MECS
Modern Energy Cooking Services

NATIONAL SCALING UP OF LPG TO ACHIEVE SDG 7: Implications for Policy, Implementation, Public Health and Environment

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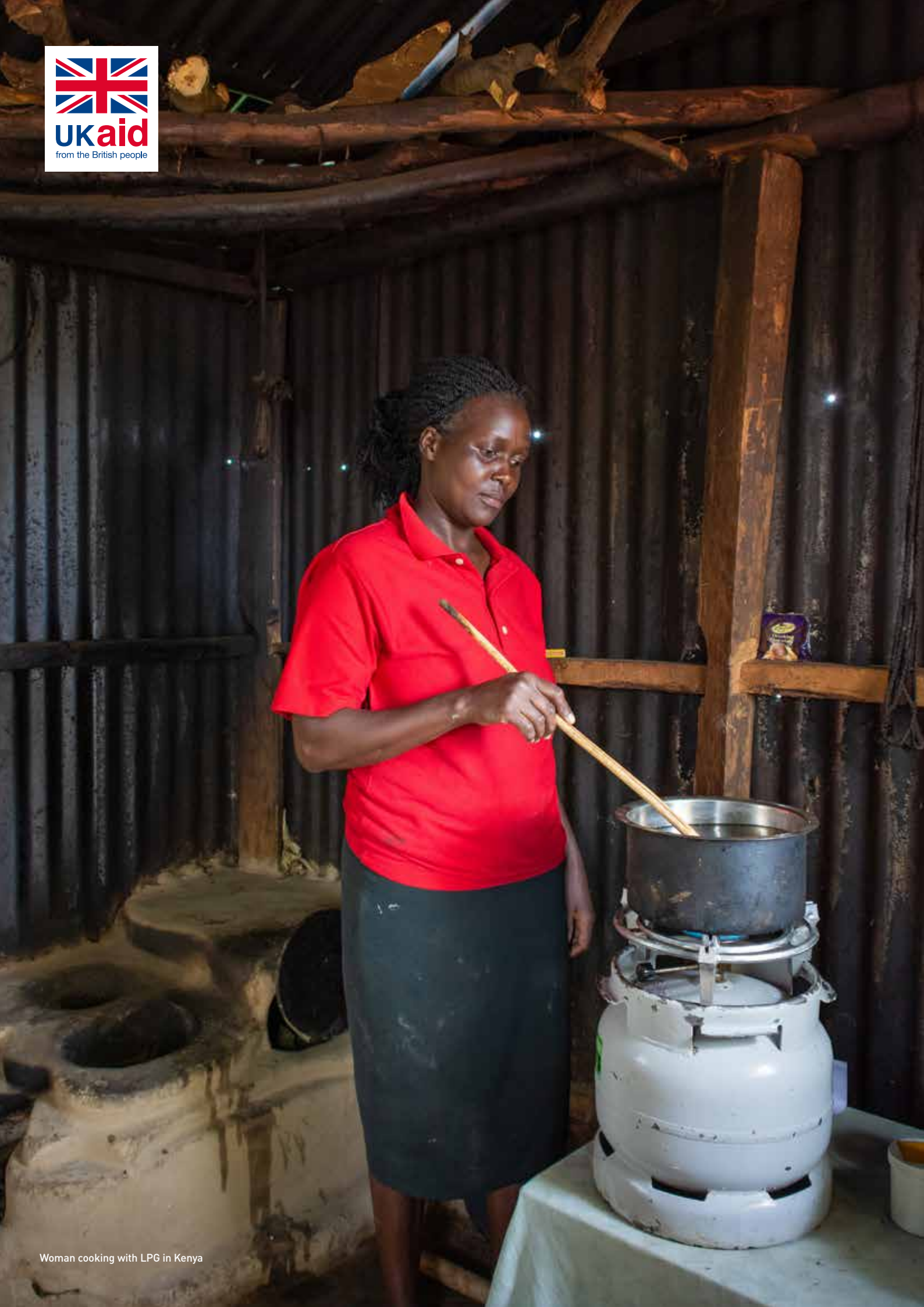


Woman cooking with LPG in Kenya

Executive Summary

In a context where taking urgent action to combat climate change is at the heart of the global agenda, energy access for cooking for low and middle-income countries (LMICs) is steadily increasing in priority since the launch of the Sustainable Development Goals.

While around 1 billion people still lack access to electricity[1], progress on promoting access to electricity has moved at a fast pace. However, close to 3 billion people continue to rely on a variety of traditional solid fuel (e.g. wood, charcoal, dung) and kerosene/ paraffin, burned in inefficient and polluting stoves, to meet their everyday household cooking and heating needs [2]. The resulting household air pollution (HAP) is the single largest environmental cause of global disease burden, responsible for between 1.6 and 3.8 million premature deaths annually [3, 4]. In addition, inefficient household cooking also impacts women and harms productivity, climate and the environment at regional and global scale.

