STEPS centre

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

Financing Sustainable Energy for All: Pay-as-you-go vs. traditional solar finance approaches in Kenya

Rolffs, P., Byrne, R. and Ockwell, D.

Financing energy

STEPS centre

Financing Sustainable Energy for All: Pay-as-you-go vs. traditional solar finance approaches in Kenya

This paper focuses on finance for Solar Home Systems (SHSs) in Kenya and asks to what extent emerging new finance approaches are likely to address the shortcomings of past approaches. Drawing on the STEPS Pathways Approach we adopt a framing that understands finance within a broader socio-technical context as a necessary but not sufficient component of achieving alternative pathways to sustainable energy access. The paper contributes in four ways. Firstly, it presents a comprehensive overview of past and new emerging approaches to financing SHSs in Kenya and their relative strengths and weaknesses. Secondly, it represents one of the first attempts in the literature to analyse the potential of new, real time monitoring technologies and pay as you go finance models to overcome the barriers faced by conventional consumer finance models for off-grid renewable energy technologies (RETs). Thirdly, by applying for the first time we are aware of a socio-technical approach, via the application of Strategic Niche Management (SNM) theory, to analyse the finance of RETs in developing countries, the analysis considers finance in the context of the social practices poor people seek to fulfil via access to the energy services that off-grid RETs provide, and the ways in which people previously paid for these services (e.g. via kerosene for lighting). This also situates the analysis within the understanding of SHSs as a niche that has to compete with the established regime of energy service provision and its attendant social and political institutional support. The paper therefore also contributes to the small but expanding body of literature that seeks to operationalise socio-technical transitions thinking and SNM within a developing country context.

About the Authors

Paula Rolffs is a former student of the MSc-programme Energy Policy for Sustainability in SPRU - Science and Technology Policy Research. Prior to her studies she was working as intern and consultant in development cooperation in the area of renewable energy and rural electrification. Subsequent to her studies she has been enrolled in the trainee programme of the European Commission in the area of climate policy.

Rob Byrne is a Research Fellow in SPRU - Science and Technology Policy Research at the University of Sussex. He also co-convenes the STEPS Centre's energy and climate change domain in the STEPS Centre. Rob's work is mainly in low carbon technological innovation in developing countries, and has been involved particularly in research on East Africa and China.

David Ockwell is a Senior Lecturer in the Department of Geography at the University of Sussex. He co-convenes the STEPS Centre's energy and climate change domain and is also affiliated to the Sussex Energy Group and the Tyndall Centre. His research, teaching and policy work focuses on climate and energy policy with particular interests in: low carbon development in developing countries; discourse and framing effects in environmental policy; and public engagement with climate change.

About the STEPS Centre

Today's world is experiencing rapid social, technological and environmental change, yet poverty and inequality are growing. Linking environmental sustainability with poverty reduction and social justice, and making science and technology work for the poor, have become central challenges of our times. The STEPS Centre (Social, Technological and Environmental Pathways to Sustainability) is an interdisciplinary global research and policy engagement hub that unites development studies with science and technology studies. We are developing a new approach to understanding and action on sustainability and development in an era of unprecedented dynamic change. Our pathways approach aims to link new theory with practical solutions that create better livelihoods, health and social justice for poor and marginalised people. The STEPS Centre is based at the Institute of Development Studies and SPRU Science and Technology Policy Research at the University of Sussex, with partners in Africa, Asia and Latin America. We are funded by the ESRC, the UK's largest funding agency for research and training relating to social and economic issues.

www.steps-centre.org.

Follow us on Twitter **@stepscentre**

Other titles in this series include:

Approach	Pathways to sustainability: an overview of the STEPS Centre approach
1. Dynamics	Dynamic Systems and the Challenge of Sustainability
2. Governance	Understanding Governance: pathways to sustainability
3. Designs	Empowering Designs: towards more progressive appraisal of sustainability
4. Agriculture	Agri-Food System Dynamics: pathways to sustainability in an era of uncertainty
5. Health	Health in a Dynamic World
6. Water	Liquid Dynamics: challenges for sustainability in water and sanitation

For more STEPS Centre publications visit:

www.steps-centre.org/publications

This publication was funded by The Climate and Development Knowledge Network (www.cdkn.org)

This is one of a series of Working Papers from the STEPS Centre
www.steps-centre.org.

ISBN: 978-1-78118-152-2

IDS Institute of Development Studies
University of Sussex SPRU – Science & Technology Policy Research
E·S·R·C Economic & Social Research Council

This document is an output from a project funded by the UK Department for International Development (DFID) and the Netherlands Directorate-General for International Cooperation (DGIS) for the benefit of developing countries.

Financing Sustainable Energy for All: Pay-as-you-go vs. traditional solar finance approaches in Kenya

Paula Rolffs, Rob Byrne and David Ockwell

STEPS Working Paper 59

Correct citation: Rolffs, P., Byrne, R. and Ockwell, D. (2014) *Financing Sustainable Energy for All: Pay-as-you-go vs. traditional solar finance approaches in Kenya*, STEPS Working Paper 59, Brighton: STEPS Centre

ISBN: 978-1-78118-152-2

First published in 2014

Acknowledgements:
This paper is based on MSc research conducted by Paula Rolffs with supervision from David Ockwell and Rob Byrne. It is currently being further refined and developed for submission to a peer reviewed journal. The paper contributes to the STEPS Centre affiliated project "Pro-poor low carbon development" funded by CDKN – for details of the project and related publications see http://steps-centre.org/project/low_carbon_development/ Paula gratefully acknowledges additional guidance from Michele Stua during the course of the research.

The authors wish to thank Adrian Smith and Michelle Stua for reviewing the working paper.

For further information please contact: STEPS Centre, University of Sussex, Brighton BN1 9RE
Tel: +44 (0) 1273915673; Email: steps-centre@ids.ac.uk; web: www.steps-centre.org

Contents

List of figures and tables

Acronyms

AECF	African Enterprise Challenge Fund
ARE	Alliance for Rural Electrification
BMZ	German Federal Ministry of Economic Cooperation and Development
BoP	Bottom of the pyramid
CBK	Co-operative Bank of Kenya
CEO	Chief executive officer
DEG	Deutsche Investitions- und Entwicklungsgesellschaft
DFID	Department for International Development
EAA	Energy Alternatives Africa
ESMAP	Energy Sector Management Assistance Program
FI	Finance institution
FKDTM	Faulu Kenya Deposit Taking Microfinance
GDP	Gross domestic product
GEF	Global Environment Facility
GOGLA	Global Off-Grid Lighting Association
GSM	Global System for Mobile Communications
IFC	International Finance Corporation
K-REP	Kenya Rural Enterprise Programme
KAKUTE	Kampuni ya Kusambaza Teknolojia
KEREA	Kenya Renewable Energy Association
KES	Kenyan Shilling
KUSCCO	Kenya Union of Savings and Credit Cooperatives
LPG	Liquefied petroleum gas
M2M	Machine-to-machine
MDG	Millennium Development Goals
MFI	Microfinance institution

MLP	Multi-level perspective
(M)Wp	(Mega)watt peak
NGO	Non-governmental organisation
PAYG	Pay-as-you-go
PV	Photovoltaic
PVMTI	Photovoltaic Market Transformation Initiative
RET	Renewable energy technology
RTM	Real time monitoring
SACCO	Savings and Credit Cooperative
SCODE	Sustainable Community Development Services
SE4All	Sustainable Energy for All
SHS	Solar home system
SMS	Short message service
SNM	Strategic niche management
SPL	Solar portable light
SSA	Sub-Saharan Africa
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
USD	United States Dollar

Summary

This paper focuses on finance for Solar Home Systems (SHSs) in Kenya and asks to what extent emerging new finance approaches are likely to address the shortcomings of past approaches. Whilst focussing explicitly on finance and drawing on a Pathways perspective (Leach *et al.* 2010), the paper rebuts the dominant framing of finance as the principal barrier to sustainable energy access for poor people. Instead it understands finance as a necessary, but not sufficient, aspect of alternative pathways to sustainable energy access. Even within the paper's explicit focus on finance, we adopt a framing that understands finance within a broader socio-technical context. This framing has subsequent implications for understanding the shortcomings of past finance approaches in delivering against the needs of poor and marginalised people in Kenya and the extent to which new finance approaches might overcome these.

