# Transforming access to clean technology: Learning from Lighting Africa

David Ockwell, Rob Byrne, Victoria Chengo, Elsie Onsongo, Jacob Fodio Todd and Joanes Atela

STEPS centre

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# Contents

# Acronyms

| | |
|---|---|
| AMDA | Africa Minigrid Developers Association |
| BOP | Bottom of the Pyramid |
| CCA | Clean Cooking Alliance |
| CDM | Clean Development Mechanism |
| DFID | UK Department for International Development |
| EEG | Energy for Economic Growth |
| EnDev | Energising Development |
| ESMAP | Energy Sector Management Assistance Program |
| GIZ | German Agency for International Cooperation (*Deutsche Gesellschaft für Internationale Zusammenarbeit*) |
| GOGLA | Global Off-Grid Lighting Association |
| IDA | International Development Association |
| IEA | International Energy Agency |
| IFC | International Finance Corporation |
| KEREA | Kenya Renewable Energy Association |
| LEIA | Low Energy Inclusive Appliances |
| LPG | Liquid Petroleum Gas |
| MDB | Multilateral Development Bank |
| MECS | Modern Energy Cooking Services |
| MFI | Microfinance Institution |
| NGO | Non-Governmental Organisation |

| | |
|---|---|
| OECD | Organisation for Economic Cooperation and Development |
| PAYG | Pay-As-You-Go |
| PV | Photovoltaic |
| PVMTI | Photovoltaic Market Transformation Initiative |
| R&D | Research and Development |
| SACCO | Savings and Credit Cooperative |
| SDG | Sustainable Development Goal |
| SE4All | The UN's Sustainable Energy for All initiative |
| SHS | Solar Home System |
| SNM | Strategic Niche Management |
| SPL | Solar Portable Lantern |
| SSA | Sub-Saharan Africa |
| TEA | Transforming Energy Access |
| UNIDO | United Nations Industrial Development Organisation |
| UON | University of Nairobi |
| VAT | Value Added Tax |
| WHO | World Health Organisation |

# Abstract

UK AID has recently invested in a new £39.8 million programme that aims to transform access to modern energy cooking services, or MECS, in Africa and Asia. In this working paper we demonstrate how reframing our understanding of how transformations happen in access to clean energy technologies, foregrounding the social and the political, together with more sophisticated, systemic understandings of how sustained technological change and innovation occurs, can increase the chances of transformative change that is environmentally sustainable and socially just. This moves beyond the largely unsuccessful track record of past interventions that tended to focus only on technology hardware and finance.

The working paper analyses the case of Lighting Africa, which successfully transformed access to solar lighting in Kenya and, as far as we are aware, conceptualises and illustrates for the first time Lighting Africa's approach. This builds on past STEPS research that focusses on building sociotechnical innovation systems.

The paper then compares the existing and planned activities of the MECS Programme in order to facilitate learning looking forward. This analysis is assisted by consideration of the important ways in which cooking as an energy service, and its related social practices, differs from lighting. It is also assisted by analysis of some critical social justice and political dimensions that were not explicitly addressed by Lighting Africa.

As well as making substantive recommendations for the future operation of this £39.8 million programme of research and delivery, the working paper provides a useful illustration of how the STEPS Pathways Approach can contribute to applied analyses of policy and practice.

**Keywords:** clean cooking, Kenya, modern energy cooking services, sociotechnical transitions, solar lighting, Lighting Africa

# 1 Introduction

1.8 billion people have access to electricity but still cook with biomass. Load shedding, weak grids, affordability of electricity, accessibility of liquid petroleum gas (LPG), tradition, perceptions, and a lack of suitable cooking appliances all act as barriers to scaling up the use of electricity or gas for cooking – clean cooking. Increasing electricity access via renewable energy generation is becoming more affordable and opening new windows of opportunity. New business models and smart monitoring are improving the reliability of LPG distribution, appliances can be made more energy efficient but still cook favourite foods so they taste right, and cooking with electricity is becoming increasingly affordable with issues of reliability and sustainability being overcome.

Building on these opportunities and the generation of new knowledge, the Modern Energy Cooking Services (MECS) Programme aims to break out of business-as-usual approaches and rapidly accelerate the transition from biomass to clean cooking on a global scale (see Batchelor *et al.* 2019 for a more detailed overview of MECS).[1]

But, while less than 1 billion people now lack access to electricity worldwide, 2.7 billion people still lack access to clean cooking (IEA 2017). Creating the conditions under which 35 per cent of the global population switch to using clean cooking technologies requires nothing short of a transformation, demanding changes in social practices, global, national and local production and supply chains, innovation practices, finance models and so on. The fact that the majority of these 2.7 billion people live in poor countries, many with fragile livelihoods and in economies where the innovation systems that support clean technology uptake are weak or nonexistent, further underscores the transformative nature of the MECS Programme's ambitions.

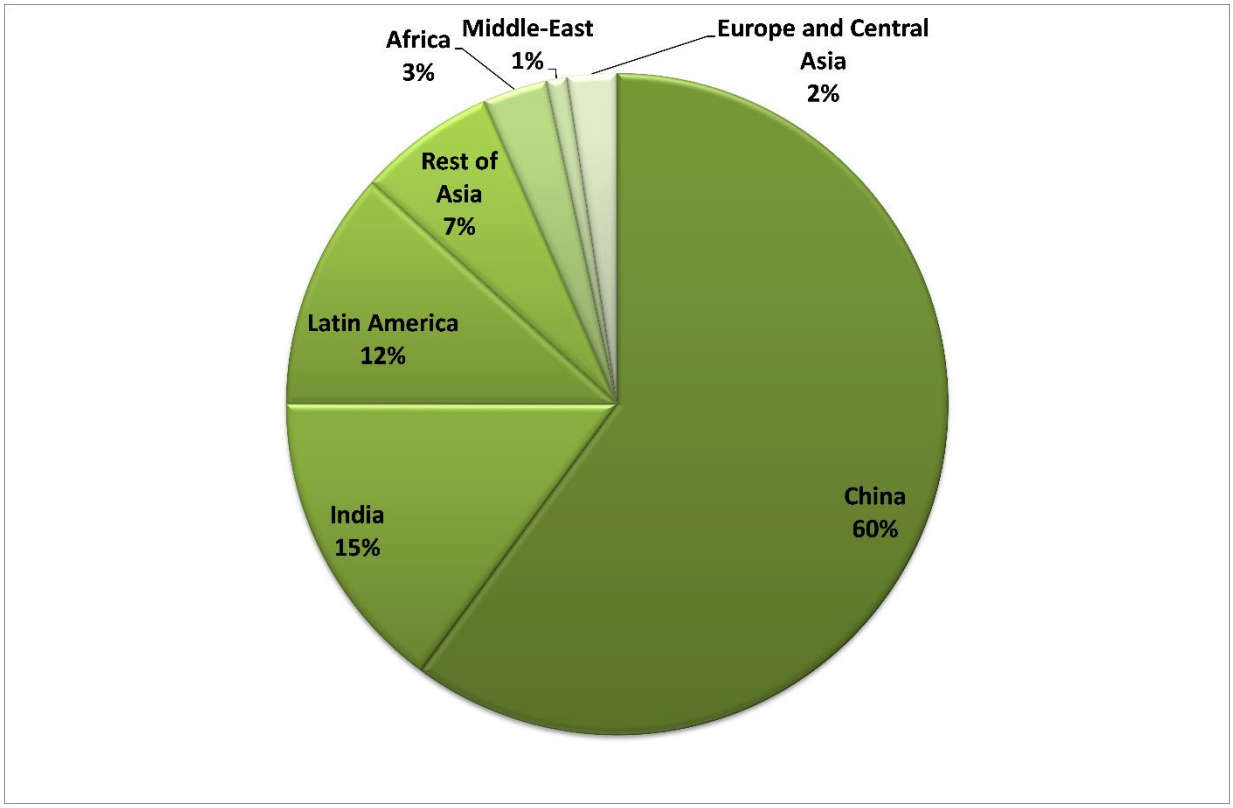
Such ambitions are, however, not new. For example, the Clean Development Mechanism (CDM – one of the delivery mechanisms under the Kyoto Protocol), was widely viewed at its inception as the right approach to transforming access to clean technologies in developing countries, whilst simultaneously allowing developed countries to meet their climate commitments. As illustrated by Figure 1.1, however, by January 2015, 60 per cent of cumulative investment under the CDM had gone to China and 15 per cent to India. Africa as a whole had accumulated only 3 per cent, including investment in the richer economies of South and Northern Africa (Ockwell and Byrne 2016). Sub-Saharan African countries outside of South Africa had hardly benefitted at all. And where countries across the Global South had accrued investment, none of this had gone into what might be considered 'new' clean technologies. Some people might react to such figures as being reasonable, given the higher aggregate emissions of China and India. As illustrated in Figure 1.2, however, even when the figures are expressed as cumulative investment under the CDM per tonne of carbon emitted, we see that Africa as a whole leveraged only about one third that of India, China or Mexico and less than a quarter the investment of Brazil.

In this working paper we utilise the STEPS Pathways Approach (Leach *et al.* 2010) to illustrate how attending to the framing of schemes like the CDM can help us understand why only certain actors seem to gain from such interventions. In simple terms, the Pathways Approach casts aside the idea of a single and normatively 'good' pathway or route to sustainable development, and emphasises the need to remain open to multiple alternative development pathways that countries and communities might pursue. This is particularly vital in the context of the complex, interrelated challenges resulting from the need to address poverty whilst simultaneously dealing with other (often competing) priorities such as climate change, environmental integrity, job creation, economic growth and social justice. Most fundamentally, the Pathways Approach recognises that who you are shapes how you 'frame' – or understand – a problem or opportunity, and that – alongside powerful interests and technological

[1] The MECS website also has a wealth of information and resources, see www.mecs.org.uk.

trajectories – these understandings have a tendency to focus on specific development pathways favoured by powerful groups to the neglect of alternative perspectives. Or they might simply represent the received wisdom (Leach and Mearns 1996) of donors or government agencies, failing to appreciate the realities of a problem from the perspective of poor households or national firms.

*Figure 1.1:* Accumulated Investment Shares Through the Clean Development Mechanism, January 2015



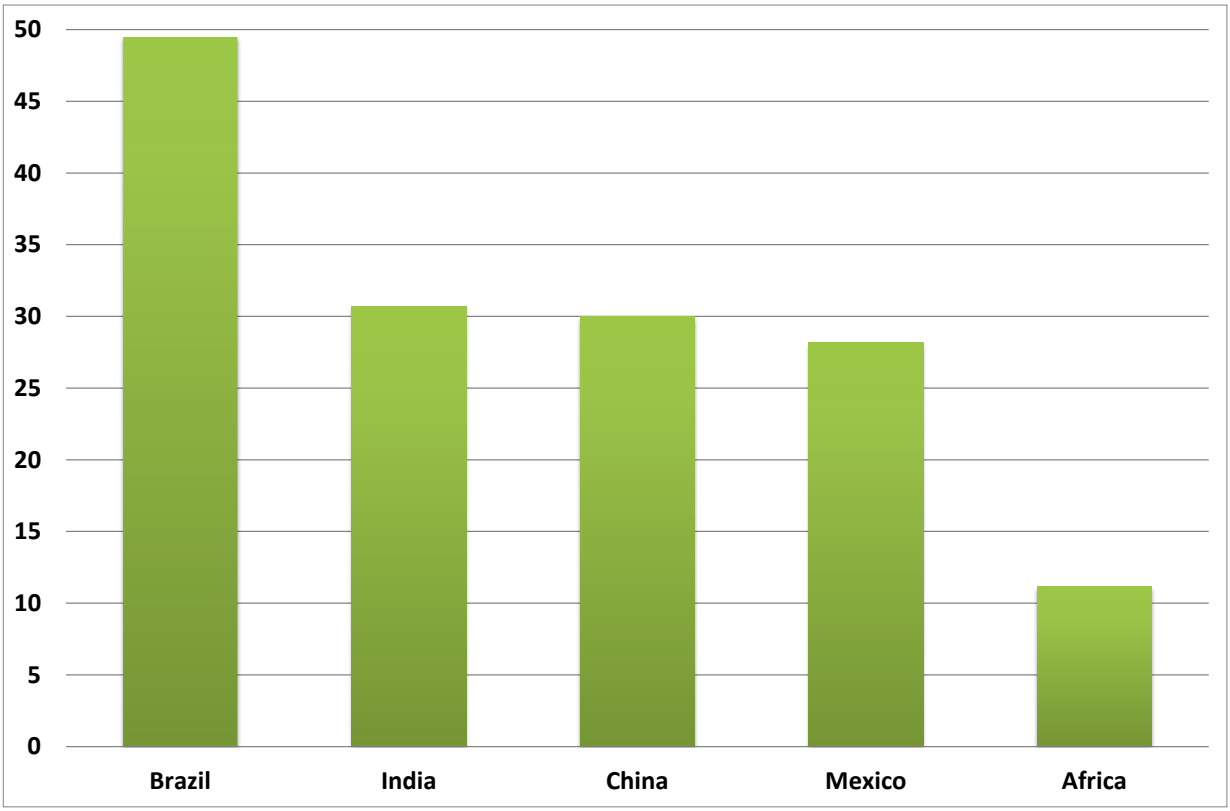

Source: Authors, based on http://www.cdmpipeline.org/

For instance, a poor household, a solar home systems vendor, a member of parliament, a multilateral development bank (MDB) and a multinational business might all frame the benefits, costs and risks of modern energy cooking services in different ways. Those various framings will lead to different narratives being told about clean cooking's role in development and different choices being made about the value of clean cooking technologies, including where, to whom and via what specific variance of the different business models that are now proliferating such values can be leveraged. These considerations apply equally whether considering approaches to providing access to clean cooking in rural villages, or models for brokering international deals with multinational companies for building large-scale programmes to scale up access to different clean cooking technologies, and their attendant services in different contexts. At all levels, critical questions need to be asked about the distribution of benefits: who gains, who loses, and how can this be changed to better deliver against the self-defined development needs of poor and marginalised people and poor countries more broadly (Scoones 2016)?

Clearly, as we have seen from the figures above, supposedly neutral clean technology finance mechanisms like the CDM have far from neutral impacts in reality. And such failures are not limited to the CDM. Examples abound elsewhere. Like, for example, the Photovoltaic Market Transformations Initiative (PVMTI) in Kenya, which had US$5 million in 1998 to attempt to transform the solar PV market in Kenya. Taking a 'hardware financing' approach similar to the CDM, in six years the PVMTI only managed to fund 170 new solar home systems (SHSs) in a country that is estimated to have had around 200,000 installed SHSs by 2005 rising to an estimated 320,000 by 2010 (Ondraczek 2013). This was

hardly a transformative outcome. Similar critiques have been levelled at the PVMTI's 'hardware financing' approach in other countries, such as India (Haum 2012).