Through guidelines published on *Indoor Air Quality from household fuel combustion* (WHO 2014), the World Health Organization (WHO) recommends a rapid transition to clean fuels such as Liquefied Petroleum Gas (LPG) and electricity to protect the health of adults and children in resource-poor settings while also offering gender, climate and environmental co-benefits [5]. Indeed, the health and climate impacts of HAP are also compounded through significant contributions to ambient air pollution [6, 7]. Tackling HAP emissions from cooking is, therefore, essential in development of national and regional air pollution control strategies [8] as well as combating climate warming [9].

This policy brief focuses on understanding the important role that LPG (bottled gas) has to play in the short to medium-term to address this urgent crisis.

1. Nearly 1.2 billion people have gained access to electricity since 2000, but population growth has offset some of the gain; the overall increase is reported as 0.7 billion since 2000.

The role of LPG in achieving clean energy for all by 2030 (SDG 7)

LPG or bottled gas is a portable clean-burning fuel that can be used for both cooking and heating. LPG is an inevitable by-product of global oil and natural gas production and oil refining. Because it is a by-product, LPG must be disposed of wherever it is created. Where not extracted and captured during operations, LPG is ignited or 'flared' into the atmosphere as a waste product contributing to greenhouse gases. About 30% of global LPG production currently goes to feedstock used for plastics and chemicals consumed by high-income nations [10] instead of fully exploiting its potential as a clean, efficient and highly scalable cooking fuel.

In terms of end-user experience for cooking, it is comparable to both natural gas and electricity [11]. The International Energy Agency (IEA) estimates that over 2.5 billion people use LPG for some or all of their cooking requirements in resource-poor settings [2] plus many more in high-income countries. Due to its portability and acceptability, LPG is a domestic clean fuel option that has achieved historical widespread penetration in a number of LMICs as well as high income countries and has great current potential for LMIC transition away from reliance on polluting solid fuels and kerosene [12]. This has been demonstrated by recent successful national-scale LPG conversion programs such as those implemented by India and Indonesia. The IEA's World Energy Outlook Special Report *From Poverty to Prosperity* highlights LPG as an achievable clean cooking solution for over half of the 2.8 billion people still needing access to clean cooking fuels and technologies by 2030 [2].

Why is LPG considered a clean fuel that can benefit health?

LPG burns very cleanly in simple, widely available and relatively inexpensive devices (e.g. household LPG stoves/burners) with almost no emission of particulate matter [13]. Stove lifespan depends on the stove material and components. Cheaply made LPG stove models (costing US$ 15-20) tend to corrode quickly and may last only up to a few years, while more robust stoves (of higher cost, e.g. US$ 30-60) can last five or more years. LPG stove efficiencies are in the order of 50% - 60% [14]. In contrast to biomass, LPG burns cleanly, independent of user operations [15]. Residential LPG cylinders, with proper maintenance, last for 20 or more years. Because of its chemical characteristics, LPG is easy to produce in a highly purified state without any intrinsic contaminants, such as sulfur, that would otherwise contribute to health-damaging air pollutants [13]. LPG is also produceable from renewable sources, as BioLPG. Like other clean fuels such as biogas, ethanol, electricity and natural gas, use of LPG achieves substantive reductions in respirable particulate matter ($PM_{2.5}$) that cannot be achieved when burning solid fuels and kerosene for cooking, and can reduce exposure to within WHO indoor air quality standards safe levels for health in every day use [5].

Forest depletion and ambient air pollution from wood fuel burning in Cameroon. *Photo credit: Nigel Bruce*

Does LPG for clean cooking contribute to climate change?

Although LPG is principally a fossil fuel, the net contribution to climate warming through CO_2 and short-lived climate pollutant (SLCP) emissions, in settings where solid biomass fuel is the predominant source of household energy, is neutral or actually beneficial when taking into account emissions of SLCPs from combusted biomass (e.g. black carbon) and the fraction of non-renewable forest sourced for firewood. This has been demonstrated by an increasing number of recent studies [15-18]. LPG burns more efficiently and with a lower emissions profile (including for black carbon and methane) than firewood, charcoal and kerosene [14]. Transition to LPG can also contribute substantially to deforestation mitigation, by reducing the demand for wood from non-renewable forests for charcoal and firewood production (primarily for sale in urban and peri-urban markets), in turn positively impacting on climate through heightened CO_2 emissions capture [16].

Cooking with electricity and gaseous fuels (including LPG) is recommended by the 2018 Intergovernmental Panel on Climate Change (IPCC) Special Report on Climate Warming of 1.5° as a mitigation measure to reduce black carbon emissions [19].

Charcoal sale at a market in central Nairobi. *Photo credit: Nigel Bruce*

Impacts on gender and livelihoods from LPG adoption

Use of LPG can significantly reduce the time spent by women and teenage girls processing fuel (e.g. chopping firewood), tending fires, cooking food, and cleaning up after cooking and can significantly decrease the time spent gathering biomass fuel. LPG gives the ability to turn on and off the flame and gives instant high heat allowing for faster cooking. LPG is perceived as a convenient, modern and desirable fuel that has social value.

Field-based studies document value attached by household cooks in having pots and utensils that are no longer blackened by smoke and that take less time to clean as a result of switching to LPG for cooking [20-22]. An emerging literature is beginning to describe how the time savings of switching from traditional solid fuels to LPG for cooking translate into opportunities for increased education (e.g. for children) and productivity (e.g. commercial income generating activities [23]) as well as for other pursuits (rest, family care etc.).

