Electric cooking in Kenya: an actor-network map and analysis of a nascent socio-technical innovation system

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Executive summary

UK Aid wishes to promote modern energy cooking services in the Global South and is investing around GBP 40 million (USD 50.5 million) through a multi-partner programme of activities – the Modern Energy Cooking Services (MECS) Programme[1] – led by Loughborough University in the UK to help achieve its ambitions. The MECS Programme encompasses several modern energy carriers that can be used for cooking, such as liquified petroleum gas, ethanol, biogas and electricity. Of these carriers, historically, electricity has enjoyed little attention in attempts to promote modern energy cooking services in the Global South. But, because of a convergence of several technological advances, cooking with electricity is becoming economically and technically feasible for a much wider group of people in the Global South than has been the case.

Electric cooking (e-cooking) has the potential to realise a number of benefits, including but not limited to cleaner household air, lower cooking costs, shorter cooking times, less deforestation, reduced greenhouse gas emissions, and some improved gender-equity outcomes. Furthermore, there is the potential to nurture local production of e-cooking appliances and related technologies that could contribute to the industrialisation ambitions of Global South countries. In short, e-cooking has the potential to contribute to progress in achieving several of the UN's Sustainable Development Goals (SDGs). None of these benefits is guaranteed. But the chances of success will be raised by fostering what we call *socio-technical innovation systems* that are centred on relevant e-cooking technologies. Fostering these e-cooking socio-technical innovation systems can in part be achieved by bringing together the innovation systems around electricity access and around clean(er) cooking that, to date, have largely been unconnected. But work will also need to be done to nurture the nexus of these two systems, especially in terms of the social practices specific to e-cooking that may be novel in many contexts.

In this paper, we report findings from our project in which we provide a first attempt to map several characteristics of Kenya's e-cooking socio-technical innovation system. The 'map' consists of visualisations of the actor-networks and actor-relations in the system along with elaborations on who the actors are, the extent and nature of their interactions, sketches of significant projects, and discussion of emerging issues relevant to the further development of the innovation system. It also includes some summary attention to the system's context and enabling environment. Based on this characterisation, we conduct a socio-technical innovation system analysis to determine the system's strengths and weaknesses, and we derive several recommendations we argue the MECS Programme could implement to further its aims more effectively.

Our socio-technical innovation system concept has been developed using insights from several academic literatures that share a common interest in understanding how technology and innovation interact interdependently with society to produce the social and technical systems upon which we rely for meeting human development needs. The concept refers to the complex configuration of several elements including a variety of actors, their capabilities and relationships, core technologies, policy context, and social

[1] See the MECS website for more information https://mecs.org.uk/about/ (accessed 12 July 2020)

practices (especially those involving the core technologies). Within this complex of interacting and interdependent elements, we see the diffusion of technologies and other innovations. And, depending on the nature of the interactions among the elements, we can also see further technological development and new innovations emerge.

A strong and well-functioning socio-technical innovation system can help a country enjoy more of the economic added value of technologies and innovations, as well as use its mastery of a technology to gain more control over its own development direction. Insights from the broad field of innovation studies show that new technologies, innovations, markets, and their associated systems need to be protected while they are developed and nurtured; they are likely to fail if exposed too quickly to 'market forces' and will face resistance or hostility from those interests that stand to lose if they succeed. A significant set of ideas in the innovation studies field has given rise to the strategic niche management approach or 'niche theory'. Developed in tandem with numerous historical studies of how new technologies have become widely adopted and adapted, niche theory points to the imperative of protection (as we noted above) and the development and growth of diverse networks of actors around a specific technology, among other evolutionary dynamics. Translated into policy-relevant terms, niche theory tells us that active public interventions are crucial for the eventual success of innovations, especially where they must disrupt a dominant technology. A specific example closely relevant to the promotion of modern energy cooking services is the development of the solar PV markets in East Africa. These markets have become successful through deliberate and active long-term public interventions. The combination of these insights forms our socio-technical innovation system concept.

Applying this concept to e-cooking in Kenya, we find there are positive signs the socio-technical innovation system is developing well, with a large number of actors showing interest in the practice. However, only a small core of these players is active in the e-cooking space at present, with the MECS Programme central to this core. Furthermore, the networks are somewhat fragmented. We find that there are only limited capabilities in Kenya to manufacture high quality e-cooking appliances, such as electric pressure cookers (EPCs), and it is unclear whether capabilities exist in other aspects of the system: e.g. in repair, waste management and recycling. The policy context is quite weak in its support for e-cooking, where favourable policy can only be inferred because there are some aspirations to promote clean cooking (although this often means cleaner biomass cookstoves). E-cooking appliances are receiving the bulk of attention from those active in the space; few are concerned with nurturing the broader socio-technical innovation system.

At this stage in our research, we can offer a range of recommendations for further nurturing the nascent socio-technical innovation system around e-cooking in Kenya. However, readers should take note that we will be conducting further research to understand how the current innovation system has evolved and, based on this, we should in time be able to say more about how to develop a strong Kenyan e-cooking socio-technical innovation system. For now, it may be the case that we are unaware of some of the MECS Programme's intended activities and so it is possible that it is already implementing, or planning to implement, some or all of our recommendations. We offer our recommendations even if this is the case. The recommendations offered in this summary are brief versions of the more detailed recommendations presented in Section 6 of the paper.

1. **Broaden and grow the actor-network in the e-cooking socio-technical innovation system**

   It is clear that only a small core of actors is currently promoting e-cooking in Kenya. A larger number of actors is interested in the practice but each one has yet to commit resources to e-cooking's development and promotion. MECS needs to continue to advocate for e-cooking among these interested actors and to recruit them to the core of active players. A pertinent example is existing development partners and NGOs who have a long history in the improved cookstove (ICS) sector and have developed networks, capabilities and infrastructure at the local level. So far, it is not clear whether MECS deliberately intends to build on the work done in the ICS sector or to create an independent e-cooking socio-technical innovation system. This question warrants further exploration. Doing so could build on existing knowledge and will help to bring a diversity of experiences and perspectives to the work of the MECS Programme, draw in resources of various kinds and build a broad constituency of support for e-cooking. Furthermore, while building the actor-network, it will be important to work across the spectrum of Kenyan society: i.e. to draw in actors at community and local levels as much as policy actors, development partners and the private sector.

2. **Strengthen and deepen the relations between and among the innovation system's actors**

   Merely connecting a diversity of actors together will be insufficient to nurture the socio-technical innovation system. The relationships between these various actors must be strengthened and deepened. Insights can be drawn from the niche theory work that emphasises the importance of setting and aligning shared visions, fostering experimentation-based learning on the possibilities and constraints of novel technologies, and developing an actor-networks that involve users. This will help to engender mutual understanding and trust, spawn new working relationships, and generate crucial learning that is more likely to flow easily around the network.

3. **Broaden the range of interventions and understandings beyond technologies and finance**

   It is unlikely that developing technologies, business models and gathering market intelligence will suffice to successfully promote e-cooking in Kenya, and certainly not to build a well-functioning socio-technical innovation system. Developing technologies and business models, and gathering market intelligence, are important elements and so support for them needs to continue. However, along with strengthening and deepening the actor-network and actor-relations around e-cooking, as we recommend above, a broader range of project interventions must be supported. In effect, projects need to work on the full set of elements that constitute the innovation system, along with how these elements interdepend.

4. **Establish a dedicated coordinating actor to help build the innovation system**

   There is a need to establish a well-resourced coordinating actor dedicated to several 'innovation system building' activities. These activities include creating a forum in which the full diversity of actors in the e-cooking innovation system can meet to discuss issues of relevance to the system's development, which would be a platform from which actors can access up-to date information on existing stakeholders, ongoing projects and collaborations. According to our respondents, the e-cooking innovation systems is currently quite opaque, and there is information asymmetry even within the small e-cooking actor-network largely composed of MECS-funded initiatives. Our respondents pointed to the lack of information on ‘who is doing what’ and where, how to source EPCs, and the outcomes of laboratory efficiency, safety and quality tests of e-cooking appliances. ACTS has begun to perform this role and so we will see in time how it develops. But a coordinating actor could also perform activities aligned with implementing the recommendations we suggest above on innovation system building: i.e. building and strengthening the network and actor-relations in a dynamic way, and broadening the range of interventions and understandings. As can be seen from experiences in solar PV in Kenya, such builders can be highly effective in nurturing a system to become a well-functioning socio-technical innovation system.

Contents

Abbreviations and acronyms

ABPP	Africa Biogas Partnership Programme
AC	Alternating Current
ACTS	African Centre for Technology Studies
ASH	Africa Sustainability Hub
CAP	Country Action Plan
CCA	Clean Cooking Alliance
CCAK	Clean Cooking Association of Kenya
CLASP	Collaborative Labelling and Appliance Standards Program
CO2	Carbon dioxide
DC	Direct Current
DFID	UK Department for International Development
EPC	Electric Pressure Cooker
EPRA	Energy and Petroleum Regulatory Authority
ERC	Energy Regulatory Commission
GACC	Global Alliance for Clean Cookstoves
GCF	Green Climate Fund
GIZ	Gesellschaft für Internationale Zusammenarbeit
GOGLA	Global Off-Grid Lighting Association
ICS	Improved Cookstove
ISH	Innovation System History
ISM	Innovation System Map
KAM	Kenya Association of Manufacturers
KEBS	Kenya Bureau of Standards
KIRDI	Kenya Industrial Research and Development Institute
KOSAP	Kenya Off-Grid Solar Access Project
KPLC	Kenya Power and Lighting Company
LEAP	Global Lighting and Energy Access Partnership

LEIA	Low-Energy Inclusive Appliance Programme
LPG	Liquified Petroleum Gas
MECS	Modern Energy Cooking Serives Programme
MEP	Ministry of Energy and Petroleum
NCCAP	National Climate Change Action Plan
NGO	Non-Governmental Organisation
OECD	Organization for Economic Co-operation and Development
Pinnsmap	Participatory innovations system map
PAYGO	Pay-as-you-go
PIPA	Participatory Impact Pathways Analysis
PV	Photovoltaic
RBF	Results-Based Finance
REA	Rural Electrification Authority
RVO	Netherlands Enterprise Agency
SACCO	Savings and Credit Co-operative
SCODE	Sustainable Community Development Services
SDG	Sustainable Development Goal
SE4All	Sustainable Energy for All
SERC	Strathmore Energy Research Centre
SHS	Solar Home System
SNV	Netherlands Development Corporation
TVET	Technical and Vocational Education and Training
UNFCCC	UN Framework Convention on Climate Change
VAT	Value-Added Tax
WEEK	Women in Energy Enterprises in Kenya

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1 Introduction

UK Aid wishes to promote modern energy cooking services in the Global South and is investing around GBP 40 million (USD 50.5 million) through a multi-partner programme of activities – the Modern Energy Cooking Services (MECS) Programme[2] – led by Loughborough University in the UK to help achieve its ambitions. The MECS Programme, as a whole, encompasses several modern energy carriers that can be used for cooking, such as liquified petroleum gas (LPG), ethanol, biogas and electricity. Of these carriers, historically, electricity has enjoyed little attention in attempts to promote modern energy cooking services in the Global South and so the MECS Programme is something of a pioneer in this respect. Because of a convergence of several technological advances in, amongst others, energy storage, ICT-enabled payment systems, and cost and efficiency improvements in generating technologies such as solar photovoltaics (solar PV), cooking with electricity is becoming economically and technically feasible for a much wider group of people in the Global South than has been the case (Batchelor et al., 2018).

Electric cooking (e-cooking) has the potential to realise a number of benefits, including but not limited to cleaner household air, lower cooking costs, shorter cooking times, less deforestation, reduced greenhouse gas emissions (if the electricity is generated from renewable energies) and some improved gender-equity outcomes. Furthermore, there is the potential to nurture local production of e-cooking appliances and related technologies that could contribute to the industrialisation ambitions of Global South countries. In short, e-cooking has the potential to contribute to progress in achieving several of the UN's Sustainable Development Goals (SDGs). None of these benefits is guaranteed. But the chances of success will be raised, we would argue, by fostering what we call socio-technical innovation systems (defined below) that are centred on relevant e-cooking technologies. Fostering these e-cooking socio-technical innovation systems can in part be achieved by bringing together the socio-technical innovation systems that currently exist around electricity access (e.g. in solar PV in Kenya) and around clean(er) cooking that, to date, have largely been unconnected. But work will also need to be done to nurture the nexus of these two systems, especially in terms of the social practices specific to e-cooking that may be, to varying degrees, novel in many contexts at present.

In this paper, we report findings from the first stage of our project, funded by the MECS Programme, in which we characterise the socio-technical innovation system around e-cooking in Kenya. A sibling paper reports our findings for the e-cooking socio-technical innovation system in Tanzania. We mention both papers at this point because they share some common text. Consequently, those who have read the sibling paper may prefer to skip Section 2 in its entirety, as the presentation of the analytical foundations and methodology, apart from some details, is practically identical to the text in the other paper. Otherwise, the text here is mostly specific to e-cooking in Kenya. In the rest of this introduction, we explain the nature and purpose of our e-cooking socio-technical innovation system characterisation (or 'map'), define briefly what we mean by the term *socio-technical innovation system*, argue why it is important to develop a socio-

[2] See the MECS website for more information https://mecs.org.uk/about/ (accessed 12 July 2020)

technical innovation system understanding of e-cooking in Kenya, and preview our main findings. We finish the introduction with an outline description of the paper.

This paper provides a first attempt to map several characteristics of Kenya's e-cooking socio-technical innovation system. The 'map' consists of visualisations of the actor-networks and actor-relations in the system along with elaborations on who the actors are, the extent and nature of their interactions, sketches of significant projects, and discussion of emerging issues relevant to the further development of the innovation system. It also includes some summary attention to the context and enabling environment of the e-cooking socio-technical innovation system. Based on this characterisation, we conduct a socio-technical innovation system analysis to determine the system's strengths and weaknesses and, building on this analysis, derive several recommendations we argue the MECS Programme could implement to further its aims more effectively. Readers should take note, however, that the characterisation is only a snapshot of the current system and so the recommendations should be seen as open to further refinement as we continue our research. More specifically, the next stage of our research involves constructing a historical account of how the current system has evolved, something we will also be doing in respect of the Tanzanian e-cooking socio-technical innovation system. Once we have these historical accounts, we will be able to conduct a comparative analysis that will likely yield new insights with which to develop more robust recommendations for the MECS Programme and others wishing to promote clean cooking services in the Global South.

Before arguing why it is important to understand a socio-technical innovation system, we should define what we mean by this term. More detailed discussion of the concept is given in Section 2.1, but we can provide a brief definition here. It has been developed using insights from several academic literatures that share a common interest in understanding how technology and innovation interact interdependently with society to produce the social and technical systems upon which we rely for meeting human development needs. The concept refers to the complex configuration of several elements including a variety of actors, their capabilities and relationships, core technologies, policy context, and social practices (especially those involving the core technologies). Within this complex of interacting and interdependent elements, we see the diffusion of technologies and other innovations. And, depending on the nature of the interactions among the elements, we can also see further technological development and new innovations emerge. Beyond this, it is possible and often desirable to attend to the broader context of competing or dominant technologies and practices, environmental pressures and the politics of change (from the micro-politics of changing practices to the 'higher' politics around national and international interests). The next phase of our research will include attention to these broader dynamics, as understanding them is best done through historical analysis. The current paper focusses only on a snapshot characterisation of the e-cooking socio-technical innovation system in Kenya and so is concerned with the actors, their capabilities and relations, the core technologies, policies and social practices.

It is important to understand the complex configuration we are calling a socio-technical innovation system because such a system is essential for helping a country direct and achieve its self-defined development goals. These goals include economic growth and development as well as more socially oriented goals such as equality and justice along with environmental integrity. In short, a well-functioning socio-technical innovation system can contribute positively to achieving a wide range of SDGs. A narrower analytical focus, such as on economics and engineering – which is often the case in the literature on energy access (e.g. see Watson et al., 2012), can only take us so far. Analysing the economics of a specific technology, for example, is of limited value in showing us how to foster the conditions for the widespread adoption of that technology, and is unable to provide recommendations for how to develop the capabilities needed to further develop the technology or, indeed, how to innovate completely new solutions. An economics focus is also unable to consider the complex interactions across the many dimensions of social and technical systems that enable those systems to endure, despite the availability of what might be 'superior' technologies or innovations (e.g. sustainable energy technologies, gender-equal practices, healthy work environments).

We need more complex analyses from which we are then able to nurture the socio-technical innovation systems required for successful adoption and diffusion of new or unfamiliar technologies and innovations, which are often in need themselves of adapting to new environments, and for building the actor-networks and capabilities needed to move beyond simply using existing technologies. A strong and well-functioning innovation system can help a country to enjoy more of the economic added value of technologies and innovations, as well as use its mastery of a technology to gain more control over its own development direction. Left to free markets, technology design and production, for example, will take place wherever there are already well-functioning appropriate socio-technical innovation systems, which are generally in the most industrially advanced countries, even if the technology is adopted widely in poorer countries. Contrary to free market orthodoxy, new technologies, innovations, markets, and their associated systems need to be protected while they are developed and nurtured; they are likely to fail if exposed too quickly to 'market forces' and will face resistance or hostility from those interests that stand to lose if they succeed.