*Figure 1.2:* Accumulated Investment Through the Clean Development Mechanism, USD per Tonne of CO2 Emitted, January 2015




Source: Authors, based on http://www.cdmpipeline.org/

This raises the question as to why, despite billions of dollars invested, an intervention like the CDM has failed to transform access to clean technologies. The clear answer emerging from contemporary research, particularly in the field of energy and development, is that mechanisms like the CDM (and the PVMTI and many others) erroneously understand the problem of access to clean technology in developing countries as one of 'hardware financing'. This characterises the problem as poor people requiring access to clean technological hardware; and producers and consumers needing access to finance to manufacture, supply and buy this hardware.

**But this two-dimensional understanding of the problem ignores three other critical dimensions that are fundamental to whether or not transformative uptake of clean technologies in developing countries is likely.** The first dimension it ignores is the sociocultural practices of potential technology users (i.e. poor people). These practices are definitive of whether or not technologies will meet intended users' needs and therefore whether or not they will be adopted. The second dimension is a sophisticated understanding of processes of innovation and technological change, which are definitive of whether firms and other key actors in developing countries are able to work with these technologies and create viable businesses and supply chains around them that serve the needs of poor people. And the third ignored dimension is the politics and political economy dimension that defines the extent to which countries and communities are able and willing to move away from existing, dominant regimes of energy practices, which are often closely aligned to the interests of powerful elites at different levels, from the global, to the national and the local.

For interventions to be able to transform access to clean cooking (or any other) technologies in developing countries, then, it is vital that they are able to intervene across these five dimensions (the conventional two dimensions of finance and technology hardware, plus the three additional dimensions articulated above), rather than repeating the mistakes of previous two-dimensional approaches. There are, however, examples of interventions that, whether deliberately or by luck, have indeed taken a five-dimensional approach to transforming access to clean technologies in developing countries. In line with MECS' transformative ambitions, this working paper therefore aims to learn from such past examples where something resembling transformations in poor people's access to clean technologies in low-income countries has been achieved. In particular, it seeks to operationalise the insights gained from the most comprehensive historical analysis undertaken to date on the reasons for the remarkable success of the off-grid solar PV market in Kenya (a market where per capita uptake of off-grid solar PV technologies is surpassed only by China) (see Ockwell and Byrne 2017). This research led to the development of a new conceptual framework than can inform policies and programmes with transformative ambitions around access to clean technologies in developing countries. The framework is known as 'sociotechnical innovation system building' and is described in more detail in Sections 3 to 5 of this working paper. For now, it is sufficient to say that a sociotechnical innovation system building approach enables interventions to go beyond past two-dimensional 'hardware financing' approaches and attend to all five dimensions necessary to transform access to clean technologies in developing countries.

This research also identified an example where successful sociotechnical innovation system building had been achieved in practice (with transformative effects), via deliberate, programmatic intervention, similar to the intended transformative intervention that characterises the MECS Programme. This example is that of Lighting Africa's efforts to transform access to clean lighting in Kenya. Lighting Africa transformed the market for solar lanterns in Kenya from an estimated 29,000 lamps in 2009 to one where 680,000 Lighting Africa certified lamps had been sold in Kenya by the end of the programme in 2013 (and that may have only represented around 30 per cent of the total market) (Castalia Strategic Advisors 2014: 85). The economic rate of return on Lighting Africa's investment is estimated to be plausibly as high as 2,000 per cent (Castalia Strategic Advisors 2014: 85).

As will become clear as this working paper progresses, a fundamental reason for the success of Lighting Africa was the fact that it started by trying to understand the sociocultural practices and self-defined lighting needs of poor people in Sub-Saharan Africa (SSA). It simultaneously engaged with producers and other actors along the supply chain to understand their needs and capabilities and match them with consumer needs, consistently communicating between consumers, producers and the supply chain as the programme progressed and the market blossomed. At the same time, Lighting Africa accompanied its work with significant efforts to bring on board different actors, including political elites, with the vision of transforming access to clean lighting for poor people in Kenya and worked directly with policymakers to address potential regulatory and broader strategic policy issues.

On the basis of our analysis of Lighting Africa and the conceptual insights from our broader research on the off-grid solar PV market in Kenya – itself informed by previous work in Tanzania, India, China and Malaysia (see Ockwell *et al.* 2008; Ockwell *et al.* 2010; Byrne 2011; Ockwell and Mallett 2012; Hansen and Ockwell 2014; Watson *et al.* 2015) – this working paper presents the results of new analysis. This new analysis revisited the data that underpinned our previous research on solar PV in Kenya, as well as collecting new data, in an effort to understand what the MECS Programme can learn from Lighting Africa's work in Kenya. Importantly, the analysis also considered the differences between cooking and lighting as energy services that intersect with both the everyday realities of poor people's social practices and the technological capabilities of production and supply chains in low-income countries. This combined analysis was then used to develop a framework to assess the implementation plan of the MECS Programme and assist it in realising its transformative ambitions around clean cooking in Africa and Asia.

The paper proceeds as follows: Section 2 sets out the methodology; Sections 3, 4 and 5 set out the conceptual bases for the analysis; Section 6 describes and analyses the activities of Lighting Africa in Kenya; Section 7 conceptualises and illustrates the Lighting Africa approach in a way that can inform MECS' work; Section 8 highlights a number of issues that were not explicitly addressed by Lighting Africa but, nonetheless, are fundamental considerations for any intervention that aims to transform poor people's access to clean technologies; Section 9 analyses the differences between lighting and cooking as energy services, providing a basis through which MECS' learning from Lighting Africa can be tempered; Section 10 then compares Lighting Africa's approach with the planned activities of MECS, providing a basis for reflection and learning. Finally, Section 11 draws some overarching conclusions.

# 2 Methodology

This study aimed to draw lessons for the MECS Programme from previous research conducted on how Lighting Africa transformed the market for solar lighting in Kenya, and to develop a draft delivery framework for MECS with which to achieve similar market transformation in the clean cooking sector.

We considered Lighting Africa to be an appropriate case study for this analysis because it is the closest example we have seen to date of sociotechnical innovation system building that has transformed poor women and men's access to clean energy technologies.

The analysis was originally proposed to focus on existing data collated by the authors on Lighting Africa within the broader context of understanding the history and success of the off-grid solar PV market in Kenya (see Byrne *et al.* 2014; Ockwell and Byrne 2017). This material consisted of data presented in 15 pieces of publicly available grey literature on Lighting Africa as well as two stakeholder workshops and over 100 hours of recorded interview testimony.

An additional analytical step was for the authors to think through the ways in which cooking as an energy service implied different considerations than lighting. Although not originally proposed, this analytical step was augmented in two ways:

1. By analysing publicly available material from the Clean Cooking Alliance (CCA) and conducting an interview with one of their key personnel. The latter data also allowed analysis of any CCA activities that mirror those of Lighting Africa.

2. By running a brainstorming workshop with Dr Helene Ahlborg of Chalmers University, Sweden, to elicit additional expert input on the implications of sociocultural differences in cooking versus lighting as an energy service. This drew on the extensive work that Ahlborg and her team have done on the uptake of technologies by poor women and men within understandings of the context in which technology users have to manage their daily lives, particularly in vulnerable, dynamic spaces (as often characterise rural areas in low-income countries).

Although not originally proposed, the authors also took additional steps to ensure that the data they previously published on Lighting Africa in 2017 were not out of date. This was ensured in two ways:

1. By identifying any new academic publications that had appeared since 2017 (when the previous research was published). This was done by searching Science Direct for the terms 'Lighting Africa' and 'Lighting Global'. The search yielded no results.

2. By conducting two new interviews with key people involved in the setting up and running of Lighting Africa from the outset (interviewees from the World Bank and the International Finance Corporation, IFC).

These data were then used to conceptualise and graphically illustrate – for the first time, as far as we are aware – a framework capturing the key components of the sociotechnical innovation system that Lighting Africa focussed on building and strengthening around solar lighting in Kenya. It also identified the key processes that Lighting Africa undertook to achieve this.

Finally, once the framework had been developed based on the previous methodological steps, the following final steps were taken:

1. Analysing the existing activities of the MECS Programme, based on the documentation available to us, and the extent to which these mirror the strategic actions of Lighting Africa.

2. Analysing any knowledge gaps that need to be filled by subsequent research under MECS.

3. Giving the managers of MECS the opportunity to reflect on this analysis and to flag any recent actions under the Programme that were either not captured in the available documentation, or that were captured but missed by the authors.

# 3 Innovation systems

The next three sections of this working paper provide the building blocks for understanding how 'sociotechnical innovation system building' can transform access to clean cooking technologies in developing countries. To do so, we break the concept down into two halves. In this section, we explain the relevance of innovation systems and, in Section 4, we explain the relevance of a sociotechnical transitions perspective.

After that, the final conceptual section of this working paper (Section 5) explains how these two conceptual fields come together to constitute a 'sociotechnical innovation systems' perspective; a perspective that is able to deal with all five dimensions of relevance to transforming access to clean technologies in developing countries. It therefore goes beyond the traditional 'hardware financing' framing of the problem and takes us towards a more transformative basis for interventions aimed at increasing access to clean cooking in low-income countries.

## *3.1 What is 'Innovation' and Why is it Relevant to Transforming Clean Technology Uptake in Low-income Countries?*

The first point to emphasise is that, as highlighted in the Organisation for Economic Cooperation and Development (OECD) Oslo Manual (OECD and Eurostat 2005), 'innovation' is not the same thing as 'invention', although the two terms are often used synonymously. Invention implies things that are new to the world. Innovation, on the other hand, can include invention, but also covers a broad spectrum of other changes. This includes incremental improvements to existing technologies as well as adaptations of existing technologies to make them suitable for new contexts. It is these latter two types of innovation that are usually most relevant in low-income country contexts.

Incremental changes (e.g. increased efficiency) can add up to significant improvements over time, as Barnett (1990: 543) observes:

> [M]uch of the increase in productivity in industrialized countries is achieved through the aggregation of myriads of minor changes to existing production processes (rather than from individual massive jumps in productivity through investment in new vintages of technology).

Adaptive innovations, on the other hand, could include changing an existing gas stove to run on biogas. Or rice cookers might be adapted to use 12-volt electricity sources, drawing on batteries charged via

solar home systems. Another example is the many adaptive innovations that have been made to mobile phone handsets being sold to poor consumers in Kenya. Foster and Heeks (2013: 343) describe the innovation responses of Chinese mobile handset firms to suggestions from Kenyan intermediaries working close to low-income consumers for modifications to handsets:

> [Innovations included] dual sim card phones (allowing users to choose the lower-cost network to phone particular contacts), translation of the phone interface into Swahili, and addition of a single-button-enabled new interface for the popular M-Pesa mobile money service.

Innovation can also apply to new processes as much as to new pieces of technology hardware. For example, a farmer adopting new soil tilling techniques to reduce rainwater run-off is being innovative. Similarly, a firm is innovating by adopting a more efficient production process for the first time, even where other firms in that sector (or other sectors, or countries) have already adopted that process.

When we speak of 'innovation systems' below, therefore, we are not speaking only about systems within which invention is nurtured, although it can be. Rather, most importantly, we are also talking about the adoption and adaptation of existing clean technologies in new contexts.

### *3.2 What are Innovation Systems?*

It is important to remember that when we consider transforming access to clean cooking technologies in countries where these technologies are not yet widespread, what we are effectively considering is a process of significant technological change, with accompanying social changes as a result of new technology use. Levels of technology ownership in different countries are also directly correlated with levels of economic wealth, thus emphasising the close relationship between technological change and economic development.

The broad technological change that characterises new technology uptake encompasses myriad actors within a specific country context, from consumers who might buy and use clean cooking technologies, to vendors attempting to source and sell them in often remote contexts characterised by vulnerable livelihoods and seasonally variable, uncertain economic conditions. It also encompasses other actors along the supply chain, all the way to producers attempting to develop appropriate and affordable clean cooking technologies, importers of technologies and technology components, and so on.

The concept of innovation systems emerged in the 1990s to better explain the success of different countries in achieving economic development – success that conventional economic theory was unable to explain (e.g. Freeman 1997; Lundvall 1992). These innovation studies scholars, through detailed empirical analysis, demonstrated that the missing link in conventional economic theory was its inability to account for different countries' capabilities to innovate and achieve technological change. More importantly, they drew attention to the fundamental importance of well-functioning 'innovation systems' in defining countries' abilities to achieve the kinds of innovation and technological change that could explain economic development.

Innovation systems refer to the network of actors (firms, universities, research institutes, government departments, non-governmental organisations – NGOs, technology users, including poor and marginalised women and men) within which innovation and technological change occurs, and the strength and nature of the relationships between them. The stronger these relationships are, the greater the technological capabilities of any given clean technology sector in any given country. Such technological capabilities exist on a spectrum from basic productive capabilities (where firms can produce or work with clean technologies), through to innovative capabilities (where firms have the capabilities to adapt or improve existing, or create new, technologies).

Where innovation systems are weak or nonexistent around specific types of technologies (e.g. electric cooking technologies or biogas digesters), as they often are in developing (and particularly low-income) countries, technology availability and uptake is highly unlikely. By focussing on building and strengthening innovation systems around specific technologies, however, transformative results can be achieved. Such results include widespread uptake of clean energy technologies. This flags an important point for consideration in seeking to promote access to MECS, focussing on the extent of development of relevant innovation systems.

The innovation system perspective is well grounded in decades of empirical research. For example, it has been used to explain the technological change and associated economic development observed across many developing country sectors (e.g. the Korean steel industry, the Kenya off-grid solar PV market and various clean technology sectors in China and India), and countries as a whole (e.g. the Asian tiger economies). It is equally able to explain the success of OECD economies (OECD 1997).

### *3.3 Building Innovation Systems to Transform Clean Technology Uptake: A Gardening Analogy*

To make the relevance of innovation systems clearer, we can use the analogy of a garden. Technological capabilities are like soil in a garden. Without initial efforts to nurture the soil's fertility, scattering seeds (bits of technology hardware) is unlikely to lead to a flourishing garden (technological change and development). Moreover, commercial gardening contractors (technology investors) are unlikely to invest effort in sowing seeds in unfertile gardens in the first place – the required context for sowing seeds and nurturing and harvesting plants is absent and investors can see that their investments are likely to fail.

Within this analogy, innovation systems can be understood as the gardens, or the broader ecosystems, within which fertile soil is to be nurtured. They provide the context within which all processes of technology development, transfer and uptake occur. And, like any ecosystem, the resilience and productivity of innovation systems rely on all critical components (or actors) being present to fulfil their roles, which, in turn, requires all actors to be connected, working symbiotically to nurture technology transfer, development and uptake.

