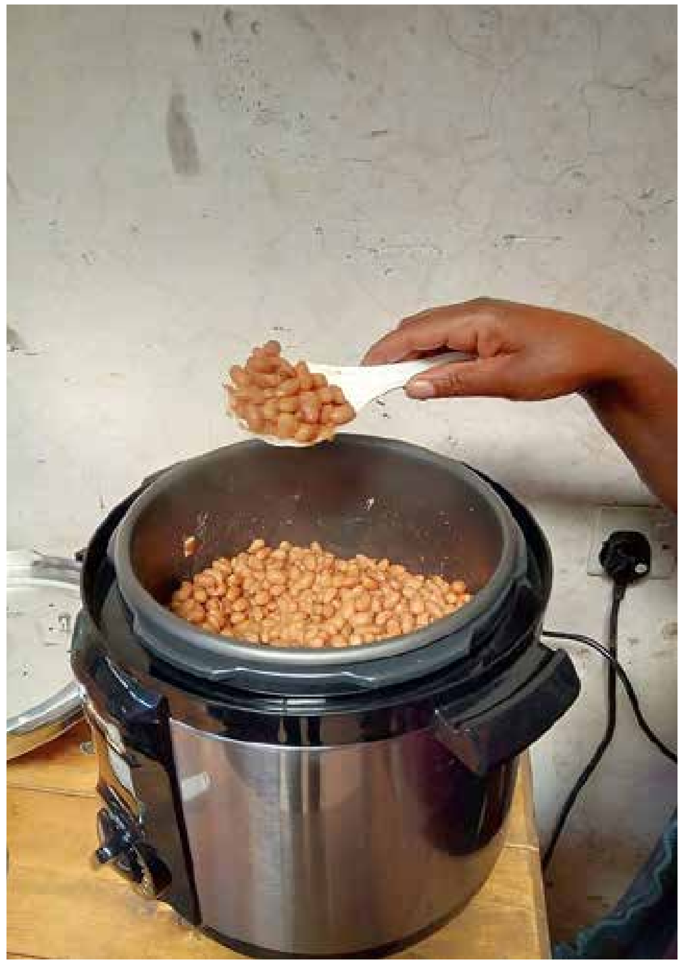
MECS
Modern Energy
Cooking Services

ELECTRIC COOKING: NEEDS, CHALLENGES AND WAY FORWARD

By Jyoti Parikh, Jon Cloke, Elisa Puzzolo, Daniel Pope and Chandrashekhar Singh

University of Liverpool
Loughborough University
15 IRADe Integrated Research and Action for Development
The Global LPG Partnership



Introduction: Clean Cooking

The United Nations Sustainable Development Goal 7 (SDG 7) stipulates universal access to modern fuels by 2030, both to mitigate the household health effects of 'dirty' fuel use (wood, charcoal, dung, kerosene) from household air pollution (HAP) and to enable them to develop productive, educational and self-fulfilling opportunities for women and girls foregone due to the labour required to obtain and use such fuels. For a long time, studies have associated household cooking energy access and its linkages to gender and health (Puzzolo et al, 2019; Cloke et al, 2019; Parikh, 1995; Cecelski, 1995; Skutsch, 1998, and 2005; McDade and Clancy, 2003).

Access to cooking energy is overwhelmingly a gendered issue because women continue to be primarily responsible for cooking in virtually all cultures. Globally, women continue to bear most of the responsibilities for all domestic tasks and spend at least twice as much time as men on unpaid domestic work (UN, 2010). The consequences of the inaccessibility or unavailability of clean cooking fuels hit women the hardest and cost women more time and energy because they are primarily responsible for performing the household chores (Westendorp, 2011). They face burden of the drudgery of collecting, transporting, and processing fuelwood (Parikh et al., 1999; Parikh and Laxmi, 2000; World Bank, 2002; Parikh, 2011)(WHO, 2014). In the process of cooking with biomass and fetching fuel for the home, women and girls forego opportunities to engage in income-generating and self-fulfilling activities and often sacrifice their education. (J. Parikh 1995)