The paper seeks to contribute to the literature on access to sustainable energy services in four ways. Firstly, it presents a comprehensive overview of past and new emerging approaches to financing SHSs in Kenya and their relative strengths and weaknesses. Secondly, it represents one of the first attempts in the literature to analyse the potential of new, real time monitoring using Machine-to-Machine (M2M) technologies and pay as you go (PAYG) finance models to overcome the barriers faced by conventional consumer finance models for renewable energy technologies (RETs). Thirdly, by applying (for the first time that we are aware of) a socio-technical approach, via the application of Strategic Niche Management (SNM) theory, to the finance of RETs in developing countries, the analysis considers finance in the context of the social practices poor people seek to fulfil via access to the energy services that off-grid RETs provide, and the ways in which people previously paid for these services (e.g. via kerosene for lighting). This also situates the analysis within the understanding of SHSs as a niche that has to compete with the established regime of energy service provision and its attendant social and political institutional support. The paper's fourth contribution, therefore, is to the small but expanding body of literature that seeks to operationalise socio-technical transitions thinking and SNM within a developing country context.

Weaknesses of past finance approaches identified by the analysis include: access to finance being limited to only small parts of the population (e.g. middle class employees of companies with hire purchase schemes); high interest rates, resulting from high transaction costs; inadequate after-sales service and customer support, resulting in widespread customer dissatisfaction and often refusal to repay loans; a lack of coordination between actors from the technology and finance sectors, causing delays and issues of accountability, linked to weak customer care. The analysis suggests new finance approaches might address these weaknesses in a number of ways: they provide wider access to finance as they are not restricted to certain groups or requirements; payment plans are adapted to match customers' existing expenditure on relevant energy services; coordination between finance and technology providers is not necessary, as both services are provided within the one-stop-shop models; existing enterprises emphasise the provision of a service rather than a technology, better attending to the needs and practices of potential users. However, new models face barriers in accessing working capital and an uncertain policy environment. They are also not yet able to reach the poorest strata of society.

Key policy recommendations include:

- Stronger commitments by the Kenyan government to new PAYG business models, nurturing market expectations and reducing the risk posed by political instability;
- More coherent support from international donors, helping to foster the protective space required for the SHS niche to compete with mainstream energy practices.;

- Linking the provision of donor grants to a requirement to share experiences gained during trial phases;
- An in-depth market study to help avoid resource intensive research by single energy enterprises;
- Orienting international development assistance towards needs assessments of the market and helping to establish political frameworks and infrastructures to facilitate further innovation. E.g. as the PAYG schemes are based on a novel application of M2M technology, it would be helpful to further test the strengths and weaknesses of the technology and to support further research and development into its cost structure, with a focus on how it might be applied within smaller systems which are critical to applications of relevance to poor people;
- Fostering networks of relevant actors across the whole of the SHS niche, from technology providers, to financiers, to mobile communications companies, to entrepreneurs, to consumers. An organisation like Kenya Renewable Energy Association (KEREA) might take on such a role, perhaps nurtured from the broader perspective that the new Kenyan Climate Innovation Centre might play. This highlights a central role for government and donors in supporting the actions of such organisations in capacity building activities across the SHS niche and beyond.

1. Introduction

The United Nations' Sustainable Energy for All (SE4ALL) initiative has brought the issue of access to modern energy services to the centre of the international development stage. It emphasises the centrality of access to modern energy services like light, refrigeration, mobile phone charging etc. to delivering wider development benefits, such as health, education, clean water and productive economic opportunities. Access to modern energy services is therefore central to achieving all of the Millennium Development Goals (MDGs) (UNDP 2007). But the scale of the challenge is enormous. Over 1.3 billion people lack access to electricity and 2.7 billion do not have clean cooking facilities (OECD/IEA 2011). More than 95 per cent of these are in sub-Saharan Africa (SSA) or in the developing countries of Asia. The problem is particularly acute in rural areas where 85 per cent of these people reside, but it is also problematic in many urban areas where those who do have access to electricity experience frequent black or brown outs.

Due to the high cost of grid extension to rural areas, around 70 per cent of sustainable energy needs will likely be met by off-grid renewable energy technologies (RETs). These include solar home systems (SHSs) or mini-grids that could be powered by solar, wind or biofuels (OECD/IEA 2011). Much of the literature dealing with barriers to the uptake of RETs in developing countries tends to frame the problem as principally comprising of high upfront costs (see Watson *et al*. 2012 for a systematic review of the literature). A Pathways perspective to understanding the problem (Leach *et al.* 2010), however, draws our attention to the fact that this is likely to be only one framing amongst multiple possible ones as to why more widespread uptake of RETs is not observed in rural areas of many developing countries. Finance is by no means the only barrier to the uptake of RETs. Indeed, a tendency to frame the problem as a simple one of financing renewable energy hardware, whilst ignoring the need to develop indigenous technological capabilities and understand the social contexts where the technologies are to be used, has been central to the failure of past policy approaches (Byrne *et al.* 2011, Phillips *et al.* 2013). This is reflected in Watson *et al.'s* (2012) finding that political and cultural barriers to electricity access are significantly under researched relative to economic and technical barriers. Therefore, whilst this paper focuses explicitly on financing RETs, the authors view finance to be a necessary but insufficient requirement for increasing access to electricity in developing countries.

Moreover, even when, as in this paper, analysis focuses explicitly on the issue of finance, it is possible to identify multiple potential framings of the problem with fundamental subsequent implications as to the extent to which different finance models deliver against the needs of poor and marginalised people in rural areas. In other words, even when focussing solely on the finance aspect of facilitating access to sustainable energy, the way in which the problem is framed and finance models designed to meet these alternative framings has a material impact in underpinning different pathways to sustainable energy access with different constituencies gaining and losing. This is illustrated in this paper via our adoption of a socio-technical stance to our analysis that explicitly analyses different finance models within the broader social contexts that define users' energy needs, and the institutional environment within which finance for RETs operates.

Whilst finance for energy is not sufficient to achieve sustainable energy for all, it is nevertheless an important part of the picture. For this reason it is concerning that Watson *et al.'s* (2012) systematic review found little attention in the literature to consumer finance for RETs in SSA. In relation to SHSs in Kenya (one of the most common examples of RETs in the country), for example, past approaches to consumer finance consisting mainly of hire-purchase and micro-finance are widely viewed to have achieved little success, particularly from the perspective of facilitating electricity access for the poorest households. This has led to the recent emergence of new real time monitoring technologies coupled with innovative new pay-as-you-go (PAYG) finance models as a way of overcoming past failures. Yet

almost no published and very little grey literature exists which attempts to systematically analyse the failure of past finance approaches in Kenya. We could only identify three studies that attend to new emerging finance approaches in any developing country context (these were Ballesteros *et al.*2012; Pueyo 2013; and Pode 2013). We also note Watson *et al.'s* (2012) finding that whilst technical and economic barriers have been widely researched, little robust evidence exists regarding interventions that might overcome these barriers. Our analysis of alternative models for financing RETs, therefore, also seeks to contribute towards addressing this weakness of the existing literature.