This analogy also draws our focus to the potential role of key actors, or 'innovation system builders', actors akin to the gardeners who are committed to nurturing the health of the innovation ecosystem. With the right approach, as demonstrated in the highly successful case of the Kenya off-grid solar PV market and by Lighting Africa's transformation of the solar lighting market in Kenya (Ockwell and Byrne 2017), such innovation system builders can intervene to build and strengthen innovation systems around specific clean technologies, including clean cooking technologies. And through this they can, in line with the aspirations of programmes like MECS, transform access to these technologies for people in developing countries. In this sense, MECS can be considered to be the gardeners, working on the fertility of the soil around key MECS technologies (e.g. e-cooking), to speed up the transition towards uptake of MECS.

### *3.4 Summary: Why is Building Innovation Systems Critical to Transforming Uptake of Clean Cooking Technologies in Low-income Countries?*

A number of points of relevance to the MECS Programme emerge from the discussion above. These include:

1. Innovation systems provide the context within which all processes of technological change (including technology transfer, development and uptake) occur.

2. Innovation systems consist of the network of actors (e.g. firms, universities, research institutes, government departments, NGOs, citizens) within which innovation and technological change occurs, and the strength and nature of the relationships between them.

3. The development of strong innovation systems around technologies can explain many existing success stories (e.g. the Korean steel industry, China's success with key low carbon energy technologies, off-grid solar PV in Kenya and Lighting Africa's success in transforming the market for solar lighting).

4. Developing countries, and low-income countries in particular, are often characterised by weak or non-existent innovation systems, particularly around new technologies, including the clean cooking technologies that are the focus of the MECS Programme.

5. It is possible for key actors to play the role of 'innovation system builders' and through this transform access to clean technologies.

Despite these insights, however, before we can properly understand the success of innovation system builders like Lighting Africa, we first need to take a step further than the traditional innovation systems literature takes us. This involves moving beyond the firm-centred focus of most of the innovation systems literature to consider how clean cooking technologies and broader processes of transformative technological change intersect directly with the lived realities and social practices of poor and marginalised women and men. To do this, in the next section, we consider some key insights from the sociotechnical transitions literature – a literature that allows us to bring the social aspects of technological change to fore.

# 4 A Sociotechnical Perspective on Technological Change

## *4.1 Putting the Social into Technological Change*

As emphasised above, a key weakness of an innovation systems perspective on how processes of technological change (like transforming access to clean cooking technologies) takes place, is its failure to account for the social aspects of such change. By this we mean the everyday, lived experiences and needs of the women and men in low-income countries whom it is assumed will adopt these new technologies. These everyday realities are, however, a critical consideration. Unless new clean cooking technologies can easily fulfil the function of existing cooking technologies, or are able in some way to 'stretch' and disrupt existing practices (think, for example, of uptake of mobile phones and mobile money in Sub-Saharan Africa), they are highly unlikely to be adopted. Moreover, in order for people to spend money on a new cooking technology, they must perceive either a material improvement in their experience of cooking (or their lives in general) as a result of the new technology, or a cost saving over time, or both.

A key way that these everyday realities of potential technology users can be accounted for is by focussing on the 'social practices' that any given technology aims to facilitate. So, for clean cooking technologies, these social practices would be cooking and eating. And these social practices will interact directly with other social practices, such as commuting to work (e.g. by a new cooking technology reducing cooking times), or opportunities for women to socialise whilst collecting wood. For clean lighting, relevant social practices include reading, or doing housework, schoolwork, or paid work after dark, as well as cooking after dark. For mobile phones, social practices would include communication and broader connectivity with others, for either social or economic purposes. And so on.

The field of sociotechnical transitions studies has emerged in direct response to this need to foreground the social as much as the technical in understanding the likelihood of widespread transitions towards the adoption of cleaner technologies. Sociotechnical transitions theory recognises that social and technical changes tend to co-evolve, often resulting in societies becoming locked into the use of certain technologies, making it hard for niches of new technologies to compete with established, dominant sociotechnical regimes (e.g. see Berkhout *et al*. 2010; Byrne 2011; Geels 2002; Geels and Schot 2007;

Raven 2005; Rip and Kemp 1998; Smith 2007; Smith *et al*. 2010). A classic example of a dominant sociotechnical regime is the use of the internal combustion engine for facilitating the social practice of personal mobility. Here it is not just the technology that matters. It is also the social practices of users, who have developed preferences for the freedom of mobility that cars can facilitate. Moreover, as our social practices around personal mobility have co-evolved with the development of the internal combustion engine, so too have our social norms, the hard infrastructures that facilitate these (i.e. roads, towns and traffic control systems built for cars rather than buses or bicycles), and the rules, regulations and formal and informal institutions that govern our mobility practices. This acts to lock us into building and maintaining roads and towns that suit cars rather than bicycles or public transport.

As will become clear below, acknowledging the existence of these dominant sociotechnical regimes and how hard it is for new niches of cleaner technologies to compete with these can provide us with important insights into how policy and practice, or programmes of research and implementation like the MECS Programme, can act in ways that might nurture clean sociotechnical niches to maximise their chances of competing with existing, dirty regimes.

### *4.2 Fitting With, or Stretching, Everyday Cooking Practices of Poor Women and Men*

There are two levels at which the sociotechnical transitions literature offers important insights of relevance to the MECS Programme and other initiatives that seek to increase access to clean technologies. These are:

1. Understanding the extent to which new technologies fit with, or are able to stretch/change, potential technology users' existing social practices (in the case of MECS, their cooking practices).

2. Understanding more broadly how niches of clean technology use might be nurtured so that they can influence, and eventually dominate, the existing, non-clean sociotechnical regime (e.g. in the case of MECS, nurturing pockets of e-cooker use to reach the point where e-cookers become the dominant technology used in any given context, rather than the existing cooking regime which is dominated by woodfuel, charcoal and kerosene).

Let us first unpack the idea of fitting with or stretching existing social practices, before addressing niche-regime dynamics in Section 4.4.

The fit-stretch idea (Hoogma 2000; Raven 2007) refers to whether or not a new technology enables the continuation of the existing social practices of the intended users (fit), or whether the technology enables users to extend their existing practices in a desirable way or creates some desirable outcome unavailable with the 'old' technology (stretch). If a technology 'fits' with existing practices and is affordable, and 'stretches' practices in some way (e.g. it offers an improvement on an existing technology: it is cheaper, more reliable, better for people's health), then the likelihood of people adopting that technology is high. If it does not fit exactly with people's existing practices but offers potential to realise another desirable practice (stretch), the chances of adoption are also high. However, if the technology only fits with existing practices – i.e. the technology is simply a direct replacement – and offers no stretch opportunities then the chances of adoption are relatively low. In other words, there needs to be a clear incentive for people to adopt a new technology (e.g. cost or time savings, increased access to desirable practices).

Let us consider an example to illustrate this. Solar cookers (Figure 4.1) offer a variety of benefits, including reduced needs for biomass collection and lower health-damaging smoke emissions in the home. However, their widespread adoption at the household level is held back because they do not 'fit' well with a number of social and cultural practices prevalent in developing countries. For example, they can only be used during daylight hours, and in the open rather than inside a kitchen. Many subsistence farmers spend daylight hours cultivating their crops. Cooking in the open rather than in an enclosed

space is also a culturally derived 'major deterrent' to the use of solar cookers for some (Sesan 2012).[2] SHSs (Figure 4.2), in contrast, can 'fit' easily into current practices around the use of light, while offering higher-quality lighting than from kerosene lanterns. But SHSs also create opportunities for 'stretching' practices. For example, the small quantities of electricity generated by SHSs can be used to power TV, radio and mobile phones, all attractive because of what Jacobson (2007) calls their 'connective' quality. That is, they enable people to connect to the world beyond their household.

*Figure 4.1:* Solar Cooker

*Figure 4.2*: Solar Home System

Source: Byrne et al (2012)

### *4.3 The Importance of the Fit-Stretch Idea for the MECS Programme*

As illustrated by the example of solar cookers, efforts to promote clean cooking technologies in developing countries are arguably the area of clean technology adoption that has been most prone to failure to date. This failure could be explained as violation of the fit-stretch principle. Strong cultural elements are definitive of cooking practices, practices which differ with culture in myriad ways, making it difficult for single technologies to fit or stretch these practices. Examples abound in the literature of improved cookstoves being distributed to poor households, often free of charge, only to be used as tables or ornaments rather than appliances on which to cook, whilst potential users continue to cook using open fires. This literature stretches back to the late 1970s. For example, Gill (1987: 138-9) describes how stove programmes in villages in a number of countries emphasised fuel economy, whereas the villagers, among other needs, '… were more concerned about being able to cook quickly than about fuel efficiency'. Villagers' other concerns included: versatility, where the stove needs to be able to accept a wide variety of combustible materials; multi-functionality, where the stove may be used for space heating and light (and, indeed, smoke may be *useful* as it deters insects and can cure food); and social and symbolic values that outweigh improved cooking efficiency.

This early literature on improved cookstoves also illustrates how engaging with potential technology users to understand their social practices around cooking can improve the chances of technology uptake. Two approaches to wood-burning stove dissemination projects, cited in Agarwal (1986), illustrate the difference that user participation can make. The first concerns an attempt in the late 1960s in Ghana to replace open fires in household kitchens with more efficient (and cleaner) wood stoves. There had been no interactions with users prior to design of the stoves, a weakness in the project that

[2] It is worth noting that new forms of energy storage may offer one way of tackling at least some of these drawbacks. Several applications to the current MECS Challenge Fund are for experimenting with new storage technologies alongside solar concentrators, which means that cooking can take place inside the house whenever the cook decides, rather than having to cook outside during hours of peak sunshine.

only became apparent much later when it was found by the mid-1970s that many of the stoves originally installed were no longer in use. Agarwal (1986: 77) quotes a vivid description, given by Hoskins (1979: 37), of the effect that the lack of understanding amongst the project implementers of cultural and cooking practices had on the stove design:

> If they had tried cooking in 1½ ft tall kettles, constantly stirring mush for ten people with a large wooden paddle, they would not suggest waist-high wood stoves (unless they also added step-stools), flat bottomed pans (which burn around the edges) and lids (for pots requiring constant stirring). (Agarwal 1986: 77)

There were other problems too. The stove used larger pieces of wood than open fires for which the women had to search further afield, increasing rather than reducing their burdens. And, if the stove was used 'incorrectly' – that is, using loosely fitting pots or not covering all the holes of the stove – it would burn more wood and cause more smoke than an open fire.

By contrast, Agarwal (1986: 83) reports on a more intensively interactive stove design-diffusion approach in north-west India undertaken by the activist and writer Madhu Sarin:

> Each stove, built from local clay, was made user-specific in terms of its location within the kitchen, its size, the cooking routine of the family, the number of potholes, the size of the pots and the overall aesthetics of design. The stove was usually built jointly by Sarin and the female members of the household, with other village women sometimes helping in or observing the process. Modifications were made after the user had utilized the stove for some time and found some aspects unsatisfactory. (Agarwal 1986: 83)

A number of benefits apparently followed this method of 'diffusion'. These included: high acceptance and satisfaction among users, with subsequent informal dissemination among family, friends and neighbours; the development of capabilities to build stoves without the assistance of Sarin; and technical success in terms of less wood burned, as well as increased ability of users to modify and repair stoves themselves.

Importantly, examples of failed cooking interventions are by no means confined to the past. The contemporary literature on clean cooking is rife with similar observations of cooking-based interventions failing to acknowledge and understand the social practices of the people whom it is assumed will adopt clean cooking technologies. For example, in a literature review of 32 recent articles on solar cookers, Iessa *et al.* (2017: 98) observe that:

> Four recurrent types of issues stand out: local needs are often not sufficiently considered, existing cooking and fuelwood practices are seen as obstacles, many articles show a prosolution [*sic*] bias and there is a lack of methodologically sound impact studies.

Again, and again, in the present as much as in the past, peer reviewed studies emerge bemoaning the failure of clean-cooking-based interventions to attend to the social and cultural practices of the poor people whom it is assumed will adopt these new technologies. And again, and again, these cite a lack of attention to poor peoples' sociocultural cooking practices when designing new cooking technologies as being fundamental to their failed uptake (e.g. see, amongst many others, Akintan *et al.* 2018; Malakar *et al.* 2018a; 2018b; Jürisoo *et al.* 2019).

As we will see later in this working paper, the culturally embedded nature of cooking practices, as opposed to, for example, lighting, have fundamental implications for the MECS Programme and the extent to which it can replicate lessons learnt from Lighting Africa. We will also see how MECS, like Lighting Africa, began with an emphasis on social practices surrounding cooking and uses detailed studies on behaviour as the precursor for any technological innovation.

### *4.4 From Clean Cooking Niche to Clean Cooking Regime*

As well as the fundamental insight of the fit-stretch principle, the sociotechnical transitions literature also offers us a broader insight into how new niches of clean technology production and adoption might begin to compete with existing, dominant sociotechnical regimes. In the case of clean cooking, existing regimes are characterised by the use of wood fuel, charcoal and kerosene for cooking. Importantly, the sociotechnical transitions literature draws our attention to how stable these existing regimes of cooking practices are. This is because they have co-evolved over long periods of time with people's cooking practices. And it is not just users' practices that make existing sociotechnical regimes around cooking stable. It is also the interests and practices of actors along the full supply chain, e.g. charcoal producers and vendors, kerosene importers, suppliers and vendors, etc. Clean cooking technologies therefore not only need to fit with or stretch potential users' existing social practices around cooking, they also have to compete with these existing, stable regimes of practices and the myriad political-economic interests that are tied up in existing sociotechnical regimes.

Importantly, as in the example of the internal combustion engine above, a sociotechnical transitions perspective emphasises how the establishment of such regimes of existing practice is the result of the co-evolution of technologies and social practices, which simultaneously involves the development of formal and informal institutions (e.g. policies or social norms). These institutions then act to further stabilise existing sociotechnical regimes (e.g. cooking with solid fuels), creating a powerful inertia against alternatives (e.g. clean cooking technologies).

Usefully, however, in the face of the inertia of existing regimes, the sociotechnical transitions literature also has much to say about how change occurs. It focusses on stable, incumbent sociotechnical regimes, understood as rules (knowledge base, belief systems, mission, strategic orientation) shared by actors within different sectors. In the case of cooking, for example, incumbent regimes would usually refer to wood fuel, charcoal and kerosene dominated production and consumption practices, which might change as a result of:

- the successful management of niches of clean cooking technologies to the extent that they compete with dominant fossil and solid fuel-based regimes (Kemp *et al.* 1998);
- 'landscape level' changes such as widespread changes in social and political demands for clean cooking (Geels 2002); or,
- the destabilisation of incumbent sociotechnical regimes (Turnheim and Geels 2013).

