Modern Energy Cooking Services: Partnering with India

1 Executive Summary

This document sets out the case for the Modern Energy Cooking Services (MECS) programme to work with India on the development and implementation of cooking with electricity. This has the potential to save millions of lives across the world, both in India and in the MECS target countries in East Africa and South East Asia.

While much has been done to attempt to reduce deaths from household air pollution by developing a range of improved biomass stoves or LPG access, we see a major new opportunity to radically change the approach as a result of the huge investments going into electricity access. For the first time, there is a real possibility of "eCooking" being financially viable and for cooking devices and systems to be developed that can work in weak grid or off-grid contexts. The fact that this then generates a much needed additional load and potential revenue stream for energy providers, as well as the potential to demonstrate and release funds as a result of the substantial carbon emission reductions, means that the barriers to households securing eCooking devices can also be massively reduced.

India is an ideal partner in this work as the agenda is of great importance with the need to reduce the deaths from household air pollution across the country and the dependency on foreign imports of LPG. India has already invested substantially in these challenges and the Government of India is now open to exploring new solutions. The Indian manufacturing, technology and research base as well as substantial trade relationships with African and Asian markets puts it in a unique position to benefit economically from the foreign as well as domestic need for clean cooking solutions.

The MECS programme has developed a Theory of Change around which a transformation programme can be built and our research into different cooking needs and solutions can complement your own research and drive the development of Indian-designed and manufactured solutions. To be effective, the programme will need to be wide-ranging and address both demand side, supply side and policy domains. We look forward to working with you to take this forward.

Building on two previous Round tables – one led by GIZ India and one by MECS in partnership with IRADe and CLEAN, on 26 February, with the help of Finovista, we are organising a Round Table to discuss the shape of this programme and the role that different bodies can play.

2 The Modern Energy Cooking Services (MECS) programme

Globally, 3 billion people still cook with biomass, yet 2 billion of these now have access to electricity[1]. The increasing investment in energy access and the gains made in electrification combined with energy efficient cooking appliances open considerable new opportunities for genuine clean cooking.

Modern Energy Cooking Services (MECS) Programme is funded by UK Aid through the Department of International Development (DfID) and represents a key example of the UK acting as a global thought leader. It is a partnership between researchers, innovators, policy makers, and ESMAP drawing on their expertise and relevant work from around the world to co-construct new knowledge with practitioners and the private sector. It is led by Loughborough University, UK. Globally, partners include World Bank, UN, WHO and national Governments along with major financial institutions.[2]

Existing strategies are struggling to solve the problem of unsustainable, unhealthy but enduring cooking practices which place a particular burden on women. After decades of investments in improving biomass cooking, focused largely on increasing the efficiency of biomass use in domestic stoves, the technologies developed have had limited impact on development outcomes. The multiple problems caused by biomass based cooking, which affect 3 billion people in low income countries, result in 4 million premature deaths annually (which is more than the combined deaths by Malaria, HIV and TB, WHO 2018[3]), contribute to climate change and cause loss of economic opportunity.

> "Clean cooking must be a political, economic, and environmental priority, supported by policies and backed by investments and multi-sector partnerships. To make that kind of change, the level of commitment and the scale of investment matter. To that end, the World Bank's Energy Sector Management Assistance Program (ESMAP) has established a planned US$500 million Clean Cooking Fund (CCF), with contributions from the Netherlands. Norway and the United Kingdom also support the Fund."

According to the World Bank a 'business-as-usual' approach will not deliver on SDG Global Goal 7 and will result in more people using biomass for cooking in 2030 than is the case now[4]. A different strategy that supports the transition of low income economies to the use of modern energy cooking services, creating access to genuinely clean cooking is needed to change this situation. **Using emerging innovations and technologies could potentially leapfrog existing harmful practices in cooking with significant development benefit**.

This programme, Modern Energy Cooking Services (MECS) aims to break out of this "business-as-usual" cycle by investigating how to rapidly accelerate a transition from biomass to genuinely 'clean' cooking (i.e. with electricity or gas). A key driver is the trajectory of costs that show cooking with (clean, renewable) electricity has the potential to reach a price point of affordability with associated

[1] Sustainable Energy for All, "SEforAll.org," 2019. [Online]. Available: https://www.seforall.org/.

[2] S. Batchelor, E. Brown, N. Scott, and J. Leary, "Two Birds, One Stone—Reframing Cooking Energy Policies in Africa and Asia," *Energies*, vol. 12, no. 9, p. 1591, 2019.

[3] WHO, "Household air pollution and health," 2018. [Online]. Available: https://www.who.int/en/news-room/fact-sheets/detail/household-air-pollution-and-health. [Accessed: 25-Mar-2019].

[4] World Bank (2015); Atur, Varadarajan; Jammi, Ramachandra. 2015. World Bank Group support to electricity access, FY2000-2014: an independent evaluation. Washington, D.C. : World Bank Group.

reliability and sustainability within a few years, which will open completely new possibilities and markets.

Whilst the overall MECS programme will focus on cooking with genuinely clean modern fuels - including gas (both LPG and Biogas), the main technology of focus for this challenge fund is Electric Cooking Appliances (particularly pressure cookers) and their acceptance both to users and to those managing loads and delivery of grid and off-grid electricity.[5]

More details can be found on the website www.mecs.org.uk and Appendix I shows the wide-ranging impact that could be achieved by a shift to modern energy cooking.

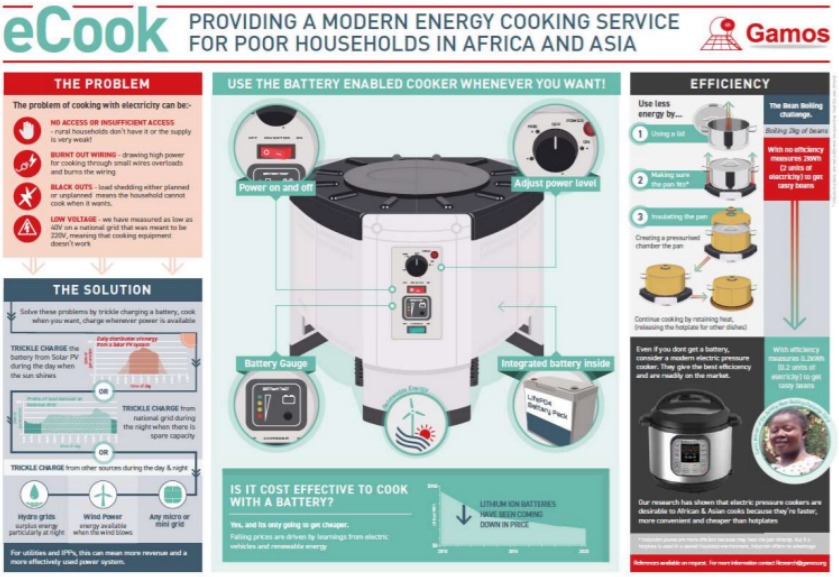

Figure 1. Research by the UK universities and innovators is laying the groundwork for a different approach to the enduring problem of cooking

3 The significance of India

India is a natural partner to MECS in the drive towards a global shift towards clean cooking given its substantial, innovation and manufacturing base, commitment and investment from the top of the Government of India to bring the many benefits of clean cooking to the Indian population, and the expertise and research that has already been invested in the search for solutions.

While there is considerable experience both within India and elsewhere of gas-based cooking with its strengths and challenges, we see value in a focus on the potential for cooking using electricity given:

- the wider range of devices that exist and could be developed offering highly energy efficient cooking options; and
- the opportunity to build electric cooking into electrification/mini-grid programmes with the benefit of creating a substantial base load that creates increased revenue generation opportunities and improved return on investment prospects.

[5] Brown, E.; Leary, J.; Davies, G.; Batchelor, S.; Scott, N. eCook: What behavioural challenges await this potentially transformative concept? Sustain. Energy Technol. Assess. 2017, 22, 106–115.

We see the potential for a great many benefits from establishing a long-term partnership between the MECS Programme and India – its Government, leading institutions and business community. We believe that this could make a huge difference towards achieving the transition from biomass to clean cooking on a global scale.