In addition, polluting household fuels cause the household to become a focus of ill-health for the most vulnerable members - women during and after pregnancy, the elderly and young children (Parikh and Laxmi 2000). Studies have shown that kerosene, for example, although treated as a 'cleaner' alternative to solid/biomass fuels, can harm lung functions and increase infectious illness through its immunosuppressant effects and increase the risk of cancer (Lim et al, 2012; Smith et al., 2014)) - an estimated 1.6 to 3.8 million annual premature deaths were attributed to HAP in 2016 (IHME, 2018; WHO, 2018)

Clean Energy and SDG

Ensuring access to and use of clean cooking fuels for all is a key Sustainable Development Goal (**SDG 7**) (Figure 1). **SDG 7** has many positive interlinkages with other SDGs (Rosenthal & Quinn 2018); for example, women with energy access hold a special role in poverty reduction (Dutta et al., 2017) by engaging in new options for livelihoods and income generation thus reducing poverty (**SDG 1**). It is one of the major barriers to gender equality (SDG 5) (Parikh, 1995), as unpaid work such as the collection, transportation and processing of cooking fuels is a hurdle for gender equality. Globally, young girls are substantially responsible for fuelwood collection and hence the quality of their education is disrupted, compromising SDG 4 which advocates quality education for all. Clean energy delivered to households is therefore a driver for the empowerment of women and girls by reducing the drudgery of firewood scavenging (Lewis et al., 2017). In terms of health, since HAP is estimated to cause 3.8 million premature deaths due to the use of solid cooking fuels (WHO, 2016), access to clean forms of energy also targets **SDG 3** on good health and well-being.

Clean cooking is interrelated with many SDGs, including for instance as a driver towards enhanced productivity and inclusive economic growth (**SDG 8**) – the energy sector offers many job opportunities. Traditional solid fuels also make substantial contributions to anthropogenic black carbon emissions (18–30%) and small contributions to total anthropogenic climate impacts of between 2 to 8% (Masera et al., 2015). Clean cooking solutions can therefore address the most basic needs of the poor, while also delivering climate benefits (**SDG 13**). Unsustainable harvesting of fuelwood contributes to forest degradation, deforestation, and climate change (FAO, 2017) and the provision of clean energy thus targets sustainable management of forests, combats desertification and halts biodiversity loss (**SDG 15**).

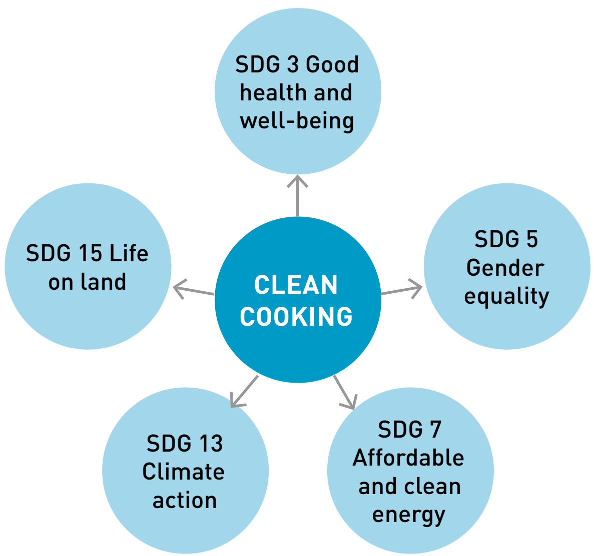


Fig1. Interlinkage between clean cooking and SDGs

LPG: Strengths and Weaknesses

Interventions to improve access to clean cooking energy in the past have mostly focused on burning solid fuels more cleanly through improved cook stoves (ICS); more recently the focus has been on cleaner fuels (e.g. biogas, liquefied petroleum gas (LPG), alcohol fuels, and solar cookers). Where there is abundant or freely gathered biomass, however, interventions focusing on the promotion of ICS have had mixed results. By way of contrast, the supply of LPG has enabled a very large number of households to access clean and convenient fuel in India, as just one example - LPG has reached 80 million households through Ujjwala scheme by Govt. of India (Ministry of Petroleum and Natural Gas, 2019).

LPG is not only a clean cooking fuel but is also convenient in that it can be carefully controlled during cooking. It is developing as a key focus for clean cooking due to the fuel efficiency, availability, acceptability and opportunities for scaling up (Puzzolo et al, 2019; Quinn et al, 2018); it is also extremely popular among household cooks. When crude oil is refined or natural gas extracted, LPG is a by-product associated with the many extracted petroleum products such as petrol, diesel and aviation fuel. Whilst LPG shares the value chain of other petroleum products, it also needs its own storage and distribution infrastructure.

