currently the price of

6 kg of LPG is about GHC 28.00 (about 6.0 USD) compared to GHC 22.00 (5.00 USD) at the time of our evaluation of the RLP in Nkoranza.

Most of the residents in rural communities are farmers who depend on seasonal crop yields. The seasonality of the respondent income challenges adoption and sustained use of LPG.

I also think that money for refilling the gas was a hindrance. Mostly the income we get here is seasonal. When crops are in season, it might be easy to refill, however when the farm produce is finished that is when the refilling will stop (FGD, LPG non-beneficiaries).

In the Nkoranza study communities, RLP participants had to travel an average of 25 km (range: 20–28 km) to refill their cylinders. Along with cost, the logistics of transporting cylinders to the filling station was commonly reported as a main barrier to the use of LPG cookstoves.

Focus group participants identified a number of benefits from LPG use as outlined below with examples of quotation from respondents.

Facilitates multi-tasking

Whilst cooking I could be doing other things. I can even wash my farm attire, eat early and sleep (FGD, LPG non-beneficiaries).

Male involvement in cooking

Before the LPG cookstoves I had the perception that cooking is for women because going to set fire to cook as a man means you don't have a wife. For now, this perception has reduced because of the LPG cook stove (FGD, men of LPG beneficiaries' household).

Business opportunities

"In some communities there were no LPG refilling station and once LPG marketing companies gets to know that there are about 2000 cylinders in circulation in one district then they feel that this is a good way to make money" (Program Officer, Energy Ministry).

Fast cooking

Before the gas came, women could spend more than two hours on cooking. But with the gas, time spent for cooking is reduced drastically because when you turn on the LPG stove, the fire doesn't go down (FGD, men of LPG beneficiaries' household).

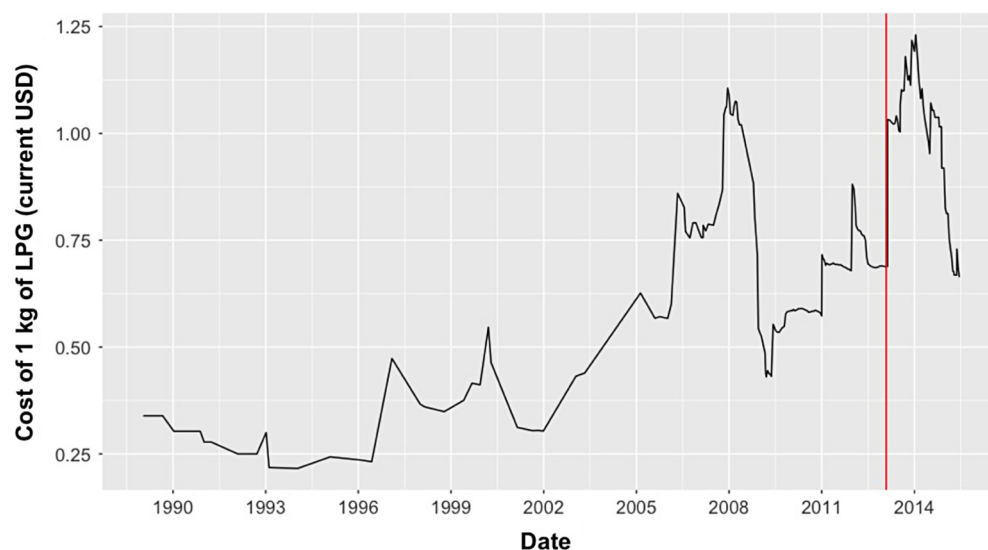


Fig. 4. Historical variability in retail LPG prices in Ghana-August 2007-June 2015. Vertical line marks the end of the subsidy (Source: Ghana National Petroleum Agency, 2017a, b; current prices) (National Petroleum Authority, 2017b).

Clean cooking

When you cook on a three-stone fire, the cooking utensils will get dark and makes washing of the utensils difficult. But with the gas stove, the utensils still look clean after cooking they don't get dark (FGD, men of LPG beneficiaries' households).

Taste of food

"The soup taste differently when you cook with the LPG cookstove because smoke does not get into it" (FGD, men of LPG beneficiaries' household).

Enhanced performance of school children

Instead of studying children have to go and fetch firewood after school but it is not like that if you are using LPG cookstove (FGD men of LPG beneficiaries' household).

Implementation

Implementation refers to the level of adherence to implementation principles or guidelines, the extent to which selected elements are implemented, and the cost.