The area that the MECS Programme is most likely to be able to focus on is the first, i.e. attempting to establish and manage niches of new clean cooking technologies to the extent that they can compete with existing regimes of cooking. MECS was initiated with ideas for solar PV electric cooking (Batchelor 2015) and the affordability argument was central to the proposition. However, it has since expanded to include other forms of modern energy. Here, another area of the sociotechnical transitions literature has emerged to respond to exactly this aim. This is the Strategic Niche Management (SNM), or 'Niche Management' field, which has emerged based on myriad empirical studies in both developed and developing country contexts.

A key feature of SNM is that it directs our attention to the co-evolution of actors' expectations about a technology in the future, their learning as they experiment with that technology in real-world settings, the networks of other actors they develop, and the extent to which various sociotechnical practices relevant to that particular technology become embedded in society. These co-evolutionary dynamics are assumed to happen in what amounts to a protective space – the niche – in which the normal pressures of market forces and technical performance are weakened, enabling essential learning to take place (Smith *et al.* 2014). Of course, these dynamics unfold within a broader context, which is conceived as consisting of the various 'regimes' (mainstream, normal or dominant ways of doing things) and a wider 'landscape' (difficult-to-influence changes such as demographics, events such as wars, etc.)

(Romijn *et al.* 2010). Eventually, some niches come to influence regimes over time, and can even replace them entirely.

Understanding the processes of how and where niches have been successful and unsuccessful in influencing regimes therefore raises the potential to understand how the MECS Programme might deliberately intervene to establish and nurture clean cooking niches. Importantly, the niche management literature also emphasises the role that key actors – or 'sociotechnical innovation system builders' (Ockwell and Byrne 2017) as we refer to them in the next section of this working paper – can play in developing a niche, raising the potential for key actors, such as those engaged in the MECS Programme, to emulate the actions of past successful sociotechnical innovation system builders (like Lighting Africa) and achieve broader uptake of clean cooking technologies.

Helpfully, the niche management literature summarises four key processes through which successful niches of clean technologies have been observed to be nurtured in the past. These are:

1. Building networks of diverse stakeholders who work together in projects, programmes and other interventions.
2. Fostering and sharing learning from research and experience.
3. Promoting the development of shared visions amongst stakeholders.
4. Supporting diverse experimentation with technologies and practices.

But action is also needed beyond the niche, such as creating landscape-level pressure on the regime to change its dominant 'sociotechnical' practices. Under such pressure, regime actors might respond by searching for suitable alternative technologies and practices, creating a period of uncertainty that acts like a window of opportunity through which the niche can develop and grow. For example, MECS is working towards changing narratives around social and political demands for cleaner cooking by integrating it more with energy access agendas, and by relating it to the current focus on the challenge of climate change (Batchelor *et al.* 2019). MECS plans to do this by working with Climate Parliament, presenting at the COP25, and working with the UN's Sustainable Energy for All (SE4All) and other high-level policy initiatives. By relating clean cooking narratives to the climate change discussion, MECS will seek to leverage landscape-level calls for reducing greenhouse gas emissions to create a landscape-level pressure on 'dirty' cooking regimes to move away from biomass-based practices.

The aspiration for MECS to combine strategic niche management theory together with landscape-level change is summarised in Batchelor *et al.* (2019), which uses the Stevens framework and draws on Batchelor's previous work with mobile money (Batchelor 2015). The Stevens framework (Stevens 2007) has some parallels with the four focal areas of Strategic Niche Management outlined above. It also calls for networks of diverse stakeholders (Stevens iii), and for a shared learning space (Stevens iv). It restates the shared vision by calling it a reframing of the problem (Stevens ii) – something particularly important for landscape-level changes. By reframing the problem, it claims it is then possible to change perceptions and public opinion (Stevens i). It then talks about influencing strategy and resource allocations.

Building on the insights from the sociotechnical transitions literature above, the next section of this working paper brings them together with the insights on innovation systems summarised in the previous section. This supports the development of a framework through which we can interrogate and make sense of the success of Lighting Africa in transforming uptake of clean lighting technologies in Kenya. This then provides the basis upon which we develop a bespoke implementation framework for the MECS Programme; a framework that is explicitly aligned with MECS' ambition of transforming uptake of clean cooking technologies across the Global South.

# 5 Sociotechnical Innovation System Building to Transform Uptake of Clean Cooking Technologies

The previous two sections of this working paper have demonstrated why well-functioning innovation systems are essential to encourage the production and uptake of new (clean) technologies. This is particularly true in low-income countries where innovation systems are often weak or non-existent. This focusses our attention on '…interconnected firms, (research) organisations and users all operating within [a national] institutional environment that supports the building and strengthening of skills, knowledge and experience, and further enhances the interconnectedness of such players' (Byrne *et al.* 2012: 1).

The previous two sections have also demonstrated why considering social aspects of technological change is at least as important as considering the role of firms and other actors. A sociotechnical understanding of the barriers and enablers of technological change focusses our attention explicitly on: (1) the social practices of potential technology users; (2) the co-evolutionary nature of technological change, innovation and social practices; (3) the extent to which new technologies fit with or stretch existing social practices; and, (4) the competition clean technology niches face from stable, dominant sociotechnical regimes.

In this final conceptual section of the working paper we bring these two areas of thinking together into one overarching framework for understanding how programmes like MECS might seek to foster transformative uptake of new technologies.

## *5.1 Sociotechnical Innovation Systems*

By bridging the two conceptual areas of innovation systems and sociotechnical transitions, based on an in-depth historical analysis of the factors that explain the remarkable success of the off-grid solar PV market in Kenya, Ockwell and Byrne (2017) develop the idea of 'sociotechnical innovation systems'. This provides a more comprehensive definition of the systemic context within which the kinds of transformation in access to clean cooking technologies that the MECS Programme seeks to catalyse might be realised in practice. This hypothesises that transformative changes in the use of clean cooking technologies will be achieved as a result of developing well-functioning sociotechnical innovation systems around specific clean cooking technologies in specific contexts.

Importantly, this new conceptualisation of how transformations in access to clean cooking technologies might be realised can directly answer the critiques summarised in the last section of this working paper around the failure of past clean cooking interventions. The social practices of users are placed in the foreground. The national contexts within which technology production and change occur receive due attention. Issues around the inertia of existing, traditional cooking practices are directly addressed. Traditional 'hardware financing' approaches, as characterised by, for example, the CDM (see Section 1), are transcended, opening up new possibilities for a more systemic, socially and culturally grounded approach to trying to transform access to clean technologies, one firmly rooted in the national realities of low-income countries and the everyday, lived realities of poor women and men. And all of this is placed into a framework for action that articulates a role for deliberate interventions by key actors. These key actors can be understood as 'sociotechnical innovation system builders'. We attend to this in the context of the MECS Programme in the next section.

Before we do so, however, we should reiterate that we are not, for a moment, arguing that finance or technological hardware are not important. Far from it, they are fundamental aspects of well-functioning sociotechnical innovation systems. But they are far from being the only vital components and any

approach that places all the emphasis on finance and hardware is, as demonstrated again and again through the history of analysis of innovation and technological change, doomed to failure.

### *5.2 Sociotechnical Innovation System Building: A Key Role for MECS*

An important insight of relevance to the MECS Programme is that, where examples have emerged in practice, successful sociotechnical innovation systems have been the result of deliberate interventions by key actors. This implies that transformative change in poor people's access to clean cooking technologies can be driven by the efforts of key actors. In this sense, the MECS Programme could seek to play the role of sociotechnical innovation system builder around clean cooking technologies within specific contexts.

Building on this insight, the rest of this working paper focusses on one programmatic intervention that looks like an example of sociotechnical innovation system building in practice. That is the example of Lighting Africa in Kenya, which we move on to describing in the next section.

Before concluding, however, we draw on the previous two conceptual sections of this working paper, as well as the wider literature, to summarise the key actions on which we might expect sociotechnical innovation system builders to focus.

### *5.3 Overarching Goals for Sociotechnical Innovation System Building*

The overall goal must be to build functioning sociotechnical innovation systems that augment the transfer, development and diffusion of clean cooking technologies and related social practices in developing countries, enhancing technological capabilities through a range of targeted interventions. These must be inclusive in their approach – attending to the self-defined needs of those countries and different groups within – if clean cooking technology uptake is to be widespread and underpin future pro-poor, sustainable development pathways. As we will see in the next section, notable in this regard is Lighting Africa, which conducted highly detailed studies of the lighting practices and needs of potential users in Kenya (and elsewhere). This suggests that further gains might be achieved by including users more actively in the design of promising solutions to their needs, rather than merely eliciting users' feedback on products that have already been developed. The overall desired result is to provide protective spaces in which clean cooking technologies and practices can be fostered, thus promoting their broader adoption, adaptation and further innovation.

In order to achieve this, we suggest pursuing four overarching goals to orient interventions. We discuss these in some detail below, and articulate in Table 5.1 a range of specific example interventions for achieving each goal. However, it is important to note that interventions to build sociotechnical innovation systems are deeply interdependent. They are therefore best implemented together in systemic fashion rather than separately.

Goal 1: Build networks of diverse stakeholders

Efforts are required to link diverse arrays of stakeholders, from technology importers and suppliers, through to policymakers and technology users. Such networks enable the flow of knowledge amongst stakeholders, each of whom can bring different resources, experiences and perspectives to bear on problem-framing and problem-solving activities. They can also become a fundamental element of sociotechnical innovation systems by establishing the linkage component of capabilities. But these linkages must be strong and meaningful. In order to achieve this, stakeholders need to work proactively together in projects, programmes and other interventions. In doing so, they are more likely to build mutual trust and understanding, as well as identify strengths and weaknesses in local technological capabilities. Simultaneously, by pursuing such activities, new technological capabilities can be built, including the development of relevant knowledge and skills.

*Table 5.1*: Specific Policies for Delivering Against the Overarching Goals for Developing Sociotechnical Innovation Systems around Clean Cooking

| **Goal 1. Build diverse networks** | **Goal 2. Foster and share learning** | **Goal 3. Promote shared visions** | **Goal 4. Support experimentation** |
|---|---|---|---|
| Link diverse stakeholders locally, nationally and internationally<br><br>Link diverse stakeholders across markets and sectors (private, public, NGO, research, etc.)<br><br>Link 'supply-side' actors with technology users<br><br>Link national government with technical experts<br><br>Link national and international firms | Commission different kinds of research: baseline studies; market research; on technology-user needs, preferences and practices; on technology performance; on education and training needs<br><br>Conduct comparative research across local, national and international scales that addresses the various research foci above<br><br>Monitor and evaluate all interventions, and make results of all research, monitoring and evaluation publicly available<br><br>Create spaces for stakeholders to reflect on research and experiences<br><br>Provide training for firms, suppliers and installers, technology users<br><br>Advise on and develop technology certification schemes<br><br>Advise on education and training needs (up to and including postgraduate training) | Convene consensus building events with different national stakeholder groups<br><br>Convene scenario building events to discuss alternative development pathways that different clean cooking technologies might enable or constrain<br><br>Facilitate opportunities for different stakeholders to feedback into the technology design and configuration processes | Encourage/incentivise treatment of 'failures' as valuable points for learning<br><br>Commission projects as experiments and learning opportunities<br><br>Experiment with technological hardware, production processes, policies, social practices, new stakeholder configurations<br><br>Experiment with linking stakeholders across markets to create new market opportunities and market awareness<br><br>Experiment with value-adding experiments working upwards through value chains |

Source: Adapted from Ockwell and Byrne (2017: 157-8)

Goal 2: Foster and share learning

Learning is critical to the development of technological capabilities and functioning innovation systems, and the resulting successful markets for clean technologies that these can support. A key role for any intervention like MECS lies in commissioning research – whether market research, academic analysis, monitoring and evaluation, baseline studies, R&D and so on – and making sure the results are publicly available. Because contexts evolve in unpredictable ways, incremental innovation supported by reflexive analysis offers a practical strategy to shape development pathways that integrate clean cooking practices. Research at all levels from local to international, and from different perspectives, can provide crucial information to help realise such reflexive change. The public availability of such information can play a fundamental role in reducing perceived risks amongst both potential investors and technology users, as well as enhance the transparency of policy processes. This facilitates clear and evolving understandings of things like: user needs and preferences; appropriate hardware components; relative performance of different technology brands; approaches that have met with success; factors that contributed to difficulties or failures and how to overcome these; training and education needs, and so on. The learning and experience that results can feed into future projects and programmes, whether publicly or privately funded.

Goal 3: Promote the development of shared visions

Linked to the need to build meaningful networks and foster learning, there is the need to create shared visions of what pro-poor access to clean cooking technologies looks like and its relevance in particular contexts, as well as what roles different clean cooking technologies play in those contexts. This is not simply a top-down effort in which clean cooking technology solutions are chosen and then stakeholders are persuaded of their merit through dissemination and awareness-raising activities. Consensus building around the importance of, and opportunities around, clean cooking is critical. Learning from research and experience provides an essential component for constructive debate and is itself enhanced by the flow of knowledge through diverse stakeholder networks. By fostering understandings of what clean cooking technologies can and cannot provide, how they work and the ways others have benefited from them, visions can develop around informed understandings of different technological options. It also affords opportunities for users to provide feedback on both their self-defined needs and their experiences (good and bad) with different technologies. As a result, shared visions develop amongst technology users, suppliers and other stakeholders relating to what and how sustainable energy technologies can underpin different development pathways. This simultaneously provides vital user feedback into both technology design and the configurations and brands that vendors and suppliers provide, with attendant implications for potential market size and profitability.

Goal 4: Support diverse experimentation

Again, linked to learning, funding is needed to provide protected spaces for experimentation with promising clean cooking technologies, practices and policies. Stakeholders throughout the supply chain need to gain experience of technologies and learn what works and what does not within specific contexts (across different countries, regions, villages, technologies, social practices, political contexts etc.). Experimentation can target a range of different aspects. It might, for example, include supporting new multi-stakeholder projects that test and develop ideas. These could relate to new technical configurations, new hardware, new social practices around existing technologies, new consumption and production practices that could improve the benefits accrued by users, and so on. Experiments might also focus on mutually supportive interventions that link different stakeholders across markets, thereby building supply chains and fostering new market opportunities where potential market players lack awareness of each other and/or potential market opportunities they might target. Interventions could also experiment with working ‘upwards’ through value chains, building on existing markets to develop progressively higher-value segments, adding value to existing sectors and fostering increasing economic returns from clean cooking technology initiatives across developing countries.

Having established these core goals of sociotechnical innovation system building, let us now turn to analysing how Lighting Africa achieved this in practice around clean lighting in Kenya.