In particular:

- The investments and support that the Government of India has already put into driving the transition for its population to clean cooking and solar PV shows its understanding of the importance of this and provides an excellent basis for developing a Government-Government partnership focused on clean cooking;
- There are tremendous business opportunities for Indian companies with the right cooking devices and business models, in the energy sector and investors that support both of these – both within India's own domestic market and across the many countries with which the MECS programme is working;
- The considerable research and policy development support provided by a number of India's leading institutions and policy think-tanks demonstrates the potential for sharing experiences, learning and methodologies with the MECS programme partners;
- The support initiatives that the MECS Programme and its partners – ESMAP, Clean Cooking Alliance, the UN, CLASP – are putting together and offering to interested companies compliments well the programmes already in place run by Indian institutions that can be extended to include a focus on clean cooking.

In December 2019, we attended a round table on Solar PV cooking for India. At this, we learnt that PM Modi has specifically instructed the PSA to identify how cooking with solar PV could become a reality for the Indian population. There is clearly a shift taking place in thinking, at the top of Government of India making this an ideal time to engage.

"While the world is working towards electric cars, in India, in addition to electric cars, electric stoves would go a long way in meeting the needs of the people. This innovation would, in one stroke, significantly impact the nation's dependence on imported fuel." **Hon'ble Prime Minister Shri Narendra Modi**

In this regard, we are organising a Workshop and Roundtable on 26 Feb 2020, at India Habitat Centre (IHC), New Delhi, A complete plan with expected outcome and Agenda are provided in Annexes 1 and 1.1.

MECS programme is active engaging in India since December 2019 and part of the two Roundtable, details as under:

- MECS programme team visited India during first week of and met with the several key stakeholders in the country. Further, also attended a "Roundtable Discussion on Solar for Cooking", organised by the GIZ India and The Clean Network on Dec 3, 2019 at New Delhi. This roundtable was attended by the dignitaries from the Office of PSA, MNRE, MECS Programme, Researcher, Policy Think Tank, Manufacturer, Franchiser and Experts. During the discussion, Govt officials has highlighted that the great need to the Solar PV cooking and happy to pilot the devices with ideal costing range is INR 50,000. A Minutes of the Meeting is **Annexure 2**

- Modern Energy Cooking Services (MECS) programme and Integrated Research & Action for Development (IRADe) has again hosted roundtable on "Nexus of Electricity and Clean Cooking" on

February 5, 2020 at New Delhi, in side-line of India Energy for All Summit 2020. This was conducted in collaborate with the Clean Energy Access Network (CLEAN). A wide variety of participants have attended the roundtable such as Manufacturer, service provider, Corporate Foundation, International Development Agency, Think-tank body, Industry Association, Financial Institution etc. The round table was structured from the prospective of manufacturer's and Support Agencies and requested there need and offering to support the Clean Cooking in the areas of research, technology, Finance and other suggestions. A Minutes of the of the Meeting is expected to be released by the organiser shortly however we have summarised inputs provided the participants in Sticky note, in **Annexure 3**

4 What solutions are we focused on?

Essentially, we are arguing that a focus on cooking powered by electricity (however generated and delivered) is both feasible and offers huge benefits due to its ability to benefit from the massive investments going into energy access. Our research has identified that a range of eCooking devices have potential in different contexts but that Electric Pressure Cookers are particularly well-suited, especially if the ones currently on the market can be modified or enhanced. These are devices that have achieved very substantial take-up in Western markets and these are becoming saturated. The markets offering the best prospects of growth are now in Africa and Asia.

4.1 Why focus on cooking with electricity?

In 2018 the number of people without electricity access fell to 860 million. However, 80% of the those who gained access are concentrated in Asia[6]. Sub Saharan Africa has major challenges, but nevertheless is making gains.

The increase in grid and off grid capacity has been significant over the last few years and created contexts whereby the idea of electric cooking could be considered. Indeed, its affordability particularly in urban areas suggests an easy gain in the challenge of clean cooking.

By 2025, Africa's population is projected to exceed that of both India and China[7]. The African Renewable Energy Initiative (AREI) plans to develop at least 10 GW of new renewable energy generation capacity by 2020, and at least 300 GW by 2030[8].

According to a recent World Bank report about half a billion people in Africa and Asia could be cost-effectively supplied with electricity through mini-grids[9]. Mini-grid models are evolving, from providing only basic electricity services for households, to providing electricity services for income generating activities.

In 2010, building on mature solar and mobile money technologies there were a number of start-ups offering a new generation of solar home systems (SHS) to remote rural markets with sustainable, affordable and safe electricity on market terms, generally using Pay as You Go business models. However, the resilience of current PAYG business models is still undecided.

[6] https://www.iea.org/reports/sdg7-data-and-projections
[7] Africa Energy Outlook 2019 - https://www.iea.org/reports/africa-energy-outlook-2019#overview
[8] http://climateinitiativesplatform.org/index.php/Africa_Renewable_Energy_Initiative

[9] Mini Grids for Half a Billion People : Market Outlook and Handbook for Decision Makers - https://openknowledge.worldbank.org/handle/10986/31926

The acquisition of new customers is a significant expense, and to get the return based on a low load consumption of a simple light makes profitability challenging.

There is then the prospect of integration between the three modes of electrification – stand-alone systems, mini-grids and grid, unlocking latent community demand for sustainable electricity.

A transition to and uptake of electric cooking depends not only on the affordability to the household per se, but to the mechanisms by which a household may spread payments. Utilities and those offering off-grid solutions, with excess generating capacity and wanting to encourage more demand, could offer the initial cost of an EPC on a lease basis, or a pay as you go through perhaps on bill financing.

By introducing a 'single investment strategy', incorporating clean cooking into the growth of renewable energy technology for grid and off-grid development, the various financial instruments currently in play to encourage renewable technologies come to the foreground. Within this context load management for cooking needs to be deeply embedded in all planning of electrification.

4.2 What devices and cooking systems show potential?

If we are to encourage cooking with electricity, there need to be devices that make this possible, for different cooking cultures. Our research has enabled us to develop a detailed understanding of what drives cooks' behaviours and choices. Devices need to support a range of types of dish, result in the expected flavours and textures and keep the price of cooking as low as possible. The Electric Pressure Cooker (EPC, or multicooker) combines energy efficiency from the use of pressurisation and insulation with versatility. Rice cookers and slow cookers also have potential. The attempts to drive eCooking using induction stoves and hotplates are constrained by their high energy requirements and power ratings. Our research has identified that certain modifications and enhancements will be key to achieving large scale acceptance and ensuring their suitability in weak and off-grid contexts.[10]

The benefits of EPCs that we have seen in our studies mirror those that are reported in the US, where these appliances are extremely wide-spread as a result of their versatility and ability to enable householders to very rapidly prepare meals from raw ingredients.

According to two market reports we have reviewed, globally in 2018, 93,883 pressure cookers were sold generating US$4,477m (growing steadily year on year from US$3,656m in 2014). Sales of Multicookers meant that in 2018, the global market reached a value of US$578.3m growing at a CAGR of 10.9% during 2011-2018. Looking forward, they expect the global multi cooker market to reach a value of US$1,049.7m by 2024, exhibiting a CAGR of 10.2% during 2019- 2024[11] [12].

We acknowledge that in some markets and some specific cultural cooking task specific appliances may be an appropriate step in the transition to modern energy like the kettle or bread making machine. For instance, lighting a charcoal stove just to boil water for tea is much more expensive than boiling the water in an electric kettle. As such, kettles could be a first step in a transition.

[10] S. Batchelor, E. Brown, N. Scott, J. Leary Experiences of Electric Pressure Cookers in East Africa?
[11] https://www.marketresearch.com/IMARC-v3797/Multi-Cooker-Global-Trends-Share-12352720/

[12] https://www.marketresearchnest.com/Global-Pressure-Cooker-Market-Research-Report-2019.html

Also, we believe there could well be a range of types of solution to meeting the needs of cooks working in weak grid and off-grid settings and aim to stimulate the development of a variety so that the best option can be available in all cases.

While commonly available Electric Pressure Cookers are highly energy efficient, being generally rated at 1kw, they do potentially place an excessive load on a minigrid if everyone in a village or town were to cook with them at the same time. There are a range of potential solutions to managing energy demand and some could be built into cooking devices or into control/feedback systems at the minigrid level.

We are not tied to electric pressure cookers. We believe that they are an efficient appliance because they combine automatic control of the heating with a highly insulated environment. Slow cookers and rice cookers also do the same. The added value of the EPC is its ability to cook under pressure which for long cook 'heavy' meals can save time and energy.

A forthcoming policy report[13]: Electric Cooking: Needs, Challenges and Ways forward provides further evidence of the relevance of electric cooking to India with recent research and policy recommendation.