Barriers and enablers to LPG uptake

While there is recognition of the value of scaling LPG household use as an important step in achieving SDG 7 on clean and affordable energy for all (as well as reducing the health burden from HAP and associated climate and gender co-benefits), there is also an increasing understanding that certain conditions are required to enable its scale up, and a number of potential barriers require solutions. The barriers vary by country, but many are common across countries.

Effective Government definition and enforcement of regulations and market rules, based on best practices and international standards, is essential to establish a viable and scalable LPG cooking market [24]. Such rules create the conditions for a safe, economically viable and scalable LPG sector, and make feasible the necessary infrastructure investment to establish and maintain a safe and reliable fuel supply chain [24]. Five key principles informed by extensive global industry experience and developed by the Global LPG Partnership (a not-for-profit NGO that aggregates and deploys global resources to help LMICs transition large populations rapidly and sustainably to LPG for cooking) frame the high-level conditions required for rapid, safe scale-up of LPG in the domestic cooking market. These are summarised in Box 1.

Box 1- Five principles for rapid and sustainable LPG market development in early-stage markets.

1. Implement and rigorously enforce effective, self-consistent LPG market rules, with central emphasis on property rights protection in marketer-owned and -branded LPG cylinders and on public safety.
2. Ensure stability and continuity of the LPG fuel supply in all regions to be served.
3. Implement stable, market-sustaining and market-stimulating policies.
4. Ensure high LPG retail density.
5. Develop a consensus-based national master plan for coordinated LPG investments and interventions.

Source: Global LPG Partnership, 2015

From an end-user perspective, there are a number of potential barriers in terms of both maximising adoption and sustained use of LPG well documented in the literature. These include (i) the initial capital costs for acquiring the consumer LPG equipment, (ii) affordability of LPG cylinder refills for some lower-income households (for sustained use of the fuel over time), (iii) convenient access to, and consistent availability of, refilled cylinders located within a reasonable travel time/distance of the consumer (or via home delivery), (iv) awareness of the potential benefits of LPG over other fuels for cooking (e.g. time, health and cost savings), (v) concerns over safety and (vi) cultural factors such as traditional values and perceptions (e.g. preferring the taste of food cooked over wood or charcoal) [21, 25, 26]. Personal experience of LPG use is important in addressing some of these preconceptions [27] and the extent of LPG use by a household adopting LPG for the first time typically increases with experience using LPG to cook and familiarity with the unadulterated taste of food cooked with LPG [28]. Most perception-based barriers to adoption and use of LPG for cooking can be addressed through increased sensitisation and education on LPG use, while supply and cost barriers need to be addressed upstream at the commercial and policy levels [29].

LPG costs compared to other purchased cooking fuels

How cost-competitive LPG is relative to other fuels varies by context, country and, in some cases, by subnational geographic area. An increasing amount of evidence from studies and market assessments indicates that the costs of LPG relative to charcoal, kerosene and sometimes other purchased biomass fuels (firewood, sawdust) can be comparable or lower, particularly in Sub-Saharan Africa urban settings [21, 30-32]. LPG refill costs depend on a number of factors, including whether LPG prices are subsidised or capped or fixed through government regulation. For example, a 12.5 kg refill in Cameroon, where LPG prices are regulated and subsidised, currently costs CFA 6,500 (US$ 11 or US$ 0.88/kg), and this cost has remained stable over time.

In India, where LPG fuel is market-priced (albeit with subsidy provided to below-poverty-line households), the non-subsidised cost of a 14.2 kg refill in India has fluctuated from a high of Rs.1207 (US$ 17.6 or US$ 1.23/kg in 2014 to a low of Rs.468 (US$ 6.8 or US$ 0.48/kg) in 2016 [33]. The uncertainty that these kinds of price fluctuations create in low-income households results in various forms of defensive or precautionary behaviours such as the simultaneous use of other fuels and stoves, known as fuel stacking [34]. In the short-run this may encourage low-income households to move back to using traditional biomass fuels until prices fall again; however if the uncertainty becomes extreme or costs of modern fuel become unacceptable over time, poor households may return to more sustained and enduring use of cheaper and more readily available biomass fuels [35]. At the same time, studies such as by Sharma et al. (2019) show that those who have used LPG for six or seven years do not opt to revert to biomass anymore [36]. This indicates that LPG adoption is a sticky phenomenon as users gain confidence in its benefits, use and availability, and as users gain experience in adapting to price volatility where it exists.

Unlike solid fuel and kerosene/paraffin that can be purchased in small daily amounts for individual cooking events, LPG typically requires the purchase of a full cylinder of fuel (filled in centralised bottling plants in cylinder sizes of 5-6 kg and 12-14 kg), that can last for several weeks with regular household use. Over time, the LPG may well cost the household less to use than these competing traditional fuels. However, the larger size of the LPG refill transaction can be a barrier for resource-poor households, who are accustomed to incremental purchasing of household fuels via frequent small transactions, and who are unable to save effectively to pay for a larger LPG refill transaction every few weeks. Various technical and payments approaches have been tested in numerous LMIC markets that have enabled LPG to be purchased via smaller, more frequent transactions. Some of these approaches have been failures from a commercial and safety perspective (e.g., cylinder top-up kiosks, microfilling stations or skids) [37], whilst others have had preliminary commercial and safety success on a small-scale pilot program basis and may prove to be scalable to a significant fraction of LMIC populations in future (e.g., Pay-As-You-Go home-delivered cylinders with smart-metered valves). Examples of companies currently in the market with this second set of approaches include KopaGas, Paygo Energy, Bboxx and Envirofit, all in the East African Community [32].