These general insights have arisen over many decades from the broad field of innovation studies, a field initially developed to understand why more traditional economics approaches could not explain a nation's economic growth. Early work in the innovation studies field generated the basic notion of a national system of innovation (e.g. see Freeman, 1987, 1997; Lundvall, 1988). But other work over the past two decades has widened the scope of analysis to include sociological insights (e.g. Geels, 2002) and ideas centred on knowledge politics (e.g. Leach et al., 2010), among many other influences. A significant set of ideas, inspired by evolutionary theory and the kinds of sources just mentioned, has given rise to strategic niche management or 'niche theory'. Developed in tandem with numerous historical studies of how new technologies have become widely adopted and adapted, niche theory points to the imperative of protection (as we noted above) and the development and growth of diverse networks of actors around a specific technology, among other evolutionary dynamics. Translated into policy-relevant terms, niche theory tells us that active public interventions are crucial for the eventual success of new technologies, especially where they must disrupt a dominant technology. A specific example closely relevant to the promotion of modern energy cooking services is the development and growth of the solar PV markets in East Africa (Byrne, 2011; Ockwell et al., 2019; Ockwell & Byrne, 2017). These markets have become successful not through free market orthodoxy but through deliberate and active long-term public interventions, an approach that continues. The combination of these insights forms our socio-technical innovation system concept, the specifics of which are further explained in Section 2.1.

Applying this concept to e-cooking in Kenya, we find there are positive signs the socio-technical innovation system is developing well, with a large number of actors showing interest in the practice. However, only a small core of these players is active in the e-cooking space at present, with the MECS Programme central to this core. Furthermore, the networks are somewhat fragmented. We find that there are only limited capabilities in Kenya to manufacture high quality e-cooking appliances, such as electric pressure cookers (EPCs), and it is unclear whether capabilities exist in other aspects of the system: e.g. in repair, waste management and recycling. The policy context is quite weak in its support for e-cooking, where favourable policy can only be inferred because there are some aspirations to promote clean cooking (although this often means cleaner biomass cookstoves). E-cooking appliances are receiving the bulk of attention from those active in the space; few are concerned with nurturing the broader socio-technical innovation system. Among a number of recommendations, we argue there is a need for a well-resourced coordinating actor to help foster the building of the wider socio-technical innovation system, a role we doubt could be played by MECS in the long-term, even though it is the de facto coordinating actor at present. As such, we recommend that the MECS Programme identify such an actor or begin developing one so that the complex and intensive work of implementing the expanded and systematic range of projects needed can continue for many years.

The paper continues with Section 2, which briefly explains the socio-technical innovation system concept and analytical framework we use as well as describing the study's methodology. Section 3 provides a summary of the context. In Section 4, we report the findings from our primary research, characterising the various elements of the e-cooking socio-technical innovation system in Kenya as it currently stands. We analyse the system in Section 5 and finish the paper by giving our recommendations for the MECS Programme in Section 6.

2 Analytical foundations and methodology

2.1 Socio-technical innovation system analysis

The objective of the discussion in this section is less about exploring and critiquing the conceptual basis for the analytical framework we use in this paper and more about describing the elements of the framework. This is because the paper is primarily concerned with assessing the state of play in the current e-cooking socio-technical innovation system in Kenya with a view to offering thoughts on how it can be nurtured, strengthened and evolved so as to better achieve transformations in clean cooking that work in the interests of poor and marginalised groups in the country. As such, the paper is intended to be most useful to practitioners working on e-cooking in general and the broader MECS Programme in particular. Our analytical framework is therefore constructed instrumentally from the theoretical work done elsewhere, although we provide here a brief review of the conceptual underpinnings of the theory as this may be useful to readers in their understandings of what we present in this paper. The conceptual underpinnings for the socio-technical innovation system approach originate from various streams of theory including, most notably, the STEPS pathways approach (e.g. Leach et al., 2010), transitions theory (e.g. Geels, 2002, 2004), strategic niche management (Byrne, 2011; Raven, 2005) and innovation systems (e.g. Chaminade et al., 2009; Freeman, 1997; Lundvall, 1992). A fuller exposition of the socio-technical innovation systems approach can be found in Ockwell and Byrne (2016, 2017).

We define a socio-technical innovation system in terms that go beyond the more traditional understanding of “innovation system”, an understanding that refers to the “network of actors, and the strength and nature of the relationships between them, from which both innovation and technological change emerge” (Ockwell & Byrne, 2017, p. 25). Our extended concept draws from the socio-technical literatures mentioned above (pathways, transitions and niche theory) to incorporate the socio-technical nature of innovation and technological change. That is, our concept includes attention to the co-productive interactions between innovations and the social practices of actors (policymakers, firms, non-governmental organisations, ordinary citizens, and so on), as well as the politics of socio-technical change.

The traditional concept of an innovation system, defined in the preceding paragraph, remains important in our enhanced socio-technical innovation system concept, although our enhanced concept expands the range of actors involved. In the traditional version, the actors of interest are firms and policymakers. Firms each have specific capabilities (skills and knowledge) they use to innovate, which can include creating and developing technologies and production processes, evolving the management of stakeholder relations, and implementing new marketing strategies (OECD/Eurostat, 2019). Policymakers set the policy environment in which firms operate, conditioning what kinds of innovation are possible, what is illegal, and so on, and setting and enforcing the regulatory regime for, amongst other issues, private property protection. Relationships between these various actors are also important because, for example, individual firms are unlikely to be able to perform all the activities necessary to produce a specific technological product or service. They will buy components from other firms, assemble these components, manufacture others, and sell to customers who may be other firms or so-called final users. In some cases, firms will collaborate with other firms to produce technologies or services. The network of actors is therefore a key characteristic of any specific innovation system, including how actors are connected to each other and the nature of their interactions.

Although this traditional innovation system concept is useful for certain kinds of analysis, it is entirely technical in its focus and so is blind to the social, cultural, political and ecological dynamics that co-evolve with technical change (Ockwell & Byrne, 2017). Understanding how these other co-evolutionary dynamics work interdependently with technical change to produce the systems that service human needs is important because they influence the direction any system takes as it develops. For example, in response to climate change, we need systems to develop in directions that rely on renewable energy sources. But steering systems away from fossil fuel-based reliance is difficult because of the interdependent relationships between, amongst others, powerful political and economic interests, social practices such as car-based mobility linked with cultural values such as freedom and independence, and established infrastructures of energy generation, storage and distribution. Socio-technical perspectives incorporate these different dimensions into analysis, seeking to generate insights useful for guiding our social systems (socio-technical systems) in more sustainable directions. We adopt these socio-technical ambitions in our enhanced concept: hence the use of the term *socio-technical innovation systems*.

Table 1: Socio-technical innovation system analytical categories

Category	Description
Central technologies	The main technologies towards which actors in the system will focus their innovation efforts
Actors	Who is involved in the innovation efforts in the system: potentially, the full range of actors, not just firms and policymakers but also NGOs, communities, households, private individuals
Actor-network	The ways in which the actors interrelate: what connections they have with each other, the nature of those connections
Policy environment	The range of policies (and regulations, laws, etc.) that can influence the system, including beyond the national level
System directionality	The trajectory of system change: e.g. growing or shrinking use of electric pressure cookers; mainstreaming or marginalising electric cooking
Social practices	The social practices of relevance, especially how these are understood by 'supply-side' actors
Broader dynamics	Various forces that can influence what is possible, desirable, and so on in system development: e.g. climate change translates to pressure to reduce emissions
Narratives	The narratives at work in the system, used to mobilise, motivate, persuade, argue, contest, etc., on issues relevant to system change

In sum, we use several categories to analyse what is happening in any socio-technical innovation system. We need to know which technologies are centrally involved in the system, which actors are involved, how these actors relate to each other (actor-networks), details of the policy environment, what 'supply-side' actors understand about 'demand-side' social practices, what direction the system is taking, and what broader dynamics are at work. We also need to understand something about what actors envisage the system will be and why, which links strongly with the direction the system is taking or could take. This brings us to the role of discourse and, more specifically, narratives in shaping a system's directionality. Narratives are important in several respects. They can justify and motivate specific kinds of action, they can mobilise others to join in with these specific actions, they can persuade others to act in particular ways – e.g. policymakers to provide resources for action, customers to buy particular products or services rather than others – and can shape identities around which groups of actors can coalesce (e.g. Byrne et al., 2018; Hudson & Leftwich, 2014; Leach et al., 2010). In short, narratives do essential political work. For analysis, we can also use narratives to infer what actors understand about the system in which they are working or the system they are trying to create. The objective of the discussion in this section is less about exploring and critiquing the conceptual basis for the analytical framework we use in this paper and more about describing the elements of the framework. This is because the paper is primarily concerned with assessing the state of play in the current e-cooking socio-technical innovation system in Kenya with a view to offering thoughts on how it can be nurtured, strengthened and evolved so as to better achieve transformations in clean cooking that work in the interests of poor and marginalised groups in the country. As such, the paper is intended to be most useful to practitioners working on e-cooking in general and the broader MECS Programme in particular. Our analytical framework is therefore constructed instrumentally from the theoretical work done elsewhere, although we provide here a brief review of the conceptual underpinnings of the theory as this may be useful to readers in their understandings of what we present in this paper. The conceptual underpinnings for the socio-technical innovation system approach originate from various streams of theory including, most notably, the STEPS pathways approach (e.g. Leach et al., 2010), transitions theory (e.g. Geels, 2002, 2004), strategic niche management (Byrne, 2011; Raven, 2005) and innovation systems (e.g. Chaminade et al., 2009; Freeman, 1997; Lundvall, 1992). A fuller exposition of the socio-technical innovation systems approach can be found in Ockwell and Byrne (2016, 2017).

We define a socio-technical innovation system in terms that go beyond the more traditional understanding of "innovation system", an understanding that refers to the "network of actors, and the strength and nature of the relationships between them, from which both innovation and technological change emerge" (Ockwell & Byrne, 2017, p. 25). Our extended concept draws from the socio-technical literatures mentioned above (pathways, transitions and niche theory) to incorporate the socio-technical nature of innovation and technological change. That is, our concept includes attention to the co-productive interactions between innovations and the social practices of actors (policymakers, firms, non-governmental organisations, ordinary citizens, and so on), as well as the politics of socio-technical change.

The traditional concept of an innovation system, defined in the preceding paragraph, remains important in our enhanced socio-technical innovation system concept, although our enhanced concept expands the range of actors involved. In the traditional version, the actors of interest are firms and policymakers. Firms each have specific capabilities (skills and knowledge) they use to innovate, which can include creating and developing technologies and production processes, evolving the management of stakeholder relations, and implementing new marketing strategies (OECD/Eurostat, 2019). Policymakers set the policy environment in which firms operate, conditioning what kinds of innovation are possible, what is illegal, and so on, and setting and enforcing the regulatory regime for, amongst other issues, private property protection. Relationships between these various actors are also important because, for example, individual firms are unlikely to be able to perform all the activities necessary to produce a specific technological product or service. They will buy components from other firms, assemble these components, manufacture others, and sell to customers who may be other firms or so-called final users. In some cases, firms will collaborate with other firms to produce technologies or services. The network of actors is therefore a key characteristic of any specific innovation system, including how actors are connected to each other and the nature of their interactions.

Although this traditional innovation system concept is useful for certain kinds of analysis, it is entirely technical in its focus and so is blind to the social, cultural, political and ecological dynamics that co-evolve with technical change (Ockwell & Byrne, 2017). Understanding how these other co-evolutionary dynamics work interdependently with technical change to produce the systems that service human needs is important because they influence the direction any system takes as it develops. For example, in response to climate change, we need systems to develop in directions that rely on renewable energy sources. But steering systems away from fossil fuel-based reliance is difficult because of the interdependent relationships between, amongst others, powerful political and economic interests, social practices such as car-based mobility linked with cultural values such as freedom and independence, and established infrastructures of energy generation, storage and distribution. Socio-technical perspectives incorporate these different dimensions into analysis, seeking to generate insights useful for guiding our social systems (socio-technical systems) in more sustainable directions. We adopt these socio-technical ambitions in our enhanced concept: hence the use of the term *socio-technical innovation systems*.

Table 1 summarises these analytical categories. Characterising the specifics of each of these categories to the extent possible provides the basis for an integrated analysis of a socio-technical innovation system, its strengths and weaknesses, and ways in which it could be improved. In turn, this provides the basis for recommendations, whether for policy or practice.

2.2 Methodology

Initial information gathering took place during an Innovation System History workshop held in Nairobi on 21 November 2019. We conducted two kinds of participatory exercises during this one-day workshop from which we produced two outputs: an Innovation System Map (ISM) of e-cooking in Kenya, and a skeleton Innovation System History (ISH). The ISH was focussed on recording various events, processes and projects that have contributed to the development of the current e-cooking socio-technical innovation system and this will be used as the basis for the second phase of our research. As such, the ISH produced in the workshop is not relevant to the focus of this current paper and so will not be discussed further here. It is the ISM or, more precisely, the Participatory Innovation System Map (Pinnsmap) that is relevant to the current paper and this formed the basis for follow-up interviews and desk-based secondary research upon which the reporting and analysis in this paper is built. Our Pinnsmapping method is an adaptation of the STEPS Centre tool *Participatory Impact Pathways Analysis* (PIPA) (Ely & Oxley, 2014), itself an adaptation of a process developed by Boru Douthwaite and colleagues (e.g. see Douthwaite et al., 2009).

Planning for the ISH workshop included identifying and selecting participants from a range of stakeholder groups who would have some interest in, and knowledge about, e-cooking in Kenya. The process of identifying participants involved reference to the database of contacts held by ACTS[3] (the workshop organisers) and consultation with Jon Leary (a researcher in the broader MECS Programme, who has spent extended periods of time working in e-cooking in Kenya) as well as some snowballing through those identified from these two sources. Selection was based on maximising the depth and range of knowledge and perspectives available to us in the workshop. Including members of the project team and organisers, as well as participants from Rwanda[4] and Tanzania, 20 people took part in the workshop.

In outline terms, the Pinnsmapping exercise aimed to enable the participants to co-produce a 'map' of the actors involved or interested in e-cooking in Kenya, to represent how these actors are connected to each other, and to characterise their relationships (e.g. funding, collaboration, and so on). The exercise was conducted over about two hours, with the Pinnsmap produced in a structured process involving all the workshop participants.

Step one in the process involved the participants identifying the appliances they thought relevant to electric cooking (i.e. not just electric pressure cookers but also, for example, electric kettles, rice cookers, and many others – see Table 2 in Section 4.1 for the list of appliances identified by the participants). For step two, the participants were asked to write on cards the names of actors in Kenya they thought were working in some way relevant to e-cooking (bearing in mind the list of appliances), with one actor named per card and with the cards colour-coded according to broad stakeholder groups (e.g. government, academic institutions, private sector, and so on). Step three involved arranging the actors (cards) so that those working closely together were clustered on the map (to the extent possible), achieved through a process of group discussion during which more actor names were added and the nature of various actor-relations began to emerge. Step four involved drawing lines on the map to show the connections between actors and marking these lines with small Post-it notes to indicate the nature of the connections or relationships. Figure 1 summarises the four steps in the Pinnsmapping exercise and Figure 2 provides a

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[3] ACTS were a research partner in project work foundational to the MECS Programme – Low cost energy-efficient products for the bottom of the pyramid, see http://www.sussex.ac.uk/spru/research/projects/lct (accessed 22 June 2020) – and so already had relevant contacts with knowledge about clean cooking in Kenya.

[4] We intended to run similar workshops in Rwanda and Tanzania to develop case studies of the e-cooking innovation systems in these countries and so invited one participant from each of the collaborating organisations in Rwanda and Tanzania to join the Nairobi workshop.

snapshot of the exercise in process. The ‘final’ map was then photographed as a record of the output and this was used to produce an electronic version of the map.