Appendix II goes into much more detail on the research evidence that underpins this.

5 Resources the MECS Programme can offer

MECS partnership also includes research partners from across the UK, with extensive experience across a broad range of key research themes that will support our transition away from a business as usual approach. The research focuses on:

- developing genuinely clean, efficient cooking technologies and energy storage options;
- providing full life cycle analysis that captures and defines costs and the characteristics of the supply side, including second life or end of life use, recycling or safe disposal of electrical appliances;
- understanding consumer culture - understanding consumer culture, demand and the social drivers for modern energy cooking services choices;
- building local capability to absorb ongoing innovations and adapt the new knowledge to different contexts and needs;
- generating evidence on other drivers for transition including understanding and optimisation of multi-fuel use;
- establishing the evidence base to support policy environments that can underpin a pathway to scale and support well understood markets and enterprises

Resources developed by the MECS Programme could be adapted to the Indian context or developed in partnership with Indian institutions:

- A comprehensive Theory of Change on which a country strategy can be built
- Economic studies of the impact of policies such as tariffs on adoption
- Modelling the impact of cooking with electricity on load profiles and demand management requirements
- Challenge Fund grants to support Research and Development

[13] ESMAP forthcoming March 2020.

- Partnerships with institutional investors and other financial institutions to support business scale-up, including a framework to enable carbon trading facilitated by eCooking device automated monitoring
- Technology development – prototyping devices, monitoring systems, integration of cooking systems into wider energy access
- Market analyses including our work with ESMAP on the use of a multi-tier framework to build a realistic picture of electricity access
- Research methodologies to enable in-depth understanding of cooking cultures, device preferences of cooks and the energy usage implications.
- Frameworks for understanding the "innovation ecosystem" that can support change

6 The MECS Theory of Change

We believe that a broad, systemic approach is needed to achieve change on the scale that is envisaged. This will require work across a wide range of partners, with multiple strands being taken forward and a broad roadmap in place[14].

This advises that the ground needs to be laid with the following:

- Stakeholder engagement
- Policy overview
- Comparative pricing of alternatives
- Market segments
- Discrete choice modelling
- Cooking Diaries

In terms of an action programme, the following are the key strands:

- Consumer Awareness
    - Aspiration – making eCooking aspirational for all
    - eChef recipes – reflecting the local cooking culture
    - Mixed media promotion – diverse routes to consumers including use of ambassadors
- Value Chain – ensure all links in the chain are in place
    - Investment finance
    - Components, assembly, spares..
    - Consumer finance
    - Marketing
    - Support, help centre, maintenance
- Policy enabling environment
    - Access to modern energy – facilitated by the addition of eCooking load
    - Import tariffs and facilitation for overseas suppliers in the value chain
    - Job creation and skills development
    - Specific/general finance
    - Public good focus – gender, health, child welfare, climate change
    - Waste disposal

[14] S. Batchelor, E. Brown, N. Scott, and J. Leary, "Two Birds, One Stone—Reframing Cooking Energy Policies in Africa and Asia," *Energies*, vol. 12, no. 9, p. 1591, 2019.

7 Stimulating the drive to solutions

As well as these enabling strands that will drive the creation of an effective market, there needs to be support for the research and innovation that is required to identify viable eCooking solutions – whether adapted/enhanced Electric Pressure Cookers or more custom built devices/systems for different contexts and needs.

There are many devices already on the market that might be applicable to eCooking for users on weak or off grid situations. The current Global LEAP Award is inviting companies already making Electric Pressure Cookers to submit their models for testing.

Some of these may still need some additional support to ensure they do not overload a minigrid or, if used at scale present too much load for a grid.

We also believe there is scope for more fundamental innovation and the design and development of new solutions that are optimized for different energy and cooking contexts and needs. A key focus for the MECS in India programme will be to stimulate and support innovation that will solve the need to enable eCooking to take place across the variety of contexts you have in India and also create products that would be effective in foreign markets.

Appendix III discusses some areas where we see particular innovation opportunities.

The aim, therefore, is to support companies at different stages in device design and development, so that we can create a "pipeline" of new products that are developed and tested, and supported to enter the market.

The table below summarises this:

Stage	support
Initial idea, conception, feasibility assessment	Innovation briefings, sandpits, hackathons, networking, matchmaking and support voucher, challenge fund for market study, introductions to UK companies/specialists
Prototype development and testing	Challenge fund and Indian Govt support for R&D, Newton-Bhabha funding, manufacturing coaching
Existing product requiring some modifications/integration	Challenge fund and Indian Govt support for R&D, Newton-Bhabha funding, Piloting. Global LEAP Award.
Viable product trials	Piloting. Global LEAP Award.
Proven solution rollout	Market intel and access, export finance. Scaling up support. Global LEAP award.

8 Towards a Programme with India

Our discussions to date show that there are a great many potential partners in India that can see the value of what could be achieved and are happy to contribute. By acting as an independent convener, we have been able to draw in a very wide range of interested parties. However, this will bring its own challenges and require an overall governance framework that can identify the strands of activity, who will be responsible for each and how the overall programme is coordinated and resourced.

Key Strands/roles will include:

- Identifying key research areas, commissioning, funding and carrying out research to understand the landscape of needs and challenges

- Identifying policy options across a range of areas/Ministries that will create the conducive environment and incentives for the programme
- Working with businesses and academia (in India and overseas) to stimulate the development of solutions that could work – potentially creating a coordinated and supported network of businesses and other organisations that can form an ecosystem
- Device and wider solution assessment to set criteria and establish which have potential and could be piloted – we would expect to find some existing products that could be piloted with minor adjustments
- Mapping, planning, financing, running and evaluating pilots at different scales, including the work of engaging with the relevant communities at the early stage to identify their cooking needs and secure their buy-in
- Promotion of the programme across multiple stakeholder groups – from consumers to businesses to energy providers and other enablers
- Providing finance and support for businesses from R&D to skill development to scaling up to foreign market access
- Management, oversight, leadership, monitoring of the programme including communication amongst all interested stakeholders of new findings or insights into what is needed

The Round Table that is to take place on 26 February will review the above options and proposals and seek to establish individuals and organisations who can lead, finance or otherwise contribute to the agreed strands of work.

Appendix I: Potential impact of the achieving a shift to clean cooking

In terms of the Sustainable Development Goals, the achieving the shift to modern energy cooking that we are seeking has far-reaching consequences. Enhanced access to Modern Energy Cooking Services (MECS), as a key part of SDG 7, can significantly help strengthen progress across a range of other SDGs (Figure 1):

- ***SDG 1 No Poverty***. Clean cooking is part of the basic services necessary to lead a healthy and productive life and saves households time and money.
- ***SDG 2 Zero Hunger***. Efficient cookstoves reduce the amount of fuel needed to cook, thus reducing the burden on families who would otherwise have to collect it, buy it, or trade their food for it.
- ***SDG 3 Good Health and Well-being***. Reducing smoke emissions from cooking decreases the burden of disease associated with household air pollution and improves well-being, especially for women and children.

Figure 1 : Access to MECS as a Key Part of SDG 7 across other SDGs

- ***SDG 4 Quality Education***. Children, particularly girls, are often kept out of school so that they can contribute to household tasks, like cooking and collecting fuel.
- ***SDG 5 Gender Equality***. Unpaid work, including collecting fuel and cooking, remain a major cause of gender inequality.
- ***SDG 8 Decent Work and Economic Growth***. Energy access enables enhanced productivity and inclusive economic growth. The clean cooking sector offers many job opportunities.
- ***SDG 11 Sustainable Cities and Communities***. Clean cooking addresses household and ambient air pollution, resource efficiency, and climate vulnerability.
- ***SDG 13 Climate Action***. Up to 25% of black carbon emissions come from burning solid fuels for household energy needs[15]. Clean cooking solutions address the most basic needs of the poor, while also delivering climate benefits.
- ***SDG 15 Life on Land***. Up to 34% of woodfuel harvested is unsustainable[16], contributing to forest degradation, deforestation, and climate change.

The recently published SDG7 Tracking Report[17] shows that, despite advances on other SDG7 targets, there is little progress on improving access to clean cooking fuels and technologies. In particular, the annual access growth rate during 2014-2016 did not keep pace with population growth, thus resulting in an increase in the absolute global deficit in access to clean cooking.

[15] https://www.who.int/sustainable-development/LR-HAP-27May2016.pdf?ua=1

[16] Bailis, R.; Drigo, R.; Ghilardi, A.; Masera, O. The carbon footprint of traditional woodfuels. *Nat. Clim. Chang.* **2015**, *5*, 266–272.