Sudanese woman cooking on LPG. *Photo credit: Olivier Levallois*

Partial LPG adoption and continued reliance on polluting fuels

Until households have a large enough relative disposable income to afford a consistent purchase of LPG for cooking, and availability of LPG is sufficient for households to use it confidently as their sole source of cooking energy, LPG will be used together with polluting alternative fuels (solid fuels and paraffin/kerosene) that are damaging to both health and environment (fuel stacking). For users who gather biomass fuel, a portion (who have cash income) may opt to spend money on LPG as a secondary fuel, but full transition to LPG is more difficult for them to achieve. Where incomes are seasonal, sporadic or highly fluctuating, LPG use may be greater in high-income months and lower in low-income months, especially among the poor. An objective of national LPG policy should be to provide as many users as possible with the choice to add LPG to their current household energy fuel mix, and with education, to encourage them to favour more exclusive use of LPG (as well as other truly clean, green alternatives to LPG, if available and affordable) over polluting cooking fuels. Studies find that the extent of transition correlates positively with income and educational levels, negatively with distance from LPG distributors, availability of plentiful and free biomass as well as intra-household gender attitudes [36, 38]. Thus, despite LPG access, full transition is unlikely to happen overnight. Partial use continues for some years. Effective policy can accelerate the transition.

Fiscal incentives, subsidies and consumer financing mechanisms

While LPG does require investment in import terminals, storage facilities, cylinder assets and distribution, this is less intensive and more adaptable across national territories than the investment required for electric grid and natural gas distribution [15]. Making LPG available for low-income household utilisation includes setting up pricing policies for the fuel and mechanisms to support the adoption of equipment necessary to use the fuel. To overcome barriers faced by poorer households in terms of the high initial start-up costs of consumer equipment acquisition, countries have implemented various strategies with varying degrees of success including combinations of fiscal incentives, subsidies, and market adjustments [29].

In Kenya for example, a number of favourable government policies for promoting widespread adoption of LPG have been introduced as Kenya has restricted reliance on kerosene and charcoal for household fuels, stimulated by deforestation concerns. Policies include (i) tax exemptions for LPG such as the VAT Zero-rating on LPG introduced in 2016; (ii) introduction of a tax on kerosene (partially to subsidise the tax relief on LPG), and (iii) a ban on logging to limit deforestation (implemented in April 2018) that has affected charcoal production and had dramatic impacts on rising costs of that fuel.

In India the government introduced a number of initiatives culminating with the launch of the Pradhan Mantri Ujjwala Yojna (Ujjwala) scheme in 2016, which included a targeted subsidy to enable more women below the poverty line to get access to equipment and fuel to start cooking with LPG (see Box 2) [39]. Sharma et al., (2019) suggests that LPG access over time promotes LPG usage both in terms of LPG per capita consumption and its share in the cooking energy mix [36]. Parikh (2019) suggests that all the Indian customers who received subsidy for 20 years and beyond may stop receiving it and would nonetheless continue using LPG, therefore proposing the concept of a self-liquidating subsidy [40]. The date of first registration is recorded with the local oil companies themselves and, therefore, the opt-out option for existing users to renounce to the LPG subsidy is easy to implement.