Access to LPG may not lead to sustainable usage among poor and rural households for a number of reasons, however. In terms of finance, barriers include difficulties in arranging large one time payments for the initial equipment needed to use LPG, as well as variable seasonal or daily incomes of certain households which can preclude being able to pay for full cylinder refills every month, as required to meet the household cooking needs. In addition, perceived apprehension over safety, lack of supply infrastructure in rural areas and inadequate distribution with prohibitive transport costs are other issues. In remote areas, LPG cylinders transported by trucks can be very expensive for the LPG distributors, if used only to service a few households. Alternatively, household members may need to travel long distances to secure LPG cylinder refills from the distribution centers located far away.

Volatility in global pricing is also a cause of concern for national budgets in countries where LPG prices are regulated or subsidized. Concentrating on a single clean fuel can pose problems in creating dependency on one source; energy source diversity, on the other hand, can enhance community resilience. There is an additional concern with reliance on LPG as a sole household given that it is a fossil fuel (producing CO_2 on combustion) that typically needs to be imported. At the same time, sustained use of LPG can result in forest protection and reduction of other climate-warming elements such as black carbon, making LPG more climate-friendly than might be expected (Singh et al. 2017, Bruce et al. 2017, Kypridemos et al. 2019).

Although LPG brings other issues to the table, it has definite advantages on its own in niche markets and can be a very useful component of a multi-fuel strategy and/or as part of a transitional strategy towards more widespread use of renewables. The benefits of a clean multi-fuel strategy in India, for instance, have been made evident (Parikh, 2018) where deployment of piped natural gas (PNG) has been combined with cooking with electricity (E-cooking) in urban and peri-urban areas, combining the availability of both resources in settings in India where this is feasible, with LPG being used in places where it is available but electricity is not.

Electric Cooking: Justification, Experiences and Challenges

The range of possibilities for cooking with clean modern energy (particularly concerning electricity) is increasing rapidly on a global basis. Electric cooking through specialized electric appliances such as electric kettles, rice cookers, ovens, insta-pots and microwave ovens is increasing now in areas where the power supply is reliable, in India and an in an increasing number of other low and middle-income countries (Smith and Sagar,2014). Such technologies include induction cookers, demonstrated by Parikh et al (2018) to have many benefits, including the potential for cooking a wide variety of local dishes compared to specialized equipment such as rice cookers.

A new generation of induction cookstoves can be used for all-purpose cooking (Smith and Sagar, 2014). Other authors (Batchelor, 2018) have stressed the benefits of battery-based cookers which extend the option of cooking during the day and night compared to those dependent on (for instance) wind energy, which have less reliability and unpredictable hours of operation in different circumstances and places. Lastly, diverse experimental hybrid cookers are being tested in countries such as Bhutan (Chheti et al, 2017), to take advantage of the country-specific development of energy portfolios based on their own domestic resources, which in Bhutan's case is hydro power.

A report by the International Energy Agency (IEA) indicates that 1 billion people do not have access to electricity but 2.8 billion people do not have access to clean household energy, indicating the substantial potential of electricity for cooking over other fuel sources (WEO 2017). Where the quality of supply is variable, the low quality of access to electricity in many global southern countries may mean it is currently more suitable for lighting, cooling, entertainment, running of household appliances, heating water and mobile charging. Nonetheless, for the overall requirements of these households electricity is ideal due to its versatility and in addition is important for activities that generate income and improves livelihoods.

Fig 2 Use of electric pressure cooker in Africa and induction cookstove in India

Another attraction for scaling electricity as a modern clean energy is related to supply. In addition to a centralized grid supply which may not be geographically feasible, there are many ways to generate electricity through locally available resources such as wind, solar, water (hydro-electric) and biogas. Even if the present electricity supply is partially resourced through fossil fuels, it is likely that this will increasingly be replaced by 'greener' electricity from renewables over time due to concern for global warming (Parikh et al. 2018). This is more likely to be the case where scaling electric cooking begins to become more feasible and affordable as technology improves.