In light of the need for further research in this area, this paper focuses on finance for SHSs in Kenya and asks to what extent emerging new finance approaches are likely to address the shortcomings of past approaches. The paper seeks to contribute in four ways. Firstly, it presents a comprehensive overview of past and new emerging approaches to financing SHSs in Kenya and their relative strengths and weaknesses. Secondly, it represents one of the first attempts in the literature to analyse the potential of new, real time monitoring technologies and PAYG finance models to overcome the barriers faced by conventional consumer finance models for RETs. Thirdly, it applies a socio-technical approach, via the application of Strategic Niche Management (SNM) theory, to analyse the extent to which emerging new finance approaches might overcome the weaknesses and barriers faced by past approaches. This is the first time we are aware of SNM being applied to analyse finance for off-grid renewable energy in a developing country context. This makes a particularly important contribution by facilitating an analysis that is able to consider finance in the context of the social practices poor people seek to fulfil via access to the energy services that off-grid RETs provide, and to understand the financing of RETs within the context of the ways in which people previously paid for these services (e.g. via kerosene for lighting). It also draws attention to the way in which a niche for financing RETs might be fostered, to the extent it is able to compete with the existing financial regime that developed without consideration of the context-specific aspects of financing RETs, especially for poor people in developing countries. The analysis thus yields a number of insights and recommendations for future policy and practice in Kenya with potential for generalising across other developing country contexts on the basis of future research. Fourthly and finally, the paper makes a contribution to a small but expanding body of literature that seeks to operationalise socio-technical transitions thinking and SNM within a developing country context (Berkhout *et al.* 2010; Byrne 2011 and Byrne *et al.* 2012). This is significant as the approach was developed on the basis of empirical studies in industrialised countries (Lachman 2013). Developing country contexts present a range of important considerations not yet adequately theorised. Verbong *et al.* (2010), for example, using SNM to explain barriers to the implementation and development of biomass gasifiers in India, identify regime instability as one of the main constraints. They identify an antagonism with the claim in socio-technical studies of needing to destabilise an incumbent regime, which in their case study is non-existent. Similar issues arise within other developing countries. In the context of Asia, it is common-place to talk of late-industrialising countries and so it is likely that some kind of widespread socio-technical configurations are present, even if they are not easily characterised as stable regimes. In SSA, however, most countries are low-income and have severely undeveloped socio-technical configurations for providing societal needs. In such contexts, it is extremely difficult to identify even weak socio-technical regimes.

In the next two sections of the paper we present our conceptual framework and methodology. We then present an overview of the SHS market in Kenya, followed by an overview, first of past finance approaches and then of new emerging approaches. A comparative analysis of the potential of emerging approaches to overcome the barriers faced by past approaches is then presented, before giving some conclusions and recommendations for policy and practice.

1.1. Strategic Niche Management: Operationalising a socio-technical perspective

This paper adopts a socio-technical perspective to its analysis operationalised via theoretical perspectives from the literature on SNM. This perspective allows the paper to address several key issues of relevance to the uptake of low carbon energy technologies which are not addressed by

existing research on finance. Firstly, it allows us to understand technologies as co-evolving with the social contexts within which they are used, recognising that new technologies will be widely adopted not simply because they successfully harness technical principles but also if their form and function are 'aligned' or 'fit' with dominant social practices, or offer opportunities to realise new practices (or 'stretch' existing socio-technical practices) that are attractive in particular social and geographical settings (Hoogma 2000; Raven 2007). This allows analysis to focus on the services for which electricity is desired/used, which arguably represents a much more salient focus for understanding the finance and uptake of any technology that facilitates such service provision.

SNM adds to this socio-technical perspective by understanding low carbon energy technologies as part of a low carbon 'niche', or protected space in which normal selection pressures that help the dominant fossil based energy 'regime' to reproduce itself are weakened or absent (Smith 2007). SNM then, in turn, recognises the potential for low carbon niches to be nurtured, developed and adopted by building networks of actors and supporting institutions that eventually result in the low carbon niche influencing, transforming or replacing the dominant fossil regime. Understanding the processes of how and where niches have been successful and unsuccessful in influencing regimes therefore raises the potential to understand where policy or, in the case of this paper, finance approaches might deliberately intervene to nurture niches with the aim of widening and deepening access to low carbon energy technologies to benefit poor and marginalised groups. SNM is used as both a management tool to design policies and experiments around socio-technical niches (see Caniëls and Romijn 2008; Schot and Geels 2008) and, as we use it here, a theory to analyse niche processes *ex-post*.

For the purposes of this paper, we conceptualise SHSs and the related energy services they provide, along with associated actor-networks and relevant institutions, as the *socio-technical niche*. Solar portable lights (SPLs) could also be considered as being part of the niche, as they offer solar lighting and in some cases phone charging (Lighting Africa 2010). However, as financing schemes for SPLs are only just beginning they are excluded from our analysis. A *socio-technical regime* includes incumbent technologies as well as established values and practices which are socially embedded and which follow an established pathway that reinforces the current, stable technological system. '[…] incumbent systems, such as large-scale, centralised, fossil-fuel electricity generation, constitute more structured and structuring 'socio-technical regimes'' (Smith *et al*. 2013: 2). In the context of this paper, any large-scale, stable system is difficult to identify. Solar electricity as a provider of lighting and phone charging is supposed to replace kerosene and batteries or other fossil fuel powered charging devices. This common practice of lighting and phone charging can be conceptualised as the regime in which the SHS niche competes/seeks to influence. It is not the same kind of stable, large-scale regime that socio-technical transitions studies traditionally incorporate, but it seems to be a suitable way to frame the regime in the case of the SHS socio-technical niche, as any large-scale incumbent technology is absent. Geels' (2002) Multi-level Perspective (MLP) also posits the existence of the *socio-technical landscape,* constituted by exogenous factors which put pressure on the regime and open up windows of opportunity for niche configurations to break through (Markard *et al*. 2012: 957). In the case of solar lighting and phone charging the identified external influences are climate change and health concerns regarding kerosene and fossil-fuel based electricity, as well as the need for poverty alleviation, especially energy poverty alleviation. All these aspects are motives for clean and affordable electrification solutions.

Within SNM studies, five categories are identified to guide analysis of the extent to which a niche could influence/is already influencing a regime. We outline these below with a short explanation of how each category is operationalised within this study.

A) Protective space. SNM argues that sustainable innovations need 'protective spaces' where experimentation and development of new technologies can take place within a supportive environment (Smith *et al*. 2013). Jacobsson *et al*. (2004: 24) cited in Smith *et al*. 2013: 3) emphasise

that spaces offer opportunities for learning and that their protection goes beyond technology policy instruments. Protection is essential at the initial stage of innovations as it 'shields' them from mainstream selection pressures. Shielding can be passive through the use of pre-existing configurations, or active through strategic intervention from actors. The process of 'nurturing' enables socio-technical niches to grow and become able to influence/enter the regime. Nurturing is defined as support processes that enable the development of innovations. Dedicated intermediating work is needed for interactive learning to take place, expectations to develop, and supportive networks to build (Smith 2007). After that stage, the protection of the niche shifts to 'empowerment'. Empowerment is mainly achieved by advocates and networks around the socio-technical niche. Actors within the socio-technical niche become outward-oriented, which means that they are active within the regime and interact with others (Smith and Raven 2012; Smith *et al*. 2013: 3).

Finance for SHSs could enable active shielding, nurturing and empowerment. At the same time, it can be a form of support for actors and institutions that might collaborate within networks and which eventually lobby for the technology. The subsequent analytical categories within SNM are embedded within the protective space, but constitute important additional foci because they force our attention on the dynamics of interacting change processes.

B. Experiments and learning. Experiments can be perceived as being part of the process of nurturing (Smith *et al*. 2013: 4). They are defined as 'initiatives that embody a highly novel socio-technical configuration likely to lead to substantial sustainability gains' (Berkhout *et al*. 2010: 262). Experiments can be 'local', which means that they take place within local contexts in specific places, supported through local networks. They generate lessons which lead to learning (Smith and Raven 2012). Within the SHS niche in Kenya, finance projects, programmes and, recently, business models by socially oriented enterprises have been experimenting with the provision of end-use-level finance. These experiments might generate learning that could strengthen the SHS niche.

In SNM, learning is conceived in two forms (Byrne 2011). First-order learning is instrumental, focussed on trying to make a particular socio-technical configuration work. As such, it is concerned with refinements to the particular socio-technical configuration and tends to result in the accumulation of facts and data. For example, these could be about the technical performance or characteristics of a specific technology or finance model. Second-order learning is more fundamental. It can occur when the framing assumptions of a particular socio-technical configuration are challenged and can therefore result in a new set of framing assumptions and a new configuration. This new configuration will then require further first-order learning to accumulate relevant facts and data and to establish working refinements. To the extent that niches are protective spaces in which to experiment, learning can generate a range of socio-technical configurations and each can develop in parallel with the others. But, given the experimental nature of niches and the uncertainties associated with any particular socio-technical configuration, it is likely that second-order learning is especially critical to developing configurations that work and that can be successfully, and widely, deployed (Schot and Geels 2008; Byrne 2011).