# 6 Lighting Africa: Transforming Access to Clean Technologies in Kenya

## *6.1 State of the Clean Lighting Market in Sub-Saharan Africa*

The global market for solar portable lanterns (SPLs) sold by affiliates of the Global Off-Grid Lighting Association (GOGLA) was estimated at 5.5 million units in 2018, with East Africa registering about 30 per cent of this total (GOGLA *et al.* 2019: 21, 37). Sales of SPLs by those not affiliated to GOGLA are not easily estimated but could be as much as twice these numbers, suggesting there was a global market of around 15 million SPLs in 2018. This is a remarkably rapid growth story, considering there was little or no market in 2007 when the Lighting Africa Programme got underway. For example, according to Castalia Strategic Advisors (2014: 85), only 29,000 lamps were sold in Kenya in 2009. The extent to which it is possible to attribute these market outcomes to the Lighting Africa Programme and subsequent efforts is arguable, but it is unlikely the SPL market would have grown so rapidly without the Lighting Africa interventions (Ockwell and Byrne 2017). It is therefore instructive to examine the Lighting Africa story in some detail to see what lessons to learn for designing and conducting systemic interventions such as those we argue are needed for achieving transformations in modern energy cooking services, systemic interventions that amount to what we have above called sociotechnical innovation system building. This section provides a brief account of the Lighting Africa story followed in Section 7 by an analysis of its activities and what seem to be the reasons for its success.

## *6.2 Pre-programme Intervention*

Prior to the implementation of Lighting Africa, the IFC spent almost three years consulting with actors in the global lighting industry, building an understanding of their interest in LED-based products for unelectrified populations, the barriers they perceived to preventing the sale of such products, and what the IFC could do to address these barriers (IFC 2007). In the year leading up to the launch of Lighting Africa, the IFC aggressively promoted the programme to lighting companies across the world, with 198 companies signing up to the project by July 2007. In terms of the sociotechnical innovation systems building framework, we can see these actions as the beginning of building networks of diverse stakeholders along with advocacy to develop a shared vision of clean off-grid lighting in Africa.

## *6.3 Lighting Africa Programme*

In September 2007, in collaboration with the World Bank and a range of supporting donors, the IFC launched the Lighting Africa Programme. In collaboration with the World Bank's Development Marketplace initiative specifically, Lighting Africa got underway with a global call for project proposals aimed at developing lighting products and delivery models for Africa's unelectrified off-grid population (Development Marketplace 2007). The hope was that advances in performance of key technologies – especially LEDs – could be harnessed to provide cheaper and better lighting for the consumers at the bottom of the income pyramid (BOP), with the call for proposals offering grants of up to US$200,000 each to projects that would develop new products and delivery models. Here, we see Lighting Africa supporting experimentation, in both technologies and ways to increase access to technologies. More than 400 proposals were received and 16 were funded, the winners being announced at Lighting Africa's first international business conference held in Accra from 6 to 8 May 2008 (Lighting Africa 2008a). This conference marked another significant step in broadening the network of stakeholders working towards clean off-grid lighting, extended further with two more business conferences under the Lighting Africa Programme, one in Nairobi in 2010 and one in Dakar in 2012, during which awards for 'outstanding'

lighting products were given (no further grant competitions were run) (Ockwell and Byrne 2017). Other conferences have taken place since 2012, but these have been run under Lighting Global[3], an affiliate programme of Lighting Africa.

### *6.4 Research Phase*

Alongside the call for proposals, Lighting Africa initiated a research phase to develop detailed understandings of different aspects of the off-grid lighting market in SSA. Nine types of studies were conducted covering consumer lighting preferences and practices, market trends and other market intelligence, supply chain mapping, gender, lighting technologies, and a study of solar lamps in chicken farming in Kenya. A total of nine policy-focussed reports covering eight African countries were also published. For Kenya, by October 2008, there were highly detailed qualitative and quantitative market assessments reporting consumer lighting preferences and practices (Lighting Africa 2008b; 2008c). These studies of consumer preferences and practices were the centrepiece of Lighting Africa's work: the interviewees contacted for this report emphasised the importance of the understanding this research facilitated, with further consumer-focussed work following later (see the next sub-section on the active intervention phase). And, one year later, Johnstone *et al*. (2009) published a baseline study for Lighting Africa of off-grid lighting products available in three Kenyan towns. In October 2010, the first report on the state of the global solar lighting market was published (Dalberg 2010), and the Kenyan policy environment relevant to solar lighting was analysed in a report in March 2011 (summarised in a policy note, see Lighting Africa 2012). Beyond Kenya, similar kinds of studies to those listed above were conducted in Ghana (the other pilot country in Lighting Africa) and six other SSA countries (Castalia Strategic Advisors 2014). From early in the programme, therefore, Lighting Africa had commissioned work that provided a strong basis for understanding the broad contours of sociotechnical innovation systems for off-grid lighting in seven African countries, and more detailed understandings of the lighting practices in the pilot countries Kenya and Ghana.

### *6.5 Active Intervention Phase*

Lighting Africa's more active interventions began in late 2008, starting with a targeted version of the quantitative study that had been conducted earlier the same year. The new quantitative study sought to identify the specific types and designs of lighting products – i.e. lighting product concepts – that were most acceptable to low-income consumers, conducting research for this purpose in November and December 2008 in Ethiopia, Ghana, Kenya, Tanzania, and Zambia (Lighting Africa 2011). A total of 1,500 consumers and traders were interviewed across the five countries. This was followed in April to May 2009 by a qualitative study in which 20 consumers per country were given lighting products to test for five nights in their own homes. Once the consumers had tested one product, they were given another for five nights again, and so on until all consumers had tested all five product types. Ten key insights arose from these studies. Affordability was, perhaps unsurprisingly, the most important concern, but there were also insights around: recharging methods (solar was popular); adequate light intensity (general room lighting was preferred to task lighting, for example); multipurpose lights were preferred (e.g. to light more than one room simultaneously, or to act as either a room light or torch); lights should be portable; lights should be able to stand freely; the battery should last at least five hours; lights need to be easy to use; they should be safe to leave unattended (i.e. present no risk of fire, even when left on overnight); and it should be easy to secure the light and its solar panel (e.g. preference was for a panel to be roof-mountable with a long enough lead to keep the light itself inside while charging). With these studies, Lighting Africa was able to build a strongly evidenced understanding of what we referred to above as the fit-stretch characteristics that lighting products could embody. In connection with understanding preferred product characteristics and functionality, Lighting Africa sought to develop quality assurance standards and in-country capabilities to test the quality of lighting products. The programme worked with global lighting stakeholders, using the feedback the programme had received

[3] See https://www.lightingafrica.org/what-we-do/quality-assurance/ (accessed 11 June 2019).

from the detailed studies of consumer preferences, to develop the standards and, after about two to three years of work, the standards were accepted by the International Electrotechnical Commission, paving the way for the standards to be adopted at the national level (Ockwell and Byrne 2017). In Kenya, Lighting Africa was successful at building basic capabilities for initial screening of new lighting products, working with the University of Nairobi where a screening test facility was established[4] along with training of test technicians.

Other active interventions included business support, facilitation of access to finance on both supply and demand sides of the market, and consumer and policy engagement, while continuing with the networking (e.g. business conferences) and advocacy initiated from before the programme began (when the IFC consulted the global lighting industry). Business support included convening business-to-business workshops, providing training for solar technicians and new supply chain entrants, and funding to encourage manufacturers to develop their own marketing strategies (Castalia Strategic Advisors 2014). The facilitation of supply-side finance entailed consultation with local commercial banks to establish finance for distributors of quality-assured lights, and with international banks and venture capital funds to mobilise working capital for manufacturers. On the demand side, Lighting Africa worked with microfinance institutions (MFIs) such as Savings and Credit Cooperatives (SACCOs) to provide consumer finance – also for quality-assured lights – bringing MFI representatives to the awareness-raising (or advocacy) roadshows the programme conducted (see the next paragraph) (Ockwell and Byrne 2017).

Consumer engagement, in addition to the research described above on lighting practices and preferences, included an aggressive marketing campaign, demonstrating solar lighting products in 254 roadshows in market towns and 1,378 forums in communities and trade fairs (Castalia Strategic Advisors 2014). Lighting Africa also ran media campaigns using text messaging and radio and TV advertising. Learning in the process of this marketing campaign, Lighting Africa later included MFIs in their roadshow teams so that customers could sign up to buy products immediately (Ockwell and Byrne 2017). In 2012, the Marketing Society of Kenya awarded Lighting Africa a prize for the 'best experiential campaign in the NGO/Government category' (Lighting Africa 2013). At a more general level, in addition to developing quality assurance standards and testing procedures, policy engagement included efforts to influence other policies relevant to the off-grid lighting market. For example, the programme worked with rural energy agencies in several countries to develop off-grid lighting programmes for incorporation into national energy policies. It is unclear whether these efforts were successful, but the programme did manage to get the Kenyan Government to abolish import tariffs on LED-based products in 2010 (Lighting Africa 2010). However, in October 2013, the Kenyan Government imposed 16 per cent value-added tax (VAT) on solar products, which some claimed reduced sales by up to 30 per cent (Ockwell and Byrne 2017).

### *6.6 Summary*

The Lighting Africa pilot officially finished in July 2013, but there was a post-implementation phase up to June 2014 (Castalia Strategic Advisors 2014). As noted earlier, it is difficult to attribute the rapid growth of the off-grid lighting market in SSA solely to the actions of Lighting Africa, but it should be clear from the above description that the programme is likely to have had a significant effect and important aspects of the market's development (as opposed to its growth) would not have happened in the absence of the programme. Indeed, the evaluation of the programme conducted by Castalia Strategic Advisors (2014) is confident in attributing much of the credit for the emergence of the off-grid lighting market to the actions of Lighting Africa. We would argue that the programme resembles something approximating the sociotechnical innovation system building discussed in Section 5 above. Below, we unpack the actions of Lighting Africa to show the specifics of this particular sociotechnical innovation

[4] See, for example, https://nuclear-sciences.uonbi.ac.ke/index.php?q=node/19410 (accessed 27 August 2019), which includes mention of ambition to expand testing capabilities.

system building example. We demonstrate that it amounted to what we would describe as a systemic intervention, in which Lighting Africa transformed access to clean lighting technologies through a process sharply cognisant of poor people's lighting practices. This foregrounding of social practices, we would argue, was fundamental to the success of the Lighting Africa Programme.

# 7 Conceptualising and Illustrating the Lighting Africa Programme

## *7.1 Explanation of the Lighting Africa Programme as Depicted in the Diagram*

Below we explain the key components and processes on which Lighting Africa focussed (depicted in Figure 7.1). This reflects the case study of Lighting Africa in Section 6.

## *7.2 Components of the Innovation System Nurtured by Lighting Africa*

**C1 Quality assurance**: This component of the innovation system includes the quality standards and testing procedures, as well as the capabilities and facilities to enforce standards and conduct tests on lanterns.

**C2 Producer capabilities and costs**: Manufacturers of lighting products are the producers referred to here, who need the capabilities to develop and make products that suit the lighting practices and preferences of off-grid populations. Suiting the preferences of off-grid populations can include products that offer functionality beyond just lighting, or what we can call 'stretching' of practices. But all this must be done within cost structures that promise attractive profits for the producers, and an important element of these is the nature of finance available to producers for securing working capital.

**C3 Monitoring state of the market**: Knowledge of the state of the market, in its broadest sense, is essential to ensure that all stakeholders can continue to make informed decisions based on analysis of evidence. This applies throughout the supply chain, to policymakers, and to analysts of all kinds.

**C4 Policy environment**: The policy environment is crucial for setting the appropriate 'rules of the game' under which all actors must play, such as quality standards, and for incentivising the direction of market development. The latter can include positive incentives to, for example, invest in solar lighting supply chains or negative incentives such as taxing polluting lighting technologies.

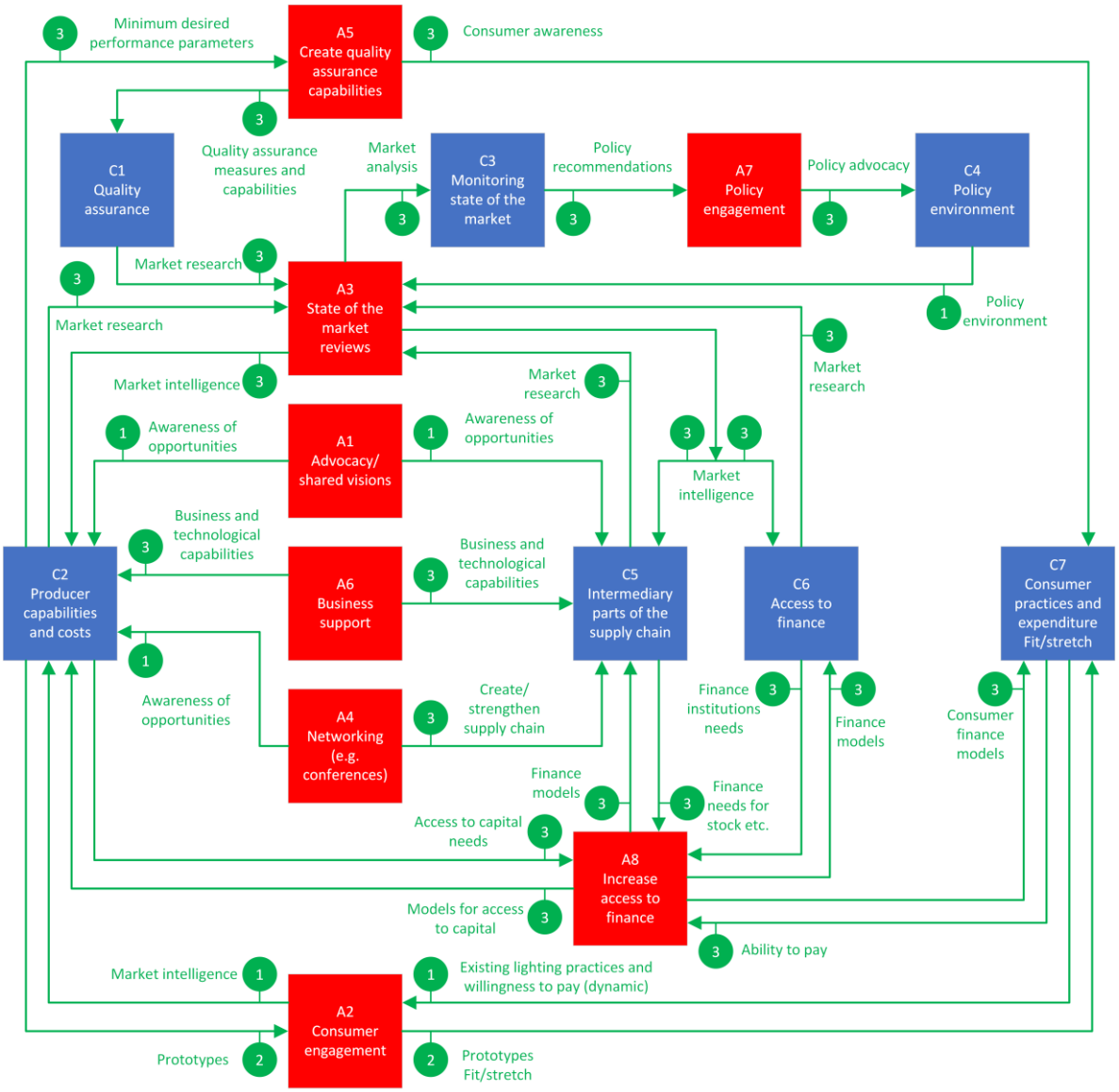
**C5 Intermediary parts of the supply chain**: This component of the innovation system includes all the actors between the manufacturers and customers. Each kind of supply chain intermediary will need specific kinds of capabilities appropriate to the products and the off-grid lighting business, and will have particular finance needs. They also need to be well connected to each other and foster good working relations between each other.