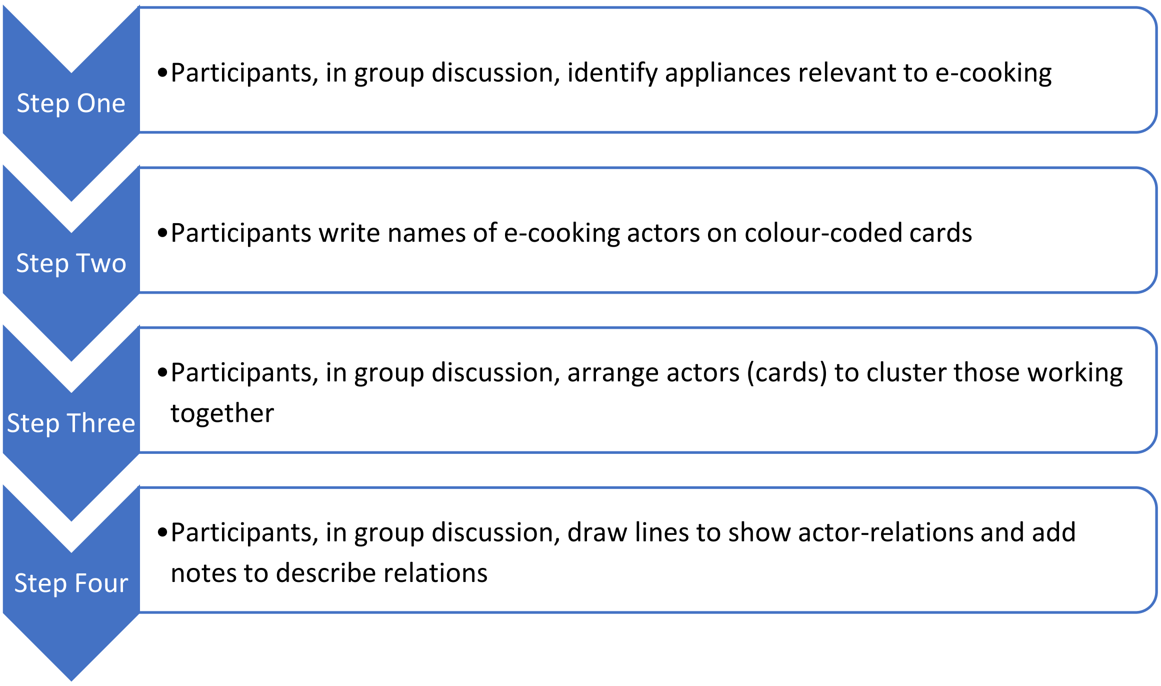

Figure 1: Pinnsmapping steps

In the months following the workshop, 25 semi-structured interviews with 16 organizations were conducted with some of those who participated in the Pinnsmapping (see Annex I for the generic questionnaire and Annex II for those interviewed). Many of the interviews were in-person and some involved site visits – e.g. to BURN Manufacturing – but, because of the Covid-19 pandemic response in Kenya, several interviews had to be conducted virtually via telephone or video communication platforms such as Zoom and Skype. During the interview, respondents described their organisation and its projects or initiatives in clean cooking and e-cooking, the partnerships or collaborations it was involved in, the cooking technologies and fuels it focussed on and its evaluation of the e-cooking innovation system as a whole. The interviews included a section devoted to the Pinnsmap, during which respondents were shown the draft ISM and asked to comment on its accuracy. Based on these comments, the draft ISM was adjusted to produce the version shown in Figure 3 in Section 4.2. The interviews also included a question on policy and this, together with analysis of secondary sources, formed the basis for the context discussion in Section 3. The interviews were audio recorded and transcribed verbatim to facilitate narrative analysis.

We analysed the information in a series of project-team virtual 'write-shops', in between which we drafted various sections of the text, with designated team members leading specific sections. We used the analytical framework discussed in Section 2.1 above and summarised in Table 1. Triangulation of the evidence involved cross-reference between the workshop material, follow-up interviews and, where available, secondary sources. For the final complete draft of the text, one author copy-edited the entire paper.

Figure 2: Some participants in the Nairobi ISH Workshop constructing the Pinnsmap

Source: Photograph courtesy of Marete Selvin

3 The context of e-cooking in Kenya

Before describing the details of Kenya's e-cooking socio-technical innovation system (in Section 4), as revealed through the Innovation System History workshop, follow-up interviews and further desk-based research, we review the innovation system's broader context. Following some general comments on Kenya's e-cooking context, we briefly review the country's state of electricity access and e-cooking. Then, after a brief overview of the policy context at both the international and national levels, we describe the main Kenyan actors and summarise the key national policies relevant to e-cooking. More specific discussion on Kenya's regulatory context is provided in Section 4.5.1. We finish this section with a discussion of various facets of the national policy trajectory – policy enablers, opportunities and potential barriers – to the extent that these are currently discernible.

3.1 General comments on the Kenyan e-cooking context

The e-cook Global Market Assessment report (Leary et al., 2018), written by some of the key architects of the MECS programme, identified conditions that showed significant potential for e-cooking in East Africa. Kenya, which acts as the commercial hub of East Africa and has a dynamic private sector and a skilled workforce, scored well using the study's series of indicators[5]. It is the economic powerhouse of the region and is regarded as having a favourable environment for entrepreneurship and innovation, especially in areas that could be considered central to e-cooking such as energy access, financial services and environmental conservation. Kenya has a reputation as a destination for energy access investment, and benefits from this. In 2017, it received the majority of clean cooking finance administered in sub-Saharan Africa (SE4All & CPI, 2019)[6].

Kenya has a history of embracing innovative business models. Mobile money services[7], for example, were pioneered in Kenya and were important for facilitating development of pay-as-you-go (PAYGO) business models[8] in the energy sector. This finance approach has been employed for several sustainable energy technologies like solar home systems, and the Kenyan PV market is considered one of the largest and most successful off-grid markets in the developing world (Byrne et al., 2018). In 2019, close to a million solar PV units were sold in a six-month reporting period (GOGLA et al., 2019). In addition, over the last 10 years, Kenya has significantly improved its electrification rate through the national grid (see Section 3.2).

Certain electrical appliances, such as electric hotplates and microwave ovens, while not widely used, are commonly available and have a long history in the Kenyan market relative to some of the newer energy-

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[5] Indicators included alternative fuel options, finance available to consumers, solar resources, the ease of doing business and the policy environment.

[6] According to the Energizing Finance report cited, Kenya received USD20 million of 2017's USD32 million clean cooking finance.

[7] Example mobile money services in Kenya are MPesa and Airtel Money.

[8] Example PAYGO companies are PayGo Energy, Envirofit and KopaGas.

efficient electrical appliances such as electric pressure cookers (EPCs). Recent research studies have shown that cooking some Kenyan staple foods – e.g. rice dishes, *ugali*, cereals such as beans, green grams and lentils, meat stews and kale (locally known as *sukuma wiki*) – is compatible with newer energy-efficient appliances. However, significant technical challenges remain with other common foods, such as chapatis, mandazi and meat roasted on an open fire (*nyama choma*) (Leary et al., 2019; Scott et al., 2019). Time, cost and energy savings were also identified. But the social and cultural implications of transitioning to new appliances and modern energy sources are less well understood, and so these are in need of further research and greater understanding.

3.2 State of electricity access and e-cooking

According to the World Bank, the percentage of the Kenyan population with electricity access has risen from around 19% in 2010 to 75% in 2018[9]. Kenya's 2019 census revealed that approximately 12 million households – equivalent to about 50% of the Kenyan population – light their homes with electricity. Especially substantial gains have been made among the rural population, where electricity access has undergone a tenfold increase in the same timeframe. The majority of electricity in Kenya is generated from renewable energy sources (prioritised by the government), the use of which has accelerated since the mid-2000s (Klagge & Nweke-Eze, 2020). Electricity supply has increased significantly and now outstrips demand, creating a surplus and, notwithstanding ongoing electricity infrastructure constraints, a more reliable supply (Godinho & Eberhard, 2019).

However, little of this electricity is used for cooking. Overall, 75% of Kenyan households use charcoal or firewood as their primary cooking fuels, which increases to 93.2% in rural areas (ROK & CCAK, 2019). Only 3% of households own an electric cooking appliance, the vast majority in urban areas. But, even among these users, liquified petroleum gas (LPG) tends to be the primary cooking fuel. Cooking with electricity is generally considered to be expensive, based on household experiences with hot plates and convection ovens in urban areas.

3.3 E-cooking policy context: international and national overview

Prominent international organisations driving forward global and national engagement with electric cooking include the Clean Cooking Alliance (CCA) and Sustainable Energy for All (SE4All), both of whom work to progress the United Nations Sustainable Development Goals (SDGs). The CCA, for example, seeks to elevate clean cooking in implementation for 10 of the 17 SDGs, which have been adopted by all UN member states and address global challenges, such as climate action (SDG13) and affordable and clean energy (SDG7). The CCA, formerly the Global Alliance for Clean Cookstoves, prioritises focus countries, such as Kenya, which receive extensive in-country engagement, and works with partner countries, such as Tanzania, that make a national commitment to support cleaner cookstoves and fuels and ascribe to the

[9] See the database from the SE4All Global Tracking Framework, shown on the World Bank's website at https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=KE (accessed 2 August 2020).

principles of the Alliance. The CCA also supports national and regional alliances, such as the Clean Cooking Association of Kenya (CCAK).

SE4All is focussed on SDG7, which has a number of targets including universal access to affordable, reliable and modern energy services by 2030, and doubling the global rate of improvement in energy efficiency. SE4All advances a clean cooking programme that undertakes strategic activities around electric and clean cooking, including research and development, technical and partnership support, and advocacy. Another prominent international actor around e-cooking in Kenya is the UK government, primarily through the MECS Programme. Among other activities, and working with local partners, the MECS Programme intends to develop new technologies that make electric and gas cooking appliances more efficient, practical, desirable and affordable for poorer households. The Programme works closely with the private and third sector to develop business models and financing methods that will help get electric and gas cooking appliances into the market.

At the national level, although energy-related policies in Kenya touch on clean cooking, none addresses e-cooking explicitly. Instead, they address clean cookstoves and technologies such as LPG, biogas and bioethanol-based solutions. Policy interventions on e-cooking can therefore only be inferred. Clean cooking energy-related policies in Kenya include the Sessional Paper No 4 of 2004 (ROK, 2004) and the National Energy Policy of 2018 (ROK, 2018b). Sessional Paper No 4 articulates the overarching energy policy framework for promoting economic growth in Kenya, whereas the overall objective of the 2018 National Energy Policy is to ensure affordable, competitive, sustainable and reliable supply of energy at the least cost in order to meet the national and county development needs, while protecting and conserving the environment for inter-generational benefits.

Clean cooking appears, to varying degrees, as part of the discourse in other relevant policy domains. The 2013 National Climate Change Action Plan (NCCAP) estimates that improved cookstoves and alternative cooking fuels could save up to 5.6 million tonnes of CO2 equivalent annually and encourages increased use of improved cookstoves. It aims to set up a programme promoting clean cooking and raising awareness. The 2010 Kenya National Climate Change Response Strategy promotes improved cookstoves and includes provisions for subsidies and tax waivers for poor households to acquire energy-efficient stoves (Karanja & Gasparatos, 2019). With high rates of forest degradation, the Kenyan government has instituted logging bans, with uneven results, and the 2016 Forest Conservation and Management Act led to increases in the cost of charcoal. Despite the increased cost and difficulties in accessing charcoal, there is no evidence of any induced shift to clean cooking. The Kenyan government also recognises the negative health impacts of household air pollution, which disproportionally affects women and children, and has worked variously with clean cooking advocates such as CCAK and GIZ to increase the supply of improved cookstoves in 14 counties. However, the Ministry of Health has no current policy on household air pollution (Ngeno et al., 2018). While discussions around clean cooking, and to a far lesser extent electric cooking, occur in different domains, these have not yet translated into clear policy statements.

3.4 Key national actors relevant to e-cooking

Several national actors are emerging in the field of e-cooking, as can be seen in the mapping reported in Section 4.2. However, the majority of e-cooking proponents are donors or other international development partners. A notable Kenyan proponent, mentioned above, is the CCAK. Other national actors include the Ministry of Energy and Petroleum, the Energy and Petroleum Regulatory Authority, and the Kenya Power and Lighting Company Limited.

The following are the national actors relevant to e-cooking in Kenya:

a) **Ministry of Energy and Petroleum:** The ministry, through the Renewable Energy Directorate, is mandated to, among other roles, formulate, review, and analyse policy regulations and guidelines on renewable energy.
b) **Energy and Petroleum Regulatory Authority***:* The Energy and Petroleum Regulatory Authority (EPRA) is established as the successor to the Energy Regulatory Commission under the Energy Act (ROK, 2019) with an expanded mandate that includes regulation of upstream petroleum and coal. Its functions also include tariff setting, review, licensing, enforcement, dispute settlement and approval of power purchase and network service contracts. The economic regulation arm of EPRA undertakes energy pricing and competition analysis, among other functions.
c) **Kenya Power and Lighting Company***:* The Kenya Power and Lighting Company Limited (KPLC or Kenya Power) – a public company partly owned by the government of Kenya with 50.1% shareholding – owns and operates most of the electricity transmission and distribution system in the country. By January 2020, it reported that it was selling electricity to over 7.5 million customers[10]. The Company's key mandate is to plan for sufficient electricity generation and transmission capacity to meet demand, building and maintaining the power distribution and transmission network, and retailing of electricity to its customers.

3.5 Summary of national policies relevant to e-cooking in Kenya

As noted above, the existing energy-related policies do not explicitly mention e-cooking. However, support for e-cooking can be inferred to varying degrees from the following policies:

a) **National Energy Policy 2018** (ROK, 2018b)**:** The overall objective of the energy policy is to ensure affordable, competitive, sustainable and reliable supply of energy at the least cost in order to meet the national and county development needs, while protecting and conserving the environment for inter-generational benefits. The policy states that the government will facilitate the establishment of strategies and mechanisms to eliminate wood fuel, charcoal and kerosene as a household energy source by 2020, in order to reduce indoor air pollution and other harm from stoves using fuels such as kerosene, of which 448,000 cubic meters were used in 2017. It aims to move consumers towards efficient renewable energy solutions such as LPG, natural gas and electricity.

[10] https://kplc.co.ke/content/item/14/about-kenya-power

b) **National Environment Policy 2013** (ROK, 2013b)**:** The National Environment Policy 2013 recognises air pollution as a leading cause of respiratory diseases such as chronic obstructive pulmonary disease, lung cancer, pulmonary heart disease and bronchitis. The effects of outdoor air pollution are compounded by those of indoor air pollution. Most households use charcoal and firewood for domestic cooking. Indoor air pollution affects both urban and rural populations. Policy statements to address these challenges include promoting alternative cookstoves and technologies that are non-polluting and construction of well-ventilated houses. E-cooking is not explicitly mentioned but we can infer it can be one of the alternative non-polluting cooking practices.

c) **Global Alliance for Clean Cookstoves' Kenya Country Action Plan (CAP) 2013** (GACC, 2013)**:** The CAP intends to promote and sensitise key national and county government institutions on the benefits of clean cooking for health, environment and economy. Necessary actions include the proactive engagement of stakeholders and members of the CCAK in ongoing policy reform processes to ensure clean cooking issues are well articulated.
Some of the action plan's urgent interventions include: creation of a national cookstoves testing and knowledge centre to determine cookstoves that meet international standards for emissions and fuel efficiency, and disseminate the information through labelling and consumer education; and establishment of a robust multi-sectoral working committee – the CCAK – to work with the government, civil society, and the private sector to track progress against the CAP and advocate for the sector.

d) **National Climate Change Action Plan NCCAP 2018-2022** (ROK, 2018a)**:** The NCCAP 2018-2022 establishes provisions to mitigate and adapt to climate change in Kenya. According to this Plan, the number of households using LPG, ethanol, or other cleaner fuels for cooking will increase by 2 million through a programme that promotes LPG storage, bottling and stock, micro-finance loan projects and local manufacture and servicing of clean cookers.

3.6 National trajectory relevant to e-cooking

3.6.1 Policy enablers

Kenya's energy policy is not explicit on e-cooking but, considering the stated goal to move consumers to efficient and renewable energy-based cooking practices, it could be reviewed to incorporate e-cooking technologies. For example, EPCs are expected to be safer and more efficient compared to ordinary pressure cookers due to their design, which includes an internal heat source and safety thermostat to regulate the heat. The target users for EPCs are households who have begun to adopt modern energy carriers such as LPG but continue to rely on charcoal for their heavy meals. These are adequate justifications to premise the review of the existing energy policy to articulate explicit and concrete actions that will enable e-cooking.

3.6.2 Opportunities

The use of cleaner stoves and fuels can dramatically reduce exposure to harmful smoke, provide myriad economic opportunities for Kenyans, and help reduce forest degradation and reduce greenhouse gas emissions. More modern stoves and cleaner fuels also reduce the time people need to spend collecting fuel, lighting fuels, tending the fire and in some cases monitoring the cooking process, freeing up time for other desired activities such as income-generation, schoolwork[11], and perhaps increased leisure time.