[17] https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019

Appendix II: Evidence of the potential feasibility of cooking with electricity and Electric Pressure Cookers in particular

The Rationale for a focus on electricity

In 2018 the number of people without electricity access fell to 860 million. However, 80% of the those who gained access are concentrated in Asia[18]. Sub Saharan Africa has major challenges, but nevertheless is making gains.

The increase in grid and off grid capacity has been significant over the last few years and created contexts whereby the idea of electric cooking could be considered. Indeed, its affordability particularly in urban areas suggests an easy gain in the challenge of clean cooking.

Providing universal access to affordable, reliable, sustainable and modern energy for all is not going to be easy. By 2025, Africa's population is projected to exceed that of both India and China[19]. The African Renewable Energy Initiative (AREI) plans to develop at least 10 GW of new renewable energy generation capacity by 2020, and at least 300 GW by 2030[20].

While grid extension-based electrification has long been perceived as the reference model in developing economies, private sector is spearheading the design of innovative electricity supply models based on off-grid technologies. According to a recent World Bank report about half a billion people in Africa and Asia could be cost-effectively supplied with electricity through mini-grids[21]. These solutions hold the potential to successfully address peri-urban and rural contexts that are characterised by limited, sparse demand as well as lower ability to pay among customers. The World Bank is working on 37 mini grids projects in 33 countries, with a total commitment of more than $660 million, with an expected additional $1.1 billion in cofinancing[22]. Mini-grid models are evolving, from providing only basic electricity services for households, to providing electricity services for income generating activities.

In 2010, building on mature solar and mobile money technologies there were a number of start-ups offering **a new generation of solar home systems (SHS) to remote rural markets with sustainable, affordable and safe electricity on market terms.** Most of these started by providing basic lighting and phone charging utilising the system as a service with prepaid mobile payments or on a pay-as-you-go (PAYG) basis. The role of mobile money was to enable companies to reduce the costs associated with bill recovery in remote rural areas, while maximising affordability and responding to the customers need to pay by small regular payments. According to GOGLA, Sub-Saharan Africa is the major market for SHS and East Africa represents 63% of the total sales by volume - 300,000 units[23].

[18] https://www.iea.org/reports/sdg7-data-and-projections
[19] Africa Energy Outlook 2019 - https://www.iea.org/reports/africa-energy-outlook-2019#overview
[20] http://climateinitiativesplatform.org/index.php/Africa_Renewable_Energy_Initiative

[21] Mini Grids for Half a Billion People : Market Outlook and Handbook for Decision Makers - https://openknowledge.worldbank.org/handle/10986/31926

[22] https://www.worldbank.org/en/news/press-release/2019/06/25/mini-grids-have-potential-to-bring-electricity-to-half-a-billion-people
[23] https://www.gogla.org/sites/default/files/resource_docs/global_off-grid_solar_market_report_h2_2018_opt.pdf

In cash sales of PAYG devices generally, India remains the largest cash market with 1.2 million units for $58 million value with Kenya buying 450,000 units[24]. The resilience of current PAYG business models is still undecided. The acquisition of new customers is a significant expense, and **to get the return based on a low load consumption of a simple light makes profitability challenging**. Nonetheless, the sector keeps growing and servicing previously unelectrified people at a fast pace.

There is then the prospect of integration between the three modes of electrification – stand-alone systems, mini-grids and grid. This should also integrate climate change and environmental factors and forecasts. Mini-grids and stand-alone systems are crucial solutions to deliver initial electricity access relatively faster than grid-based solutions. They can unlock latent community demand for sustainable electricity.

Mitigating upfront payments. A transition to and uptake of electric cooking depends not only on the affordability to the household per se, but to the mechanisms by which a household may spread payments. The requirements are to mitigate the upfront cost of devices to the consumer. Utilities, with excess generating capacity and wanting to encourage more demand, could offer the initial cost of an EPC on a lease basis, or a pay as you go through perhaps on bill financing. The same is true for off-grid solutions including mini grids and solar home systems. However, in the case of these latter options, the developer themselves need finance to mitigate the upfront capital expenditure of investment in renewable energy, with enough flexibility in terms of debt, equity or grant financing that they can pass the benefits on to the consumer in terms of mitigating the household upfront expenditure on appliances.

By introducing a 'single investment strategy', incorporating clean cooking into the growth of renewable energy technology for grid and off-grid development, the various financial instruments currently in play to encourage renewable technologies come to the foreground.[25] By inclusion in planning for larger projects, clean cooking could leverage long-term loans associated with a special purpose vehicle (SPV), typically involving guarantees, loans and project bonds. Auctions have brought the costs of development and construction of RE down, the availability of a feed-in-tariff has been a win-win for development of distributed electric generating capacity based on RE, tax incentives have enabled greater revenue generation. A key point is that as renewable energy investments grow over the coming ten years, clean cooking has an opportunity to leverage such larger investments and to use power purchase agreements to bridge the current shortfall in SDG7 clean cooking requirements.

Within this context **load management for cooking needs to be deeply embedded in all planning of electrification**.

What cooking devices show potential on electric pressure cookers?

The typical electric appliance found in retailers in sub Saharan Africa and Asia, is a hotplate. The cheaper hotplates have a heating element exposed to the air, and a pan sits on top of it. The heat transfer between hotplate and pan has considerable losses, and for this reason some people suggest induction stoves. While induction stoves improve the heating up of the pan, the sides of the pan still

[24] Ibid

[25] S. Batchelor, E. Brown, N. Scott, and J. Leary, "Two Birds, One Stone—Reframing Cooking Energy Policies in Africa and Asia," *Energies*, vol. 12, no. 9, p. 1591, 2019.

radiate heat, and for longer term cooking such as simmering beans for an hour or more, the losses are considerable.

Batchelor et al[26] explain that unlike other cooking fuels that rely on combustion, electricity does not need air flow to create heat. It therefore opens up the possibility of the food being cooked in a highly insulated environment. This principle is used in many popular electric cooking appliances, such as rice cookers, slow cookers and thermo pots. Having raised the temperature of the device to the cooking temperature, the insulation reduces heat loss, meaning that little to no extra energy is required to continue to cook the food (see Figure 3). Indeed this is the basis of the 'fireless' cooker, sometimes called Wonderbag or Lindamoto. A pot of beans, for instance, is cooked for some minutes to remove toxins, and then taken off (any) stove and placed in the fireless cooker. With the highly insulated bag keeping the temperature high, the beans continue to cook – thus saving fuel.

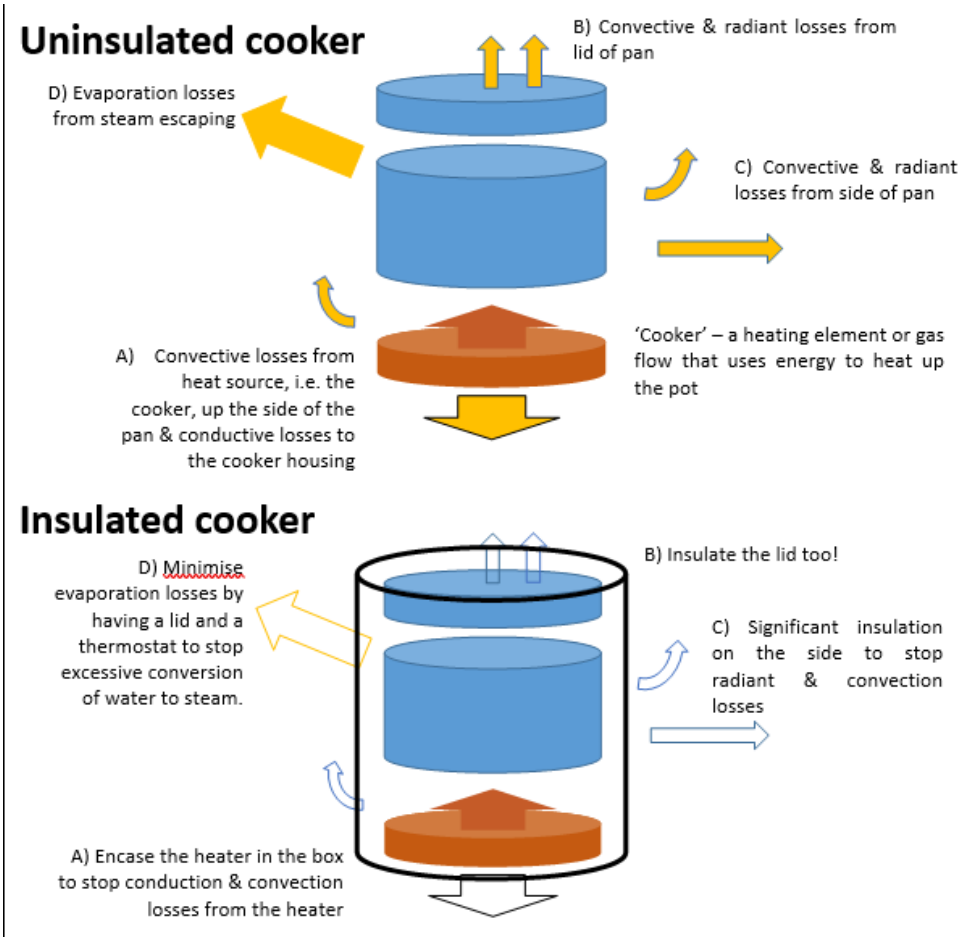

Figure 3: Heat loss mechanisms mitigated by insulating the cooking pot and heating device. Adapted from Batchelor et al.[27].