C. Actor-networks. Networks of actors are important for building robust support for socio-technical practices, for facilitating knowledge exchange, for enabling interactions between stakeholders and for providing access to resources. Networks might be more effective if they are broad, which means the involvement of a large variety of stakeholders, and if they are deep, meaning there exists strong commitment amongst all actors and organisations (Schot and Geels 2008: 40-541). The key official networks around SHSs and other solar applications in Kenya are Lighting Africa, the Global Off-Grid Lighting Association (GOGLA) and the Kenya Renewable Energy Association (KEREA). Lighting Africa is an International Finance Corporation and World Bank programme that seeks to catalyse sustainable markets for affordable, off-grid lighting technologies for low-income households in SSA countries

(Lighting Africa 2013). GOGLA[1] aims to represent all companies and market participants who are involved in off-grid lighting around the world. KEREA's aim is to facilitate the growth of renewable energy businesses. It provides information on markets and technologies and promotes capacity building and networking (KEREA 2013).

D. Expectations and visions. In SNM expectations and visions are variously specific articulations of the future in which particular socio-technical configurations are usually central (Byrne 2011). For example, rural electrification based on SHSs can be considered an expectation. A vision would include more than this relatively vague articulation by including the means by which the expectation can be realised. Such means might include business models, supportive policies and technical specifications for the SHSs themselves. Both expectations and visions can be linked directly with first and second-order learning. That is, an expectation can act as a goal, arising from a set of framing assumptions, towards which actors engage in first-order learning as they try to realise the expectation. In doing so, they begin to detail the means by which that expectation can be realised and therefore begin to detail a particular vision. When framing assumptions change through second-order learning a new expectation is generated and further first-order learning in this new direction will begin to detail a new vision. However, both expectations and visions need to be sufficiently robust, specific and stringent (and be 'shared' collectively) to have long-term effects on the evolution of a niche (Raven 2005).

Examples in the case of finance for electricity access are international development agendas like the Sustainable Energy for All (SE4All) initiative. A number of other relevant expectation or vision-oriented policies and initiatives exist in the context of SHSs in Kenya. The Kenya 2030 Vision is a development programme that is supposed to transform Kenya into a 'newly industrializing, middle-income country providing a high quality of life to all its citizens by 2030 in a clean and secure environment'. (Republic of Kenya 2007, cited in Hope 2013: 209. Kerosene Free Kenya is a project aiming to reduce greenhouse gases and improve the health situation by replacing fossil energy for lighting and cooking (Ministry of Environment, Water and Natural Resources 2013). All these initiatives and programmes have the potential to support the SHS niche via connecting to global and national agendas which express relevant needs and ways solar technologies might meet them.

E. Institutions. Institutions include laws, regulations and policies as well as practices, norms and conventions regarding a particular socio-technical configuration (Byrne 2011: 19). A critical process in developing from a niche to a regime is the structuring of practices that can be adopted widely. Institution-building (whether formal or non-formal) is therefore an important process that co-evolves with those outlined above as a niche develops. From the perspective of SHSs in Kenya, this would include the co-evolution of governmental regulations, such as import taxes or quality standards, and solar technologies. This category also directs analytical focus towards consumer behaviour, socio-cultural practices and the relevant energy services that SHSs might facilitate.

[1] http://global-off-grid-lighting-association.org/

2. Methodology

The analysis in this Paper is based on a literature review of grey and published literature triangulated via in-depth, semi-structured interviews. As literature on consumer finance for RETs in Kenya is sparse, a snow-ball technique as well as suggestions and evidence via email, telephone and Skype calls with several experts helped to detect reliable and publicly available sources such as project reports, research and consultancy documents, government documents and press articles, as well as websites.

The research began by developing a detailed picture of the SHS market in Kenya. It then concentrated on identifying and analysing past and new emerging finance approaches for SHSs in Kenya, focussing on case studies. As no generic study on consumer finance approaches in Kenya appears to exist, the case studies help us to catalyse descriptive and explanatory elements in order to identify common issues that characterise the strengths and weaknesses of different approaches and identify elements that might lead to future successes or failures. The case studies were identified via an initial review of the literature and discussions with individuals who have been involved with, or have in the past researched, the SHS market in Kenya.

Information on past finance approaches is based primarily on a review of reports of international development agencies that were produced to communicate lessons learned from specific projects. Wherever possible, alternative different sources and independent studies have been consulted in order to reduce the reliance on reports which might over-emphasise successes whilst under reporting lessons that might be perceived as 'failures'. This was further assisted by triangulation via in-depth, semi-structured interviews.

Table 2-1: Interview partners

Interviewee	Interview category	Name	Organisation
1	New PAYG model	Nick Hughes	M-KOPA
2	New PAYG model	Simon Bransfield-Garth	Azuri
3	New PAYG model	Klara Lindner	Mobisol
4	Past finance approaches	Charlie Miller	Sunny Money/ SolarAid
5	Past finance approaches	Mark Hankins	African Solar Designs
6	Past finance approaches	Arne Jacobson	Schatz Energy Research Center, Humboldt State University (USA)
7	Past finance approaches	Teddy Ongamo	Former employee at Kenya Union of Savings & Credit Co-operatives

As no studies exist of the emerging new finance approaches, data collection here focussed on expert interviews and information provided by companies' websites. The case studies analysed are M-KOPA, Mobisol and Azuri. These are currently the three biggest schemes offering PAYG payment plans for off-grid SHSs in Kenya. As the models only began a few years ago it is not possible to draw conclusions on their actual performance, as it is for previous finance schemes. The application of SNM concepts,

however, enables comparative analysis with former finance models, based on their potential to perform better than past finance approaches in relation to the core analytical categories of SNM.

The semi-structured expert interviews consisted of one face-to-face interview in the United Kingdom (UK) and six interviews by Skype, with individuals in Kenya, the United States and Germany (see Table 2.1). Interviewees were divided into two categories. First, a group of four experts on SHSs in Kenya, with a private-sector, a non-governmental organisation (NGO) and academic background were interviewed to identify salient features of barriers faced by past finance approaches. The interview questions were structured around the five analytical concepts of SNM (Appendix A). The second category of interviewees consisted of individuals from each of the three new PAYG finance initiatives in Kenya; the chief executive officers (CEOs) of M-KOPA and Azuri and an employee of Mobisol. Again, interview questions were structured around the SNM categories (Appendix B). Table 2.1 lists the interviewees and numbers them. The numbers are used as references for quotations in the remainder of this paper.

3. Consumer finance and the socio-technical SHS niche in Kenya

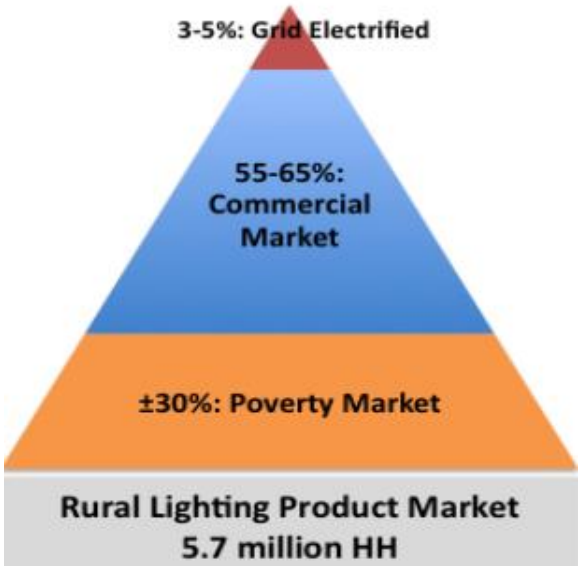
This section presents contextual detail on what we conceptualise as the SHS niche in Kenya and the role of finance within it. It begins by introducing the market for SHSs in Kenya. It then introduces the Kenyan finance sector and the different generic consumer finance models that exist for financing SHSs.