An EPC, for example, offers the ability to cook the most energy intensive foods using less than a fifth of the energy of an electric hotplate and at a fraction of the cost of any other fuel (Leary et al., 2019). However, the appliance is little known throughout Kenya and, until now, has been difficult to obtain. Through media exposure, there is an opportunity to popularise 'smart' cooking practices[12]. In 2017, Kenya Power commissioned the TV series *Pika na Power* (Cook with Electricity), which promoted electric cooking and was broadcast on national TV and through social media, albeit with mixed results. More recently, Kenya Power has integrated EPCs into their portfolio of electric cooking devices alongside induction and infra-red stoves, which they market and publicise through activities such as public events hosted at Electricity House in the Nairobi Central Business District where their cooking demonstration kitchen is located. Electric cooking in rural areas is being promoted through *Shamba Shape Up*, a reality TV series aired on Citizen TV, which is the largest media house in Kenya. The series features small scale farmers participating in cooking demonstrations using EPCs.

3.6.3 Potential barriers

Several 'barriers' to adopting clean cooking were identified at the launch of MECS in East Africa[13] in May 2019. These included people's perceptions of the safety of electric cooking, lack of awareness, low availability of distribution points, and affordability and availability of appropriate appliances. Most households could cook with less than 2kWh per day, much less than cooking with charcoal. Cooking with charcoal uses five times more energy than LPG and ten times more than efficient electric cooking appliance (Chepkemoi et al., 2019; Scott et al., 2019). But, according to the National Cooking Sector Study conducted by the Ministry of Energy in 2019, only 3% of households own an electric cooking appliance such as a mixed LPG-electricity stove, electric coil stove or microwave oven. This is largely attributed to the cost of electricity and the high cost of the appliances (ROK & CCAK, 2019): e.g. the survey reported average retail prices for the mixed-LPG stove of KES 28,920 (USD 270) and KES 39,250 (USD 366) for urban and rural users respectively. The initial cost of an EPC is estimated in the order of KES 7,000 (USD 65). If electric cookstoves and appliances are to be adopted in low-income areas, then instalment-based payment models may be one way to overcome cost barriers (Chepkemoi et al., 2019).

During the MECS East Africa launch, other identified 'barriers' to scaling up the use of electricity or gas for cooking included load shedding, weak grids, poor availability of LPG, and perceptions. Tradition was also identified as a barrier, along with the intensely cultural nature of cooking (implying that cultural practices are barriers). However, we should be cautious about seeing tradition and cultural practices as barriers that

[11] https://www.cleancookingalliance.org/country-profiles/focus-countries/4-kenya.html

[12] https://mecs.org.uk/ecps-in-kenya-a-huge-almost-completely-untapped-opportunity/

[13] MECS East Africa was launched in a workshop jointly organised by Loughborough University, ACTS, CLASP and Gamos, at Strathmore University Energy Research Centre.

might be dismantled. Any difficulties associated with traditional and cultural practices accommodating electric cooking are not purely technical impediments that can be challenged by providing accurate technical information. The extent to which traditional and cultural practices could become more accommodating to electric cooking is dependent on social and political processes that must be both embedded and driven locally rather than being imposed from 'outside' through technocratic efforts, no matter how well-merited.

Finally, as part of its response to the Covid 19 crisis, the Kenyan government recently introduced measures that raise the VAT rating of several products used in the assembly, manufacture or repair of clean cookstoves. Formerly zero-rated, VAT on these products was raised in the 2020 Finance Bill to the standard 14% rate[14]. The bill may have further implications for e-cooking by removing VAT exemptions for batteries, and solar and wind energy equipment. As part of an enabling policy environment, the government could consider reintroducing or extending the incentives it introduced to bolster the adoption of clean cookstoves: e.g. reducing the import duty on e-cooking equipment; implementing a zero rating for tax on electric cooker parts; and creating VAT exemptions for the inputs used for the manufacture and assembly of cooking technologies[15].

[14] Some changes in VAT rating, such as those on the supply of LPG, have been delayed for one year, until 2021.

[15] https://www.cleancookingalliance.org/country-profiles/focus-countries/4-kenya.html

4 Socio-technical innovation system actors and relations

Having briefly reviewed the context of the Kenya e-cooking socio-technical innovation system, we now report the findings from our research. These were gathered through the Pinnsmapping exercise in the Nairobi Innovation System History (ISH) workshop and follow-up interviews with participants from the workshop and other actors in the innovation system, alongside a review of organisational, industry and media reports collected through desk-based research. We first review e-cooking technologies available in Kenya and then provide visualisations of the actor networks in the e-cooking innovation system, describing the key actors and their relations. Section 4.5 reviews the innovation system's enabling environment, and we finish in Section 4.6 with a discussion of a range of emerging issues revealed by our research.

4.1 Technologies in the e-cooking innovation system

In Kenya, wood fuels – i.e. charcoal and firewood – are the most commonly used primary cooking fuel, currently being used by 75% of Kenyan households, as revealed by the Kenya Household Cooking Sector Study (ROK & CCAK, 2019). In rural areas, over 93% of households use charcoal or wood as their primary fuel. In urban areas, kerosene remains the most dominant fuel among the urban poor (Dalberg, 2018). As noted in Section 3.6.3, only 3% of households own an electric cooking (e-cooking) appliance. However, it is worth noting that, according to information from our interviews, there is a lack of consensus in the sector on the exact proportion of households using electricity to cook. The Sector Survey focussed primarily on three electric appliances: the mixed liquified petroleum gas (LPG)-electricity stove, the electric coil stove, and the microwave oven. Findings from our Pinnsmapping exercise and follow-up interviews revealed an extended list of e-cooking appliances (see Table 2): those used for food preparation such as chopping, mixing or blending; those used to heat water or food; and those used to 'cook' food by applying heat.

Table 2: Electrical cooking appliances identified during the Pinnsmapping exercise and interviews

Electric cooking appliances		
Bread maker	Electric pressure cooker	Microwave oven
Coffee maker	Food mixer	Multi-cooker
Deep fryer	Hot plate	Popcorn machine
Electric blender	Ice-cream maker	Rice cooker
Electric burner	Immersion cooker	Sandwich maker
Electric kettle	Induction burner	Toaster
Electric oven	Infrared burner	Yogurt maker

The vast majority of users of e-cooking appliances are in urban areas but most of them rely on LPG as the primary cooking fuel. As we noted in Section 3.6.3, the low adoption of e-cooking appliances is partially attributed to poor affordability of the appliances (see Table 3 for price ranges of various e-cooking appliances), and the high cost of electricity for cooking.

Electric pressure cookers (EPCs) are considered a new entrant into the system, even though they have existed for some time, albeit in a negligible number of households and in retail stores. The rate of adoption of EPCs is gradually increasing, and much of the effort around EPCs in Kenya is connected to the MECS Programme.

Table 3: Price ranges of locally available electric cooking appliances

Cooking appliance	Approximate price range (USD)	
	Minimum	Maximum
Electric pressure cooker	69	382
Electric oven	52	235
Slow Cooker	73	73
Rice Cooker	29	355
Kettle	8	170
Electric hot plate	9	91
Induction stove	31	196
Microwave	54	490
Air Fryer	70	297

Source: (Rousseau, 2020)

4.2 Actor-network visualisations

Upon identifying which e-cooking appliances or technologies are being used in Kenya, we sought to identify and classify the specific actors who use or work with these technologies in different ways. We focussed on organisations and individuals involved in various aspects of the e-cooking socio-technical innovation system. These included actors involved in research and development (R&D) activities, quality assurance standard development and enforcement, market development to extend access to e-cooking appliances and supporting technologies and systems, supply-side and demand-side financing of e-cooking technologies and initiatives, education, advocacy and policy support for e-cooking and other related activities in the sector. We also investigated whether each actor interacted with others in those activities and the nature of those interactions, and we developed two visualisations of the resulting actor-networks relevant to e-cooking in Kenya.

Figure 3 depicts the outcome of first iteration of the Kenya e-cooking actor-network. This 'map' was derived from the Pinnsmapping exercise during the Nairobi ISH workshop and additional data from follow-up interviews. The actors are colour-coded based on their category: e.g. private sector, regulatory authorities, funders/financiers, and so on, as shown in Figure 3. The figure also includes a set of abbreviations and acronyms. The connections between these actors are depicted with arrows, which indicate the primary 'direction' of the relations without describing the nature of the relationships. In some cases, the relationship is reciprocal, indicated by a bi-directional arrow. Findings from our interviews and further analysis revealed that this map also captures all those actors who are already doing some work around 'clean cooking' in Kenya but are yet to start concrete projects, programmes or initiatives specifically on e-cooking. These actors are enthusiastic about e-cooking and are supportive of any new developments in this area. However, due to their current strategic focus, budgetary constraints, capacity issues and, in some cases, uncertainty or scepticism on when efforts on e-cooking are likely to yield measurable outcomes, they are yet to take concrete steps to invest in or promote e-cooking.

In an effort to identify specific actors from the map in Figure 3 who are currently running active projects, programmes or initiatives in e-cooking, we progressively validated this map with each actor interviewed in our study. Our respondents first confirmed if they are doing anything on e-cooking and, if so, with whom they are working in those efforts. They also confirmed – to the best of their knowledge – which other actors in the sector were active in e-cooking, and in which specific initiatives or programmes. Figure 4 depicts the resulting 'core' network of actors who are actively promoting e-cooking in some way in Kenya. The actors are colour-coded in a similar way to Figure 3. This map further captures the nature of the relationships between actors: e.g. funding flows, collaborations in efforts such as cooking demonstrations, product supplies or distribution, and so on. In the following sections, we describe the actors in both visualisations and elaborate on their efforts related to e-cooking, and the relationships in the socio-technical innovation system.

4.3 Key actors in the e-cooking innovation system

The discourse around the use of electricity in the energy sector has to a large extent focussed on lighting. However, e-cooking at the household level is increasingly being considered viable, as is electricity for commercially productive uses. Cooking would increase household consumption of electrical energy, especially now that there is increased effort in mini-grid development, extension of the national grid, and significant developments in solar home systems. Consequently, actors in the e-cooking socio-technical innovation system overlap with those in the energy sector more broadly in Kenya. We will see below that many energy projects and initiatives bringing together various actors have in some ways tackled issues around clean cooking. The following section outlines the main actor categories identified in the e-cooking socio-technical innovation system in Kenya.

Legend

- Private Sector
- Regulating Authority
- Financier
- Academic Institutions
- Non-Profit Organisations
- Civil Society
- Government

Actor abbreviations and acronyms

ACTS	African Centre for Technology Studies
AfDB	African Development Bank
ASH	Africa Sustainability Hub
CCA	Clean Cooking Alliance
CCAK	Clean Cooking Alliance of Kenya
CHAMAS	Informal cooperative societies
CLASP	Collaborative Labelling and Appliance Standards Program
DFID	Department for International Development
EnDev	Energising Development
GIZ	German Corporation for International Cooperation
KAM	Kenya Association of Manufacturers
KBS	Kenya Bureau of Standards
KOSAP	Kenya Off-Grid Solar Access Project
KPLC	Kenya Power and Lighting Company
LEIA	Low-Energy Inclusive Appliance Programme
MECS	Modern Energy Cooking Services Programme
SACCO	Savings and Credit Co-operative Society
SCODE	Sustainable Community Development Services
SNV	Netherlands Development Organisation
UN	United Nations

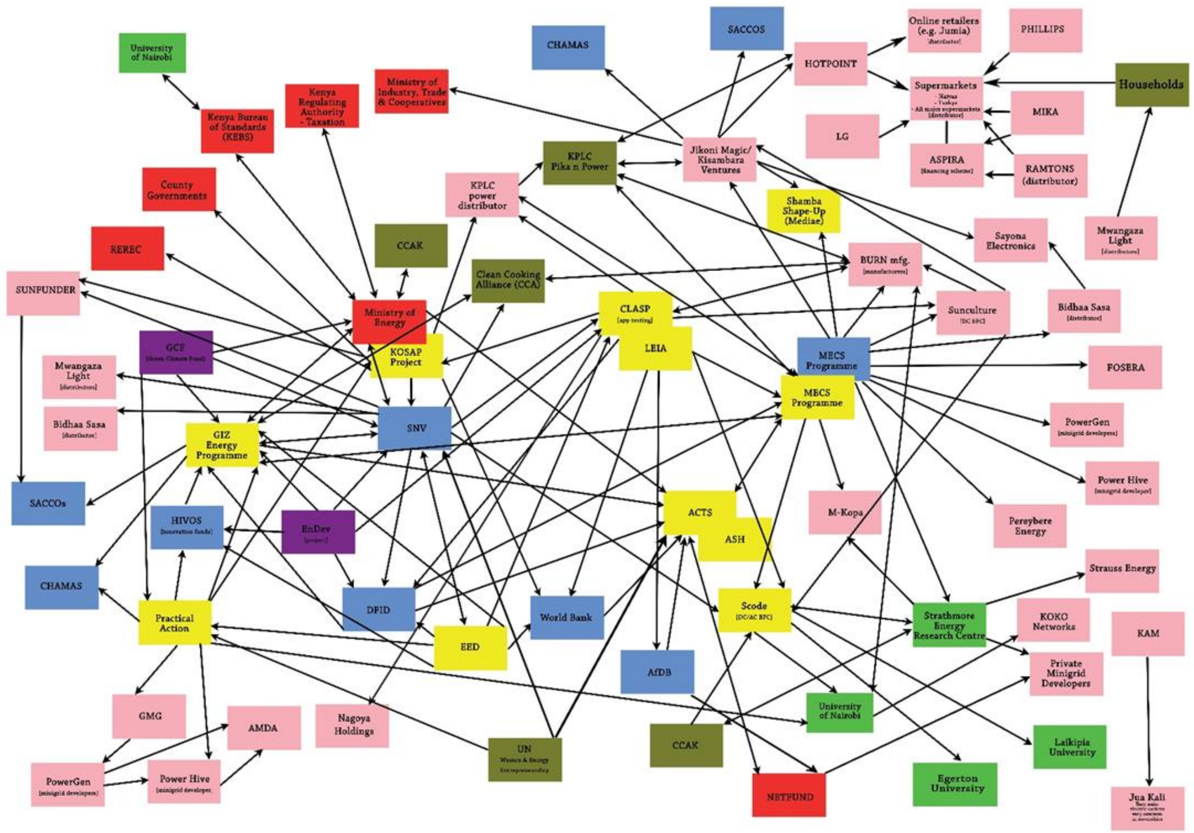

Figure 3: Actor-network map of the Kenya e-cooking socio-technical innovation system

Source: Authors' construction based on the Pinnsmapping exercise and follow-up stakeholder interviews

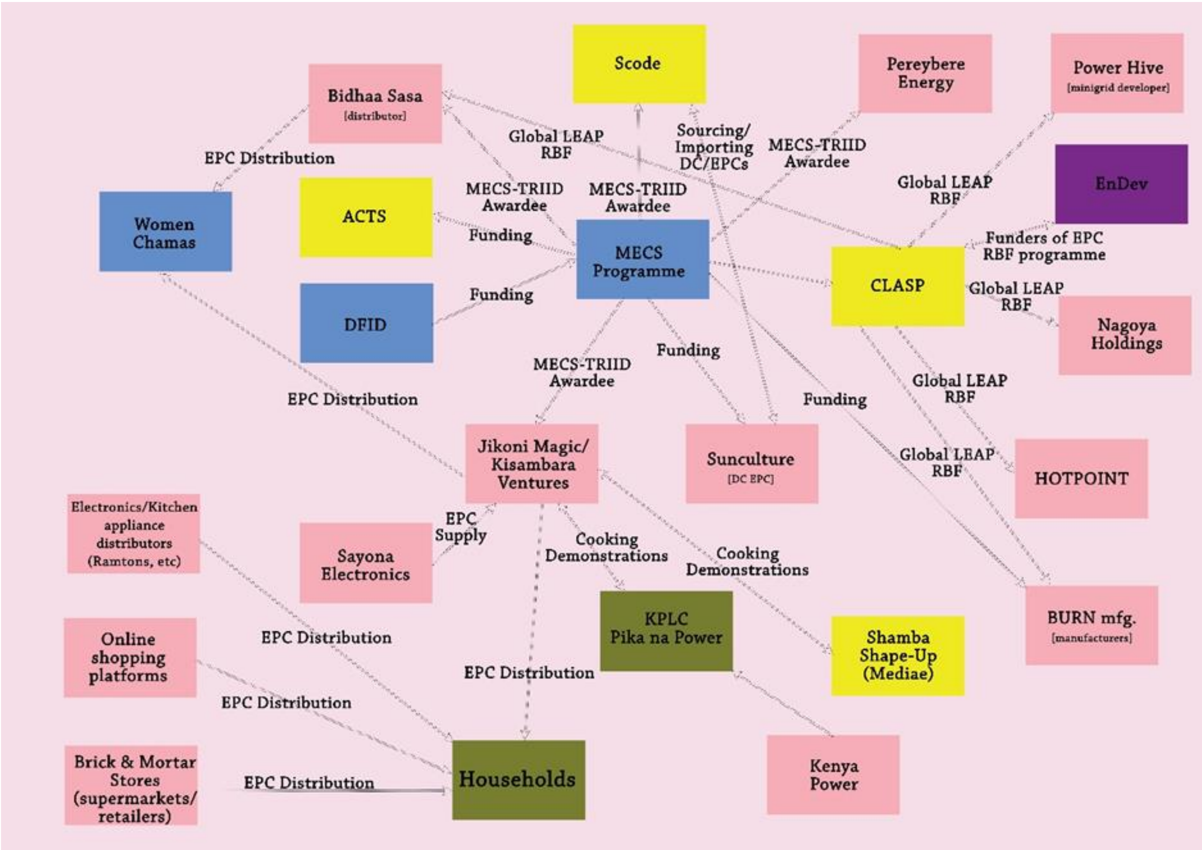

Figure 4: Core actor relations of the Kenya e-cooking socio-technical innovation system

Source: Authors' construction based on Pinnsmapping and stakeholder interviews
Note: The map shows only those who are active in e-cooking in Kenya, along with the nature of their relations

4.3.1 Non-governmental and non-profit organisations

Clean cooking in Kenya is populated with a number of international donor, non-governmental or non-profit organisations. Key players include the German Gesellschaft für Internationale Zusammenarbeit (GIZ), Practical Action, Hivos East Africa and the Collaborative Labelling and Appliance Standards Program (CLASP). The German-funded GIZ, which has a dedicated energy programme, has supported technology and market development for energy-saving cooking technologies and other basic energy solutions in Kenya for many years. The work of the GIZ Energy Programme builds on experiences from various projects across the Global South and, in particular, the Energizing Development (EnDev) programme. In Kenya, GIZ has so far focussed on improved biomass cookstoves and, due to its interactions with many of the other larger actors in the sector, it is one of the central actors in the clean cooking innovation system. Recently, the EnDev Programme has started to finance market development for EPCs in Kenya.