Figures 3 and 4 (below) illustrate the disparity between access to electricity and access to clean cooking in some African and Asian countries (WEO, 2017). Countries with wide access to electricity and low access/adoption of clean cooking through other fuels have good potential to adopt electric cooking technologies to scale access to modern clean cooking. The proportion of the population with access to clean energy is low in African countries, however, and in particular requires interdisciplinary research and policy interventions encompassing health, environmental, cultural, and economic issues to address this deficiency (Armah et al., 2019).

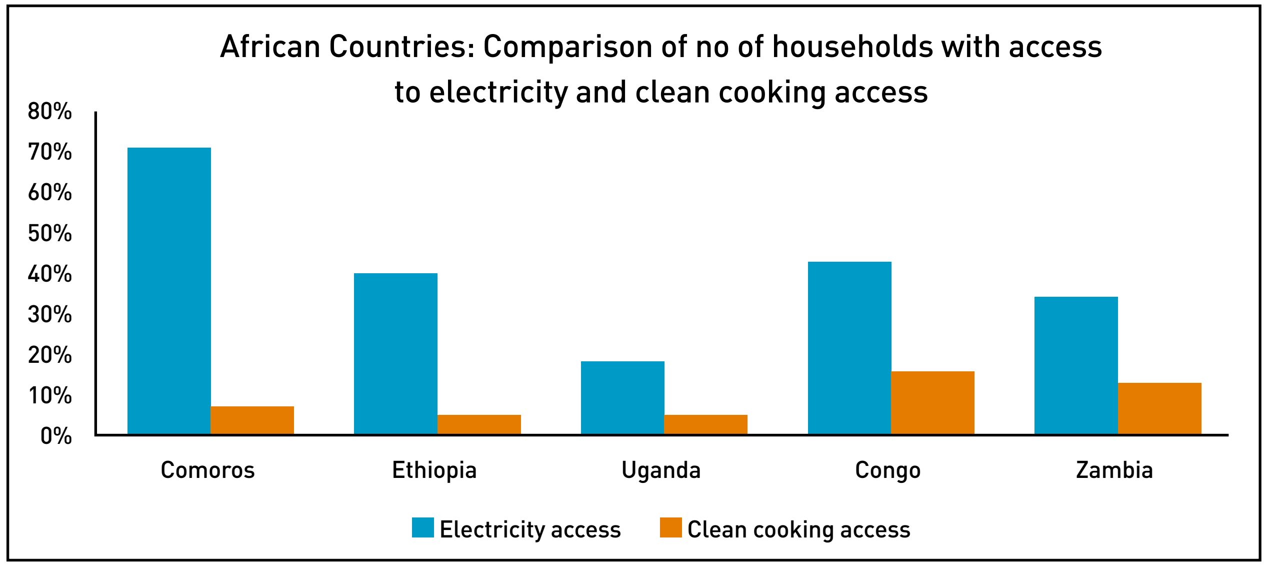


Fig.3 Comparison of access to electricity and clean cooking (e.g. LPG) in some African countries.