3.1. The SHS niche in Kenya

Kenya has a population of over 43 million people and an annual GDP growth of 4 per cent (World Bank 2013). Around half of the population lives on less than USD2 per day and around 80 per cent of the population is located in rural areas (Bawakyillenuo 2012: 414). Less than 30 per cent of the population is connected to the electricity grid, with urban access at 50 per cent and rural access at only 5 per cent (Ministry of Energy 2012, cited in Pode 2013: 616). It is unlikely that the grid will be extended to rural areas with sparse populations and low commercial electricity consumption, a situation confounded by the high costs of grid extension. Hence, off-grid electrification is often the most viable form of electricity access for the majority of the rural Kenyan population. Solar based electricity services are a suitable technical option for stand-alone power generation at the household level due to the abundance of solar energy and the appropriateness of its small-scale application.

According to Lighting Africa (2012a), there exist three different electricity markets in rural Kenya: the small grid electrified market; the commercial market; and the poverty market.

Figure 3-1: Market segmentation for rural electrification in Kenya



Source: Lighting Africa 2012a

Due to a relatively large rural middle class, the commercial market in rural Kenya is large compared to other SSA countries, making it an attractive market for SHSs. So-called 'poverty markets' have a lower level of kerosene use and SHSs might not be appropriate for them at current cost. For this market, SPLs would be a feasible option if their cost could be spread (Lighting Africa 2012a). A financial analysis for SPL shows that even with an interest rate of 40 per cent, an SPL of KES3,500 (USD40) can be repaid within 28 weeks, given a daily expenditure on kerosene and phone charging of KES20 (USD0.23) (Hannappel *et al.* 2013). The total market size for rural lighting products comprises 5.7 million households. For the 55–65 per cent of rural Kenyans without electricity access but with a reasonable income, solar PV technologies in the form of SHSs are seen to be the best option for clean and

affordable off-grid electrification (Lighting Africa 2012a; Ondraczek 2013). In addition, the cost of SHSs is decreasing rapidly and in many developing countries, including Kenya, solar PV technologies are already claimed to be relatively competitive (Bazilian et al. 2013).

It is estimated that 320,000 SHSs had been installed by 2010 in Kenya, accounting for 10 megawatt peak (MWp) (Ondraczek 2013: 407). The systems typically have a capacity of 14-20 Wp and are primarily used for lighting and mobile phone charging. Annual sales have grown from around 1,000 in the late 1980s to 25,000 within the past years (Jacobson 2004; Lay *et al*. 2012: 3; Ondraczek 2013: 409). Current numbers are probably higher, as the pay-as-you go finance initiative, 'M-KOPA', alone has recently sold around 10,000 systems within about two months (M-KOPA 2013). According to Pode (2013: 615) the Kenyan Government has installation targets of 600,000 SHSs between 2012–2030. It is argued that during the first decades of its existence, the Kenyan SHS market was catalysed mainly by donor support, based on the mainstream neo-liberal international development agenda (Bawakyillenuo 2012).

Solar photovoltaic technology emerged as an important tool for rural electrification at a time when neo-liberal policies dominated mainstream development thinking. In the late 1980s and 1990s, a period that some have called the age of 'market triumphalism' (Peet and Watts, 1993), mainstream development policies emphasised economic liberalisation, privatisation, and market-based approaches to service provision (Kapur *et al.* 1997; Jacobson 2007: 145).

Kenya has one of the world's largest off-grid SHS markets and is the only country in the region with its own solar panel assembly plant[2], but despite the market size and potential, only around 4.4 per cent of rural households had an SHS by 2011 (Ondraczek 2013). Even though this number is likely to be higher now, it means that SHSs are still a niche technology which has not yet replaced the more common practices for lighting and phone charging which, according to Lighting Africa (2012b), are usually met by kerosene and batteries.

Several significant studies exist on SHSs in the Kenyan context (Hankins 1993 and 1996; Jacobson 2004; Byrne 2011; Ondraczek 2013). High up-front costs are widely observed to be a major barrier for large scale up-take of SHSs and a lack of access to end-use-level finance is identified as one of the major obstacles to overcoming this (Acker and Kammen 1996; van der Plas and Hankins 1998; Jacobson 2004; Kabutha *et al*. 2007). Several studies presenting case studies of finance for SHSs exist (Pode 2013; Laufer and Schäfer 2011; Asif and Barua 2011), but no generic analysis has been conducted of consumer-finance models for SHSs in Kenya. Those studies that do exist focus mainly on finance schemes during the 1990s. Only a few donor financed reports and manuals make key issues, lessons learned and suggestions publicly available (Hankins and van der Plas 2000; Krause and Nordström 2004; Magradze *et al*. 2007; Kabutha *et al*. 2007; Kariuki and Rai 2010). Within this literature there is a focus on finance schemes where some kind of participation by industrialised country actors is involved, so little information exists on those arrangements where participation of foreign assistance is absent.

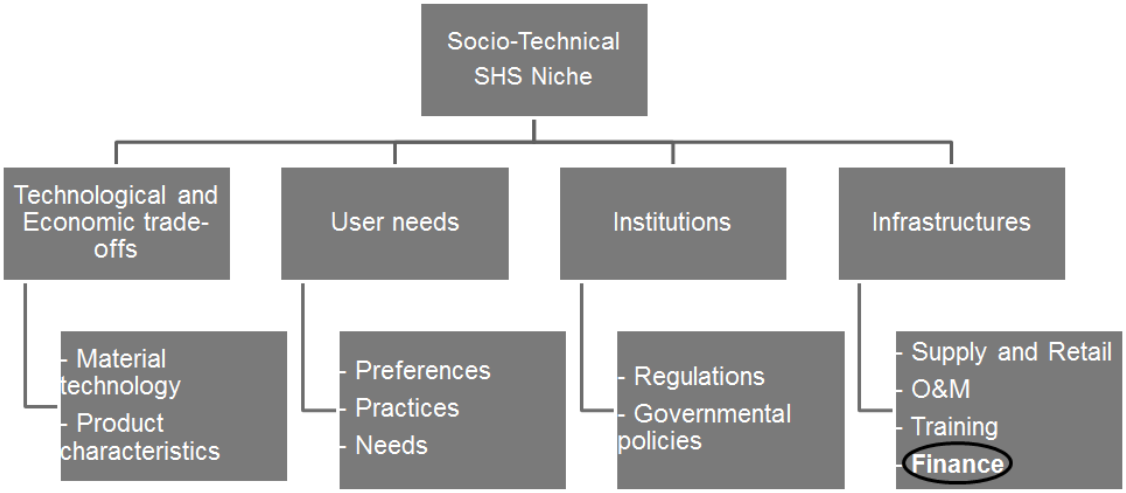
As many people cannot afford the upfront costs or see the investment as being too risky in relation to a new technology, financing has been seen as a key way of helping them to overcome this cost and risk barrier. Several attempts have been made to introduce finance schemes aimed at spreading the cost of SHSs. In Kenya, these finance schemes started in the 1990s with support from international development organisations, which tried to introduce loans for SHSs via banks, Savings and Credit Cooperatives (SACCOs) and microfinance institutions (MFIs). Such attempts were built on the general praise of microfinance and success stories from micro-financed SHSs in other countries, but it did not meet with similar success in Kenya. In fact, due to several issues related to accessing finance and

[2] http://www.ubbink.co.ke

technical challenges, projects often did not proceed beyond the pilot phase. The 'failure' of these solar loans stands in contrast to the relative 'success' of local hire-purchase arrangements. Hire purchase schemes operate in agreement with particular employers, who act as guarantors for the consumer. Repayments are taken directly from the employee's salary on a monthly basis. The interest charged is usually much higher than the already high rates charged by MFIs. However, hire purchase has been the most successful approach to date in Kenya, when measured in terms of SHSs sold through consumer finance. Nowadays, new approaches to consumer finance for SHSs and solar lighting are emerging in Kenya based on PAYG type arrangements. These business models are linked to real time monitoring (RTM) via machine-to-machine (M2M) technologies that enable remote payment control. The main strategies of these new approaches are to reach low-income customers through down-payments and instalments that allow for flexible payments.