Currently, the RLP does not have a documented implementation plan for LPG distribution. The National Petroleum Agency is leading the development of an overarching Ghana LPG policy document (Akoloh, 2017). When completed, this policy will put forth an implementation plan for the RLP. While promising, this new policy framework will be hindered by the fact that the RLP had not been systematically evaluated. To date the RLP has no systematic monitoring and evaluation component and thus no mechanism for adjusting the program based on feedback. The Nkoranza field evaluation described above comprises the first effort to assess program performance. The Ministry of Energy has a research department responsible for monitoring programs but lacks the resources to do so. There is no monitoring and evaluation framework to guide their activities.

The original aim and structure of the RLP being implemented by the Ministry of Energy has not changed, though the mode of operation/distribution has altered. At launch, the distribution of the LPG cylinders and cookstoves to beneficiaries in designated districts was initiated with a *durbar* (community meeting) to launch the program before distribution. Currently, the launching is not being done and the distribution is done by the district assembly (the local political administrative unit). However, it emerged during our stakeholder interviews that there are challenges with the current mode of distribution because after the cylinders, cookstoves and accessories have been delivered to the district Assembly, there are perceptions that the local personnel sometimes share it among their favorites. Consequently, the Ministry of Energy is evaluating the possibility of returning to the original mode of field operations and distribution of LPG by the distribution team from the Ministry.

Maintenance

Maintenance refers to how individuals or interventions continue to exhibit the desired changes; how changes are maintained; or how new barriers to use is prevented or mitigated. In the review of the RLP and interviews, the following potential promoters or barriers to the programs maintenance were identified.

Lack of spare parts for stoves

We observed that study participants did not have access to spare parts for stoves and the accompanying hardware. Anecdotally, this caused a small number of households that were initial enthusiastic users revert to fuelwood after experiencing minor damage to stove

parts. The lack of spare parts may also pose a safety risk if RLP households continue to use stoves with faulty parts.

Monitoring and evaluation

The research and statistics directorate of the Ministry of Energy carries out monitoring and evaluation activities periodically to check if the purpose for which beneficiaries were given the stoves is being fulfilled. This indicates commitment to ensure the RLP is monitored to meet its objectives. However, the directorate indicated its willingness to collaborate with other research institutions to strengthen its research activities and in particular to evaluate stove use by beneficiaries. The SEforALL program has a regular newsletter (Energy-Commission, 2017c) that outlines the number of stoves distributed by the program but does not report on stove use. The need for collaboration in monitoring and evaluation was emphasized as below.

"It will be great to collaborate with you (Kintampo Health Research Centre), share experience and support each other in the conduct of research especially in the areas of writing proposals, data management and analysis and report writing" (Respondent, Ministry of Energy).

Diversified sources of LPG supply

LPG supply is produced from diversified sources thus limiting the risk of monopoly and inadequate fuel supply (MoP, 2016). LPG is produced by the Ghana Gas Company as a byproduct during the processing of natural gas to lean gas for electricity generation. LPG is also imported into the country by private individuals and companies. Currently there are about 23 LPG importers in Ghana in addition to the Ghana Gas Company (CBOD, 2017). This diverse set of sources – including domestic production – is a core strength of the sector.

Implementation of LPG cylinder recirculation model

In Ghana, discussions on the recirculation model dates back to 2010 (Energy-Commission, 2016) but the urgency to get it into policy for implementation gained momentum in October 2017, after a gas explosion at a refilling station in Accra that led to loss of lives and properties (Abdul-Hamid, 2017). The Government of Ghana through the NPA is in the final stage of stakeholder engagement to implement the "LPG Recirculation model" (or LPG Cylinder Exchange Model). In this model, consumers will pay an upfront deposit for an initial cylinder and subsequently pay for only the LPG (Energy-Commission, 2012a; National Petroleum Authority, 2017a). This model is likely to improve the safety of LPG cylinders as LPG retailers will be held to quality standards. The shift to recirculation is also expected to result in a sharp uptick in the number of LPG distribution points.

Political will to continue the implementation of RLP

In spite of the change in political party in charge of government in 2017, the current administration appears committed to continue the implementation of the RLP and to streamline it where necessary. This was clearly captured in the 2018 budget and the Government is developing new strategies such as implementation of the recirculation model and commissioning of new cylinder refilling stations (Ofori-Attah, 2017).