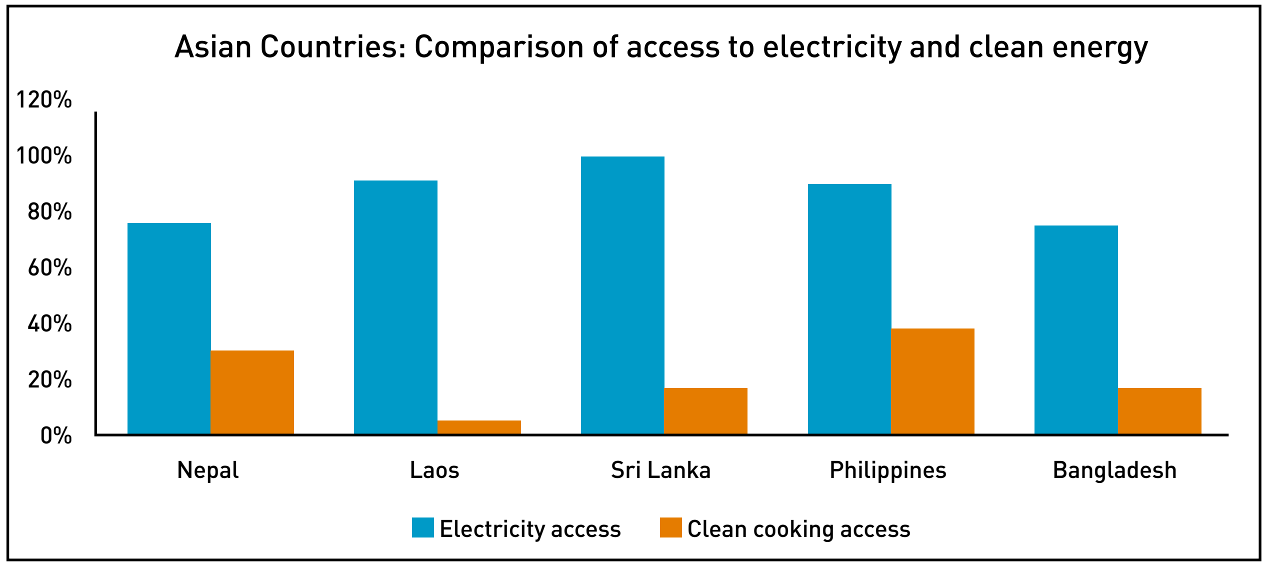


Fig.4 Comparison of access to electricity and clean cooking (e.g. LPG) in some Asian countries. Source: WEO (2017)

Some Asian countries have been successful in reaching very high electrification rates (even in those with relatively poorer economies such as the Philippines) (Bhattacharyya, 2012) but even in these settings the proportion of the population with access to clean household energy access for resource-poor households is still low – governments still have a tendency to equate coverage with access, but they are not the same thing. Many of the LMICs[1] with populations which rely on polluting biomass for their household energy are either landlocked countries in the interior with no direct access to ports for imports (such as Nepal, Uganda and Laos) or island countries with no access to fossil fuels (such as Sri Lanka, Mauritius etc.). These countries may benefit from other (hybrid) options, such as utilizing wind and solar for electricity generation for cleaner household energy, because LPG will have to be imported.

Since electricity is often already available in many more households than LPG, clean cooking with electricity might be a better option in some LMIC contexts than gaseous fuels. One substantial advantage of electric cooking is that it is emission-free at the point of use and can, when used exclusively or with other clean energy options, eliminate kitchen concentrations of, and hence exposures to, health-damaging HAP. The figures below show that there are many countries where access to electricity is far higher than LPG access – which begs the question, where should effort be focused, and are there multiplier effects? If effort is put into strengthening electricity supply, for instance, it also helps in other development activities.

An important consideration in the scaling potential of a reliable source electricity for clean cooking is its utility for other important energy requirements: e.g. lighting, heating, recreation (television, internet), home appliances, mobile charging and industry, as well as for community purposes such as street lighting, health centers, rural industries, education centers etc. Thus, the expense of establishing an electrical infrastructure has multiple societal benefits, rather than addressing one specific role such as clean cooking.

With current expansion (through investment and infrastructure) and strengthening of policies around electrification occurring globally, electricity is anticipated to be both a readily available and widely adopted clean household energy source in the near future, with the potential for surpassing LPG as a modern energy cooking solution. One feature for this transition is the more straightforward transfer of energy as electricity through cables, rather than in cylinders through trucks and tankers as required by LPG.

To ensure a smooth transition to electricity for cooking, the reliability, availability and cost of the electricity supply are essential considerations, as well as the quality of power connectivity that provides high voltage reliable power. These components are also critical to meeting the demands on electricity for the range of other tasks that electricity is routinely used for elsewhere (e.g. household and industrial use), which is why expansion of reliable access to electricity is closely aligned with economic growth and development.

For rural communities, economic development will only take place when households are provided with a higher quality, affordable access to electricity to help supply home-based or small industries, productive agriculture, and other activities for livelihoods. Thus, comprehensive access to electricity is a necessary (but not sufficient) precursor to economic development, as well as providing an important source of clean cooking to benefit health and climate.

Review of Current Experiences in Promoting Electric Cooking: learning from Ecuador and India

Ecuador is an upper middle-income country in Latin America that has recently embarked in a national program to replace LPG cooking with renewably-sourced electricity, given the country's growing hydro-electric capacity. The induction stove program -'El *Programa de Eficiencia Energetica para la Coccion* (PEC) – which was launched in 2015, aimed to replace LPG-based cooktops with an electric system for 3.5 million families (80% of all households) by 2018 (Gouldet al., 2018). As of 2014, more than 90% of households cooked primarily with LPG (which is very heavily subsidized in Ecuador) (Gould et al, 2019).