Another core international non-profit in the sector is Practical Action. Its work in Kenya is broad-based, including agriculture and clean water in informal urban settlements. Practical Action also has a long history in the clean cooking sector where the mission has been to stimulate the adoption of clean cookstoves and extend access to electricity. Like GIZ, their work has focussed mostly on improved cookstoves, and new developments around ethanol. In the same vein, Hivos, another international NGO, has a long history in the clean cooking sector in Kenya. The activities of the organization include developing the domestic biogas market, where the gas is then used for cooking and lighting. Hivos is also involved in advocacy work at the national and regional level to embed clean cooking in the political agenda. Recently, Hivos has entered the debate around e-cooking using solar home systems (SHSs) and mini-grids (Couture & Jacobs, 2019).

Finally, CLASP is a key actor in quality standards and market development for solar and electric appliances in Kenya. As an international non-profit, its broad mission is to improve the energy and environmental performance of appliances used in households in order to mitigate growing energy demand. CLASP is now spearheading the development of standards and protocols for testing and labelling EPCs. In 2017, CLASP developed a strategy through which the government and other actors can implement standards and labelling policies and programmes in Kenya. Further, CLASP – through the Global Lighting and Energy Access Partnership (LEAP) Awards Electric Pressure Cooker competition – is testing and approving appliances that meet minimum energy performance, quality, and safety standards. Most recently, CLASP is supporting the development of supply chains for EPCs in Kenya through Results-Based Finance (RBF) funded by the EnDev programme.

Although Hivos and Practical Action are core organisations promoting clean cooking in Kenya, they have yet to make significant investments in the development of e-cooking as an alternative. Much of the focus remains on improved biomass cookstoves and ethanol. They support new developments around e-cooking but lack funding and strategic support to begin projects in this area. As Hivos puts it, the hope is that their advocacy and reports[16] "have spurred debates and hopefully materialize in extra finance for electric cooking".

4.3.2 Private sector

Established commercial actors in the e-cooking socio-technical innovation system primarily consist of local distributors and retailers. These include Hotpoint Appliances Ltd, Sayona Electronics, Nagoya Holdings Ltd, Philips East Africa and local supermarkets. These retailers and distributors focus on importing appliances such as electric cookers, microwave ovens, multi-cookers, air fryers, electric kettles and, more recently, infrared and induction burners. The retail stores tend to be located in urban areas. New entrants in this sector include Bidhaa Sasa and Jikoni Magic (also known as Kisambara Ventures Ltd), all Kenyan start-ups who are distributing EPCs to lower-income and rural households by adapting and developing new delivery models, discussed further in Section 4.6.2. Also venturing into the sector is Pereybere Energy, a private research firm who is at the initial phase of piloting metered EPC use in rural areas in Kenya. Their proposed

[16] "Putting clean cooking on the agenda", A Q&A with Rita Poppe, September 21, 2019, available at: https://www.hivos.org/blog/putting-clean-cooking-on-the-agenda/ (accessed 9 August 2020)

trial entails distributing EPCs to households at a subsidized cost and meeting their electricity costs for the duration of the study in order to study the usage patterns.

Manufacturing of e-cooking appliances in Kenya is still nascent. Only one firm has been identified so far: i.e. BURN Manufacturing, which is in the R&D phase of an EPC customised to local conditions. SCODE Enterprises is also contemplating manufacturing an EPC, but the idea is still at the concept stage. Thus, there is yet to be a locally manufactured e-cooking appliance arising out of the formal sector. However, participants in the innovation systems mapping exercise reported that artisanal electric stove producers in the informal sector are fabricating electric cookers using the spiral hot plate design. These cookers are highly inefficient and are not available in the open market. Users include university students, who have access to 'free' energy on their campuses, and households, mainly in informal settlements, who have illegal connections to the national grid and thus are unconstrained by the cost of electricity.

Entities who generate and distribute power in Kenya are a core part of the e-cooking socio-technical innovation system. The largest is Kenya Power who owns and operates most of the electricity transmission and distribution infrastructure in the country and, according to its website, is selling electricity to over 7.5 million customers (as of June 2020). However, this statistic indicates physical connections to the grid rather than electricity consumption and, according to some sources, the count includes households who are within connection distance of a grid-connection point, whether connected or not. To encourage the use of electricity for cooking, Kenya Power operates a public demonstration kitchen called *Pika na Power* (Cook with Electricity, mentioned in Section 3) in which the public is taught at no cost how to cook local foods using induction burners, infrared burners, multi-cookers and EPCs.

Other relevant players in the electricity sub-sector include KenGen, Kenya Transmission Company and the Geothermal Development Corporation. Private mini-grid developers are increasingly recognised as key players as they extend access to power in rural areas. Two examples are PowerHive and PowerGen. Further, the SHS market is quite well developed, where the target market is off-grid areas in rural Kenya. As part of the solar product offering, companies bundle various low voltage home appliances such as radios, phone chargers, televisions, and agricultural machinery and electric pressure cookers that draw power from batteries charged by solar PV modules. Various R&D efforts are ongoing in several enterprises: for instance, SunCulture Kenya Ltd, who sells solar-powered irrigation solutions, is exploring how to improve the performance and usability of EPCs on their Solar Energy System. M-KOPA Solar Kenya Ltd is exploring how to implement a PAYGO solar-powered e-cooking model they call "Pay As You Cook". SCODE has piloted solar e-cooking in off-grid and weak-grid rural communities in Kenya.

4.3.3 Financing organisations

The World Bank, SNV in partnership with GIZ, SunFunder, Practical Action, Hivos and MECS were identified as the most active organisations who have financed or funded initiatives in the clean cooking sector. The World Bank has extended a credit facility of USD 150 million to enable marginalised communities in Kenya to access modern energy services through off-grid solar. Funding is being channelled through the Kenya Off-Grid Solar Access Project (KOSAP). Part of KOSAP is the Clean Cooking Solutions Challenge RBF facility that is allocated USD 5 million and is managed by SNV. While SunFunder is a partner in KOSAP, their management role focusses on a solar debt facility. The KOSAP programme is discussed further in Section 4.4.1.

GIZ, in partnership with SNV, is offering financial incentives to private sector players in the form of an RBF within the EnDev Programme. This paves the way for companies in solar, cookstoves, mini-grids, street lighting, biogas and grid connection to set up businesses in 25 off-grid areas that are pre-defined within the programme. In a different initiative in 2020 managed by CLASP, the EnDev Programme is also offering financial incentives to encourage organisations to purchase and distribute EPCs in Kenya. Practical Action, as part of an enterprise development programme, has been funding women entrepreneurs in the different energy value chains, who will be engaging in the distribution of cookstoves, solar lanterns, solar home systems, and briquettes as part of a project called the Women in Energy Enterprises in Kenya (WEEK). The funding goes towards developing and building the capacities of the women entrepreneurs. The WEEK project is however not focussed on e-cooking, although electric appliances are not excluded.

The MECS Programme is the first to focus exclusively on modern energy services for cooking, with much focus on e-cooking in Kenya. As part of its mission to induce a transition away from overreliance on biomass, the Programme has undertaken activities to directly fund innovators through a number of challenge funds, and recipients in the e-cooking domain include BURN Manufacturing, Sustainable Community Development Services (SCODE), Bidhaa Sasa, Jikoni Magic, SunCulture Kenya Ltd, Fosera Solarsystems GmbH, M-Kopa Solar Ltd and and Pereybere Energy. The goal of these is to stimulate innovation and market development for modern energy cooking technology and systems with a view to advance e-cooking as the cleanest and most sustainable way of cooking. As a step towards smoothing the supply chain, MECS has been involved in designing initiatives around linking enterprises and households to EPCs. One such initiative within The Global LEAP Awards programme managed by CLASP is an RBF programme that provides incentives to encourage the private sector to purchase and distribute energy efficient EPCs. This RBF is funded by the EnDev Programme.

4.3.4 Civil society

Civil society actors in the Kenya e-cooking socio-technical innovation system include the aforementioned Clean Cooking Association of Kenya (CCAK), a member of the Global Clean Cooking Alliance, and women's self-help groups and households. CCAK is a professional association established to coordinate innovation and design, testing, production, marketing, and use of clean cookstoves and fuels. They also advocate for clean cooking to be included in government policy, to create public awareness and to build the capacity of member organisations. The association has 34 paying members comprising representatives from government, academia, the private sector, development partners, NGOs and individuals active in the clean cooking sector. CCAK has played a pivotal role in bringing together actors in the clean cooking sector in Kenya, giving them a platform to voice their concerns and to advocate for their interests. However, CCAK's budget remains limited and therefore its capacity is constrained. Further, the most active members tend to be development partners and non-profit organizations.

Social media platforms such as YouTube, Facebook and Instagram have become an increasingly important and influential conduit for creating awareness of cooking practices, and organising networks of individuals and organisations interested in sharing knowledge on cooking. Various 'YouTube Chefs' in Kenya have gained popularity by sharing local recipes to an expanding audience. Some of these cooking channels, such as Jikoni Magic, promote e-cooking appliances by demonstrating their use with local ingredients, and educating viewers on their cost, sourcing and maintenance. In Kenya, Facebook hosts various groups focussed on cooking, the largest being "Let's Cook Kenyan Meals" (72,000 members) and "Lets Cook Kenyan Meals Market Place" (90,000 members). In these groups, fans share recipes and information on where to affordably source cutting-edge cooking appliances – among them, e-cooking appliances – and fans cam also exchange, dispose of or purchase cooking appliances.

Given that cooking in Kenya is highly gendered, women's self-help groups play an essential role in educating, empowering, and financing women in the decision to acquire kitchen implements, among them cooking appliances. Women are also being targeted in funding and capacity building initiatives to enable them to start and scale enterprises in the clean cooking value chain, and to legitimise new cooking technologies.

4.4 Relations between actors in the e-cooking socio-technical innovation system

Our innovation system map indicates that actors coalesce around collaborative projects or initiatives. These are often multilateral donor-funded projects spearheaded by the local government or by large non-governmental organisations. Most of these projects are focussed on stimulating the expansion of the national grid, development of mini-grids in rural and remote areas, and market development for the use of electrical appliances. For two decades, the focus has been on the solar industry, especially solar lanterns and solar agricultural products such as solar dryers and irrigation pumps. The structure of these projects and programmes nevertheless has implications for how modern energy cooking services may evolve in Kenya.

4.4.1 Kenya Off-Grid Solar Access Project

The Kenya Off-Grid Solar Access Project (KOSAP), mentioned above, is a flagship project of the Ministry of Energy and Petroleum (MEP), financed by the World Bank, aimed at providing electricity to parts of the country that are not served by the national grid. The five-year project (2018-2023) targets 1.3 million households in 14 marginalised counties[17] in northern and north-east Kenya. Component 2 of KOSAP is designed to drive electrification to support the use of solar and clean cooking technologies in off-grid environments. Thus, the project is seen as a key plank in the ambitious National Electrification Strategy that aims to ensure universal access to electricity by 2022. Key partners in the project include MEP, Kenya Power and the Rural Electrification Authority (REA). SNV and SunFunder partly manage the financing facilities. Although the programme invited applications from enterprises who can manufacture or purchase

[17] The 14 counties are West Pokot, Turkana, Marsabit, Samburu, Isiolo, Mandera, Wajir, Garrisa, Tana River, Lamu, Kilifi, Kwale, Taita Taveta and Narok.

and distribute ‘higher tier’ clean cooking solutions, which includes e-cooking appliances, no application was received focussed on distributing e-cooking appliances. Therefore, the programme has yet to finance e-cooking market development directly.

4.4.2 The Energising Development Programme

The Energising Development (EnDev) Programme is a multi-donor partnership working in 25 countries in the Global South and it aims to promote sustainable access to modern energy services that meet the needs of the poor. The Programme is coordinated by GIZ and the Netherlands Enterprise Agency (RVO) with funding from Germany, Netherlands, Sweden, Norway, the United Kingdom, and Switzerland. In Kenya, EnDev aims to facilitate access to modern cooking energy by promoting the adoption of improved cookstoves as well as off-grid electrification in rural and peri-urban areas. In this regard, since 2012, its work has focussed on market development for improved cookstoves and energy-efficient small solar systems.

EnDev Kenya is a major programme in the coordination efforts in the cookstove sector. The implementing partners include GIZ, the Netherlands Development Organization (SNV), Hivos, and Practical Action. GIZ is the lead agency for the implementation of the programme. EnDev is funding a number of debt facilities targeted at improving the uptake of clean cooking fuels and technologies. As for cooking with electricity, the programme has a new partnership with CLASP and MECS to fund the first ever RBF programme for EPCs. Further to this, the SNV is managing an EnDev-funded debt facility (an RBF) for private sector players looking to set up businesses in predefined off-grid areas, while Hivos is implementing a biogas RBF.

4.4.3 The Green Climate Fund

The Green Climate Fund (GCF) is the world’s largest dedicated fund helping developing countries reduce their greenhouse gas emissions and enhance their ability to respond to climate change. It was set up by the United Nations Framework Convention on Climate Change (UNFCCC) in 2010. It channels climate finance to developing countries who have committed to the Paris Agreement. The Fund is mandated to especially pay attention to the needs of societies that are highly vulnerable to the effects of climate change. GCF aims to catalyse a flow of climate finance to invest in low-emission and climate-resilient development, driving a paradigm shift in the global climate change response.

4.4.4 Summary of relations between actors in the e-cooking innovation system

Although these projects do not have an explicit focus on e-cooking – apart from the EnDev-funded RBF – they give indications of the potential trajectories for its evolution. It is likely that the same actors – who have long and well-established histories in the energy/electricity sector, and who have developed deep relationships with each other and the Kenyan government based on collaboration in various projects – may play a role in e-cooking. They contribute significantly to the discourse around potential transition pathways given their involvement in advocacy and policy development.

From the actor-network map (see Figure 3) and interviews, it is further evident that there is little collaboration between actors in the private sector and those in the non-profit world and government. This may be because commercial actors rarely plug into policy discussions and forums organised by MEP, and those by non-profit actors. As a consequence, various developments in R&D remain obscured to such actors. This may indicate that there is a lack of neutral or open forums in which they can meet and deliberate on emerging issues in the sector.

As the new entrant focussed exclusively on modern energy for cooking, the MECS Programme has quickly become a significant player in the socio-technical innovation system. It is evident that, so far, every actor who is carrying out a new initiative around e-cooking is connected to the MECS Programme. Thus, MECS has the potential to provide a forum where diverse actors – especially those in the private sector – can learn and collaborate[18]. However, the MECS network is only nascent, and so actor interactions to date are few and ad hoc.

4.5 The enabling environment

4.5.1 The regulatory context

Regulatory authorities in the energy sector form a key part of the e-cooking socio-technical innovation system environment. As reviewed in Section 3, key institutions are the MEP and the Energy and Petroleum Regulatory Authority (EPRA), who develop policies that govern the energy sector as a whole. MEP has prioritised clean cooking actions proposed under the SE4All Action Agenda (ROK, 2016). This is evidenced by its work to promote a bioenergy strategy and its work within Component 2 of KOSAP supporting clean cooking.