Whilst rice cookers are also insulated and automated, they are not sealed and their control system is much simpler, merely dumping full power into the pot until all the water has been vaporised. However, they are much more useful than their name suggests, as one participant noted: "I have

[26] S. Batchelor A Talukder, R Uddin, S K Mondal, S Islam, R Redoy, R Hanlin and M. Rezwan Khan; "Solar e-Cooking: A Proposition for Solar Home System Integrated Clean Cooking," *Energies*, vol. 11, no. 11, p. 2933, Oct. 2018.

[27] ibid

learnt that rice cookers are badly named – they can cook so much more than rice!" It should also be noted that because of the insulation, 'full power' on a rice cooker is generally much lower than on a hotplate, which has important implications for systems where peak power is a constraint, such as battery-supported cookers or mini-grids.

In addition to minimising heat losses through insulation, the Electric pressure cooker (EPC) adds the option to pressurise. This raises the boiling point of water and enables the food to be cooked faster. Figure 5 shows that after the initial pressurisation, the hotplate in an EPC only comes on periodically to maintain the temperature in the sealed environment inside and resulting in considerable energy savings. As Prof. R. Khan states: "*it is temperature that cooks food, not energy per se*"[28]. The EPC (or multicooker) simply combines an electric hotplate, a pressure cooker, an insulated box and a fully automated control system (Figure 4)

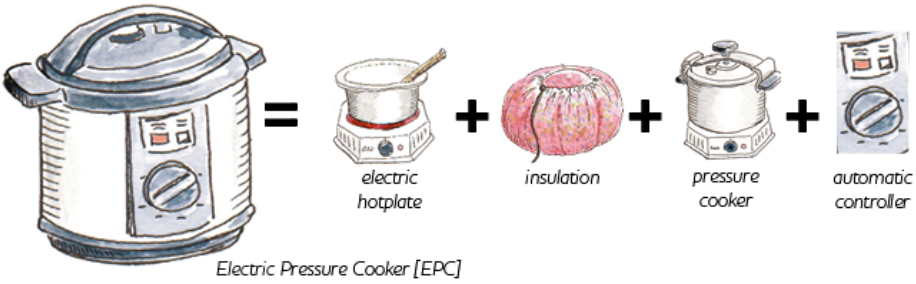

Figure 4: The fundamental components of an EPC.

Figure 5: Typical load profile for a 700W rated EPC on a half hour cooking cycle[29]

As stated above, the EPC goes further by pressurising the system; during this stage the boiling point of water is raised up from 100°C to around 120°C. The increased temperature enables the food to cook faster, resulting in shorter cooking times and therefore reduced energy consumption. 'Manual' stove-top pressure cookers (heated by charcoal and gas) are common in East Africa, although their safety is of concern to many users. EPCs integrate an array of safety and control features, offering multiple redundancies if any one were to fail (see Figure 6). It controls the energy input into the device, such that the cook can walk away and leave the device cooking autonomously.

[28] ibid
[29] T. Couture and D. Jacobs, "Beyond Fire: How to Achieve Electric Cooking," HIVOS & World Future Council, 2019.

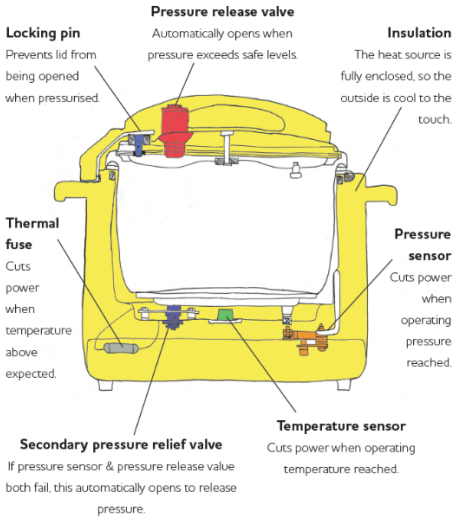

Figure 6: Automatic control and safety features of a typical EPC[30].

While the sealed environment has a positive effect on energy consumption, the sealed, blind, nature of pressure cooking can make inexperienced cooks nervous. They believe that more stirring is required, or they need to see the food to make sure it is cooking, or has not overcooked. Such responses hold back many cooks from utilising the EPC. In fact, much less stirring is needed, as no water escapes from the sealed environment during pressure cooking and the temperature is automatically limited to 120°C, so it is almost impossible to burn the food. In the data below we identify whether these beliefs are an insurmountable barrier to using EPCs in East and Southern Africa or whether the other benefits might outweigh this particular challenge.

A short review of other cooking devices on the market[31]

The global **slow cooker** market was valued at over $1.2 billion in 2014. Jarden, whose slow cooker from Crock-Pot sold more than four million units in 2014. The market for slow cookers has grown as they offer additional benefits compared to a traditional pressure cooker at a lower price than a multicooker. While multicookers are priced between $80 and $350, slow cookers can be purchased in the price range of $50-$220.

A comparison of slow cookers and EPCs shows…

Slow cookers - Slow, even heating traps the moisture of the food product, so usually there's no need to add water. The appliance is temperature controlled, and you're not supposed to take the lid off during cooking, so little supervision is required. It is typical that meals in a slow cooker take approximately four hours on high heat or six to eight hours at a lower temperature.

- Slow Cooker Pros
    - Preferred for "low and slow" recipes like beans and gravies where longer simmering or stewing adds flavor. (Beans don't even necessarily need to be soaked first like they

[30] J. Leary *et al.*, *The Kenya eCookBook: Beans & Cereals Edition*, no. September. Nairobi, Kenya: Available from: www.MECS.org.uk , 2015.
[31] https://www.hormelfoods.com/inspired/story/the-debate-slow-cookers-vs-multicookers/

would if you're using a multicooker.)
    - Deemed the ultimate "set it and forget it" cooking appliance.
    - Preferred for making party food because it can be kept warm for a long period of time.
- Slow Cooker Cons
    - There are fewer functions (though certain late models have a sear function).
    - Though they don't need to be tended to, it might not be the best idea to leave them on all day when no one is home.
    - Meal prep still requires planning. For instance, if you forget to put the ingredients in the pot before you leave the house or before you go to sleep, there's no fast fix to the meal.

Multicooker - This is the next evolution of the pressure cooker, and it does many things, including slow cooking, pressure cooking and rice cooking. The pressure function works with steam heat (achieved by heating water to 30 degrees over the boiling point) and yes, pressure — measured in pounds per square inch (PSI). These cookers also perform other functions like searing, sautéing, making cakes

- Multicooker Pros
    - Extremely versatile, performing all the cooking steps that used to require a stovetop and oven.
    - It can accomplish formerly hands on tasks, like sautéing, with the push of a button.
    - Can make multiple dishes at the same time with "pot-in-pot cooking."
    - The pressure setting cooks food much faster than any conventional cooking method.
- Multicooker Cons
    - There is a learning curve to mastering the multifunction cooker; many believe they need a science lesson before they can cook with it.
    - It has a heating element only at the bottom instead of around the perimeter like slow cookers do.
    - You can't see or taste the food during the cooking process.
    - While it can sear, sauté and steam, it cannot replace the flavor gained from a grill.