Fig. 5 Hotplate was more efficient and cost effective as compared to LPG

1. LMIC (Low and Middle Income Countries) a classification by World Bank to define low-income status based on gross national income (GNI) per capita in 2014. Low-income countries have GNI per capital of $1,045 or less, Lower-middle-income countries have GNI per capital of $1,046 to $4,125, and Upper-middle-income countries have GNI per capital of $4,126 to $12,735.

Initial stove laboratory testing which compared LPG, electric, and induction cookers showed that the cooking time, energy consumption and cost were less than using LPG and the induction cooking option was more efficient and with no carbon footprint (Martinez-Gomez 2016). However, the induction stove program has been less successful and slower than expected in its implementation, reaching 740,000 stoves purchased by the end of 2017, with the target subsequently adjusted to 3.5 million households by 2023 and then eventually removed in favour of slower, market dependent sales of induction equipment (Gould C.F et al., 2018).

The PEC program includes a consumer credit for stove purchase provided through state electric utilities, allowing participants to make monthly payments as part of their electricity bill (plus 80 kWh of free electricity, which is an amount projected to cover household cooking for a family of five for a month). The four-burner hotpot induction stoves cost between US$150-600 (and up to $800 for 4 burners with electric resistance ovens), plus extra costs for induction-compatible cookware and installation costs for a 220 V circuit (Gould et al. 2018).

The majority of stoves have been purchased through either government credit or monthly instalments for up to $800 for 48 months through electricity bills (Gould et al. 2018). Evidence shows a continued demand for subsidized LPG among Ecuadorian households, shortfalls in the programme implementation and delays by the utility companies and electricians in the 220V connection installations, factors which have all contributed to the limited success of the programme (Serrano 2018, Gould et al. 2019).

In another study by the International Research and Development institute (IRADe-PR-57 2018), a pilot experiment was carried out to test the potential of induction cooking in providing a viable option for clean cooking in India. The study was conducted in two states of India, Chhattisgarh and Rajasthan, to explore the practicality of cooking with an induction cooktop in both rural and peri-urban areas. It involved surveying 200 households to be potential study sites out of which a sample of 50 was chosen; all received induction cookers plus 2 compatible utensils at a subsidized cost of Rs. 500 ($7.5) (the market price was Rs.2000($ 30).

The main aim was to test the social acceptability and potential sustainability of the device in meeting all household cooking requirements. The selected rural households showed that, over a two-month period:

- An induction cooktop was comparable to the efficiency and operating costs of using LPG, provided that there was a reliable electricity supply (the situation only in one of the two study states (Chhattisgarh)).
- Cooking with the induction cooktop has potential to replace both cooking with biomass fuels and LPG, in situations where LPG retailers were located a distance from the households (problems in supply).
- The taste of food, cooking patterns, and safety-related aspects were found to be satisfactory for induction cookers, informing the need for targeted campaigns to remove potential misconceptions of non-users.
- The induction cooktop addressed a range of problems associated with traditional solid fuels including health (from exposure to HAP), cleanliness of the kitchen, storage and safety and longer preparation time involved in cooking with such fuels.

Fig. 6 a) Demonstration activity to ensure user-friendly handling of the induction cooktop

Fig. 6 b) The social acceptability and ease of induction cooktop use in rural households

BOX 1: PROSPECTS FOR E-COOKING IN SUB-SAHARAN AFRICA

To ensure universal access to electricity in Sub-Saharan Africa, studies indicate that US$41 - US$55 billion needs to be spent annually up to 2030, compared to about US$8 billion currently (Johnson et al., 2017; Schwerhoff and Sy, 2017). The gap in access between countries in the region and the urban rural gap is substantial and, in rural areas, lagging behind population growth, whilst access in urban areas is increasing faster than the population. Nonetheless, the priority of many governments and institutional lenders to countries with substantial rural-urban gaps is grid extension, even though in a range of contexts decentralized systems represent a cheaper, faster vehicle towards electrification (Chirambo, 2019).