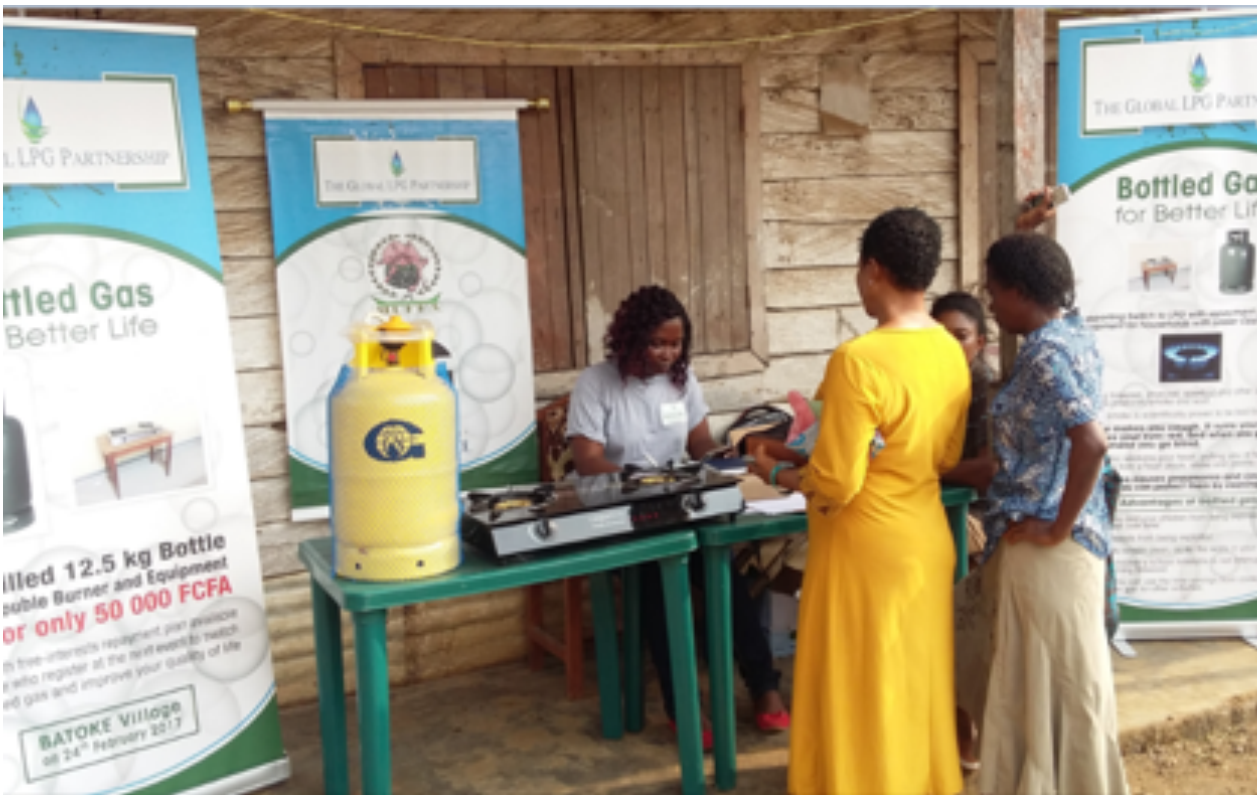
Where subsidies do not exist for initial LPG equipment purchases, consumer-financing mechanisms such as microfinance to fund initial acquisition of the equipment can help poorer households overcome financial barriers to start using LPG (see Table 1). While the degree to which commercial LPG microfinance is diffused is not fully known (especially in regions with more established LPG markets such as Latin America or Asia), a number of efforts have been documented. These include projects that have registered for Gold Standard carbon credits[2] such as the Darfur Low Smoke Stoves Project in Sudan [41] or the microfranchised LPG distribution projects by Entrepreneurs du Monde in Burkina Faso and Haiti [42], or other initiatives such as the Bottled Gas for Better Life initiative by the Global LPG Partnership in Cameroon and Kenya [43]. A summary of these projects is provided in Table 1.

Table 1: Example of microfinance schemes to support low-income users to adopt LPG

NAME OF THE INITIATIVE & IMPLEMENTING ORGANIZATION	COUNTRY	SCHEME DESCRIPTION	REACH AND STATUS
Darfur Low Smoke Stoves Project by EcoAct (previously called Carbon Clear) and Practical Action	Sudan	Poor households gain access to LPG equipment for cooking through a microfinance credit revolving fund. Loan repayment times and amounts vary (e.g. 9 or more months, with flexible repayments during low-income seasons such as during Ramadan). Participants are also trained on LPG use and safety as well as other areas such as business case writing. The project has also helped establish village saving and loan associations where women can save money collectively and loan it out, helping them to purchase larger items they require.	Started in 2011. Reached 11,700 households as of 2017. The project has been awarded by the United Nations Framework Convention on Climate Change (UNFCCC) Momentum for Change Initiative, recognising the contribution to climate change adaptation and mitigation. Status: Ongoing. Expected to end in 2020 when the project will be handed over to a local women's development association network to be continued beyond carbon credit generation[3].
Bottled Gas for Better life by the Global LPG Partnership (GLPGP)	Cameroon and Kenya	6-month microfinance loans of US$ 80-100 are provided to families to purchase a double burner LPG stove, a filled 12.5/13 kg LPG cylinder, and accessories. Loans are re-paid in monthly instalments with commercial interest rates. Participants also receive training and education on benefits of LPG and how to use LPG safely [43].	Started in 2017 in Cameroon and in 2018 in Kenya. Reached 772 households as of 2019. Status: Ongoing

2. The Gold Standard carbon credit certification is a process which requires projects to reduce carbon emissions and deliver measurable sustainable development and environmental benefits to local communities.
3. Correspondence with Eco Act, 2019.

NAME OF THE INITIATIVE & IMPLEMENTING ORGANIZATION	COUNTRY	SCHEME DESCRIPTION	REACH AND STATUS
Expanding LPG access in Haiti through microfinance services by Entrepreneurs du Monde)	Haiti	Loans provided for LPG starter kits covering single-burner LPG stoves with 6kg filled cylinder (US$ 60) and 2-3 burners LPG table stoves with 12kg filled cylinder for commercial cooking (US$ 300-600) [44].	Status: Started in 2014 2,037 LPG start-up kits sold as of 2018 Status: Ongoing.
Expanding LPG access in Burkina Faso through microfranchised distribution by Entrepreneurs du Monde	Burkina Faso	Household loans provided for LPG equipment in the form of 6kg cylinder with on-top burner and locally manufactured metal stand to support pots, for a value of US$ 55 [45]. The loans are provided by a local social enterprise[4].	Status: Started in 2014. 1,959 LPG single-burner kits sold as of 2017 [46]. Status: Ongoing.