The global market for EPCs

We have investigated the latest reports on the EPC market, globally, in order to understand how the markets we are focusing on in Asia and Africa compare, and to draw lessons from the experience of Western markets. EPCs can also be referred to as Multicookers. Two reports have been drawn on:

- Multi Cooker Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2019-2024 - IMARC Group[32]
- Global Pressure Cooker Market Research Report – Market Research Nest[33]

They define the devices, geography, etc. differently, hence their findings are not entirely consistent.

According to the Pressure Cooker report, in 2018, 93,883 pressure cookers were sold generating

[32] https://www.marketresearch.com/IMARC-v3797/Multi-Cooker-Global-Trends-Share-12352720/

[33] https://www.marketresearchnest.com/Global-Pressure-Cooker-Market-Research-Report-2019.html

US$4,477m (growing steadily year on year from US$3,656m in 2014). According to the Multicooker report, in 2018, the global multi cooker market reached a value of US$578.3m growing at a CAGR of 10.9% during 2011-2018. Looking forward, they expect the global multi cooker market to reach a value of US$1,049.7m by 2024, exhibiting a CAGR of 10.2% during 2019- 2024.

The split of market share growth figures in each report are:

Region	Pressure Cooker market share 2018 - %	Pressure cooker latest annual growth - %	Multicooker market share 2018 - %	Multicooker projected growth to 2024 - %
North America	15	7	45	9
Europe	17	5	26	11
Asia-Pacific	61	5	20	12
Middle East and Africa	3	9	5	11
South America	3	6	4	11

Of the pressure cookers sold, 89% were Electric Pressure Cookers (up from 87% in 2014 – so EPCs are increasing in popularity), and 87% were for home use, rather than commercial. The Multicooker report finds 71% of multicookers are for home use.

Independent assessments of Electric Pressure Cookers and evidence of their take-up

Assessments of the future market potential for EPCs/multicookers from these reports and elsewhere[34] include:

Drivers for take-up

- Healthier eating
    - The increasing instances of obesity are making consumers more conscious about their health and dietary habits, encouraging them towards new cooking and healthy living practices. Consumers are now incorporating healthy eating practices and shifting from junk food to home cooked food.
    - Because of the cooking approach, vitamins and minerals are not leached (dissolved) away by water, as they would be if food were boiled in large amounts of water. Due to the shorter cooking time, vitamins are preserved relatively well during pressure cooking.
- Cooking at home
    - Increasing consciousness of the high calorie and fat content in foods served at restaurants is also driving people to enjoy home-cooked meals. Multi-cookers have the potential to bridge two conflicting desires: preparing meals from “scratch” and making meal preparation as fast and painless as possible.
    - Consumers overwhelmingly say that cooking a meal from scratch at home is their preferred approach to food preparation. According to GlobalData’s 2018 Q3 survey, 74% of consumers globally and 66% in the US see this as preferable to eating prepared or

[34] https://www.hormelfoods.com/inspired/story/the-debate-slow-cookers-vs-multicookers/
https://www.cnbc.com/2018/11/26/how-instant-pot-became-a-kitchen-appliance-with-a-cult-following.html
https://www.retail-insight-network.com/comment/multicooker-trend/
https://www.kerry.com/insights/kerrydigest/2019/easier-faster-better-appealing-to-the-instant-pot-consumer

packaged meals at home, ordering meal delivery, or eating at a restaurant or other foodservice operation.
    - Most at-home dinners are still made from scratch, but this trend has declined in recent years because consumers do not have the time to prep ingredients and prepare homemade meals, according to NPD Group.
- Versatile
    - The electric pressure cooker is an upgraded product of the traditional pressure cooker and rice cooker. It combines the advantages of the pressure cooker and the rice cooker to completely solve the safety problem of the pressure cooker and relieve the safety hazards that the ordinary pressure cooker has plagued consumers for many years.
    - Multi cookers are used for several applications like boiling, simmering, baking, frying, deep frying, grilling, roasting and steaming. Besides this, they can also be utilized for warming, reheating or cooking food at different time intervals.
    - Due to the convenience provided by multi cookers, they are gradually replacing kitchen appliances like pans, ovens, stoves, microwaves, deep fryers and bread-makers.
- Efficient use of water, energy and time
    - Pressure cooking requires much less water than conventional boiling, so food can be ready sooner. Using more liquid than necessary wastes energy because it takes longer to heat up; the liquid quantity is stated in the recipe. Pressure cookers can use much less liquid than the amount required for boiling or steaming in an ordinary saucepan. It is not necessary to immerse food in water. The minimum quantity of water or liquid used in the recipe to keep the pressure cooker filled with steam is sufficient.
    - Less energy is required than that of boiling, steaming, or oven cooking.
    - Since less water or liquid has to be heated, the food reaches its cooking temperature faster.
    - As the number of working members in the families rises, people are increasingly opting for time-saving electric appliances for their kitchen.
    - Though people are cooking more frequently, there is a trend of cutting corners. Of the Americans who cook at home, 75% invest in electric appliances that help in saving time and require low maintenance.
- Peer pressure and word of mouth promotion
    - The online sales of Instant Pot are largely fuelled by the word-of-mouth marketing strategy.

Consumers want home-prepared, fresh and healthy food without the hassle of investing time and effort into actually preparing and cooking a meal. Electric multicookers have been sold as the perfect tool to simplify and speed up the cooking process.

According to NPD Group, "multicookers are hitting all of the hot buttons for today's consumers—speed and convenience in healthy at-home meal-prep, multi-functionality, and ease of use.

Data points showing the scale of take up

- On 2018 Amazon Prime Day promotion in July, Instant Pot sold over 300,000 units in just 36 hours.

- The Instant Pot community Facebook page—which has 1.5 million members—focuses on recipe suggestions and promotes the Instant Pot recipe app. Facebook offers roughly 200 different groups dedicated to Instant Pot.
- Amazon carries over 1,000 cookbooks that target electric multicookers - written by amateurs and professionals alike, including numerous on specialized cooking focuses ranging from vegan to ketogenic and paleo diets.
- According to a recent CNBC report quoting sales data from the NPD Group, sales of multi-cookers increased by nearly 80% to over $300 million in the US in 2017. That growth figure has actually accelerated this year, running just under 100% for the year-to-date.

Use of different appliances at cooking East/Southern African foods[35]

Controlled tests in a 'kitchen laboratory' for the eCookBook in Kenya revealed that EPCs can save up to 85% of the cost of cooking 'heavy foods' on charcoal. 'Heavy foods' typically involve boiling for an hour or more on conventional stoves. They include beans, tripe, githeri (beans and maize stew) and stews with tougher cuts of meat.

A fireless cooker utilises the principles of insulation (but not pressurisation) as a means to save fuel on any conventional cooking device during the simmering section of a recipe. For beans, the pot is heated until they are partially cooked (there is a need to cook until the toxins are removed) and then the pot is transferred into the fireless cooker and sealed in an insulated environment. Because the temperature is maintained with minimal heat losses, the food continues to cook with no further input of energy. Figure 2 shows that judicious use of the fireless cooker can save between 10 to 15 KSh (0.10-0.15 USD) on fuel for charcoal, kerosene, LPG or an electric hotplate.

As it is an insulated appliance, a fireless cooker is effectively inbuilt into every EPC, allowing it to prevent heat from escaping from the pot throughout the entire recipe (not just the simmering stage). As a result, Figure 2 shows that whilst cooking on LPG or an electric hotplate works out roughly the same cost as charcoal, the pressurisation and automatic control features of the EPC make it an order of magnitude cheaper. Kerosene is slightly cheaper than charcoal, LPG or an electric hotplate, however still several times more than the EPC.