EPRA (in its former guise as the Energy Regulatory Commission, ERC) has developed draft regulations for biomass cookstoves – The Energy (Improved Biomass Cookstoves) Regulations, 2013 (ROK, 2013a). It imposes a variety of requirements related to licensing, installing improved cookstoves, and record-keeping, upon a wide range of cookstove industry stakeholders and consumers. Such regulation is yet to be developed for e-cooking appliances. Whenever one becomes available, it is likely that EPRA, whose additional mandate is to enforce standards for both domestic and institutional cookstoves, will be involved in the process.

Last-mile connectivity is a big priority of the Kenya government and, as more households are connected to the grid through efforts by the REA, the potential for mass e-cooking rises. The ambitious National Electrification Strategy targets universal access to electricity by 2022. Apart from efforts by Kenya Power to stimulate adoption of e-cooking appliances through the *Pika na Power* programme, so far, there has been minimal effort at national and local government levels to support e-cooking. However, e-cooking is considered part of clean cooking, thus efforts directed towards clean cooking are relevant to e-cooking.

Regarding testing of cookstoves and appliances, the government, through the Ministry of Industrialization and Enterprise Development, has given the official mandate to the Kenya Industrial Research and Development Institute (KIRDI) to use its testing laboratory. However, the University of Nairobi also runs a

[18] ACTS has recently taken on the role of providing such a forum, funded through the MECS Programme.

competing testing facility. Both organisations work closely with the Kenya Bureau of Standards (KEBS). KEBS is mandated to develop standards, measurements, and conformity assessment regimes for locally made and imported goods. Further, KEBS has an existing performance standard for improved biomass cookstoves, which certifies qualifying products and issues a KEBS Standardization Mark that allows the product to be commercialised. However, Kenya is yet to develop dedicated quality assurance standards for e-cooking appliances. To address this gap, Strathmore Energy Research Centre is planning to conduct a scoping study into standards for e-cooking appliances. CLASP observed the need for better coordination of institutions, policies and regulations on quality assurance for cooking appliances (CLASP, 2017), and, as part of its contribution to this gap in Kenya, CLASP is testing electric pressure cookers in accredited labs through the Global LEAP awards programme.

The Kenya Revenue Authority is also an important player as it implements the tax regime applied to clean cooking. For instance, in the 2020 Finance Bill, a 14% Value Added Tax (VAT) on clean cookstoves and LPG – both previously VAT-exempt – was introduced and is expected to harm the adoption of clean cooking by dampening consumer demand and further investments in the sector[19]. Similarly, VAT was introduced on off-grid solar equipment and accessories, and this is also expected to negatively affect efforts to extend energy access in off-grid areas. As a ripple effect, this tax may stifle efforts to stimulate adoption of e-cooking appliances in solar-powered mini-grids, micro-grids and solar home systems.

4.5.2 Academic research, education and training

In the energy sector in general, universities and Technical and Vocational Education and Training (TVET) in Kenya play an essential role in training students who then flow into the labour market. These institutions also produce and diffuse innovations in the energy sector and, with regard to cooking, two institutions stand out: the University of Nairobi, and the Strathmore Energy Research Centre (SERC) located at Strathmore University, Nairobi. Apart from having a long-standing research programme on clean cooking, the University of Nairobi has a testing laboratory that has tested a variety of biomass cooking appliances and, lately, solar cookstoves. The lab, which also conducts field testing, was involved in trialling the SCODE Enterprises biomass stove that is fitted with an electric fan. SERC conducts research, training and consultancy on renewable energies (especially solar energy) and energy efficiency. SERC has a solar testing laboratory funded by GIZ, and they work closely with KEBS with whom they hope to provide global accreditation for PV components.

4.5.3 The media

The media in Kenya have been key players in efforts to stimulate adoption and use of cleaner cooking solutions and to encourage behaviour change. Local newspapers, especially *Business Daily, The Daily Nation* and *The Star* regularly report on issues around cooking, often advocating for changes in the tax regime and

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[19] "Proposed taxes will negatively impact the clean cooking sector", David Njugi, 3 June 2020, *The Star*, available at: https://www.the-star.co.ke/opinion/2020-06-03-proposed-taxes-will-negatively-impact-the-clean-cooking-sector/ (accessed 9 August 2020)

household behaviour, while reporting developments in new technologies in the sector. Independent campaigns such as *Upishi Digi* (translatable perhaps as Digital Cuisine), supported by the Clean Cooking Alliance and Population Services Kenya, rely on digital media such as WhatsApp to share information on stove purchasing and use.

A new collaboration between *Shamba Shape Up* – a farm 'makeover' reality television show for small farmers – YouTube chef Agnes Kaylonge (also known as Jikoni Magic) and Kenya Power's demonstration kitchen *Pika na Power* have further revealed the potential to use the media to educate households on how to use new-entrant e-cooking appliances. Programming sometimes involves live demonstrations of how Kenyan dishes can be cooked on an electric pressure cooker in a rural environment. Also as mentioned in Section 4.3.4, social media have offered an alternative channel to educate and influence the public to adopt novel cooking practices and appliances, and exemplars include Jikoni Magic[20] and, more recently, Nimoh's Kitchen[21].

4.6 Emerging issues in the e-cooking socio-technical innovation system in Kenya

4.6.1 Technological research and development

One of the biggest challenges and opportunities for facilitating a transition from the current reliance on biomass in Kenya to the use of electricity for cooking is the availability of cooking technologies. Distributors have indicated that there is a shortfall in the supply of EPCs in the market, which translates to limited access for their customers. Those that are available are considered expensive for a household earning the median income in Kenya. Other challenges include the failure of e-cooking to align with cultural and behavioural practices around cooking in Kenyan households, and the fact that the cooking technologies available are not designed to withstand conditions in weak-grid or off-grid environments in rural Kenya.

The development of mini-grids, microgrids and solar home systems in off-grid rural areas has offered a promising opportunity to diffuse e-cooking appliances outside urban areas. However, the design and manufacture of appliances that can be used within these setups has to take into consideration whether the energy supplied is Direct Current (DC), Alternating Current (AC) or a combination of the two. DC solar home systems have proliferated in Kenya because they are more modular and cheaper than AC systems. As a consequence, many off-grid households are using DC power, but the market for AC electric cookers is larger and more established globally. This has spurred R&D in DC cookers, a process that is fraught with various technical design challenges, among them the melting of power cables during cooking due to the higher current inherent in low voltage systems supplied by batteries (typically 12-48V, as opposed to 220V grid electricity). A pilot project by SCODE Enterprises and Loughborough University that was trialling DC cookers in Nakuru in Kenya faced challenges due to safety concerns around power management in a DC EPC. The DC EPCs that were being used for the trial have been temporarily replaced with AC EPCs supported by inverters. These repurposed EPCs may be redeployed upon passing the testing criteria under the Global

[20] https://jikonimagic.com/

[21] https://cookingwithnimoh.wordpress.com/

LEAP Awards. SunCulture, which supplies solar home systems, argues that in the future there will be a need to transition into AC power across the board given the global lock-in to AC power and the size of the market for quality-certified AC-powered appliances. The MECS programme, through its Challenge Fund, is working to develop high-quality DC versions of popular AC EPCs such as Sayona in Kenya, and Nikai in Tanzania.

Another challenge in the sector is energy storage in solar-based mini- and microgrids or stand-alone home systems, or in severely weak-grid environments. Both environments call for storage solutions to either store energy generated from sunlight during the day or from intermittent electricity supplied from the grid. R&D efforts are now focussed on building batteries that can either be installed in the home or embedded in the e-cooking appliance to enable the household reliably cook at night or when there is a power outage. These batteries often also need to be able to support cooking along with other energy needs in the household. Feedback from SunCulture's customers trialling the EPC has shown that sometimes batteries are drained by e-cooking, thus preventing the household from using stored energy to carry out other tasks such as powering the irrigation pump. This has had a negative effect on households' decisions to use the electric cooker. The challenge is to manufacture small or portable but high-capacity (energy-dense), fast-charging, robust or durable and safe batteries that are affordable. Lithium-ion is currently the most cutting-edge battery type, and options under consideration include using recycled lithium batteries to lower the cost. Cost is a huge deterrent for low-income households and incorporating high-quality batteries into any e-cooking system would compound the overall price. Thus, there is a need to develop business models that can facilitate the acquisition of such systems. We discuss this further in the next section.

Households in off-grid areas often have little experience with using electrical appliances apart from lighting, televisions, radios and mobile phones. Beyond customer education through demonstration to build confidence in using new appliances, product design is a crucial issue to ensure that the appliances are intuitive. For instance, enterprises have quickly learned that rural customers prefer to use EPCs that have a rotary dial as opposed to a digital interface. Further, the appliance needs to be easy to clean and it should have few moving parts. There is also resistance to using Teflon pots, which are common in the EPCs in the market. The demand is for steel pots because they are easier to maintain. Finally, there is a preference for larger appliances that can be used to cook big meals in rural households, which can sometimes have up to 15 members, not taking into account guests who share in meals. As one respondent summed it up, the main challenge in the solar and e-cooking sector is a hardware one. While significant strides have been made on the business model dimension (addressed below), the industry as a whole is still lagging in developing hardware that is not only robust and locally relevant, but also meets or even surpasses international standards.

The upfront investment in e-cooking appliances is generally higher than that of biomass stoves, and sometimes out of reach for households who rely on firewood. Most e-cooking appliances, including the electric pressure cooker, cost upwards of KES 7,000 (USD 65). The main argument advanced is that the capital cost would be recouped over time through lower payments for energy compared to expected spending on firewood, charcoal, briquettes, paraffin and even LPG. Nevertheless, it is worthwhile exploring R&D to lower the cost of appliances. Local actors such as BURN Manufacturing and SCODE Enterprises are exploring how savings can be made in the process of assembling the appliances. However, to a large extent, these cost implications have been addressed by developing business models that enable households to acquire and pay for appliances over time. This aspect is discussed in the next section.

4.6.2 Retail business models

E-cooking appliances have generally been targeted at urban dwellers who are connected to the national grid. This is evident based on the type of electrical appliances imported into Kenya. For instance, the focus has been on LPG-electric cookers and microwave ovens, and specialised appliances such as mixers, food processors and blenders. More recently, the retail market, especially supermarkets and high-end electronics shops, features appliances such as the air fryer, infrared cookers, induction burners and EPCs. The supply of such products assumes that many urban dwellers have higher disposable incomes and are amenable to using such appliances.

However, the target market has now begun to expand as more rural households are connected to the national grid. Further, there are significant developments in mini- and microgrids in various parts of Kenya. Kenya is also one of the pioneers of solar home systems, which have diffused rapidly in rural Kenya (Byrne, 2011). These developments have created a new segment of potential users of e-cooking appliances. Several organisations in the retail sector have started to build business models around this target market. For example, SunCulture, whose core business focusses on solar irrigation, has begun to distribute EPCs to rural farmers as an add-on appliance.

The conventional distribution channel for electric appliances has been through retail stores, primarily through supermarkets, as we noted above. However, in order to reach rural markets, enterprises have had to explore alternative ways of building distribution infrastructure while lowering costs. As one enterprise explained, distribution is one of the most expensive dimensions of the business given the infrastructural constraints that rural and remote areas in Kenya face. A common alternative has been to distribute through agents. Firms identify and develop relationships with pre-existing small retail shops in desired locations to carry their product. They also opt to establish new agents who are then branded after the company. Other organisations such as Bidhaa Sasa and SCODE choose to create regional 'hubs' in rural market centres, where each hub acts as a centre of operations in that region. BURN Manufacturing's agency model focusses on woman-to-woman marketing, where female 'super customers' are identified as brand champions or product ambassadors to sell stoves – on commission – in the communities.

In urban areas, electrical appliances are typically sold through a cash-based system as customers are able and willing to pay upfront. However, this approach mostly serves high-income and middle-income customers. As lower-income and rural customers have become a viable market for electrical appliances, the need to develop payment models that make electrical appliances more affordable has become more pertinent. The most popular payment system so far has been the PAYGO model that has already been tested in the SHS market. Here, customers make a down payment that allows them to take the electric cooker home, and they are given an instalment plan that spans 6 to 12 months. To be able to sustain such a model, the enterprise has to determine who will absorb the risk of potential non-payment. Larger companies tend to absorb this risk themselves, but the cost of related appliances increases to cater for the risk premium. This is also because it is expensive to keep track of customers to ensure that they adhere to the payment plan and, when all else fails, to repossess the appliance. Such an approach is also technology-intensive; the company needs robust IT systems that can reliably maintain such records and issue SMS alerts. Companies who are not capable of absorbing these risks instead opt for a hire-purchase model, where customers who have a salary can pay the company in instalments (taken directly from the customer's salary at source) while enjoying use of the product.

Another innovative approach has been to co-opt the Group Liability Model that is common in the microfinance industry. A pioneer in Kenya in this regard is Bidhaa Sasa whose market is currently in Western Kenya. Instead of relying on technology to manage risk, the model relies on social networks, especially amongst women. Customers who would like to purchase the product have to find five others equally interested in it. They then buy the products as a group (usually self-help groups locally known as *chamas*) and a common instalment plan is agreed, with the group acting as a payment guarantor. The group members are then trained together on how to use the appliance – in Bidhaa Sasa's case, women are trained to use an EPC – and they would support each other's training after that. For Bidhaa Sasa, the women often became repeat customers for additional product offerings within the company. Therefore, the group model serves three purposes: access to credit, education and marketing. However, the company must invest significant effort to develop strategic but personal relationships with the *chama*s.

Finally, various actors in the system are exploring the potential for utility-enabled appliance financing for e-cooking appliances that would converge e-cooking retail business and electrification efforts at the national level (Waldron & Hacker, 2020). This model is an adaptation of the PAYGO model already being trialled by SHS companies and mini-grid providers who bundle electric appliances as part of their offering. Utility-enabled appliance financing in Kenya would leverage Kenya Power, the national electric utility company's knowledge, infrastructure and customer relationships to sell e-cooking appliances directly to households. Kenya Power has already made significant capital investments to connect urban and rural households, and it has built the infrastructure to monitor and measure electricity consumption, payment and disconnection channels, and regional service delivery outlets. To increase electricity usage in households beyond lighting, the utility company could complement its core business of selling electricity with retailing electrical appliances to its customers. The utility could partner with retailers to supply appliances, and with appliance finance enterprises (where there is a significant gap in the market) or microfinance institutions to offer financing options to customers. Payments for cooking appliances could be recovered directly through the electricity tariffs and/or managed through a PAYGO model, and lessons can be drawn from it 'Stima Loan' programme that targeted low-income households who could not afford the connection fees upfront. Implementing such a business model in Kenya would however be dependent on regulations and political will.

4.6.3 Supply-side financing

To encourage adoption of clean cooking technologies in lower middle-income and low-income households, both in urban and rural areas, the government and international funding agencies have explored RBF as a way to incentivise the delivery of outcomes through financial rewards. In Kenya, the RBF framework has been primarily coordinated by the EnDev Programme through project hosts and implementers such as GIZ, SNV, Hivos and, most recently, CLASP. RBFs have previously been used to stimulate diffusion of solar technology and deployment of mini-grids: e.g. the EnDev RBF on Solar PV Hybrid Mini-Grids and the EnDev Pico PV RBF. Programmes with a cooking dimension that used this approach include the Kenya Higher Tier Cookstoves Market Acceleration project funded by DFID through the EnDev Programme (which has supported 20 companies), the Africa Biogas Partnership Programme (ABPP) and KOSAP. In these programmes, the objective is to lower market entry barriers associated with clean cooking. Beneficiary organisations pre-finance activities to lower market barriers, and incentives are paid upon verification that the end-user indeed purchased the cookstove or, in the case of the ABPP, the bio-digester is constructed. These programmes have promised significant reductions in CO2 emissions, and high numbers of deployed clean cookstoves and households reached.

The programmes have achieved some successes. For instance, the EnDev Higher Tier Cookstoves RBF programme attained its target by supplying 81,347 stoves. According to reporting from the ABPP, 65,000 bio-digesters were installed in the five ABPP countries including Kenya, and 65,000 rural and peri-urban households got access to clean energy for cooking. However, data on sustained use at the household level are lacking. Respondents in our interviews further indicated that some elements in the design of these programmes were problematic. First, there are high barriers to participation as the projects do not finance capital and inventory costs. Thus, start-ups and small enterprises are in effect locked out from participating. KOSAP2 amended this by incorporating ex-ante support for supply chain development and inventory. Second, in KOSAP, the expected costs of entering the markets in marginalised counties, which turned out to be quite significant, were not factored into the programme design. Because of this oversight, counties require investments from highly capitalised businesses as they need to conduct costly campaigns to encourage appliance-adoption and behaviour change. Third, the process of verification of end-users has proved to be challenging, as reported by the implementing partner SNV. Most beneficiary enterprises do not have highly developed IT systems to facilitate tracking of end-users, and there is potential for fraud.