Women registering for LPG microfinance package in Cameroon. *Photo credit: GLPGP Bottled Gas for Better life Initiative.*

In recent years, 'pay-as-you-cook' systems that allows consumers to pay small amounts for their gas usage has started to be promoted and has the potential to help overcome the barrier of recurrent large refill transaction costs. The latest generation of pay-as-you-go systems for LPG employ wirelessly Internet-connected "smart valves" with embedded meters and controls which allow users to prepay for small quantities of LPG that are then released by the smart valve until the prepayment amount is used up. The valves have an extra cost (which is typically higher than the cylinder itself) and companies have to recover the added costs. Advantages and disadvantages of PAYG LPG vs. traditional microfinance are summarised in Table 2.

4. The social enterprise in Burkina Faso, Nafa Naana, is also promoting a package containing a solar kit, a three burner LPG stove and 12 kg filled cylinders for the value of US$ 235 to be repaid over 15 months. See https://www.facebook.com/NafaNaana/photos/a.506256062837404/2172349889561338/?type=3

Table 2 - Consumer-financing mechanisms to lower the cost barrier: microfinance and pay-as-you-cook (PAYG LPG)

	MICROFINANCE	PAY-AS-YOU-GO (PAYG)
PROS	• Microfinance is an established practice in development contexts, including for energy services • Fixed loan repayment schedules allow customers to plan their household cash flows • No additional technology costs (e.g. for smart-meters) added to use the LPG equipment unlike in PAYG	• Customers decide how much fuel to purchase and when to purchase it on a pay-as-you go basis • The initial start-up costs 'disappear' under a subscription fee or as a surcharge to the LPG fuel cost • The combination of home delivery services, coupled with assured refill delivery before the cylinder goes empty (due to smart meter monitoring), has the potential to maintain high customer satisfaction • Customers interact with just one service provider for equipment, equipment service, refills and cash transactions; PAYG provider has incentive to monitor operational performance of cylinders/meters
CONS	• Need to coordinate several parties including microfinance institutions (MFI) and LPG fuel/ equipment providers • Many MFIs prefer to give "productive" loans rather than "consumption" loans • MFIs' well-established lending criteria and underwriting processes, while lowering default risks, are sometimes slow and unwieldy, unintentionally locking out non-traditional borrowers. • Microfinance programs are not usually intended to finance ongoing LPG refill purchases, just the starter kit	• Initial costs are high and margins are low for the LPG provider, due to high cost of the smart meter and associated technical infrastructure • PAYG provider needs expertise in financing as well as in LPG delivery or need to partner with a separate LPG distributor • PAYG providers carry significant consumer purchase loyalty risk on their balance sheets • Switchover risks: over time, if a PAYG customer's fuel demand increases, they may choose to switch to purchasing full cylinders instead of paying the surcharge for small fuel amounts

What scale can LPG achieve?