Nonetheless, at a time when growing rural populations are driving a scarcity in fuelwood supply and an increase in charcoal prices, solar costs (panels, batteries) have been coming down for some time and grid electricity prices across Africa (unreliability aside) are often comparable with charcoal for cooking (Gamos, 2018). There are in addition countries such as Kenya and Tanzania where nascent but growing solar markets imply a substantial market for stand-alone (or grid-connected) solar-electric cooking technologies deploying battery storage in locations where a price per Kwh advantage is developing.

It can be anticipated therefore that two versions of existing e-cooking technologies, solar and grid-powered supported by battery storage, would have advantages in two different locations – 1) rural areas where solar is applicable but with no grid supply, and 2) urban areas where there is a grid supply and where battery storage offsets the unreliability of supply (Batchelor et al, 2018). Scaling up, however, would require a business model which offsets the initial capital costs of such a system and allows e-cooking to compete with traditional (free) fuels over time on an appropriate pay-as you go model.

Ways forward to upscale electric cooking

Upscaling clean cooking initiatives in communities that have electricity but do not currently have a reliable supply of LPG could, therefore, give substantial positive results in LMIC settings where there is a high reliance on polluting solid fuels for cooking. In support of such an aim, a comprehensive study of the potential for using different samples and geographical locations would be beneficial in understanding the social acceptability of electric cooking to make a convincing case for its expansion from a policy perspective. The findings from this research could then be used for strategies for enhancing the adoption of e-cooking and the development of appliances such as regular hotplates and induction cooktops, recently available Insta-tops, and other e-cooking appliances.

There are still however substantial challenges to achieving this scale, not only in terms of securing funding for the investment in electricity infrastructures (including mini-grids), but also in ensuring this supply is reliable and sufficient to meet the demands of cooking with electricity. One example of this issue can be seen in South Africa where, despite being a country in which 84.2% of the population had access to electricity in 2016[2], communities experience recurrent 'outages' in supply which require households to use alternative fuels for cooking, including LPG and solid fuels (Kimemia & Annegarn, 2016), even though coal-generated electricity is the dominant domestic fuel given the abundance of coal in the country. Strategies for enhancing adoption of e-cooking at scale require further research, investment and community based programs supported by the right policies.

Further research: Identifying research problems at the interface between electric cooking and the consumer

Further research includes the need for:

- ✔ Comprehensive analysis of e-cooking with large population samples across heterogeneous contexts and settings to understand relevant issues for communities in meeting their everyday cooking requirements for households and families.
- ✔ Combined research initiatives working with stove manufacturers and consumers to understand what technologies address household requirements for cooking with electricity.
- ✔ Understanding the barriers to adoption of e-cooking and how to address these, including (i) reliability of electricity supply during the cooking time, (ii) ease of fulfilling all cooking needs (iii) convenience of operating e-cookers.
- ✔ Understanding the socio-cultural benefits of e-cooking for the entire family (especially for women and children).
- ✔ Research into combining electric cooking with mini grids and the challenges of enhancing grid loads at appropriate timings, as well as compatibility with other loads.

2. World Bank, Access to electricity (% of population), accessed 25/6/19 at https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS

Areas of Policy Development

Particular areas for developing policy in this arena include:

- ✔ Understanding the infrastructural implications of widespread adoption of e-cooking possibilities to accompanying electrification strategies.
- ✔ Understanding the implications of upscaling e-cooking for the scaling and strengthening of the grid supply and its reliability, safety and security in LMIC settings.
- ✔ Understanding the role of decentralised mini grids, which are now seen as one of the major options to providing a large number of unserved persons with electricity in many countries where people are also likely to be using biomass for cooking. Therefore, building and planning mini grids that also serve a vital basic cooking need for all is a challenge needing socio-techno-economic solutions which need to be planned and piloted.
- ✔ Developing a range of consumer-flexible payment models in LMIC settings (e.g. prepaid, postpaid or pay-as –needed by loading a card).
- ✔ Developing policies towards both on- and off-grid supply possibilities through widespread pilot activities and community experimentation.
- ✔ Liaising with grid suppliers/parastatals to coordinate policy and implementation.
- ✔ Working with the technological challenges of e-cooking with manufacturers.
- ✔ Providing input into national educational and training (TVET) systems to increase knowledge and understanding of e-cooking and the problems of biomass cooking, especially on a community basis.
- ✔ Developing entrepreneurial business models for outreach and supply of all e-cooking applications, including local business networks.

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