Risks to sustainability

Inadequate funding for the program

Though the Ghana Government is committed to RLP, there is currently inadequate funding to support the program.

Government is quite challenged when it comes to funding. The ministry has the plan to do this on a larger scale but this is all subject to the

amount of money that ministry of finance has at its disposal for the RLP. Lobbying to get funds has always been a challenge (Respondent, Energy Ministry).

The LPG compensation margin derived from LPG price build-up is the only dedicated source of funding for the program. The levy imposed on LPG is Ghp10/kg (USD 0.02) which translates into an increase in ex-pump price by 4% (ACEP, 2016). The margin in the LPG price build-up

works against the purpose of access and affordability since it in turn increases the end user price of LPG.

Inadequate LPG refilling station

The 50% LPG penetration target for 2020 is unlikely to be achieved given the limited number of refilling stations nationwide especially the three northern regions of Ghana (Fig. 5), limited supply and

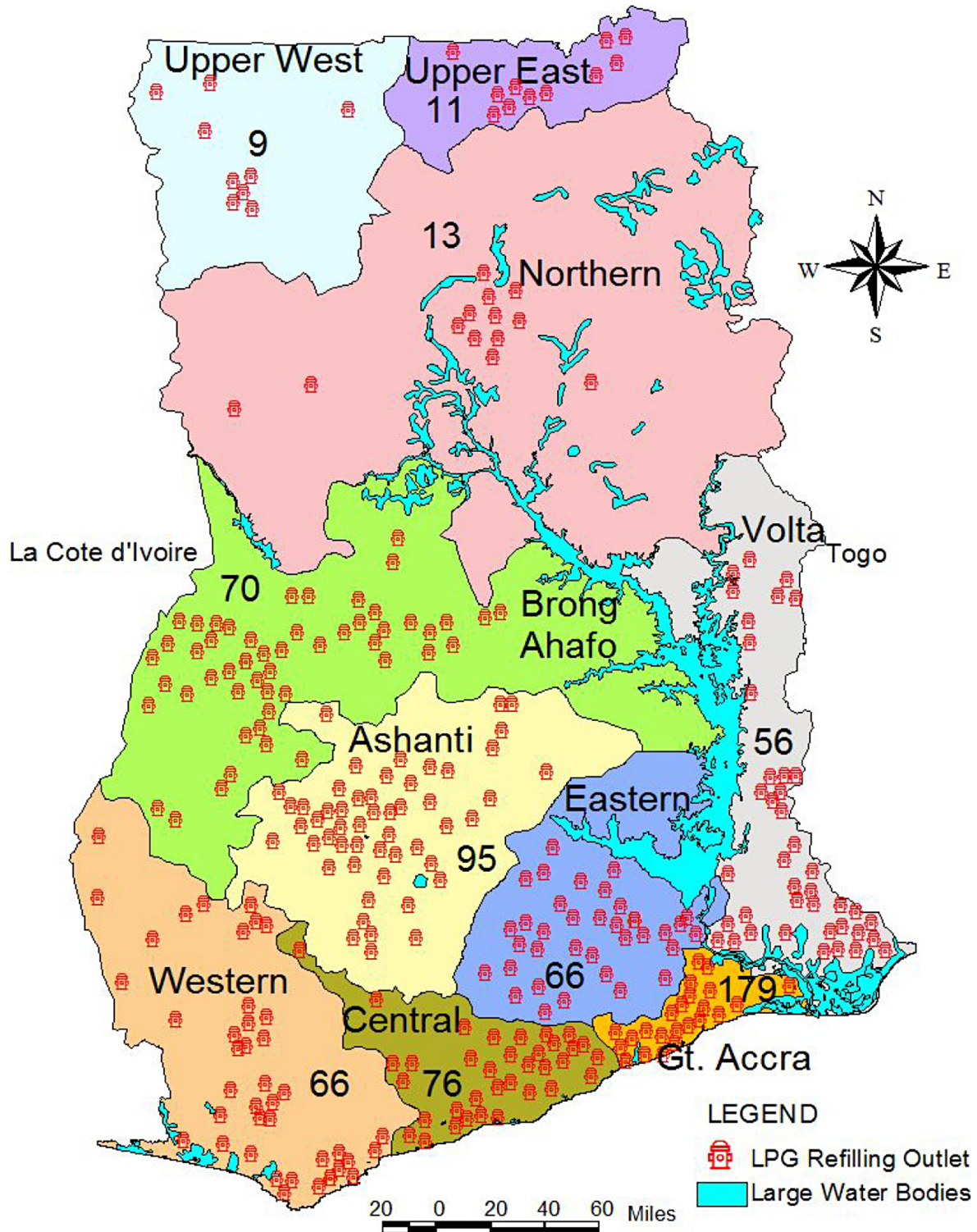


Fig. 5. Location of 641 LPG refilling stations in Ghana (based on Ministry of Energy 2017 Data).