In an attempt to mitigate some of these issues, CLASP deployed a new EnDev-funded e-cooking-focused RBF programme that enables beneficiary enterprises to access funding ex-ante. It also does not limit the targeted geographical scope, and neither does it set a minimum threshold on the number of stoves or appliances to be sold in a given region. The programme is still at the inception stage, but results may demonstrate further programme design improvements that may work for e-cooking market development activities.

4.6.4 Barriers in the supply chain

As demand for e-cooking appliances such as EPCs rises, there is an increasingly acute shortage of devices on the market. First, as reported by various respondents, only a few brands of EPCs are available in Kenya: Von HotPoint and Sayona. As indicated by Jikoni Magic and Bidhaa Sasa, based on their market activities, most consumers prefer rotary dial brands, namely Sayona, which so far is the only available rotary dial brand in Kenya. Sayona EPCs are imported from China by a limited number of importers, the largest being Nagoya Holdings Ltd. Because EPCs have been slow-moving products in retail stores, they have usually been imported in low quantities. As demand at the retail level has begun to rise, it has been difficult for retailers to convince importers to order larger consignments of the appliances. As one entrepreneur observed, importers would rather fill their containers with television sets than EPCs. Consequently, there is an extreme shortage in the market, and companies have begun to look for sourcing possibilities elsewhere in the region.

4.6.5 Quality assurance standards

Part of the mission to transition to cleaner cooking technologies is the development and implementation of standards and labelling policies and programmes. According to CLASP, such programmes entail testing of products, establishing performance criteria for efficiency, emissions and safety, and awareness creation (CLASP, 2017). As indicated earlier, Kenya has two testing laboratories: one at the KIRDI and one at the University of Nairobi. KIRDI is reported to be lacking technical capacity and reliable equipment and, as a result, testing new appliances often faces delays, and sometimes test results are not accurate. Due to this, manufacturers sometimes opt to take their appliances to the University of Nairobi, which, apart from faster turn-around times, is flexible in doing field tests. Manufacturers also occasionally prefer to engage testing laboratories abroad to be assured of the quality of the tests and the reliability of the reports.

There have been discussions on the need to develop localised standards that take into account contextual factors such as grid instability, and factors around weather (capacity to withstand the direct heat from the tropical sun when cooking outdoors or in hot rural kitchens). Different safety requirements may need to be considered based on preferences such as cooking on the floor level where children can easily come into contact with the appliance, and the need for insulation of covers to avoid burns (which would have the co-benefit of increasing efficiency).

As the product market for e-cooking appliances, especially for EPCs, is young and limited, there is still a lack of market and product performance information on aspects such as quality, the robustness of the appliance to withstand vigorous cooking methods for local foods/dishes such as *ugali* and *mukimo,* reliability in rugged rural kitchens, maintenance and local repair in case of breakage, trustworthiness of warranties offered, sourcing for spare parts, etc. Retailers are generally unwilling to invest funds and effort to test appliances, and they would like to ensure that they are selling quality products to maintain customer loyalty.

4.6.6 Actor attitudes on the trajectory of development around e-cooking

There have been significant investments in the national improved cookstoves market, which is now growing rapidly. Considering that most households in rural areas continue to rely on firewood, this market has yet to reach maturity. Thus, the focus of initiatives by government, development partners, non-governmental organisations and by advocacy groups remains on diffusing improved cookstoves in the medium-term.

Practical Action has argued that the bottom-tier improved cookstoves market is saturated, and that shifts are needed towards advanced biomass, LPG and electricity. The organisation projects that, by the year 2030, 17% of Kenyan households will be using electricity for cooking (Practical Action, 2017). Other industry actors are more sceptical, seeing mass adoption of e-cooking before 2030 as overly ambitious. Therefore, actors such as the government and development partners allocate practically no resources directly for e-cooking. There is more confidence from the private sector where enterprises are willing to experiment with electric pressure cookers. Where available, these actors have received grant funding from a development partner such as UK Aid (indirectly through the MECS Programme).

Kenya is viewed favourably by foreign and local actors as having a conducive environment for innovation. There is political will among policymakers and regulatory authorities in Kenya who remain tolerant of experimentation and potentially risky developments, just as they did during the development of the mobile money innovation M-Pesa and subsequent mobile phone-based PAYGO models that have been adopted in the e-cooking domain. Consequently, foreign investors have been attracted to the clean cooking space, and there are speculations that Kenya may lead the way in East Africa in developing breakthrough technologies and business models for e-cooking.

5 Socio-technical innovation system analysis and discussion

5.1 Actors, networks and central technologies

Fundamental to an innovation system is the network of actors centred around the technology of interest. Judging by the actor-network depicted in Figure 3, the e-cooking socio-technical innovation system in Kenya would appear to be relatively strong, considering it is still only nascent. A range of actors is present in the system – policymakers, researchers, private firms, NGOs, funders, and others – but many are not yet active in e-cooking; rather, they hold an interest in the notion but are not yet ready to invest beyond monitoring developments in the market and wider system, especially private sector actors (with some notable exceptions). As such, the e-cooking innovation system in Kenya could be said to possess a promising actor-network but is constituted only by a small core of dedicated players (as shown in Figure 4), with the MECS Programme being perhaps its central actor.

An important characteristic of an innovation system's actor-network is the nature of the relationships between its actors. At the level of awareness, there is evidence from our Pinnsmapping that interested and active e-cooking players know about the existence of each other, at least to some extent. Deeper and stronger relationships, however, are more fragmented across the network. In the appliance supply chain, for example, there are well-established connections through which a variety of electrical cooking appliances moves, from importers and distributors through to retailers and to customers. But the supply chain is focussed on servicing the urban wealthy and middle class who are perceived to be the main – perhaps only – customers willing and able to buy electrical cooking appliances such as EPCs. Market demand for these products seems to be growing, perhaps beyond the wealthy and middle class, but this 'signal' has not been picked up by importers who, instead, prefer to import products such as TVs for which market demand is more certain.

Actor-network relationships appear to be strong amongst some NGOs, development partners and government departments, all of whom have been interested and active in promoting cleaner cookstoves for many years to reduce both the demand for biomass and household indoor air pollution. Some of these actors are now becoming more interested in e-cooking but have not yet committed resources to its development and promotion. Perhaps because they have been active for so long in promoting cleaner cookstoves, their interest in e-cooking appears to be focussed on promoting electrical cooking appliances and not on development of the many other dimensions of the e-cooking socio-technical innovation system.

A striking characteristic emerging from our research is the weak relationships between most private sector actors engaged in the e-cooking space, on the one hand, and public and third sector actors on the other hand. In general, the relationships that go beyond public and third sector actors are those with specialist e-cooking private sector players: e.g. BURN seems to have strong relations with public and third sector actors. Moreover, the specialist private sector actors seem to be poorly connected to the rest of the retail supply chain, preferring instead to develop their own supply networks. The strongest relationships in the active e-cooking innovation system seem to be those between the MECS Programme and its Challenge Fund grant holders.

Some of the Challenge Fund projects are looking beyond technologies[22]. For example, projects include an e-cooking jobs census, an effort to promote "smart cooking solutions" that might connect directly with social practices, and development of a PAYGO business model. But the other four Challenge Fund projects listed on the MECS website seem to be focussed on appliances. Technology projects are certainly needed, and there may have to be many more in order both to experiment with technical solutions and to develop a range of appliances to match different user preferences, but there may also need to be many more projects aimed at other dimensions of the innovation system (e.g. actor-relations, policy environment, social practices, narratives, etc.). Furthermore, it is likely that each project will need to include a variety of stakeholders rather than one actor. Multi-stakeholder projects would serve several innovation system-building needs beyond finding technical solutions and generating market intelligence. For example, they could help to build stronger relations in actor-networks, expand the networks, draw in resources, develop broader capabilities and facilitate the circulation of learning. The benefits of learning would also be strengthened if projects report publicly and disseminate actively and widely. And there is potential in some of the other existing clean cooking or energy projects in Kenya to develop a sharper focus on e-cooking and to enrol a wider range of actors into the nascent networks, but this will require careful preparation if these projects are to do more than develop or finance technologies.

5.2 Social practices and narratives

It is unclear the extent to which e-cooking actors have engaged with the cultural dimensions of cooking[23] in Kenya. Jikoni Magic is probably the best example of where this may be happening as Agnes Kalyonge, who runs the company, is highly motivated to promote Kenyan cuisine and to work with e-cooking appliances in her social media and other demonstration efforts. Cooking demonstrations via the TV reality series *Shamba ShapeUp* and via Kenya Power's *Pika na Power* programme are other examples. These efforts may be more powerful than others for raising awareness and demand, assuming that a female Kenyan demonstrating how to make the best use of electrical appliances would act as a strong role model in the deeply gendered domain of household cooking. Other more information-based efforts to persuade householders to change behaviours may be less effective, even if there are clearly evidenced efficiency, cost and health benefits to be enjoyed from a switch to electric cooking. Jikoni Magic is reaching thousands of Kenyans over social media, but the poor in rural areas may not figure strongly among those reached. Still, it may be possible to extend Jikoni Magic's approach to more people through various media and demonstration campaigns, with Shamba ShapeUp being the best exemplar as it reaches upwards of 11 million people across Kenya.

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[22] See the MECS Programme website for profiles of the Challenge Fund award holders: https://mecs.org.uk/challenge/ (accessed 28 June 2020)

[23] BURN Manufacturing claim to design and test their products in close consultation with users – see their website https://burnstoves.com/ (accessed 1 August 2020) – but we have not seen an independent source evaluating this claim so are unable to say with confidence the extent to which this process engages with the cultural dimensions of cooking.

To support such campaigns, it will be important to develop a strong narrative that resonates with ordinary Kenyans. At present, to the extent that any narrative is in play, it is focussed on primarily ‘technical’ characteristics or outcomes of electric cooking practice: e.g. efficiency, cost, quality, and health outcomes. These are attractive to policymakers and development actors. They may also be attractive to ordinary Kenyans, but it is an open question whether they will be enough to persuade people to invest in the necessary appliances, assuming they have access to enough electricity for cooking, and the new skills needed for their use. This brings us to the importance of gaining a deep understanding of cooking practices, not just cooking behaviours. Behaviours form only one element of the practice concept, which connects behaviours co-productively with skills and meanings (Cherunya et al., 2020). Electric cooking, with EPCs for example, disrupts behaviours and needs new skills. If together these changes disrupt the cultural meaning of cooking, there is a chance electric cooking could fail unless the new meaning is itself attractive. Understanding what meanings could be attractive, and how they could fit with changed behaviours and new skills, could be a good way of developing a powerful narrative that appeals to ordinary Kenyans, both male and female.

5.3 Policy narratives and enabling environment

Another important feature of narratives is what they reveal about the way actors understand the system in which they are trying to intervene. Judging by the policy statements on cooking, and much of the effort of others in the clean cooking space (not just e-cooking), the ‘system’ they appear to imagine is comprised of a set of technical challenges. Solutions then centre on technical fixes: improved technologies, better standards, more information, the right finance, and so on. Without doubt, these are important elements of the system, even if it is only conceived in traditional innovation system terms. However, they are not sufficient. Other elements must be understood, and they will need appropriate interventions. For example, while it is clear there is effort to build some local capabilities – especially in manufacturing of EPCs and in servicing market demand through improved business models, amongst others – there seems to be little effort to address the lack of technical support needed for repair and maintenance of appliances or recycling and waste management. Some of these other capabilities may already exist but it would be better to research the extent to which they do and thus be able to address the potential lack of capabilities in a structured way that meets any growth in electric cooking.

In effect, solutions to the challenges facing the ‘system’, as that term is understood by many in the clean cooking space, seem to be to create an enabling environment for entrepreneurs and leave development to the market, albeit under the supervision of a regulatory regime. But this approach is unlikely to work quickly or effectively, given that the e-cooking socio-technical innovation system is nascent and characterised by a range of uncertainties. Promoting the development of an innovation system such as this will require much more active intervention from the public sector. At present, this activism appears only to be coming from development partners through their funded projects: e.g. the MECS Programme and the EnDev Programme. Policy in Kenya needs to be more explicitly proactive on e-cooking. The specifics of such policy can be developed from the experience of others in promoting new technologies, practices and innovation systems. As elaborated elsewhere, for example, much could be learned from the Lighting Africa project (e.g. see Ockwell et al., 2019) and the efforts of key actors more generally in solar PV in Kenya (e.g. see Ockwell & Byrne, 2017).

These key actors worked over time to 'build' the solar PV socio-technical innovation system we now see in Kenya and so this is why Ockwell and Byrne (2017) refer to them as socio-technical innovation system builders. Their building activities were varied and many, where they intervened on the multiple dimensions of the solar PV innovation system in often small piecemeal projects funded by donors. Examples of their interventions include designing and implementing technology projects together with other actors. One successful example was achieved while working with a Kenyan battery manufacturer to develop a 'solar battery' – a modified car battery that could withstand a deeper daily discharge and so be more sustainable in SHSs. Other battery manufacturers followed suit once they saw the market success of this battery, and the manufacturer who was involved in the project went on to become a major PV supplier in Kenya. But these system builders also intervened in other ways, including experimenting with solar PV microfinance models (largely unsuccessfully, but important for generating learning about microfinance), conducting policy development workshops that challenged – and, it is claimed, influenced – the official energy policymaking process, researching the ways in which SHSs were being used in households (and publishing the results), training various PV actors (vendors and technicians), publishing a renewable-energies focussed regional periodical, and much more. In addition, the Lighting Africa project, which with about USD 6 million was much better funded then the earlier system builders, conducted an expensive countrywide awareness raising programme to promote solar lanterns and ran several international industry conferences. There is no space here to elaborate on all the activities these system builders conducted (instead, see Ockwell et al., 2019; Ockwell & Byrne, 2017 for more), but the activities could be an important reference for how MECS strengthens its e-cooking efforts in Kenya.

5.4 Summary

In summary, whilst there are encouraging signs the e-cooking socio-technical innovation system in Kenya is developing in positive ways, there are many actions needed to strengthen it. The actor-networks are currently small and fragmented and consist of a much smaller core that is actively engaged with e-cooking, where the core consists of those connected with the MECS Programme. There is a lot of focus on technologies, which is important, but less on other dimensions or aspects of the innovation system. Many of these dimensions will need to be developed in tandem with those already receiving attention. One way to achieve broader intervention impacts is to implement multi-stakeholder projects – perhaps as a complement to the Challenge Fund projects, which are implemented by individual actors. This will help broaden the networks, draw in more resources, develop a wider set of capabilities, strengthen actor relationships throughout the innovation system, and facilitate the circulation of learning. Such projects could work on technologies, finance, supply chains, policy (including standards and regulations), social practices, market intelligence, raising awareness, demonstrations, media campaigns, and others.

To realise these kinds of projects, it will likely be necessary to establish a dedicated coordinating actor. ACTS has begun to build a community of practice around clean cooking (not just e-cooking) in Kenya, starting with online (because of Covid-19) stakeholder engagements. But this kind of forum, while needed, is insufficient to nurture the innovation system. Much more activist interventions will be necessary, working on the full set of innovation system dimensions (see the recommendations in the final section for more about these). In the absence of such an actor, the choice and nature of projects will be ad hoc, and the chances of learning beyond project boundaries will be severely limited. Moreover, the endeavour to promote e-cooking will need a constituency of support comprised of a diversity of actors who can develop a shared identity and strong narrative. A dedicated coordinating actor can foster these kinds of developments, provided the actor is sufficiently resourced and is able to focus their activities on the needs of the innovation system over a period of years. This role may be too much for the MECS Programme itself to fulfil, although it could be considered the de facto coordinating actor at present. But the MECS Programme is already active in many countries and must oversee the activities of many project partners so it is unlikely that it could also manage an intensive country-focussed set of projects and other actions as suggested here. It may be better to identify an existing Kenyan actor – ACTS is perhaps a good candidate, but others may also be appropriate – who could take on such a role or begin developing such an actor in-country.

6 Recommendations for the MECS Programme

It should be clear from our findings that the socio-technical innovation system emerging around e-cooking in Kenya is developing in broadly positive ways. With the help of a range of stakeholders, we have been able to identify an encouraging number of actors who have a strong interest in e-cooking and there are some market signals that EPCs are starting to be taken seriously as an attractive technology that can facilitate cheaper, more efficient and healthier cooking practice outcomes. But the number of players actively engaged with e-cooking is much smaller than the network of those who only express an interest at this time, and the 'core' network is somewhat fragmented at present. Although there are several policies in place that could help nurture the development of the e-cooking socio-technical innovation system, none is explicitly focussed on e-cooking and so there are no specific policy instruments to foster the practice. Moreover, the policy orientation seems closely aligned with free market philosophy, which is not conducive to the creation of new markets or the nurturing of innovation systems. As demonstrated in much of the innovation studies literature, including that concerned with socio-technical transformation, such efforts require active public sector interventions over long periods of time.