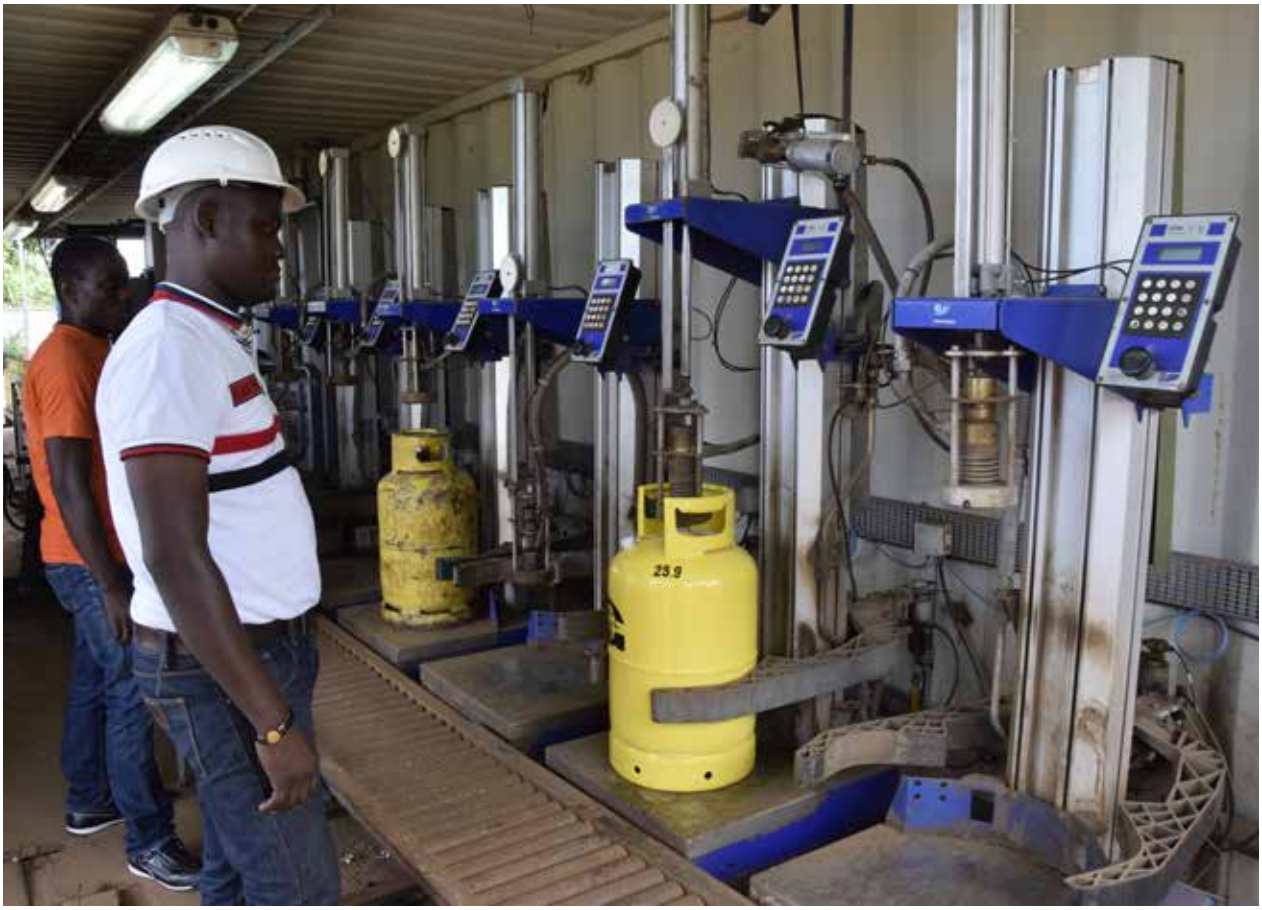
In countries operating under correct policy and regulatory conditions (established and enforced by the government), LPG market expansion can be effectively financed and reach significant scale. Latin America is one such success story where several countries (e.g. Brazil, Ecuador, El Salvador etc.) have transitioned away from traditional use of polluting domestic fuels to establish LPG as the primary fuel of choice [47], although stacking is occurring in rural areas [48, 49]. Morocco, a lower middle-income country in North Africa, is also achieving remarkably high LPG penetration rates with over 95% of the population using LPG or other clean fuels for cooking [50]. In addition, the last decade has also seen countries such as India and Indonesia being able to reach unprecedented scale in adoption of LPG for domestic use, through subsidized provision of access to LPG initial equipment for millions of households in just a few years (see Box 2). However, sustained use of LPG can only be achieved by increasing accessibility through widespread and numerous points of sale/retail outlets.

As part of efforts to meet clean and universal energy access for all by 2030, countries in Sub-Saharan Africa have set specific ambitious targets for domestic fuel use, including significant increases in LPG use. Examples of national targets for LPG penetration include 58% in Cameroon, 50% in Ghana and 35% in Kenya by 2030. Rwanda is working towards reducing biomass fuel use by 40% by 2024 through LPG promotion. Summary of national targets compiled for a selection of Sub-Saharan countries is shown in Table 3.

While there is a set of specific market rules and practices that are globally demonstrated and recognised as essential for safe and sustainable scale-up of an LPG market for cooking, this set must also be adapted by each government (with appropriate expert guidance) to the local conditions in each country, reflecting in particular the country's political priorities and stakeholder priorities regarding the nature of competition and the proper balance between consumer benefit, government fiscal involvement or support, and adequate profitability and risk tolerance in the supply chain.

Table 3 – Examples of national LPG penetration targets in Central and East Africa by 2030

COUNTRY	POPULATION (MILLION), 2016	GDP PER CAPITA (US$), 2016	% OF POPULATION USING CLEAN FUELS/ TECHNOLOGIES, 2016	LPG PENETRATION TARGET, 2030	SOURCE
ANGOLA	28.8	3,309	48%	100% by 2025	CEMAC/CEEAC Livre Blanc de l'Energie [51]
CAMEROON	23.4	1,374	23%	58%	National LPG Master Plan [52]
GABON	2.0	7,079	79%	100% by 2025	CEMAC/CEEAC Livre Blanc de l'Energie [51]
KENYA	48.5	1,462	13%	35.3%	SEforAll Action Agenda [53]
RWANDA	11.9	711	<5%	40% LPG penetration in urban areas by 2024	SEforAll Action Agenda [54]
TANZANIA	55.6	878	<5%	>75% access to modern cooking solutions	SEforAll Action Agenda [55]



LPG cylinder filling. *Photo credit: Nigel Bruce*

Box 2 - Learning from India and Indonesia that have provided LPG access to millions of households in 3-5 years.

The potential for very rapid LPG scale-up across national territories has been recently demonstrated by Indonesia and India, which have both implemented state-driven, national-scale household energy transitions for clean cooking.

Indonesia launched a kerosene to LPG conversion program in 2007 to reduce the Government's subsidy on kerosene. Approximately two-thirds (over 50 million) of all households gained access to LPG for cooking between 2007-2012, resulting in an increase in national consumption from 4.7 Kg/capita in 2007 to 24.4 Kg/capita in 2015 [1]. The programme distributed free starter kits, which included a 3 kg cylinder, one burner stove with hose and regulator and a free first gas fill, to households and micro-businesses (e.g. food-street vendors). Subsequent 3 kg refills were offered at a subsidized price for all.