[35] Leary, J.; Serenje, N.; Mwila, F.; Yamba, F.; Scott, N.; Batchelor, S.; Leach, M.; Brown, E. eCook Zambia Country Report: Opportunities and Challenges in Zambia; Lusaka, Zambia, 2019. Batchelor, S.; Leary, J.; Sago, S.; Minja, A.; Sawe, E.; Shuma, J.; Scott, N.; Leach, M.; Brown, E. eCook Tanzania Country Report—Opportunities and Challenges in Tanzania; Dar es Salaam, Tanzania, 2018 Leary, J.; Myint, A.; Hlaing, W.W.; Sane, S.; Soe, T.T.; Scott, N.; Batchelor, S.; Leach, M.; Brown, E.; Siew, K. eCook Myanmar Country Report: Opportunities and Challenges in Myanmar; Yangon, Myanmar, 2019 All available online: https://www.mecs.org.uk/working-papers/

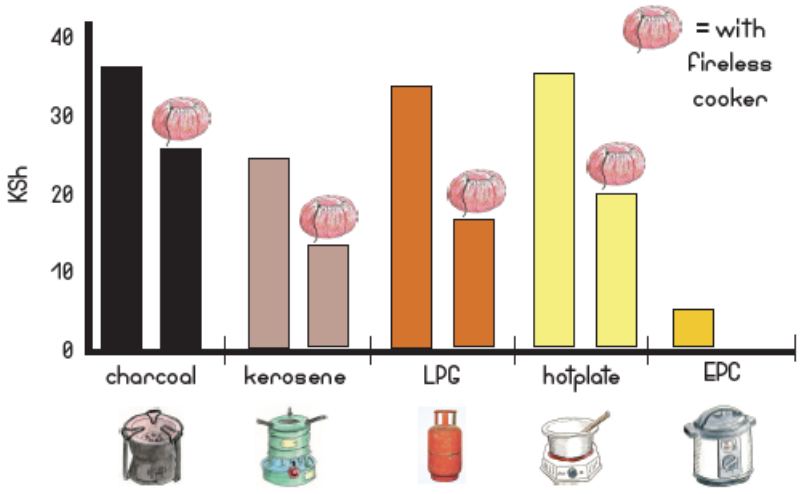

Figure 2: Cost comparison for ½kg dried yellow beans on the most popular fuels in urban Kenya (Nairobi costs, July 2018)[36].

Energy savings on 'heavy foods' are clearly substantial in controlled and semi-controlled conditions; however, it is important to understand how they fit into the kitchen routines of everyday cooks. The evidence from the cooking diaries shows that 'heavy foods' comprise approximately one third of all dishes on a typical urban East African household's menu (see Table 1). In fact, many other dishes can also be cooked on an EPC, however there are several that are extremely challenging on most models of EPC available on the market today (e.g. chapati).

A typical East/Southern African menu can be understood as composing of a set of categories of dishes, each with varying degrees of compatibility with EPCs. We propose the following categories:

- 'Heavy' foods – usually require boiling the main ingredient (e.g. beans) for over an hour on a conventional stove and may also contain a frying stage with extra ingredients to add flavour (e.g. a tomato and onion sauce).
- Staples – normally boiled for approximately half an hour. Some require stirring (e.g. ugali, porridge), but others are simply left to boil (e.g. rice).
- Quick fryers – usually fried for 5-15 minutes, a shallow pan and high heat is often preferred, but not essential. Access to the pan is usually required to stir the food and prevent burning.
- Deep fryers – food is completely submerged in oil at 175-190°C.
- Flat breads – medium heat, evenly distributed across a shallow pan is required to cook the whole of the flat bread at the same rate. Access to the pan is required to turn the bread frequently.

Table 1: Categorisation of typical Kenyan foods by their compatibility with EPCs.

Food category	Frequency on urban Kenyan menu	Typical dishes	Compatibility with EPCs	Energy savings with EPCs	Enablers

[36] J. Leary *et al.*, *The Kenya eCookBook: Beans & Cereals Edition*, no. September. Nairobi, Kenya: Available from: www.MECS.org.uk , 2015.

'Heavy foods'	32%	Beans, matumbo (tripe), meat stews	Users instinctively use EPCs	High (50-90%)	Cooking times & water quantities for popular local foods
Staples	39%	Ugali (maize meal), rice	Users use EPCs if encouraged	Moderate (20-50%)	Demonstrations, extra EPC
Quick fry	20%	Sukuma wiki (kales), eggs	Users use EPCs if encouraged	Low (5-20%)	Demonstrations, manual heat control, extra EPC, shallow pan
Deep fry	2%	Mandazi (donut), fried chicken, chips	Users cannot currently use EPCs	Low (5-20%)	Manual heat control or deep fry settings (175-190°C)
Flat breads	4%	Chapati (flat bread)	Users cannot currently use EPCs	Low (5-20%)	Manual heat control & shallow pan
Other	3%	Unknown			

The data suggests that it is actually possible for urban Kenyan households to cook over 90% of their menu on an EPC.

Table 2: Measured and modelled energy consumption for 100% electric cooking on a mixture of inefficient and efficient appliances.

	Median daily energy consumption (kWh/ household/day)	**Household size (no. ppl)**	**Median per capita daily energy consumption (kWh/person/day)**
Zambia			
100% electricity measured, median	1.63	7.9	0.21
Total if EPC at 90% of menu	*1.1*		*0.14*
Tanzania			
100% electricity measured (with EPC proportion modelled)	2.06	4.2	0.49
Total if EPC at 90% of menu	*1.44*		*0..34*
Kenya			
100% electricity measured (with EPC proportion modelled)	1.4	3.1	0.46
Total if EPC at 90% of menu	*0.96*		*0.30*

User experience of EPCs[37]

Whilst cost, driven by energy efficiency, may be a strong driver, if the cooker is not easy to use and the food is not as tasty as usual, households will be unlikely to adopt it. This section presents insights

[37] ibid

from the exit survey from the Kenya cooking diaries, which asked the households who had been using EPCs (plus rice cookers and hotplates) for a month, about their experience with this new cooking device.

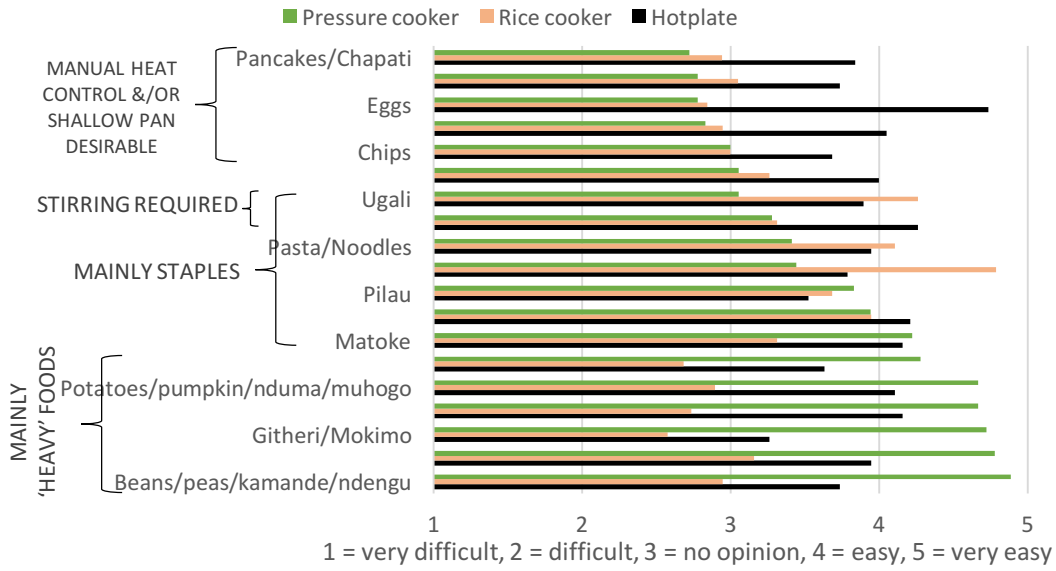

Figure 3: Average responses to the question from 20 trial households in Kenya: "how easy is it to cook each food on the eCookers?" Ranked by ease of cooking on an EPC.

'Heavy foods' such as beans or matumbo (tripe) that usually require boiling for an hour or more to soften are unsurprisingly rated as much easier to cook on the EPC than the hotplate (Figure 3). In contrast, foods that require manual heat control &/or a shallow pan, such as chapati or mandazi, are rated much easier on the hotplate.

Perhaps surprisingly to some, food cooked on electricity was rated as the tastiest, just ahead of LPG & charcoal (Figure 4). Wood & kerosene lag far behind. Figure 5 shows that whist some respondents missed the smokey flavour in specific foods, many did not miss it at all.