distribution infrastructure and the limited total storage capacity and coverage which constrains distribution and access. Though there has been increase in the number of refilling stations in the three northern regions of Ghana from 2011 to 2017 they are still inadequate. Within this period, the number of refilling stations has increased from 6, 4, 3 (Mensah, Kemausuor, & Brew-Hammond, 2014) to 13, 9 and 11 in the Northern, Upper west and Upper East regions respectively. It is anticipated that the shift to the cylinder recirculation model may help address this issue.

Delay in production by the Ghana Cylinder Manufacturing Company

The Ghana Cylinder Manufacturing Company is the only company manufacturing and supplying LPG cylinders to the RLP. It is sometimes unable to meet the RLP's demand for LPG cylinders due to delay in the importation of raw materials for production.

There are delays in receiving raw materials because they are imported and a lot of bureaucracies are involved to get them to the factory for production. Consequently, there are production challenges at the National level and sometimes the distribution team gets ready but do not have the cylinders to go for distribution (RLP Programs Officer, Energy Ministry).

Discussion

Our case study documented Ghana's RLP. Our findings suggest that the RLP is not contributing enough to Ghana's overarching goal to expand LPG access to 50% of Ghana's population by 2020 considering the low number of LPG cookstoves distributed and the few number of recipients who actually use the LPG stoves.

Recipients of LPG cookstoves are not able to sustain the use of the LPG because of financial constraints (Karimu et al., 2016) accentuated by an income seasonality. The beneficiary's inability to sustain the use of LPG is abundantly clear in our data from the five Nkoranza communities, where only 8% of RLP beneficiaries were still using their LPG stoves 18 months after delivery and where none of the study participants reported switching to LPG as a primary fuel. Financial constraint was a barrier to sustained use of LPG because beneficiaries were mainly farmers who depend on seasonal crop yields and thus lack regular source of income to support LPG purchases. A caveat is in order however: these communities may not represent effectiveness of the RLP nationally. Further evaluation is needed to understand how adoption and effectiveness vary across the country especially after the cylinder recirculation model is implemented. Related to the issue of financial constraints and LPG pricing is the LPG compensation margin which is used to fund the RLP. The margin increases the price of LPG.

Effective scaling up of programs requires the systematic use of evidence and it is essential that data from implementation monitoring is linked to decision making throughout the scaling up process. A key success factor for scaling up programs is the importance of establishing monitoring and evaluation systems (Milat, Bauman, & Redman, 2015). The Energy Ministry has a Research and statistics department but this unit lacks the human and infrastructure resources to monitor the programme. As part of the general monitoring activities of the ministry's projects, the unit visits few beneficiaries to ask if they are still using their LPG stoves. These activities are not systematically carried out based on protocols but rather random administrative checks. The research findings from the evaluation of the program in Nkoranza will (Kintampo Health Research Centre, 2016) will be useful in this regard.

Beyond systematic use of evidence and M&E in the program scale up, the program must revisit the strategies required for LPG scale up in Ghana spelt out in the 2010 Energy Sector Strategy and Development Plan (MoE, 2010). One of the strategies was the establishment of a Natural Gas Processing Plant to produce LPG. Though the Ghana Gas company was established in 2011, it is yet to produce the estimated 70% of Ghana's LPG needs. In 2017, about 36% of Ghana's total LPG supply

was produced in Ghana. Effort must be put in place to increase domestic production to make LPG more accessible. On the issue of supply infrastructure BOST operates depots that are strategically spread across the country including Greater Accra (Tema), Volta, Akosombo, Buiepe in the northern region and Bolgatanga in the Upper East region. Though the long term goal is to construct LPG storage and supply infrastructure in all regional and district capitals, there is the need to increase the number of LPG filling stations nationwide, especially the three northern regions of Ghana.