**C6 Access to finance**: Finance plays a crucial role in most parts of the innovation system, on both the supply and demand sides of the market. But each kind of actor will have different kinds of finance needs, requiring different kinds of finance models.

**C7 Consumer practices and expenditure, and fit/stretch characteristics**: Consumers will have various existing lighting practices shaped by a range of conditions that may be different across contexts. For low-income consumers, these conditions and contexts may be especially constraining of the practices that are possible. Lighting products will tend to be attractive if they can not only meet the existing needs (or fit with existing practices, including expenditure patterns) but also if they meet other preferences (or stretch what is possible into new desirable practices). Examples of these fit-stretch characteristics are the provision of lighting (fit) that is clean, bright and safe (stretch). The idea that clean, bright and safe lighting stretches practices refers to the new or improved (or desired) practices this facilitates such

as enabling children to study more effectively (and more safely) compared with studying under kerosene lanterns. Further stretching could include the additional functionality of charging a mobile phone.

*Figure 7.1*: An Illustrated Conceptualisation of How Lighting Africa Transformed Access to Solar Lanterns in Kenya




Source: Authors

## *7.3 Activities in the Lighting Africa Programme*

Having sketched what each component of the sociotechnical innovation system does, here we explain what actions Lighting Africa took to nurture these components.

**A1 Advocacy/shared visions**: This activity got underway before the Lighting Africa Programme started, beginning with the IFC's engagement in extensive global advocacy around the issue of access to clean lighting in off-grid areas of Sub-Saharan Africa. Through this, the IFC persuaded companies with an interest in lighting products (manufacturers, assemblers, distributors) of the market opportunities of LED-based technologies for meeting the lighting needs of off-grid and poor populations. By the time Lighting Africa launched in 2007, about 200 organisations had signed up to participate in the project (IFC 2007). With the launch of the Development Marketplace Grant Competition, the programme began to share the vision more widely, promoting the market opportunities of the unserved needs of 'poor households, communities and businesses' who constituted this 'market segment' (Development Marketplace 2007). As the programme continued, so did its development of a vision for clean off-grid lighting, evolving through the more detailed understandings of lighting practices and research into the emerging market. All this was promoted and shared widely by making reports publicly available, further widening the constituency of support for the programme and the vision of clean off-grid lighting.

**A2 Consumer engagement**: One of the actions identified for intervention in the Lighting Africa Programme was understanding customer needs and preferences, addressing the lack of information on lighting and energy use in off-grid areas. Specific information gathered through end-user survey and consultation methods included needs and preferences of lighting services, total spending, purchasing criteria, and social and cultural drivers of lighting choices. Qualitative and quantitative results from research into these lighting practices were published in October 2008 (Lighting Africa 2008b; 2008c) and made freely available on Lighting Africa's website, providing market intelligence for lighting technology producers and others interested in the off-grid lighting challenge. Moreover, the research included testing a range of electric lighting prototypes whereby consumers were given test products for five nights at a time and then asked to comment. Ahead of the start of the programme, the idea that lighting products could include more functionality than simply lighting was already part of the thinking, and appeared in the Development Marketplace Grant Competition call, where there was reference to charging mobile phones, for example (Development Marketplace 2007). But not all manufacturers adopted this idea of 'stretch'. One of the interviewees for this report spoke of a manufacturer who decided including mobile phone charging functionality would make their lighting products too expensive for the market. The product they released (without phone charging functionality) did not do well, while those who did release lanterns with phone charging did sell their products. As a result, the manufacturer changed their products to include phone charging. This anecdote underlines the importance of paying attention to user needs.

**A3 State-of-the-market reviews**: In addition to research into consumer lighting practices and the pre-programme intervention supply chain, Lighting Africa commissioned research into the policy environment relevant to off-grid lighting. Further research monitoring the evolution of the market during Lighting Africa's interventions and beyond was also commissioned, including attention to the evolving policy environment, the quantity and quality of available lighting products, the development of producer and supply chain capabilities and business models, and various finance needs. As with the initial research into poor people's lighting practices and needs, all these research reports were made freely available on Lighting Africa's website. We can see the various forms of state-of-the-market reviews as performing several nurturing functions in the sociotechnical innovation system building process. Most obviously, the knowledge generated was important to many existing, but also new, actors, providing evidence for them to further evolve their various activities (marketing, business decisions, policy recommendations, etc.). But we can also see these research activities as progressively improving articulations of the sociotechnical innovation system: that is, by providing detailed information about various aspects of the emerging innovation system, the specifics of a shared vision also became clearer and the evidence became more robust for promoting the benefits to others of supporting the intervention. This last point is important for widening the adoption of a shared vision, drawing a diversity and increasing number of stakeholders into the evolving off-grid lighting networks.

**A4 Networking**: The IFC began networking when engaging in advocacy and fostering shared visions prior to implementing Lighting Africa. Networking continued throughout the project, especially through three biennial international conferences. The first of these took place in Ghana in May 2008 (attracting over 500 participants),[5] where the 16 winners of the Development Marketplace Grant Competition were announced. Networking also occurred through business-to-business workshops and training events for various stakeholders in the supply chain, from product manufacturers through to technicians (Castalia Strategic Advisors 2014). But, as we noted above regarding the state-of-the-market reviews, other actions contributed to network building. The documentation made freely available was useful, especially to those interested in detailed understandings, but it also helped to foster a specific and well-evidenced vision that could then be further shared, persuading others to join the growing networks of off-grid lighting stakeholders. This has outlived the specific intervention period of Lighting Africa in the form of the Global Off-Grid Lighting Association.

**A5 Create quality assurance capabilities**: Part of the work to understand consumer needs and preferences involved identifying minimum performance parameters for lighting products. Examples of such parameters, determined in close consultation with consumers, included acceptable light levels and hours of operation for lighting products, the nature of lighting provided (e.g. task or flood lighting), battery recharging times, additional functionality (e.g. mobile phone charging), and acceptable price points. In further consultation with manufacturers, a set of minimum performance parameters was agreed that would also be technically realistic and economically viable for producers. Over time, and in continuing consultation with stakeholders, Lighting Africa facilitated the development of off-grid lighting product quality assurance standards that were eventually adopted at the global level via Lighting Global. In Kenya, Lighting Africa worked with the University of Nairobi to create in-house capabilities for initial quality screening of new lighting products, where those products successfully passing initial tests would be sent elsewhere for full quality assurance assessment. According to Lighting Global, as of June 2018, 249 products (pico-products [6] and solar home system kits) had met the quality assurance standards.[7] An important element of the process of creating quality assurance standards, according to the interviewees contacted for this report, was the continual engagement with consumers, seeking their feedback during the roadshows mentioned above. This feedback was passed onto producers so that they could improve their products, learning directly from the market in a way similar to that reported by Foster and Heeks (2013) in regard to feedback about mobile phones to Chinese manufacturers. Here, again, we see the importance, and effectiveness, of paying attention to consumer preferences, even in what might usually be taken to be the exclusive domain of technical expertise.

**A6 Business support**: In addition to general private sector support (e.g. networking, consumer and market research, development of quality assurance standards), Lighting Africa provided more specific training and advisory services to actors in the supply chain. These included training solar lighting technicians and new entrants to the supply chain, as well as advice about and support for business finance (see below). The programme also went beyond networking to establish a private sector consortium that evolved into an advisory council that discussed how Lighting Africa could improve its activities to better meet the needs of private sector stakeholders (Castalia Strategic Advisors 2014). Here we see Lighting Africa nurturing the private sector aspects of the sociotechnical innovation system – the business ecosystem as some might call it – helping to build capabilities specific to the needs of the SPL supply chain. But, again, the approach reflects how Lighting Africa paid attention to consumer preferences, this time paying attention to business needs. Interestingly, for an actor such as the IFC,

[5] World Bank news portal (16 September 2008) http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:21514564~menuPK:34480~pagePK:34370~piPK:116742~theSitePK:4607,00.html (accessed 11 June 2019).

[6] We use the term 'pico-products' to mean small solar lighting systems up to 11W, combining what GOGLA (2019), for example, call portable lanterns and multi-light systems.

[7] See the Quality Assurance statistics at https://www.lightingglobal.org/quality-assurance-program/product-testing-data/ (accessed 11 June 2019).

who might be considered to assume market forces alone would drive businesses to build their own capabilities, this was a highly interventionist strategy.

**A7 Policy engagement**: Along with providing analysis of the policy environment (as part of its market research efforts), Lighting Africa provided advice to policymakers based on evolving evidence and analysis from the entirety of its market research. As noted in Section 6, this included attempts to influence the wider policy environment, such as developing frameworks for promoting clean off-grid lighting within rural energy strategies and advocacy to remove regulatory disincentives to the growth of the off-grid lighting market, with mixed results. One of the ways in which the programme attempted to strengthen its advocacy was by working in alliance with Kerosene Free Kenya, for example, but the mixed results of these efforts suggest that too few policymakers were persuaded to adopt the vision of clean off-grid lighting articulated through these campaigns. In the end, the main focus of the programme's policy advocacy was on encouraging governments to adopt its quality assurance standards and tests, which had been developed in consultation with stakeholders of all kinds, including consumers. At least in Kenya, this advocacy was achieved by working with local solar PV stakeholders through the national industry association – the Kenya Renewable Energy Association (KEREA) – who worked closely with the Kenya Bureau of Standards to develop PV-specific standards and regulations aimed at ensuring high-quality practices and technologies in the Kenyan PV market. This is another example of working closely with stakeholders on the ground as opposed to attempting a more top-down imposition of policy change. In the process, stakeholders could develop closer relations, adopt the shared vision, and 'own' the results of any policy change achieved. So, this work, although aimed at providing policy advice, also benefited the sociotechnical innovation system in other ways.

**A8 Increase access to finance**: From the outset, Lighting Africa's intent was not to provide finance itself but, rather, to facilitate better access to producer, vendor and consumer finance 'where the need is apparent and the uptake feasible' (IFC 2007: 36). On consumer finance, for example, Lighting Africa worked with MFIs by including, as we noted above, their representatives at the roadshows they conducted across Kenya (Ockwell and Byrne 2017). This meant potential customers could immediately start the process of purchasing a clean light, if they had been persuaded by the information presented to them during the roadshow, as opposed to having to investigate further themselves after the roadshow had finished. On the supply side, Lighting Africa worked at two levels of finance. For local distributors of quality-assured lighting technologies, it worked with local banks to establish credit facilities for companies to increase their stock of products. And Lighting Africa worked with international banks and venture capital funds to establish finance facilities so that product manufacturers could access working capital (Castalia Strategic Advisors 2014). In terms of sociotechnical innovation system building, these activities most obviously nurtured the finance elements of the system. But we can also see a further broadening of the networks, this time recruiting different kinds of finance institutions, from the local-level SACCOs through to global capital. These efforts look to have paid off well in terms of the increasing number of clean off-grid lighting products available and the increasing number of people getting access to them. But we also need to be cautious about the longer-term impacts of what is an evolving political economy around off-grid lighting (Byrne *et al.* 2018), with the potential for its 'disciplining' effects on the policy space open to governments (Newell and Phillips 2016), and the potentially punishing impacts of repayment demands on low-income consumers (Mader 2015). These kinds of political economy implications were not addressed by Lighting Africa, along with a number of other issues, and we will reflect on these in Section 8.

# 8 What Lighting Africa Did Not Address: Technical, Political and Social Justice Considerations

Whilst Lighting Africa took an impressive and highly effective systemic approach, grounded in explicit attention to the social aspects of clean technology uptake, there remain some areas that the programme did not address. We list these here to highlight the fact that they are nevertheless issues of relevance to a programme such as MECS, working on clean tech uptake by poor and marginalised women and men in low-income countries. Some of these are generic, others are more specific to the increased energy demands of cooking relative to lighting.

### *8.1 Technical Considerations*

- A transformation in levels of electric cooking in any country has significant implications for electricity supply. The intersection between on-grid and off-grid electricity supply and increasing electricity demand therefore warrants close attention.
- Similarly, increased use of mobile pay-as-you-go (PAYG) energy supply and payment systems could have significant implications for mobile network capacity and infrastructure.
- Potential waste implications and opportunities for re-use and recycling also require explicit attention at early design and programme planning stages.

### *8.2 Political/Political Economy Considerations*

- Questions need to be asked as to the extent to which value accumulation as a result of new cooking technologies and accompanying social practices is achieved within low-income countries, or whether value accumulation occurs in other countries that are supplying technology hardware. Qualitatively different types of value creation are also important to consider, e.g. the types of jobs created, the internal distribution of surplus within in-country production sites, etc. Similarly, know-how and know-why knowledge transfers are also critical parts of ensuring that a transformation in clean cooking leads to long-term capacity building in low-income countries, as opposed to being retained by international technology firms based elsewhere.
- Similarly, questions might be asked as to any potential impacts of the import of clean cooking technologies on balance of payments in low-income economies. Although this may be offset to some extent by reductions in kerosene imports if people switch away from cooking with kerosene.
- Politics and political economy dynamics can also often be definitive of the success of interventions around new technologies and social practices (e.g. see Byrne *et al.* 2018; Pedersen and Nygaard 2018). These might, for example, relate to the extent to which national-level policy priorities support or oppose clean cooking initiatives, as well as the extent to which clean cooking initiatives are aligned (or not) with powerful interests in any given country (Baker *et al.* 2014), or internationally (Newell and Phillips 2016). This also highlights the importance of balancing between delivering against local versus national priorities. For example, it has been suggested that where governments are most in touch with local needs/aspirations there tends to be a greater focus on cooking within national policy and planning.
- Importantly, the impact of politics and political economy dynamics has been observed to play out as much at the village or community level (as well as inter-village levels), as at regional, national or international levels (Ahlborg 2017).