Spreading the costs of SHSs is a major rationale for providing finance for electricity access at a household level to adapt it to traditional consumption patterns (Lucas *et al.* 2013: 11; Hankins and van der Plas 2000; Watson *et al*. 2012). In this way, finance can be conceptualised as an enabling infrastructure for niche development. But it is important to understand finance within the many other elements of the socio-technical SHS niche in Kenya, as illustrated within Figure 3.2. This illustrates the complexity of the socio-technical SHS niche. Finance as an enabling infrastructural consideration is interlinked with technological and economic trade-offs as well as user needs and institutions. Figure 2 also serves to emphasize the uniqueness of a socio-technical niche within a given context. This goes some way to suggesting why replicating success stories of finance models for SHSs from other countries might be limited, as will be seen in the case studies below.

Figure 3.2: Dimensions of the socio-technical SHS niche



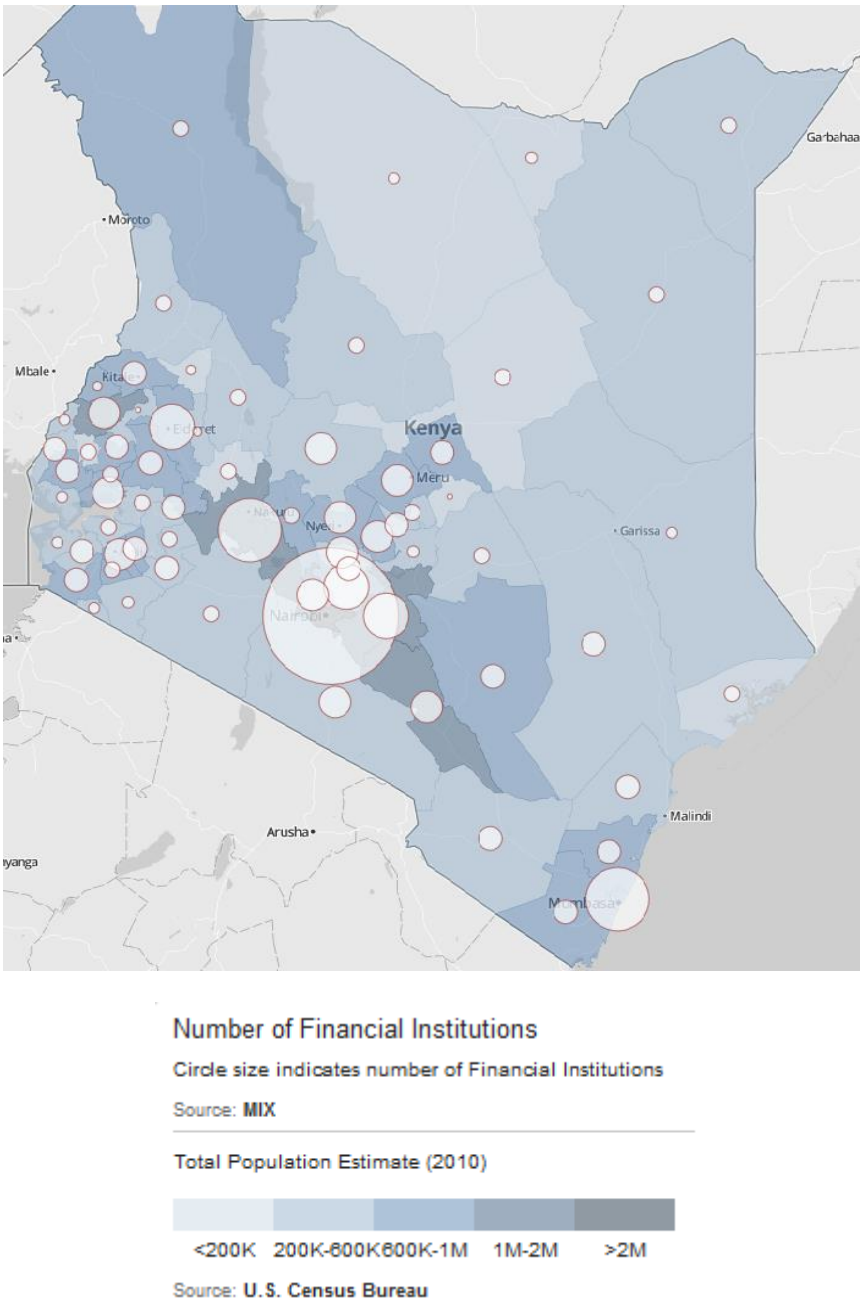
Source: Based on Byrne (2011: 36)

3.2. Kenya's finance sector

Consumer finance approaches for SHSs needs to be understood within the broader context of Kenya's finance sector. From the perspective of financial inclusion, Kenya has a mixed profile. The portfolio of financial institutions in Kenya is larger than in many other SSA countries, partly due to high degree of financial liberalization. However, access to formal financial services remains limited (Morris and Kiburi 2009: 17). Statistical analysis of the World Bank Findex database from 2011 shows that 45 per cent of the adult population had an account at a financial institution, including post offices and MFIs. However, only 10 per cent had borrowed money from a finance institution (FI) in 2011 (see Appendix C). In total, nearly 40 per cent of the population is financially excluded, meaning they do not use either formal or informal financial services (Morris and Kiburi 2009: 17).

The outreach of FIs to rural areas, where finance for off-grid electricity is needed, is limited. The map in Figure 3.3 shows that the majority of FIs are located in regions with high population density, which are generally urban areas. However, since 2007 mobile money is playing an increasing role and has significantly changed the pattern of financial inclusion in the country. By 2012, around 70 per cent of the adult population had signed up with M-PESA, Kenya's mobile phone-based money service. Over 37,000 retailers are now present in Kenya and 60 per cent of money transactions in the country go through M-PESA for an amount equal to 20 per cent of the gross domestic product (GDP), an achievement that banks in the country have not been able to reach (Omwansa and Sullivan 2012; Nique and Arab 2013: 6). The financial landscape of the country as well as the recent developments in mobile money services shape the finance schemes which have developed within the SHS niche.

Figure 3.3: Quantitative geographical presence of finance institutions in Kenya

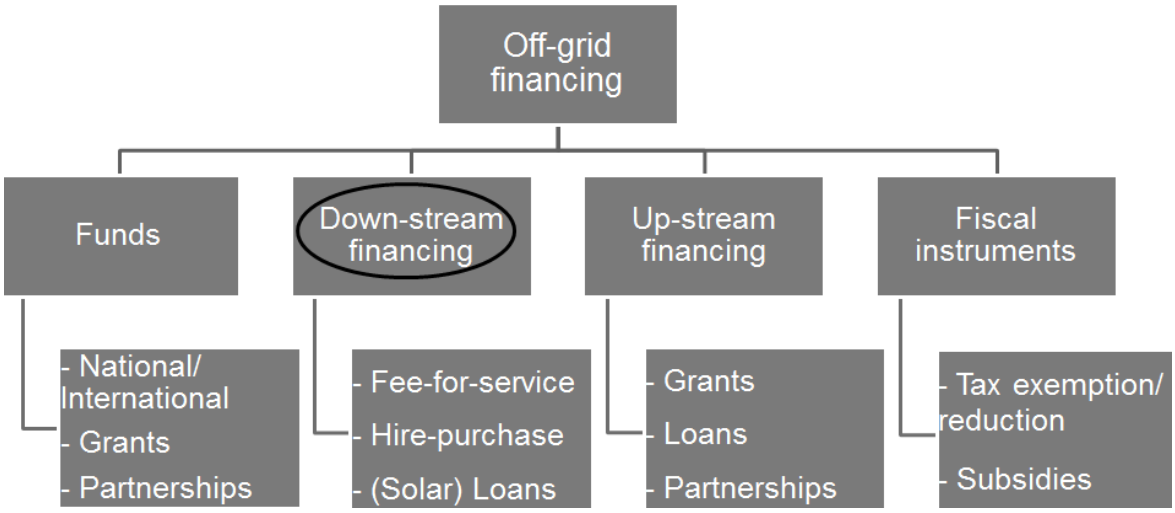


Source: Mixmarket 2013a

3.3. Consumer finance approaches

Access to finance for RETs can be divided into two components: downstream financing is directed to consumers through credits or payment plans, while upstream financing is directed to enterprises by business de-risking, for instance in the form of working capital. Funds and fiscal instruments can support the provision of finance. This is illustrated in Figure 3.4.