The Ghana Cylinder Manufacturing Company is the sole manufacturer of cylinders for the RLP. GCMC does not have the capacity to produce enough cylinders and accessories for distribution. It is therefore important for the Ghana government to fast track the recapitalization of the Ghana Cylinder Manufacturing company to facilitate production of LPG cylinders or engage the private sector to participate in the cylinder manufacturing (IMANI, 2017). This should be done in an effective certification and regulatory environment to attract the interest of private investors to invest in the industry. The government could also provide incentives for the importation of cylinders to augment those produced locally during the recapitalization process. This will support fast distribution of the LPG cylinders and increase the potential for adoption. Additionally, the government may need to invest in infrastructure expansion, particularly investment in cylinders to achieve Ghana's target LPG use of 50%.

In terms of health benefits, we did not find a significant relationship between LPG use and CO exposure, which comes as no surprise given low usage rates. Continued use of 3-stone fires by neighbors who don't benefit from the program may also attenuate the benefits of use even in those households that do completely switch to LPG (Pope, Bruce, Dherani, Jagoe, & Rehfuess, 2017). Stove stacking may be inevitable, but in our surveys, beneficiaries have returned to the exclusive use of wood fuel mainly because of financial constraints and the fact that fuel wood was gathered rather than purchased.

Conclusion

Fuel cost, poor LPG access, and an inadequate implementation framework hinder the RLP Ghana's overarching goal to expand LPG access to 50% of Ghana's population by 2020. This implies that some financial aid might help. The implementation of the cylinder recirculation model could ease access to LPG.

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Conflict of interest

The authors declare no conflict.