- Moreover, even where politics and political economy considerations are not definitive of whether or not a project or programme goes ahead, they can nevertheless exert significant influence over who gains and who loses from any specific intervention (Scoones 2016).

### *8.3 Social and Social Justice Considerations*

- Little attention seems to have been given to date to issues of data handling where mobile platforms are being used to facilitate access to clean technology in low-income countries. This has implications for researchers as well as companies using this data in terms of protecting users' personal data and the ethical implications of collecting, storing and using those data in different ways (despite its many attractions for informing research and business model design).
- Sociotechnical transformations often have unintended consequences that are both good and bad. As much as possible, it is important to think through how these might play out if transformations in clean cooking are achieved. For example, potential positive and negative implications for gender equality need to be considered (as expanded on below). This goes much further than a narrow market focus on, for example, number of e-cookers in use, asking instead what broader development goals are being impacted and how. This is being increasingly thought about in relation to results-based finance, for example. Currently, indicators in results-based financing electrification programmes refer to connections made, whereas there is a growing recognition that what should be measured (and, in the market model, paid for) is the impact of connections.
- Interventions around cooking in developing countries are likely to have significant implications in terms of sources of social inequality. The source of social inequality that gets most attention tends to be gender. However, other sources of inequality, such as ethnic background, class, education and so on may be equally affected, or definitive of the distribution of benefits that are accrued from any interventions under MECS. Assuming that any intervention might be gender neutral is erroneous. Even seemingly beneficial advances, such as the emergence of pay-as-you-go payment models, can impact on gender relations and other aspects of social inequality, sometimes serving to reinforce existing gendered inequalities (Marshall *et al.* 2017; Winther *et al.* 2017; Ockwell *et al.* 2019). Bearing in mind how centrally cooking tends to be a gendered practice, with the burden falling principally on women and girls, specific consideration of the gendered implications of interventions via the MECS Programme, which are not specifically dealt with in the framework presented in this working paper, are therefore important and necessary. Recent work in the field of gender, energy and development has been insightful with regard to the kinds of interventions that might have more positive impacts on gender relations. These warrant close attention in relation to the implementation of MECS (e.g. see Ulsrud *et al.* 2018; Winther *et al.* 2018).
- Before people switch to clean cooking technologies there may be a need for campaigns to educate people on the health implications of cooking with wood, charcoal and kerosene. Although, notably, much like smoking, little progress seems to have been made as a result of health campaigns around cooking. Similar to smoking, education may need to be accompanied by legislation before significant change is observed. However, importantly, like legislation around smoking in the UK, the public will have had to have reached a level of understanding around the health impacts of cooking before they are likely to accept such legislation without negative electoral implications (Ockwell *et al.* 2009).

# 9 Transforming Lighting Versus Transforming Cooking

Before attempting to learn from Lighting Africa's approach, it is important to note that cooking constitutes a very different energy service than lighting. These differences must temper any attempt within the MECS Programme to directly replicate the actions of Lighting Africa.

As already noted in the thinking behind MECS, 'cooking is a cultural experience' (MECS 2018c: 11) and so innovations towards clean cooking are likely to be resisted if they mean changes to the way people eat, the taste of the food and perhaps even cooking processes. The cultural embeddedness of cooking is therefore the most obvious difference compared with lighting, and potentially poses the most significant challenge for translating the Lighting Africa approach to a framework for achieving the transformative goals of the MECS Programme. Furthermore, we should understand the ways in which the cultural significance of cooking extends beyond people's needs and preferences centred on food; needs and preferences that themselves go beyond nutrition and the satisfaction of hunger. That is, culture is expressed and reproduced to some extent through food and cooking practices. In contrast, lighting is much less culturally specific and much more functional. The extent of any deeper significance associated with lighting may include electric light as symbolic of modernity and higher social status, but we would argue it is relatively straightforward to identify lighting needs, preferences and practices, and to express these in technical terms for use in product design. And it is relatively easy to design a clean lighting product with extra functionality, such as mobile phone charging, that creates opportunities for attractive stretching of practices.

The cultural embeddedness of cooking also reinforces wider gender norms (Malakar *et al.* 2018a), presenting further complexity in the challenge of translating Lighting Africa's approach. Reinforcement of gender norms can have both positive or negative consequences. For example, the adoption of e-cookers could mean reduced burden on women to collect firewood (Sovacool 2012), but it might also limit their space for socialising with other women. This, too, can have positive and negative implications. In Guatemala, for example, being seen to be collecting firewood or milling corn three times a day for tortillas can demonstrate fulfilment of women's perceived social obligations, with implications for community acceptance or isolation.[8] And, in the home, the cookstove – or fireplace – may form an important centre of family social life, with associated norms for a woman's role as homemaker, connected in cultural and practical ways with the technologies, tools and arrangements of domestic space. Cherunya *et al*. (forthcoming) develop the concept of 'oscillating domestic space' as a way to capture the shifting nature of the relationships between needs, time, space and practices, where complex contexts (e.g. culturally-specific cooking practices) require new technologies to fit with existing domestic infrastructure, needs, aspirations and the meanings people evolve with these new technologies.

Clean cooking technologies are likely to be more complicated than those for clean lighting. This extra complication is in part to do with the configuration of pieces of hardware, but it also arises from the nature of cooking itself compared with the simple operation of lights (notwithstanding some extra complication for charging the lights). That is, new cooking technologies could be more disruptive of home life (as we noted above), at least during a period of transition, and so, bearing in mind the previous note about oscillating domestic spaces and practices, we cannot assume the adoption of clean cooking technologies will only require some minor behaviour change. As we note below (in Section 10, A2 Consumer engagement), when it comes to the phase in the MECS Programme of testing cooking technologies, there may be many unforeseen challenges related to the more or less significant disruption of domestic spaces.

[8] These findings are emerging from doctoral research conducted in 2019 by Victoria Kasprowicz.

Understanding the context-specific complexities of cooking and its embeddedness in cultural and social life is therefore going to be important for avoiding the pitfalls of so many former clean cooking interventions (Iessa *et al.* 2017). This will require using a wider lens than one that focusses only on cooking processes. And it will be important to not only consider the benefits of clean cooking technologies, but also the benefits (perceived or real) of current 'dirty' cooking practices. For example, fire and smoke can fulfil other roles such as curing meat or repelling insects. In short, if the MECS Programme is successful, clean cooking technologies will disrupt – more so than clean lighting – existing practices and could reshape social structures, so we need to ask what is being displaced by clean cooking technologies and what the implications of this will be. There is already some discussion of this within the MECS Programme in relation to incorporating electric mosquito killers with electric cooking devices or even LPG.

# 10 Lessons for MECS from Lighting Africa

Reflecting on the actions of Lighting Africa, as presented in Figure 7.1 and discussed in Section 7, we now look at the lessons for the planned activities of MECS.

**A1 Advocacy/shared visions**: Amongst the programme partners, there is already a basic shared vision at the general level of the benefits of, and potential for transforming, clean cooking (MECS 2019a). Under this general vision, there is some clarity over e-cooking amongst a smaller group within the partners, especially the programme leads and those who have been working on the eCook concept for several years, as evidenced by the MECS proposal (MECS 2018a). For those partners who are relatively new to the eCook concept, the adoption of a shared vision is only at a formative stage. The other clean cooking concepts – centred around LPG, biogas and perhaps ethanol – seem less developed within the MECS Programme at present. Assuming this will change, there are questions over what the implications will be for the various programme interventions. For example, around each of the clean cooking technologies there would likely be a substantially different sociotechnical innovation system, even if the different systems also overlap. And this may also be different for different cooking technologies, with a sense at present, for example, of a strong narrative around e-cooking, but a less well developed narrative around LPG and biogas (see Batchelor *et al.* 2019 for an illustration of changing narratives around MECS). This raises challenges for how the MECS Programme will promote a changed narrative: e.g. will there be one narrative, or different narratives; what would a shared vision look like for each of these narrative options; who would need targeting when it comes to advocacy? Contrast this with Lighting Africa's focus on LED-based off-grid lighting technologies, a focus that lends itself to developing one single clear narrative and vision for wider adoption. Nevertheless, it is promising that MECS is already clearly aware of the need to focus on changing narratives, as demonstrated by Batchelor *et al.* (2019), including moving away from the 'business as usual' improved biomass efficiency focus that previously dominated narratives and action around clean cooking.

Developing and advocating for shared visions links directly with the network-building component of the programme's activities (discussed below). There are many network-building activities planned, but these seem strongest in regard to the programme consortium and relatively 'close' actors such as other energy access research programmes and long-standing players in the clean(er) cooking space (MECS 2018a; 2019b). This makes sense for building a strong (and potentially powerful) constituency of support for MECS. Importantly, however, the programme is now also focussing on advocacy and coalition building at national levels in the Global South. This will remain a priority area for MECS as it moves into its next stage, now that all partners in the programme are contracted.

The Challenge Funds offer an opportunity to extend the network beyond the core group, and to introduce new ideas into the evolution of a changed narrative and shared vision. Six

companies/organisations have already been contracted via the Challenge Fund and there are another 25 projects under consideration (at the time of writing). The logframe includes reference to various stakeholder meetings and workshops throughout the first three years of the programme (MECS 2019b). Aspirations are understood to include extending the coalition to other clean energy research programmes and initiatives – e.g. Transforming Energy Access, (TEA), Low Energy Inclusive Appliances (LEIA), Energy for Economic Growth (EEG) – the UK Department for International Development (DFID) and MDB country offices, and UK Research Councils. Since the change of narrative is about getting cooking onto and embedded into energy access agendas and investments, it is important for MECS to engage with players such as the Africa Minigrid Developers Association (AMDA) who traditionally have not worked with cooking. Output Area 1 'Transition Pathways', led by the Energy Sector Management Assistance Program (ESMAP), also includes value chain experiments to test the theory of change. Depending on how these are conducted, there could be useful advocacy and development of shared visions, but these seem to be planned for years four and five (if we have identified them correctly in the logframe).

Lighting Africa offered grants of up to US$200,000 per project, awarding 16 grants from the 400 or so proposals received (Lighting Africa 2008a). Whilst the projects are not necessarily comparable across Lighting Africa and MECS, MECS has already conducted a Challenge Fund in cooperation with LEIA, funding six projects of about US$100,000 each, and launched a MECS Challenge Fund with grants of up to £30,000 each. It is currently discussing a Global LEAP Award of two US$100,000 prizes and will launch further Challenge Funds in the future. It has a budget of several million for this activity of crowding in private sector and value chain actors to the new proposition.

**A2 Consumer engagement**: The MECS Programme was grounded on attempts to understand the social and physical processes involved in cooking, and the behavioural change required for some eCook uses of MECS was fundamental to planning the programme (Brown and Sumanik-Leary 2015). There is already some work completed analysing cooking processes and preferences in four countries (Kenya, Zambia, Myanmar and Tanzania), including new knowledge about e-cooking effects on food taste (MECS 2018c). These data have been used to inform the basis for responses to the first Challenge Fund call (MECS 2019c). Work within MECS plans to extend this aspect of the research by mapping and understanding consumer culture, demand and social drivers of MECS choices, and will build on this work to conduct further replicable surveys (MECS 2018c; 2018a). From within the MECS university consortium, the southern partners, and resulting from Challenge Fund projects, there will be various prototypes developed. These will be tested by consumers so they can feed back into further design or design improvements (MECS 2018c; 2018b). MECS plans, under the Consumer Culture aspect of the work, to develop and evolve consumer awareness campaigns (based on, for example, public health campaigns) and to co-create ideas for use by governments, businesses and NGOs to further increase consumer awareness (MECS 2018c). The programme has an explicit intention to develop ways to overcome potential gender-based 'dissonance' between the needs of women (the likely primary beneficiaries of MECS) and the decision-making authority of men in the household (who are understood to be reluctant to spend money on cooking technologies) (MECS 2018c).

To date, prototype testing of a range of MECS system parts has been undertaken in real world situations in East Africa and Asia. Lighting Africa tested prototype lights by giving them to consumers for five nights at a time and then changing the light so the same consumers would test another for five nights, and so on until all the five different lights had been tested by all consumers (Lighting Africa 2011). For the MECS Programme, after convening focus groups to determine the key issues and conducting choice modelling surveys among a wider cohort to determine the key characteristics on new technology, MECS worked with cooking diaries. These asked householders to continue to cook in their normal way for two weeks, documenting their menu, energy use and the processes by which they cook, followed by switching to electric cooking on various appliances for four weeks with continued data gathering. This investigated changes in menu, system components and acceptability of the devices. These processes will form the

starting point for any prototyping design work within the programme's target countries. As this sketch of previous and planned MECS prototyping and consumer engagement work implies, it is important to note that, compared to trialling solar lantern prototypes, there is the potential for a highly complicated prototyping schedule and feedback plan. Plus, if consumers are to test more than one prototype there is likely to be a lot of disruption to their home lives. If any behaviour change is required, the prototypes will need to be in place for some extended period of time. These challenges are currently being considered by the MECS management team.

**A3 State-of-the-market reviews**: Various pieces of work are planned in the MECS Programme that will provide information relevant to our understanding of what we could call the state of the market for clean cooking. The programme started with a global study based on national data, using these data to identify where the prime markets for MECS might be (Batchelor *et al.* 2018). During years two and three of the programme, case studies will be developed on key drivers of MECS transition pathways (MECS 2019b). According to the MECS proposal, the transition pathways component will generate the evidence for how and when MECS transitions can happen, solve problems over scaling and develop a theory of change that is country-context sensitive (MECS 2018a). Within the technology and business model component of the programme, there will be work to characterise eCook-relevant innovation systems in Kenya, Tanzania and Rwanda (MECS 2019b), and these will be used to propose a practical framework for how to transform such innovation systems (UOS 2019). The component on changing the narrative will provide results measurement and dissemination of learning through, for example, publishing policy-relevant documents and providing other knowledge transfer services to stakeholders (MECS 2018a; 2019b). And other information directly relevant to policymaking will emerge from the work on life-cycle assessments (MECS 2018b), transition pathways (MECS 2019b), and innovation systems (MECS 2018b). Finally, MECS includes plans to develop better global tracking of data on access to modern energy cooking services so as to incorporate the information into Sustainable Development Goal 7 (SDG7), the energy access sustainable development indicator (MECS 2018a; 2019b).