Figure 3-4: Off-grid financing sources and options



Source: Based on Bhattacharyya (2013: 470)

As Figure 3.4 shows, different options exist for down-stream off-grid RET financing. The most common formal finance schemes in Kenya and other SSA countries are described below. Fee-for-service is common in several SSA countries but not so much in Kenya. The country's most common SHS finance schemes have been hire-purchase agreements and credits. Loans comprise consumer loans and revolving credits as well as microfinance and mobile and M2M enabled finance.

Fee-for-service

Within a fee-for-service model, the SHS is not owned by the user but by the technology provider or a company that installs the system. The customer pays a monthly fee that allows them to use the system. This payment scheme has been used mainly in South Africa, backed with large subsidies (Hankins 2004: 22).

Hire purchase

Employers have an agreement with a technology supplier and offer SHSs to be paid for under a hire-purchase agreement. The monthly amount is then deducted from the employee's salary. Interest rates are usually very high and loan periods vary between 6 and 18 months. This is a common way of purchasing goods in many SSA countries, including Kenya (Hankins 2004).

Consumer loans and revolving credits

Such loans comprise general consumer loans as well as specific SHS loans. Approaches to establishing SHS loans have often been initiated through development cooperation and then handed over to local finance institutions (FIs). 'Revolving credit' refers to a credit scheme where customers pay a flexible commitment fee which allows them to use the money when needed. The interest paid by one recipient is re-used by other customers. This system is often used within donor-supported schemes. Consumer loans are typically offered by commercial banks and SACCOs. In the past commercial banks initiated SHS loans in Kenya but did not continue, as transaction costs of administering and verifying consumer loans for rural customers were considered to be too high. They generally charged interest rates ranging from 15 per cent to 38.9 per cent (Pode 2013: 616).

The Kenyan SACCO sector is the largest in Africa (Morris and Kirubi 2009). SACCOs offer their standard or product specific loans via membership organisations primarily to civil servants and employees of the agricultural sector. Their outreach into rural areas, especially in Kenya, is larger than that of commercial banks and their interest rates (2 per cent–12 per cent), as well as their security requirements, are lower (Hankins 2004: 19-24; Pode 2013: 616).

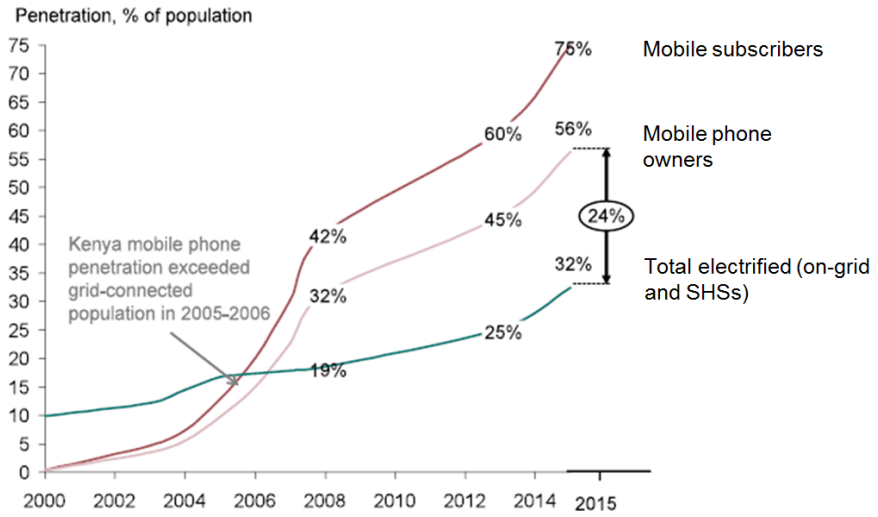
Microfinance

Microfinance has for a long time been seen as the single best solution for financial inclusion of the poor population (Napier 2011: 5). For that reason, it has also been tested for the provision of finance for SHSs by international donor organisations. Furthermore the success of micro-financed SHSs in other countries, like under Grameen Shakti in Bangladesh or Selco in India, has triggered attempts at replication (Lighting Africa 2010; Asif and Barua 2011; Pode 2013). However, traditional microfinance impact has been questioned by various studies (Napier 2011; Koh *et al*. 2012). For instance, there are heavy critiques regarding high loan rates which can lead to increased poverty levels through high interest rates (Rooyen *et al*. 2012). Many microfinance programmes focus entirely on the support of micro-enterprises and often include capacity building aspects, to provide the poor not only with money but also with training in order to help them use the money productively in an efficient and sustainable way. Hence, micro-finance SHSs have often been linked to productive use (Napier 2011; Collins *et al*. 2010). In the East African region, Kenya has a relatively well developed microfinance infrastructure. Nevertheless, it is far from being as well-developed a network as in Bangladesh and MFIs are perceived as lacking the resources to specialize in certain consumer products like SHSs and the energy sector in general (Interviewee 6).

Mobile and M2M enabled pay-as-you-go credits

The scale of mobile phone penetration together with RTM technologies enabled a new model of finance for SHSs, based on a PAYG schedule. By 2006 the number of mobile phone subscribers already exceeded the number of people with access to electricity. As Figure 3.5 shows, in 2010 mobile phone subscribers were double the amount of people who were either connected to the grid or getting electricity from an SHS, and this trend is expected to continue. Such development is seen as a driver for electricity demand and, at the same time, as an opportunity to enable electricity and lighting access through SHSs and SPLs (Lighting Africa 2010).

Figure 3-5: Mobile ownership and electrified population in Kenya



Source: Based on Lighting Africa 2010

Many start-up businesses have evolved following the success of M-PESA. In fact, most of these companies provide either finance for water or energy (Ehrbeck 2013). In early 2012, Safaricom

decreased M-PESA tariffs on the smallest transactions from KES 10-49 (USD0.1–0.5) to KES3 (USD0.03). This enables micro-payments, reaching poorer population and making micro lending possible (Nique and Arab 2013).

Innovative business models based on flexible mobile payments and vouchers emerged, offering SHSs for a certain down payment and subsequent instalments paid via scratch cards or mobile payment over a certain period of time. Monitoring of payment and systems is realised by M2M technologies which send information via the Global System for Mobile Communications (GSM) network to system management centres (Pueyo 2013: 6). The payment plan can be viewed as a form of microfinance as small loans are being disbursed. However, it also differs significantly from traditional microfinance models and is therefore treated as a new finance model in this paper.

4. Empirical findings

4.1. Past finance approaches

This section provides an overview of the key hire-purchase and micro-credit schemes identified through this research and assesses the challenges and obstacles they faced. It begins by giving an overview of hire purchase schemes in Kenya, before providing specific case studies of consumer finance schemes for SHSs. A summary of the main barriers faced by these past finance approaches is then provided at the end.

As emphasised above, there is a widely held belief that cost is the main constraint for the uptake of (high quality) SHSs in Kenya (and elsewhere) and that this problem can be tackled by the provision of finance (Interviewee 5; Acker and Kammen 1996; van der Plas and Hankins 1998). According to estimates by Hankins (2004) and Jacobson (2004), the Kenyan market has been dominated by cash sales for a long time. The possibility of spreading the cost has traditionally been facilitated through informal credits, offered by local SHS dealers to their customers on a trust basis, allowing a certain amount to be paid over several months with a mutually-agreed interest rate. Another way to spread the cost is modular cash purchase, i.e. buying the system in pieces (Acker and Kammen 1996; Hankins 2004). However, since the 1990s several attempts have been made to introduce formal finance models for SHSs. These comprise well-documented microfinance projects based on donor grants during the late 1990s and early 2000s. There are also examples of local MFI, SACCO and bank-based microfinance and hire-purchase agreements with limited or no intervention through international development cooperation. This is probably the key reason for a lack of documentation and reporting on these kinds of finance initiatives for SHSs in Kenya. Of all the literature reviewed for this study, only one PhD thesis includes a short overview of the role of hire purchase (Jacobson 2004). Byrne (2011) also addresses it briefly in relation to Tanzania (Byrne 2011: 186-188) and Hankins (2004) touches on the 'success' of hire purchase in Kenya (Hankins 2004: 22). In the description below, therefore, it was only possible to provide a general overview of hire-purchase schemes, whereas detailed case studies are provided of donor funded consumer finance projects. Due to the reasons described below, these donor funded finance models for SHSs were not very successful.