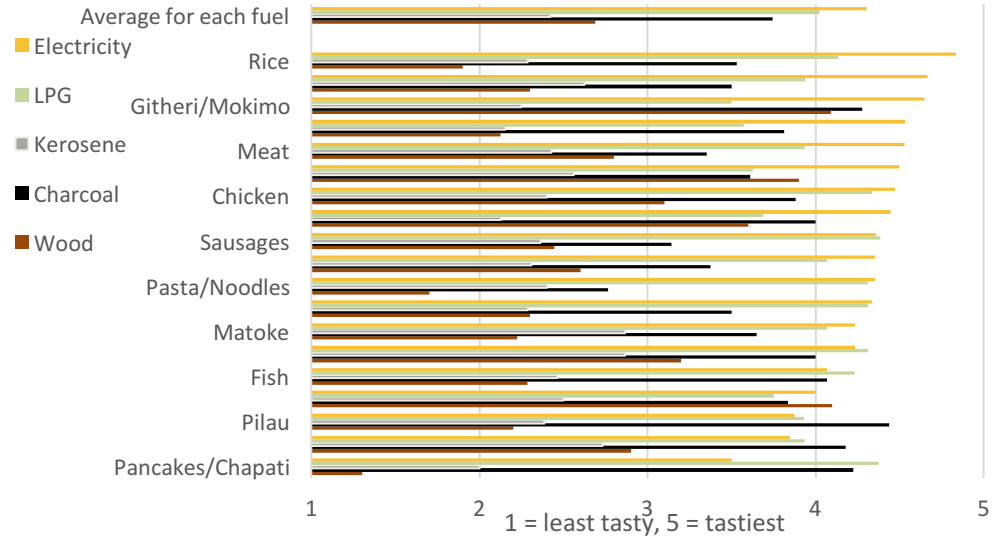

Figure 4: Average responses to the question from 20 trial households in Kenya: "Do foods taste different when cooked on different fuels? If so, please rank each fuel for each food." Foods ranked by tastiness when cooked with electricity.

Figure 5: Responses to the question from 20 trial households in Kenya : "Do you miss the smokey flavour of food? If so, for which dishes in particular?". Words sized according to the number of responses.

The automated control systems of the EPC & rice cooker makes cooking easier, enabling multi-tasking & preventing food from burning (Figure 6). Being able to cook faster & keep the kitchen clean are also both highly valued by the urban participants of the Kenya cooking diaries study, however, priorities may well be different in rural areas. Figure 7 shows that the rice cooker & EPC have clearly found a place in almost every participant's home.

Figure 6: Responses to the question from 20 trial households in Kenya: "What were the best/worst things about cooking with electricity?"

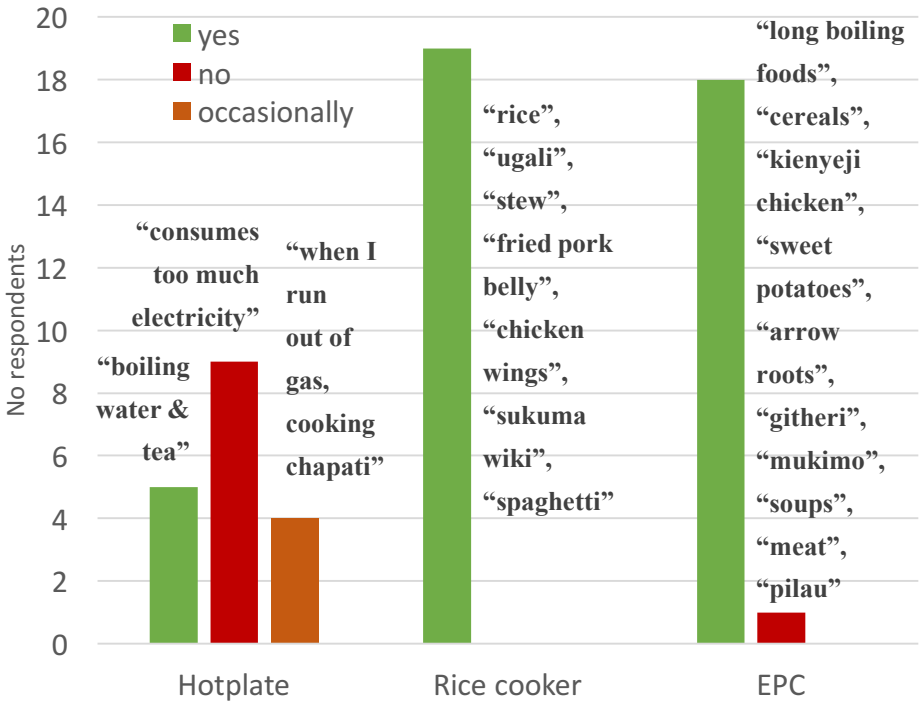

Figure 7: Responses to the question from 20 trial households in Kenya: "We are done with our survey and are leaving the cookers with you. Will you continue using the e-cookers or will you switch back to your old stove?"

The evidence to date shows that EPCs are significantly more energy efficient than electric hotplates in both laboratory and real kitchen environments. The empirical data from the kitchen laboratory shows that EPCs can cook the most energy intensive dishes with just one fifth of the energy of electric hotplates. This is complimented by results which show that everyday cooks choose EPCs for about half of their cooking and that across the full range of dishes they were used for, they use approximately half the energy of electric hotplates. Cooking with both hotplates and EPCs was found to use approximately 2kWh per household per day, with the cook choosing to cook 50% of the menu on an EPC. Analysis of the range of dishes that make up a typical menu and experimentation in the kitchen laboratory has shown that EPCs are capable of cooking over 90% of the typical urban Kenyan menu. Training and experience are likely to move the proportion of EPC use from 50% nearer to 90%. In poorer households which are used to only having one 'device' for cooking, the EPC is likely to be used for a greater proportion of the menu.

Appendix III: Innovation Challenges

Two immediately evident innovation challenges are:

- Make a large capacity device that cooks using, heat and pressurization, with all necessary safety features and well insulated – and heats up and then retain temperature without needing a constant energy consumption, compatible with an electricity source that cannot cope with lots of 1kw devices all working together.
- Make a device that can cook different types of bread – energy efficiently, without too high a power load, and recreates the product close enough to the original to be acceptable. A key challenge in an EPC is to cook chapati or shallow fry an egg. Many EPCs have a sauté mode which keeps the heating element on when the lid is open - the problem then is not so much the heating element as the depth of the pan, that prevents lifting the final product without breaking it up. Are there modifications that could address this[38]?

The following are some other areas where our research suggests there is scope for innovation:

- **Lower power efficient appliances**: - Most EPCs have heating elements that draw 1kW power or more when on and have a 6 to 8 litre pot. There are EPCs on the market that present 3 litre pots and have a power rating at 600 or 700W, however these are considered too small for the majority African market. In weak grids (weak by virtue of their transformers, or wiring) drawing high power can trip fuses or burn out wiring and transformers. We think that there is room on the market for an EPC that present a 6l pot being heated by between 500W to 700W. Applicants suggesting such a device should discuss what tests they will conduct to ensure the resulting device will have a good consumer experience.
- **Other modified efficient appliances**: - Rice cookers can be used for much more than just rice. However, many are set up to switch off when the rice is cooked, and to use them for other recipes requires some adaptation of the device.
- **Enhanced insulation:** – the air gap in most rice cookers and EPCs is quite effective. The weakness of many devices is the seal around the lid and the insulation built into the lid. What could be done to enhance the overall heat retention of cooking appliances while still maintaining an acceptable cooking experience for the user.
- **Robustness:** - the cooking environment in Africa can be quite harsh with higher environment temperatures, dust and rough handling by users. How can appliances be made more robust.
- **User experience of appliance: -** Many EPCs do not have handles on the pot, and this makes holding it to stir hot food difficult. Some of the newer brands have now addressed this, but tend to be the more expensive end of the range. Some recipes require the user to stir the food during the cooking process. EPCs are predicated on not having to stir the food. Are there modifications or adaptations that could be introduced that enabled the user to stir the food during the cooking process (in an EPC or in a pan with a lid). Are there more local solutions as additions to cheaper EPCs.

[38] We note that there are commercial chapati cookers, and frying pans. The data from Kenya suggests that 90% of a typical menu can be cooked in an EPC, and so to purchase a whole appliance for a small percentage of the menu seems cost inefficient. However, if the applicant wishes to argue the case that a secondary appliance is the best way of tackling this issue, the proposition should include details of how this may affect household finances.

- **Direct current appliances: -** The majority of EPCS are based on alternating current (AC). When we consider the off-grid markets in Africa and Asia, there is a need for a direct current device. These appliances might be applicable to Solar Home Systems and DC mini grids. Can a DC based energy efficient appliance be created.

The above list is not exhaustive and not intended to be limiting to the range of potential solutions. The examples are presented to illustrate that we see value in everything from a small additional tool that might help the user use an electric cooking appliance for their traditional cooking, to significant redesign of an appliance to enter a relatively new market (such as off-grid DC use).