India started a series of reforms to its universal LPG subsidy scheme back in 2014, including the Direct Debit Transfer of LPG Scheme (PAHAL) through which the LPG subsidy was transferred directly to users' bank accounts, and the 'Give it up' campaign' to encourage wealthier households to voluntarily give up their LPG subsidy to benefit poorer households. These two initiatives culminated in the launch of the Ujjwala scheme in 2016, to provide a capital subsidy for LPG start-up equipment (a double burner, one 14.2 kg cylinder and accessories) to below-poverty-line women.

The Government had originally targeted 50 million homes by 2019, but given the success of the scheme, the target has now been increased to 80 million by 2020. As of December 2018, 90% of all Indian households owned an LPG cylinder and stove (Government of India 2019).

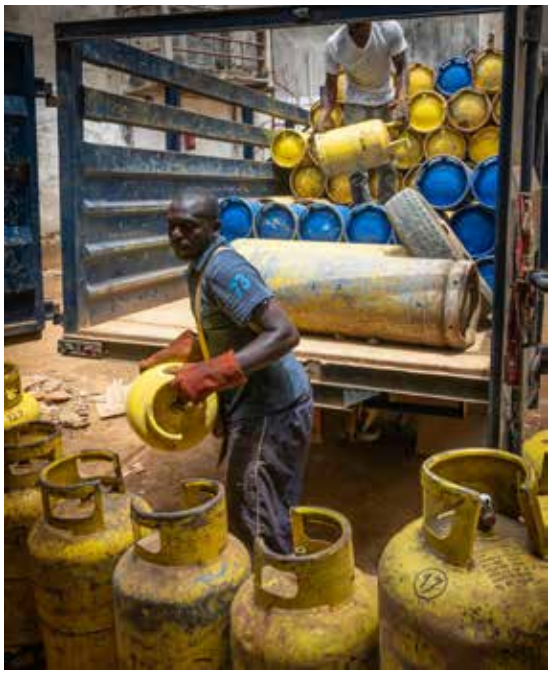
While the program has been remarkably effective at increasing access to LPG among the rural poor, new efforts have now to be put in place to promote sustained use among the poorest segment of the population that continues to rely on traditional free biomass for cooking even after gaining access to subsidized LPG connections. Keeping in mind the purchasing power of the poorest, smaller-size 5kg cylinders were also promoted and camps were launched to distribute cylinders.

Discouraging the use of solid fuels and promoting more habitual use of LPG (or at least a mix of clean fuels) is deemed essential by the Indian government for achieving gender empowerment and environmental benefits with the associated health co-benefit. The Ujjwala scheme has generated electoral impacts for the party which launched it. Moreover, piped natural gas (PNG) is now actively being pursued to cover urban customers to avoid the need for cylinder transport.

Progress towards a fully renewable, green LPG: what implications for policy?

BioLPG, as a potential successor fuel to LPG, is a renewable resource produced from organic feedstocks. It is chemically identical to conventional LPG and utilises the same fuel systems, storage and distribution infrastructure, markets, and household equipment as the existing LPG fuel, without modification. Therefore, it could be substituted in all existing applications of LPG, from transport to cooking and heating [56].

BioLPG was produced for the first time in Europe some years ago and is becoming available in countries like the UK, the Netherlands and the US. BioLPG is not yet being produced by or imported by low-income countries. Future widespread production and distribution of BioLPG for cooking purposes could and should be pursued for uptake in developing country contexts.



LPG cylinders unloading

Conclusions

In the transitioning from reliance on polluting solid fuels and kerosene for household energy needs towards universal adoption of clean fuels, governments from LMICs need to plan the role LPG can play in their energy strategies, particularly taking into account cost-benefit analyses and the implications for infrastructure, the country energy portfolio and the desired role to be played by state support for LPG use by the poorest.

Rather than assuming an axiomatic benefit from a widespread transition to LPG, LMIC governments need to devise preparatory strategies covering a range of different issues. Most important is to which segments of their populations LPG should initially be promoted, noting that these segments' general capacity to afford LPG will evolve over time with economic growth, demographic change and energy investment. Additionally, if the infrastructural, finance and targeting aspects of an LPG roll-out campaign are not adequate, they will limit the ability of the poorest and most vulnerable to access LPG and benefit from LPG use. Even with successful campaigns, fuel stacking will remain a precautionary behavior for as long as it takes for consumer confidence in the safety, reliability and household cost-benefit of the expanded LPG system to become enculturated.

LPG is undoubtedly one of the few available and clean cooking options that can achieve significant scale and it is the fastest, proven scalable solution presently available. To achieve global recommendations for rapid transition to clean cooking energy in accordance to SDG 7 and to reduce household air pollution, LPG is an essential step in the short-medium term on the way to even cleaner renewable energy for cooking (e.g. solar PV/renewable grid electricity), which is currently a long way from achieving sufficient scale. In parallel, further efforts should be directed to expand BioLPG production for use as cooking fuel in LMICs countries, to add a fully renewable and already available fuel to the existing conventional propane-butane LPG mix.

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