References

- Abdul-Hamid, M. (2017). New government regulatory measures. *Following gas explosion at atomic junction* Retrieved from: <http://presidency.gov.gh/index.php/2017/10/12/new-government-regulatory-measures-following-gas-explosion-at-atomic-junction/>.
- ACEP (2016). ACEP press statement on energy sector levies. Retrieved 12 Sept, 2017, from: <http://www.acepghana.com/news/88/>.
- Acharibasam, J. B., & Apatinga, G. A. (2014). Ghana and the liquidified petroleum gas dilemma critical analysis of Ghana's LPG policy. *International Journal of Energy and Environmental Research*, 2(2), 1–8.
- Ahunu, L. (2015). LPG promotion program. Retrieved 12 Sept, 2017, from [https://new-acep-static.s3.amazonaws.com/working-reports/THE+LPG+PROMOTION+PROGRAMME+\(1\).pdf](https://new-acep-static.s3.amazonaws.com/working-reports/THE+LPG+PROMOTION+PROGRAMME+(1).pdf).
- Akoloh, C. (2017). Gov't to re-introduce cylinder recirculation module in early 2018. Retrieved from: <http://ghananewsonline.com.gh/ovt-to-re-introduce-cylinder-recirculation-module-in-early-2018/>.
- Arthur-Mensah, G. (2017). Government rolls out tough regulatory measures to curtail frequent gas explosions. Retrieved 19 Feb, 2018, from <http://www.ghananewsagency.org/social/gov-t-rolls-out-tough-regulatory-measures-to-curtail-frequent-gas-explosions-123491>.
- CBOD (2017). The CBOD is the representative body of bulk oil distribution companies. Retrieved from: <http://cbodghana.com/about-us/>.
- Cooke, E. F., Hague, S., Tiberti, L., Cockburn, J., & El Lahga, A. -R. (2016). Estimating the impact on poverty of Ghana's fuel subsidy reform and a mitigating response. *Journal of Development Effectiveness*, 8(1), 105–128.
- Edjekumhene, I., Atta-Owusu, F. O., & Ampong, C. (2007). Ghana LPG gas sector study. <https://openknowledge.worldbank.org/bitstream/handle/10986/12727/706580ESWOP1000PUBLIC00000GhanaLPG.pdf?sequence=1&isAllowed=y>.
- ENERGIA (2015). LPG: Increasing the energy options benefitting women worldwide. Retrieved 1, 16, from <http://www.energia.org/cms/wp-content/uploads/2016/01/ENERGIA-FINAL-lr-1.pdf>.
- Energy-Commission (2012a). Ghana sustainable energy for all action plan. Retrieved from: <http://energycom.gov.gh/files/SE4ALL-GHANA%20ACTION%20PLAN.pdf>.
- Energy-Commission (2012b). Sustainable energy for all. *Rapid assessment gap analysis Ghana*. Ghana: Energy Commission, Ghana and WHO.
- Energy-Commission (2016). 2016 energy (Supply and Demand) outlook for Ghana. Retrieved from: http://www.energycom.gov.gh/files/Energy%20Commission%20-%202016Energy%20Outlook%20for%20Ghana_final.pdf.
- Energy-Commission (2017a). 2017 energy (supply and demand) outlook for Ghana. Retrieved from: <http://www.energycom.gov.gh/planning/data-center/energy-outlook-for-ghana?download=31:energy-outlook-for-ghana-2017>.
- Energy-Commission (2017b). Ghana: 2017 energy (supply and demand). Retrieved from: <http://energycom.gov.gh/data-center/energy-outlook-for-ghana>.
- Energy-Commission (2017c). *GHANA SEforALL NEWS*. 4. Retrieved from: http://www.energycom.gov.gh/files/Ghana_SE4ALL_Newsletter_Jul-Sep-17.pdf.
- Fullerton, D. G., Bruce, N., & Gordon, S. B. (2008). Indoor air pollution from biomass fuel smoke is a major health concern in the developing world. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 102(9), 843–851.
- GCMC (2014). Ghana cylinder manufacturing company. Retrieved 24/09/2017, from: <http://gcmcgh.com/index.htm>.
- GCMC (2017). Ghana cylinder manufacturing company. Retrieved from: <https://www.businessghana.com/site/directory/oil-and-gas/397835/GHANA-CYLINDER-MFG-CO-LTD>.
- Ghana Statistical Service (1992). Ghana living standards survey (GLSS3). Retrieved from: <http://siteresources.worldbank.org/INTLSMS/Resources/3358986-1181743055198/3877319-1190221709991/G3report.pdf>.
- Ghana Statistical Service (2000). Ghana living standards survey (GLSS4). Retrieved from: <http://www.ilo.org/surveydata/index.php/catalog/391/download/4520>.
- Ghana Statistical Service (2008). Ghana living standards survey (GLSS5). Retrieved from: http://www.statsghana.gov.gh/docfiles/glss5_report.pdf.
- Ghana Statistical Service (2012). 2010 population & housing census Accra: Ghana statistical service. Retrieved from: http://www.statsghana.gov.gh/docfiles/2010phc/Census2010_Summary_report_of_final_results.pdf.
- Ghana Statistical Service (2014a). *2010 population and housing census: district analytical report, Nkoranza north district*. Ghana Statistical Service Retrieved from: http://www.statsghana.gov.gh/docfiles/2010_District_Report/Brong%20Ahafo/NKORANZA%20North.pdf.
- Ghana Statistical Service (2014b). *Demographic and Health Survey 2014*. Accra: Ghana Statistical Service Retrieved from: <https://www.google.com/g>
- search?q=Demographic+and+Health+Survey+2014&oq=Demographic+and+Health+Survey+2014&qs=chrome..69i57j0i5.1625j0j4&sourceid=chrome&ie=UTF-8.