We can, therefore, offer a range of recommendations at this stage in our research for further nurturing the nascent socio-technical innovation system around e-cooking in Kenya. However, readers should take note of the caveat that we will be conducting further research to understand how the current innovation system has evolved and, based on this, we should in time be able to say more about how to develop a strong e-cooking socio-technical innovation system in Kenya. It may be the case that we are unaware of some of the MECS Programme's intended activities and so it is possible that it is already implementing, or planning to implement, some or all of our recommendations. We offer our recommendations even if this is the case.

1. **Broaden and grow the actor-network in the e-cooking socio-technical innovation system**

   It is clear that only a small core of actors is currently promoting e-cooking in Kenya. A larger number of actors is interested in the practice but each one has yet to commit resources to e-cooking's development and promotion. MECS needs to continue to advocate for e-cooking among these interested actors and to recruit them to the core of active players. A pertinent example is existing development partners and NGOs who have a long history in the Improved cookstove (ICS) sector and have developed networks, capabilities and infrastructure at the local level. So far, it is not clear whether MECS deliberately intends to build on the work done in the ICS sector or to create an independent e-cooking socio-technical innovation system and, in our opinion, this question warrants further exploration. Doing so will help to bring a diversity of experiences and perspectives to the work of the MECS Programme, draw in resources of various kinds – including financial, human and political resources – and build a broad constituency of support for e-cooking. Furthermore, while building the actor-network, it will be important to work across the spectrum of Kenyan society: i.e. to draw in actors at community and local levels as much as policy actors, development partners and the private sector.

   One effective 'tool' for recruiting actors to the nascent innovation system would be a powerful narrative. MECS is already well advanced with such a narrative in the case of development partners and, potentially, policymakers. This is based around what we might call traditional development indicators such as cost, efficiency and health outcomes. An additional element, of interest to policymakers, would be the national economic and industrialisation benefits of locally-manufactured e-cooking appliances, but this has not yet been incorporated into the narrative. Although this 'development' narrative is well advanced, a narrative that is appealing to ordinary Kenyans is less clear. We suggest that such a narrative could be developed from much more focussed research on cooking and related practices as enacted in Kenyan households (and we say more about this in our third recommendation) that goes beyond the cooking diaries framework. This research would seek to understand the sensemaking around cooking practices, the legitimacy of the existing cooking fuels and technologies, and the social structures that reinforce current ways of cooking. We emphasise that this research needs to use the full social practice theoretical lens if it is to be useful, not just focus on cooking behaviours (although it is important to understand these as well).

These narratives can be strengthened with the emergence of more evidence, and this will help to persuade more actors to join the innovation system network. As they join, and as they themselves adopt the narratives, they will become advocates for e-cooking, further spreading the narratives and further recruiting actors to the network. Also, with more and increasingly robust evidence, more actors will be persuaded to commit resources to promoting e-cooking, which should expand the number of e-cooking projects and bolster the evidence gathering needed to continue the cycle of network recruitment. MECS can drive this process initially, especially by supporting a diverse set of projects that each includes actors from different sectors including, where possible, communities. We say more about such projects below in our third recommendation.

2. **Strengthen and deepen the relations between and among the innovation system's actors**

Merely connecting a diversity of actors together will be insufficient to nurture the socio-technical innovation system. The relationships between these various actors must be strengthened and deepened. Insights can be drawn from niche theory (as mentioned in Section 2.1), which emphasises the importance of setting and aligning shared visions, fostering experimentation-based learning on the possibilities and constraints of novel technologies, and developing an actor-network that involves users (Raven, 2005). This will help to engender mutual understanding and trust, spawn new working relationships, and generate crucial learning that is more likely to flow easily around the network.

As with the previous recommendation on enhancing the innovation system networks, one method to enable the strengthening and deepening of relations is the implementation of a range of project interventions, and we provide more specific information on this in the third recommendation. But, in addition to implementing projects, MECS can work with its in-country partners to organise events that bring actors together to discuss issues in the e-cooking domain[24]. One of these issues is the current

[24] We are grateful to Jon Leary for the suggestions about events and projects that include actors from both the clean cooking and energy access innovation systems.

separation of the energy access and clean cooking agendas and the bulk of their respective networks or, more specifically in our terminology, socio-technical innovation systems. The e-cooking innovation system can learn from these two fields as well as help to bring them together for common cause. In this vein, deeper learning and relationship building could be fostered by including a mix of clean cooking and energy access actors in the same projects. Again, we say more on projects in our third recommendation, to which we now turn.

3. **Broaden the range of interventions and understandings beyond technologies and finance**

It is unlikely that developing technologies, business models and gathering market intelligence will suffice to successfully promote e-cooking in Kenya, and certainly not to build a well-functioning socio-technical innovation system. Developing technologies and business models, and gathering market intelligence, are important elements and so support for them needs to continue. However, along with strengthening and deepening the actor-network and actor-relations around e-cooking, as we recommend above, a broader range of project interventions must be supported. In effect, projects need to work on the full set of elements that constitutes the innovation system, along with how these elements interdepend.

For example, the promotion of EPCs purposively disrupts the well-established cooking practices that contribute to the current mainstream 'dirty' cooking socio-technical innovation system. Deep understanding of these well-established cooking practices – in the fullest sense of the practice concept – could elicit important insights for easing the transition from 'dirty' to 'clean' cooking by suggesting in what ways currently dominant practices might accommodate new practices. Part of this easing process could be to identify a positive EPC narrative that is convincing to ordinary Kenyans, as we argue in Section 5.2 and discuss in our first recommendation above. In support of this, projects could, for example, focus on understanding dominant cooking practices as well as working with ordinary citizens to understand how EPCs are disruptive and what is attractive or unattractive about the new practices that would need to be adopted. But, again, we should emphasise that this is about the practice concept in its fullest sense, not just in terms of behaviours.

Some of this kind of work has started: e.g. MECS research with cooking diaries, although this is primarily about cooking behaviours, and its choice modelling work to elicit perceptions of electric cooking. The publication of the Kenya eCookBook and MECS' work with Shamba Shape Up represent steps towards direct influence over cooking behaviours. But the meaning dimension of cooking and related practices is only emerging. This aspect of the understanding of e-cooking needs much more systematic research to build a robust evidence base, which should include 'testing' of the meanings that such research reveals. Testing could take the form, for example, of incorporating identified meanings into awareness raising campaigns such as those conducted by Lighting Africa. These were events run across Kenya that were akin to the kinds of marketing mobile phone companies use: colourful stage shows with music and giveaways. At the same time, in Lighting Africa's case, solar lantern companies and microfinance representatives were present, and the technologies were on display for customers to try. Those who wanted to buy lanterns were able to do so immediately, or they could begin the process of securing a microfinance agreement to do so.

Beyond practices, other projects could explore what policy changes are needed to foster development of the innovation system, not just policies focussed on market growth (such as reduced tax rates, awareness raising, accurate technical information, and so on, important though these are). This does not only mean desk-based research to survey the policy environment at the national level, as we have done for Section 3. It should also mean conducting focussed research within projects that seek to test new practices, for example, where the current policy environment may be found to impede progress. And identifying what changes need to be made to the policy environment would be strengthened by understanding the extent to which the 'dirty' cooking socio-technical innovation system could prevent (or at least resist) the promotion of e-cooking. In line with the socio-technical transitions literature mentioned in Section 2.1, this would mean understanding the dirty cooking regime. Alternatively, or in addition to understanding the regime, political economy analysis of dirty cooking could be helpful.

Other interventions could focus on strengthening the supply chains and still others on building the range of technical capabilities available in-country, including for local manufacture of e-cooking appliances. Furthermore, especially to help strengthen actor-relations, such projects should be multi-stakeholder wherever possible, looking to include a diversity of actors who each can contribute to the projects and who may be affected by them. These kinds of projects could also be useful for bringing together actors from energy access and clean cooking, drawing on their respective knowledges and capabilities but building new knowledge and capabilities specific to e-cooking. The Challenge Fund could be an effective vehicle for incentivising these kinds of projects[25] by stipulating, for example, that projects establish new relationships across the two fields – clean cooking and electricity access – so as to generate new learning. These projects could be focussed on technologies but they could also focus on understanding what lessons need to be brought from the two fields into the e-cooking domain – whether technical or more broadly 'social' – amongst many other possibilities.

4. **Establish a dedicated coordinating actor to help build the innovation system**

As we observe in our characterisation in Section 4.4 of actor-relations in the e-cooking socio-technical innovation system, and as we argue in our analysis in Section 5, there is a need to establish a well-resourced coordinating actor dedicated to several 'innovation system building' activities. These activities include creating a forum in which the full diversity of actors in the e-cooking innovation system can meet to discuss issues of relevance to the system's development, which would be a platform from which actors can access up-to date information on existing stakeholders, ongoing projects and collaborations. The e-cooking innovation system is currently quite opaque, and there is information asymmetry even within the small e-cooking actor network largely composed of MECS-funded initiatives. Our respondents pointed to the lack of information on 'who is doing what' and

[25] Again, we are grateful to Jon Leary for this suggestion.

where, how to source EPCs, and the outcomes of laboratory efficiency, safety and quality tests of EPCs. ACTS has begun to perform this role and so we will see in time how it develops. But a coordinating actor could also perform activities aligned with implementing the recommendations we suggest above on innovation system building: i.e. building and strengthening the network and actor-relations in a dynamic way, and broadening the range of interventions and understandings. As can be seen from experiences in solar PV in Kenya and Tanzania, and as summarised in Section 5.3, such builders can be highly effective in nurturing a system to become a well-functioning socio-technical innovation system (Byrne, 2011; Ockwell et al., 2019; Ockwell & Byrne, 2017).

The MECS Programme is performing this role at present but is unlikely to be able to continue doing so for the long term as it already has many project partners and projects active in many countries. Our recommendation is, therefore, that MECS begin looking to establish a local dedicated actor to perform the innovation system builder role and to seek funding appropriate to its implementation over a period of many years. We should add, however, that the specific activities this actor should implement will depend on learning carefully from similar experiences elsewhere and translating those experiences to the cooking domain in Kenya. The experience of Lighting Africa is one model from which to learn but others may also be helpful, and translating lessons from the experiences in one practice domain (e.g. lighting) to cooking is not necessarily straightforward (Ockwell et al., 2019). So, while research into the experiences of others will be helpful, the implementation of lessons learned in experiments in e-cooking in Kenya would need to proceed reflexively so as to adjust activities over time.

ACTS' role providing a forum for discussion is only the start. Much more active work needs to be performed by whoever is the innovation system building actor (or actors). We have given some examples of the kind of active work needed, some of which MECS has already initiated but not all, and some of what MECS has initiated could be deepened. This work will likely require significant and long-term resources – Lighting Africa spent about USD 6 million in its Kenya interventions – and a system building actor who has the capabilities to develop interventions strategically while learning reflexively during implementation to adjust what it does. These are challenging observations but it is clear that e-cooking already has a useful base from which to build a well-functioning socio-technical innovation system in Kenya.

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Annex I: Interview guide for organisations in the Pinnsmap

[Name of organisation]

SECTION A. General questions

1. About the respondent
   a) Name
   b) Role/designation in the organisation
   c) No. of years worked in current organisation
   d) No of years worked in the energy sector; e-cooking subsector
   e) Previous organisations and roles on those organisations (related to energy and cooking)

2. About the organisation
   a) When did the organization start work on energy?
   b) What is the scope of work done by [the organisation] in the country in the energy sector? What are the focus areas of the organisation?
   c) Involvement in e-cooking:
      i) When did the organisation first get involved in the cooking sector?
      ii) Which departments are involved in projects or initiatives in the e-cooking sector? How large are those departments?
      iii) Does the organisation do any research and development (R&D)/ in e-cooking?
      iv) List and describe the organisation's independent projects on e-cooking (chronologically)
      v) List and describe the organisation's multi-partner/multi-stakeholder projects on e-cooking
         (1) When did it start? Ongoing? Has it ended? When?
         (2) Which partners does the organisation work with in these projects?
         (3) What stimulated the formation of the partnership/ project? e.g. which events, new policies/policy changes, opportunities, etc?
         (4) What were the objectives of the partnership/interaction?
         (5) What technology(ies) was (were) being focused on in the project/partnership?
         (6) What were the achievements of the project? Successes and failures in the interaction?
         (7) Was there any resistance within the project/partnership?
         (8) What were the lessons learned?
         (9) Next steps
      vi) Beyond the projects above, what activities has the organisation engaged in to advocate/lobby for e-cooking diffusion and adoption?

vii) What other factors in the operating environment have influenced the development of e-cooking projects/initiatives/partnerships in the organisations? e.g. specific events, policies, opportunities, technological developments, etc.

SECTION B. Specific questions (based on the Pinnsmap)

- Show the printed Pinnsmap to the respondent
- Probe the respondent to respond to their organisation's position on the map, the identified partners, and description of interactions
  If there are interactions in the map that were not mentioned in Section A, part 2, move on to question 3 below.

3. Please expound further on this organisation's relationship with:
   [Point out the previously omitted organisations that interact with the respondent, and probe further based on the specifics of that interaction. The questions below would help pre-empt some answers on the relationship on the Pinnsmap]

   Example for GIZ

   a) <u>Chamas</u> to create a platform to reach potential customers for piloting trials:
      i) Tell us more about the piloting trials.
      ii) To what extend has this platform worked?
      iii) Which cooking technologies were being piloted?

   b) <u>SACCOS</u> to achieve gender mainstream access to clean cooking
      i) Which SACCOS has GIZ worked with? Since when?
      ii) Which aspects of clean cooking are covered in this initiative? Which e-cooking technologies were involved?
      iii) What is the model of the relationship with SACCOs?
      iv) What is gender mainstreaming in this context important?
      v) Has this approach been successful?

   c) <u>HIVOs</u> (innovation funds) to generate possible funding for consumers doing the pilot
      i) Is this the same pilot with chamas?
      ii) Who provides the funding?
      iii) Which e-cooking technologies were involved?
      iv) Has GIZ – HIVOs collaboration been successful in generating this funding? How?

   d) <u>SNV</u> to promote and pilot e-cooking in refugee camps

i) When did this partnership begin? In which projects?
ii) Which refugee camps have been targeted in this partnership?
iii) Which e-cooking technologies were involved?
iv) What approach is used to promote e-cooking in refugee camps?
v) How successful is the approach used?

e) Clean Cooking Alliance to lobby for clean cooking internationally
   i) Describe the nature of the lobbying efforts with the CCA
   ii) To what extend has the partnership been successful?

f) EED had received funding from GIZ to lobby for clean cooking and e-cooking
   i) What specific project received this funding? When?
   ii) What were the goals of the project? Who was being lobbied?
   iii) What are the achievements of the project?

SECTION C. The bigger picture

1. To the best of your knowledge, is the rest of the map accurate? Are there stakeholders or players that are key to e-cooking in Kenya that were left out of the map?
2. Are the interactions between the players captured accurately? Do you know of collaborations that are not highlighted within the map?
3. Which actors on the map are the most powerful? What is their influence?
4. Which actors are creating resistance in the development of e-cooking in Kenya?
5. Which ones have potential to influence the map (the e-cooking innovation system) significantly in the future?
6. What are your thoughts on the trajectory of the e-cooking innovation system in Kenya?
7. What role has policy /government played in e-cooking, beyond rhetoric?
8. What other elements of the operating environment or context are missing on the map?

Follow-up

9. Do you have partner organizations or contact persons working in e-cooking in Rwanda and/or Tanzania?
10. Who else can you recommend that we speak to for a richer understanding of e-cooking?

Annex II: List of organisations and persons interviewed

Organization	Name of Representative	Designation
Bidhaa Sasa	Rocio Perez	Cofounder and Director
Burn Manufacturing	Jessie Press-Williams	Design Engineer
	Phoebe Oriama	Electronics Engineer
CLASP	Sam Grant	Director Clean Energy Access
	James Wakaba	East Africa Director
	Hannah Blair	Communications Associate
	Monica Wambui	Associate
EED Advisory	Murefu Barasa	Managing Partner
	Ruth Gichuhi	Senior Associate
	Martin Kitetu	Senior Associate
GIZ	Anna Ingwe	Component Leader Energy
Hivos	Kevin Gikonyo	Social Entrepreneurship Lead
Jikoni Magic	Agnes Kalyonge	CEO and founder
KPLC Pika na Power	Wairimu Njehia	Manager
Ministry of Energy	Myra Mukulu	Technical Advisor on Cookstoves, KOSAP
Pereybere Energy	Dr Evan Wanjiru	Cofounder
	Dr Charles Kagiri	Cofounder
Practical Action	Jechonia Kitala	Manager
SCODE	John Maina	Director
SNV	Irene Mutisya	RBF Cookstove Project Assistant
	Fredrick Amariati	RBF Consultant
Strathmore Energy Research Center	Anne Wacera Wambugu	Quality Manager
SunCulture	Charles Nichols	Cofounder and CTO
	Max Garnick	Product Manager
University of Nairobi	Dr Jacob Kithinji	Associate Professor, Department of Chemistry