All the pieces of work described above will clearly be useful in different ways to the implementation of the MECS Programme, and many will be useful to other stakeholders and a wider audience. There are plans to provide synthesis reports on the state of the market for clean cooking, similar to those provided by Lighting Africa and GOGLA, and revised state-of-energy-access reports, knowledge papers on electric cooking and briefing notes on behavioural change have been commissioned by ESMAP as part of the programme. Such synthesis reports would not necessarily follow the format of those for the state of the off-grid lighting market; indeed, there is an argument for developing a different format, given the more complex nature of the clean cooking challenge compared with off-grid lighting. The point is that the Lighting Africa knowledge products were found to be useful to new entrants to the off-grid lighting market (Castalia Strategic Advisors 2014), and they were likely useful to others too, such as analysts and policymakers. The CCA has begun to provide something similar, publishing in 2019 their inaugural snapshot of the clean cooking industry (CCA 2019). But reporting of the fuller kinds of knowledge emerging from the MECS Programme (i.e. not just concerned with an industry snapshot) could be useful to a wider range of stakeholders, both within the MECS networks and beyond. Alongside synthesis reporting, or perhaps in support of it, there could be other targeted knowledge products that may not yet have been considered, such as on clean cooking technology standards. These are all considerations that we understand the MECS team is currently working through. To this end, it might be useful to review the knowledge products published by Lighting Africa and GOGLA, including an assessment of their usefulness, so as to develop a comprehensive dissemination strategy. And, related to this, it is important that all knowledge products, including any potential state-of-the-market synthesis reports, be made freely available. Agreements are in place for such products to be hosted on the CCA website, as well as on the World Bank and MECS Programme websites.

**A4 Networking**: The initial networking of the MECS Programme appears to be concerned with convening a tight coalition of partners who will work towards a shared common goal of promoting MECS

(MECS 2018a). From the available documentation, we assume the 'tight coalition' refers to the MECS consortium partners and anchor Southern partners in the 16 countries. Beyond this, as we described above (see A1 Advocacy/shared visions), the aspiration appears to be to extend the coalition to include other clean energy research programmes, such as TEA, LEIA and EEG, the country offices of DFID and the MDBs, and the UK Research Councils. And there are hopes, too, to connect with others: e.g. bilateral donor agencies such as the German Agency for International Cooperation (GIZ) and programmes such as EnDev.[9] Other network-building and extending opportunities exist within the programme plans. The Challenge Funds, for example, might draw in new actors, including many in the private sector. MECS Output Area 5, on changing the narrative, includes planned stakeholder meetings and workshops during the first three years of the programme (MECS 2019b). And Output Area 1, on transition pathways, includes value chain experiments to test the theory of change that this work area will develop.

The above actions suggest that MECS is attuned to the need for, and acting to realise, attracting a diversity of actors to the network, as the sociotechnical innovation system building framework would suggest is important. For the work on value chain experiments, there could be further opportunities to deepen and broaden the MECS network but, according to the logframe, these will not be available until years four and five of the programme (MECS 2019b). As such, there will be increased pressure on the narrative-changing work to achieve broad network building in these latter stages of the programme, and to do so throughout the supply chains, as well as amongst research and policy circles, in ways that help to develop productive relationships.

**A5 Create quality assurance capabilities**: MECS Output Area 2, on technology and business innovations, including through the Challenge Fund projects, will likely generate a large amount of information and knowledge relevant to developing product standards and specifications. MECS is clearly attuned to the importance of standards and quality assurance, with reference to this is in Output Area 4 in which ESMAP will publish standards and specifications for technologies (MECS 2018a). And other links are being made with the United Nations Industrial Development Organisation (UNIDO) and the World Health Organisation (WHO). There are plans to build capabilities in-country for implementing standards, or testing technologies or products, mirroring the extensive work done by Lighting Africa in this regard. Specific work on standards has been commissioned by MECS, and standards are also being integrated into part of MECS' strategy. As part of MECS' partnership with LEIA, it is also launching a Global LEAP Award on electric pressure cookers, which will involve detailed testing (both in terms of performance and usability) and will be used as a pre-qualification for results-based finance. The MECS team are also engaging with international standards workshops (e.g. a forthcoming one in Uganda).

This part of the programme's work is therefore clearly in line with that of Lighting Africa, which invested a lot of effort in developing quality assurance standards, based on extensive engagements with both consumers and suppliers, and subsequent activities to get the standards and quality assurance tests approved at the international level.

Potential waste implications and opportunities for re-use and recycling also require attention at early design and programme planning stages. There is a stream of MECS' work on life-cycle analysis which anticipates the issues of waste and sustainability. This therefore goes beyond the work of Lighting Africa, which did not address issues of waste and recycling (as far as we are aware).

**A6 Business support**: Business support opportunities exist in various parts of the MECS Programme, although it is in Output Area 2 on technology and business innovations where this is most clearly planned. Here, there is reference to trialling business model prototypes in selected countries (MECS 2018a) and to a Challenge Fund call on business models (with the additional possibility of strengthening

[9] Energising Development (EnDev) is an energy access partnership financed by six donor countries: the Netherlands, Germany, Norway, the UK, Switzerland and Sweden. EnDev works in 25 countries in Africa, Asia and Latin America. See https://endev.info/content/Main_Page (accessed 23 August 2019)

women's empowerment) (MECS 2018c). And where the Challenge Fund provides grants for businesses to develop product or technology concepts, this could also be considered business support (MECS 2019c). Other, more general, business support opportunities lie in the conceptual framework for understanding clean cooking supply and demand, which ESMAP is expected to produce within MECS' transition pathways work (MECS 2018a) and from which useful information for businesses could be forthcoming. Business support opportunities may also arise from some of the networking activities if they facilitate, for example, business-to-business relationship building (see A4 Networking ).

Further relationship building between businesses might be promoted in the value chain experiments, along with other kinds of business support. MECS has identified value chain experiments to work with businesses and various kinds of business support as a strategic priority. This is an area that is receiving considerable attention under the development of a funding addendum. Around £10 million is dedicated to scale-up, and the MECS team is currently reviewing a range of approaches to this including: results-based financing, social investment funds, crowdfunding, etc. An initial report on this is currently under development.

As implied in this brief description of MECS' activities on business support, however, there is a lack of clarity in various aspects of the plan. The extent to which these activities will indeed provide business support depends on the way they are conducted. For example, the value chain experiments could use highly participatory techniques to achieve deep interactions with and amongst various businesses along the value chain, working with specific clean cooking products and technologies as well as business models. Or they might involve working only with individual businesses on specific aspects of the value chain, in isolation from other players in the chain, to achieve only narrow learning objectives. We suggest that the more participatory and networked approach would offer better opportunities to build sociotechnical innovation systems around MECS than a narrow and individually-targeted approach. Furthermore, it is unclear whether there will be any training for different kinds of actors in the value and supply chains. Lighting Africa did provide various kinds of training, including for solar technicians and vendors. Drawing from the experiences and knowledge emerging from various parts of the programme, MECS could consider what kinds of training would be useful for the different actors along the supply chains.

The MECS team has signalled their awareness that such activities might be needed in MECS. One of the issues MECS faces is how far to try to create new structures and how far to integrate within existing structures. There is an additional dilemma for MECS in that it is interested in both the clean cooking and the electrification sectors, which have different training and skills development needs. MECS is working to embed these issues within current TEA initiatives on curriculum development, and is also working with ESMAP on skills in relation to new forms of energy storage as part of the new Energy Storage Partnership.[10]

**A7 Policy engagement**: Several parts of the MECS Programme include work relevant to policy engagement. Much of this work – but not all – will occur through the activities we describe above in the sub-section on state-of-the-market reviews: a framework for understanding demand and supply for clean cooking; case studies of key drivers of MECS transition pathways; life-cycle assessments; sociotechnical innovation system mapping; and data tracking on access to modern energy cooking services. But other activities will be important, such as the articulation of consumer practices and preferences (see A2 Consumer engagement), and the development of technology standards and specifications (see A5 Create quality assurance capabilities).

[10] For more on the Energy Storage Partnership, see https://www.worldbank.org/en/news/press-release/2019/05/28/new-international-partnership-established-to-increase-the-use-of-energy-storage-in-developing-countries (accessed 23 August 2019)

Whilst all these activities can provide evidence useful to policy engagement, and there are plans to publish policy-relevant documents, the work to develop shared visions will be important for policy advocacy. This advocacy element of the MECS Programme is most clearly planned in the ambitions for establishing, by the end of the third year, three country-specific action plans along with operational models for scaling up MECS experiments (MECS 2019b). And the work on changing the narrative could include efforts to influence policymaking.

Although there are, therefore, many activities relevant to policy engagement, the extent to which these will be used for policy advocacy is unclear in the MECS plans at present. The bulk of evidence and knowledge MECS will generate is likely to be a mix of social, economic and technical insights – particularly with evidence emerging from consumer engagement. However, the programme will also be developing shared visions and new narratives that could include more political aspects.

Whilst the programme may wish to avoid overtly political activities, the importance of the political dimension of achieving transformation should not be underestimated. With this in mind, it might be beneficial for MECS to establish alliances with locally situated as well as international campaigns that seek to promote cleaner cooking, going further than the aspiration to learn from public health campaigns stated in the plans so far (MECS 2018c). Lighting Africa, for example, worked with Kerosene Free Kenya as a way to open policy space for promoting clean lighting. In this respect, the CCA may already be active internationally (as are other MECS partners, like Power4All and Climate Parliament), but there may be scope for nationally focussed alliances through which MECS narratives can be tied to prominent, local sociopolitical agendas. Tracking MECS for SDG7 will be useful for policy engagement. The programme is currently drafting a working paper called 'A Political Economy Analysis of MECS' to guide this political dimension of the programme. Whilst there will be various activities concerned with the policy environment, there are also plans to advocate actively for specific policy changes at international, national and local levels. This will be led via the engagement activities within the 12 target countries, plus work with a number of different actors including the Climate Parliament.

**A8 Increase access to finance**: Financing features in the MECS Programme, most clearly in the work to develop operational models for scaling up finance from the World Bank's International Development Association (IDA) and from other MDBs (MECS 2018a). Discussions about these scaling models are planned with three countries by the end of year five (MECS 2019b). The technology and business innovation work, and projects in the Challenge Fund, could include developing business model prototypes that incorporate business and consumer finance needs. For example, one of the work areas that the University of Surrey is conducting is in economic modelling of solar home systems for e-cooking (MECS 2018b). This will be helpful for assessing the affordability of eCook systems for consumers. And there is reference to adapting PAYG consumer finance models for use in increasing access to biogas. The focus on the word 'services' in the programme title assumes that new communication and payment technologies will reduce the initial outlay and PAYG payments for consumers (MECS 2018b: 2).

Several other finance-relevant areas of MECS activities are also currently emerging. These include social investment funds that are under discussion with Acumen and AMDA, to the level of £500 million, results-based financing from multi-donor sources (EnDev) and results-based financing from within the World Bank (Uganda), both of which flow through the private sector. MECS also has IDA lending to Uganda under discussion (£400 million). The economic modelling by, for example, the University of Surrey and the evidence on affordability that will emerge from the consumer engagement work could also be brought together to develop both business and consumer finance models, perhaps with other work coming from specific Challenge Fund projects. Lighting Africa, as we discussed in Section 6, investigated finance needs throughout the value and supply chains, and engaged different kinds of finance actors for different parts of these chains, from manufacturers right through to consumers. In line with this approach, we understand that MECS' business model prototypes will include business finance, and

there is a plan to investigate finance needs across the value chain, particularly as part of the social investor support.

# 11 Conclusion

This working paper has summarised evidence that supports the need for a more sophisticated understanding of processes of technological change if interventions, such as the MECS Programme, are to maximise their chances of realising their transformative ambitions in practice. This means going beyond the traditional, two-dimensional focus on finance and engineering based technology hardware fixes, and moving towards a five-dimensional, systemic understanding of how technological change can be facilitated in developing countries. It demands attention to other dimensions, including: social and cultural practices around technology uptake and use; politics/political economy dimensions that determine the likely success and distributional implications of any given intervention in any given country or locality; and, more sophisticated accounts of how innovation, technological change and economic development occur.

The working paper has described how the innovation studies literature, based on decades of detailed empirical analysis, has developed an understanding of technological change and economic development as being facilitated through the development and strengthening of innovation systems. This draws our attention to the myriad different actors who play a role in innovation and technological change within developing countries, their levels of technological capabilities and the strength of the relationships between them.

The working paper has also described how the sociotechnical transitions literature adds two critical dimensions to this understanding, by moving beyond the firm-centric focus of the innovation systems literature, bringing into our field of vision the role that potential technology users play (in the case of the MECS Programme, poor women and men whom it is assumed will adopt clean cooking technologies). The insights from the sociotechnical transitions literature centre around the need to foreground the social, rather than the financial or technical, in seeking to transform poor people's access to clean cooking technologies. Indeed, it was this foregrounding of the social that our analysis of the Lighting Africa Programme above suggests was fundamental to the successful transformation of the off-grid solar lighting market in Kenya. A sociotechnical transitions perspective emphasises how clean cooking technologies need to either fit with, or be able to stretch, the existing cooking practices of the poor people in developing countries whom the MECS Programme aims to benefit. It also helps us to understand how niches of clean cooking technology use might be nurtured in ways that allow them to compete and transform existing regimes of unclean cooking practices.

By beginning to analyse the differences between the social practices around lighting and those around cooking, together with our analysis of the activities that MECS already has underway, it was possible to produce a bespoke delivery framework for MECS. This is based on our analysis and conceptualisation of how Lighting Africa achieved transformative impacts in Kenya, and our adaptation of this approach based on the specificities of MECS. As emphasised above, however, whilst we believe this framework has significant utility in maximising MECS' chances of achieving transformative results, the framework nevertheless is unable to account for issues pertaining to politics/political economy and social inequalities, such as gender relations. Specific accompanying analysis on the implications of the latter for MECS (and vice versa) is therefore strongly encouraged.

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# Transforming access to clean technology: Learning from Lighting Africa

## STEPS Working Paper 110

UK AID has recently invested in a new £39.8 million programme that aims to transform access to modern energy cooking services, or MECS, in Africa and Asia. In this working paper we demonstrate how reframing our understanding of how transformations happen in access to clean energy technologies, foregrounding the social and the political, together with more sophisticated, systemic understandings of how sustained technological change and innovation occurs, can increase the chances of transformative change that is environmentally sustainable and socially just. This moves beyond the largely unsuccessful track record of past interventions that tended to focus only on technology hardware and finance.

The working paper analyses the case of Lighting Africa, which successfully transformed access to solar lighting in Kenya and, as far as we are aware, conceptualises and illustrates for the first time Lighting Africa's approach. This builds on past STEPS research that focusses on building sociotechnical innovation systems.

The paper then compares the existing and planned activities of the MECS Programme in order to facilitate learning looking forward. This analysis is assisted by consideration of the important ways in which cooking as an energy service, and its related social practices, differs from lighting. It is also assisted by analysis of some critical social justice and political dimensions that were not explicitly addressed by Lighting Africa.

As well as making substantive recommendations for the future operation of this £39.8 million programme of research and delivery, the working paper provides a useful illustration of how the STEPS Pathways Approach can contribute to applied analyses of policy and practice.