- Ghana Statistical Service (2014c). Ghana living standards survey (GLSS6). Retrieved from: https://www.google.com/gh/search?ei=laKWwTWBNSzkwVhVhKE4&q=GLSS+6&oq=GLSS+6&gs_l=psy-ab.3.013j0i22i10i30k114.114894.119194.0.121141.6.6.0.0.0.331.1169.0j1j3j1.5.0...0.1c.1.64.psy-ab.1.5.1166...35i39k1j0i13i167k1j0i131k1j0i167k1j0i20i263k1j0i10k1.0.ZB3gCy3Vqyw.
- Ghana-Web (2013). More than half of Ghana's population live in urban areas. Retrieved 23 Feb, 2018, from: <https://www.ghanaweb.com/GhanaHomePage/NewsArchive/More-than-half-of-Ghana-s-population-live-in-urban-areas-276110>.
- Glasgow, R. E., Vogt, T. M., & Boles, S. M. (1999). Evaluating the public health impact of health promotion interventions: the RE-AIM framework. *American Journal of Public Health*, 89(9), 1322–1327.
- IMANI (2017). IMANI: Ideas for making government's gas cylinder exchange programme work in Ghana. Retrieved 9 Sept, 2017, from: <http://www.imaniafrica.org/2017/08/10/imani-ideas-making-governments-gas-cylinder-exchange-programme-work-ghana/>.
- Inkoom, D. K., & Crentsil, A. O. (2015). *Estimation of indoor air pollution and health impacts due to biomass burning in rural northern Ghana*.
- Karimu, A., Mensah, J. T., & Adu, G. (2016). Who adopts LPG as the main cooking fuel and why? Empirical evidence on Ghana based on national survey. *World Development*, 85, 43–57.
- Kemausuor, F., Obeng, G. Y., Brew-Hammond, A., & Duker, A. (2011). A review of trends, policies and plans for increasing energy access in Ghana. *Renewable and Sustainable Energy Reviews*, 15(9), 5143–5154.
- Kintampo Health Research Centre (2016). *Assessing LPG adoption and sustainability in the Ghana rural LPG program*. Kintampo Health Research Centre (Unpublished work).
- MacCarty, N., Still, D., & Ogle, D. (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.
- Mensah, G. S., Kemausuor, F., & Brew-Hammond, A. (2014). Energy access indicators and trends in Ghana. *Renewable and Sustainable Energy Reviews*, 30, 317–323.
- Milat, A. J., Bauman, A., & Redman, S. (2015). Narrative review of models and success factors for scaling up public health interventions. *Implementation Science*, 10(1), 113.
- MoE (2010). Energy sector strategy and development plan Ghana. Retrieved from: https://ouroilmoney.s3.amazonaws.com/media/documents/2016/06/09/energy_strategy.pdf.
- MoP (2016). Gas master plan. Accra. Retrieved from: <http://www.energymin.gov.gh/sites/default/files/06-14%20GMP%20Updated.pdf>.
- Morden-Ghana (2011). Fuel wood consuming Ghana's forest. Retrieved from: <https://www.modernghana.com/news/328240/fuel-wood-consuming-ghanas-forest.html>.
- Mubarik, A. (2017). Cylinder recirculation policy: gas shortage looms as Christmas approaches. 19 Feb from: <http://www.pulse.com.gh/news/business/cylinder-recirculation-policy-gas-shortage-looms-as-christmas-approaches-id7735823.html>.
- myjoyonline (2017). Driver's mate with no LPG training caused gas leakage - Interim NPA report. Retrieved Feb 19, 2018, from: <https://www.myjoyonline.com/news/2017/October-14th/drivers-mate-with-no-lpg-training-caused-gas-leakage-interim-npa-report.php>.
- NPA (2017a). National Petroleum Authority. Retrieved from: <http://www.npa.gov.gh/news/cylinder-re-circulation-module>.
- NPA (2017b). Petroleum service providers. Retrieved 23 Feb, 2018, from: <http://www.npa.gov.gh/service-providers>.
- Ofori-Attah, K. (2017). *Budget statement and economic policy of the government of Ghana for the 2018 financial year*. Ministry of Finance Retrieved from: <https://www.mofep.gov.gh/sites/default/files/budget-statements/2018-Budget-Highlights.pdf>.
- Petersson, E. (2016). Emmanuel Kofi: No more long queues for gas. Retrieved from: <http://www.ghanalive.tv/2016/10/15/emmanuel-kofi-no-more-long-queues-for-gas/>.
- Pope, D., Bruce, N., Dherani, M., Jagoe, K., & Rehfuess, E. (2017). Real-life effectiveness of 'improved' stoves and clean fuels in reducing PM2.5 and CO: Systematic review and meta-analysis. *Environment International*, 101, 7–18.
- Reuters (2013). Ghana scraps fuel subsidy to reduce budget deficit. Retrieved 24 Feb, 2018, from: <https://www.reuters.com/article/ghana-subsidy/ghana-scraps-fuel-subsidy-to-reduce-budget-deficit-idUSL5N0EC3X920130531>.
- TheGuardian (2017). Ghana vows improved safety to stop gas fires, blasts. Retrieved from: <https://guardian.ng/news/ghana-vows-improved-safety-to-stop-gas-fires-blasts/>.
- UNDP (2014). *Liquefied petroleum gas (LPG) substitution for wood fuel in Ghana – opportunities and challenges*. United Nations Development Programme in Ghana.
- WHO (2011). Indoor air quality guidelines: household fuel combustion. Retrieved 28 Feb, 2018, from: <http://www.who.int/indoorair/guidelines/hhfc/en/>.
- WHO (2017). Indoor air pollution health and burden of disease. <http://www.who.int/indoorair/info/briefing2.pdf>.
- World Bank (2017). *The World Bank data*. Retrieved 3 Feb, 2018, from The World Bank Group <https://data.worldbank.org/country/ghana>.