4.1.1 Hire-purchase credits

Hire-purchase credits for SHSs resulted in high sales numbers in the late 1990s until around 2003 (Interviewee 5). Hire purchase is a common way of financing consumer goods like cars, TVs and other household devices. Typically, hire-purchase credits are given to customers who are employed and get a regular salary, as the credit is deducted from the person's salary. In Kenya it is typically the teacher's association which has contracts with a specific hire-purchase company. The fact that the teacher's association or any other employer who offers hire-purchase schemes operates with only one hire-purchase company leads to a quasi-monopoly and missing competition, which has resulted in very high interest rates of around 40 per cent, making the price of an SHS 80 per cent to 150 per cent higher. The loan periods are usually short (between six and 18 months).

The first effort to establish hire-purchase finance in the early 1990s was not successful, but the second attempt initiated in 1997 resulted in high sales and a general trend began for companies importing solar photovoltaic (PV) modules starting to supply their products via hire-purchase schemes (Hankins 2004: 22; Jacobson 2004: 181). The market share of hire-purchase financed SHSs was estimated to be around 15 per cent by 2004 (Hankins 2004). However, those credits mainly targeted the rural, employed, middle-class population and excluded the so called bottom of the pyramid (BoP), poorer population.

As well as the failure of hire-purchase to service the needs of poorer households, a lack of technological knowledge amongst hire-purchase agents and hence the missing technical support has also been identified as problematic (Interviewee 5; Jacobson 2004). Even though hire purchase is widely understood to be the most successful finance scheme in the early 2000s, there is no publicly available documentation on numbers of sales by hire-purchase companies to support this assertion and we were not able to identify any case studies which would exemplify the hire-purchase experience (Ondraczek 2013).

4.1.2 Case studies of solar loan approaches

Since the 1990s there have been several attempts to establish end-use level SHS finance schemes for rural Kenyans through commercial and cooperative banks as well as MFIs. The best known and largest are donor driven approaches through the Global Environment Facility (GEF)/World Bank Photo Voltaic Market Transformation Initiative (PVMTI) and United Nations Development Programme (UNDP)/World Bank Energy Sector Management Assistance Program (ESMAP). There have also been some smaller experiments by individual banks and MFIs (Jacobson 2004: 183; Byrne 2011: 124-130). According to Lighting Africa, three MFIs in Kenya are currently offering loans for SHSs (Lighting Africa 2012).

By 2004 these approaches had not resulted in large sales numbers. Compared to cash sales and hire-purchase deals they made a very small fraction of the market. Whereas cash sales and hire purchase accounted for over 20,000 sales annually, these initial microfinance models only resulted in the sale of a few hundred systems (Jacobson 2004: 183). The case studies of these schemes identified through this research are detailed below.

World Bank Energy Sector Management Assistance Program (ESMAP). Documentation on ESMAP is mainly in the form of an implementation manual (Hankins and van der Plas 2000) published by ESMAP itself. It summarises the experience of ESMAP's approaches to provide guidelines for future finance attempts. The approach adopted by the programme consists of a group loan provided through cooperation between a finance institution and a technology provider, who is supposed to give the customer technical guidance (Hankins and van der Plas 2000).

ESMAP and the Ashden Trust (a grant giving charitable trust) provided funds under the management of Energy Alternatives Africa (EAA), a Kenyan consultancy specialising in renewable energy technologies, to test two approaches with the Kenya Rural Enterprise Programme (K-REP) and one with the Co-operative Bank of Kenya (CBK). Both financial institutions first had to be convinced to offer finance for SHSs, as they did not know the technology well and only agreed due to the risk mitigation potential of the grants. Ultimately, all approaches trialled under ESMAP experienced difficulties in the implementation of the finance mechanisms and none was continued past the close of the scheme. ESMAP is thought to have funded installation of a total of only around 100 systems within 18 months (Byrne 2011: 125–126).

In the case of the two K-REP approaches, loan groups were selected by K-REP themselves and by EAA. The EAA-selected groups were already familiar to EAA and were expecting more favourable lending terms. This led K-REP to withdraw the loan in May 1997 (Hankins and van der Plas 2000: 19-38). Problems of accountability occurred among the K-REP selected groups relating to technical issues between the customers, the installers and K-REP. this resulted in payback default amongst nearly half of all the customers:

> […] People refused to pay when their system malfunctioned; technicians failed to honour their commitment to provide maintenance services over the two years of the loan repayment; and technicians failed to respond to customer requests for assistance. Finally, loan repayment seemed to be taken less seriously over time.
> (Hankins and van der Plas 2000: 6-27).

GEF/World Bank Photovoltaic Market Transformation Initiative (PVMTI). Even though ESMAP faced several challenges and is generally perceived to have been a failure, it still provided some important lessons which could be built upon by PVMTI. PVMTI was implemented in Kenya, Morocco and India to stimulate the emerging local solar-PV markets through the provision of USD30 million in total, of which USD5 million was used for both demand and supply side initiatives in Kenya from 1998. The impact of the project was expected to lead to a worldwide PV sales increase of 5% per cent within five years (Magradze *et al*. 2007; Byrne 2011: 128). Projects under PVMTI were based on proposals which had to fulfil the requirement of a minimum investment of USD500,000. This high amount limited participation to finance institutions, which proved to have slow administration processes and legal restrictions. After long negotiations, three deals were approved: one with Barclays Bank, Kenya; one with the Equity Building Society; and one with Muramati SACCO (Hankins and van der Plas 2000: 29; Byrne 2011: 127-128).

Barclays Bank distributed funds for solar lending to several SACCOs. However, it was plagued by problems. The Kenya Union of Savings and Credit Cooperatives (KUSCCO) was supposed to identify SACCOs for Barclays. As this was taking a long time, Barclays was unsatisfied with the process. At the same time, KUSCCO was concerned about bringing customers to their competitor Barclays, and SACCOs feared losing their reputation among customers because of service delays (Byrne 2011: 128).

The Equity Building Society project also faced delays and cumbersome negotiations. Equity was supposed to offer loans for PV entrepreneurs with PVMTI mitigating the risks. However, in the end both the IFC and Equity Building Society withdrew from the deal because of legal issues (Ngigi 2008, cited in Byrne 2011: 128).

Muramati tea growers SACCO is one of the larger SACCOs in Kenya and was supposed to demonstrate that the SACCO sector could offer an attractive channel to the PV market. The initiative had already been started through ESMAP and was continued by PVMTI. However, due to a number of challenges only 150 to 170 systems were installed before the project was stopped and the money was returned (Magradze *et al*. 2007: 43; Byrne 2011: 129). The system price offered by the supplier was too high. Installation costs were also too high as a team from the capital 90 kilometres away had to camp on-site for the duration. A maintenance program was also missing and the scheme faced problems with accountability for technical problems. The scheme has not financed any other systems since (Interviewee 7; Kariuki and Rai 2010: 11).

Guided by the advice of some actors in the Kenyan SHS niche, the attempt to establish consumer finance through PVMTI stopped after several years and after restructuring the initiative in 2004, it shifted towards capacity and expertise building in the solar PV sector in the project period from 2005 to 2009 (which got extended until 2011). PVMTI recognised that:

> capacity building and technical assistance may be more important than business finance […] At the time PVMTI was introduced, and for several years thereafter, the Kenyan market was not prepared for the financial product and services that PVMTI offered.
> (Magradze *et al*. 2007: 43)

In the second phase of the initiative, a PV curriculum, training courses, and manuals as well as a quality assurance programme were developed (Magradze *et al*. 2007: 42; Byrne 2011: 129).

Michimikuru SACCO solar electrification project. The Michimikuru solar electrification project is an example of a small scale attempt to offer SHS loans to a specific community via a SACCO. It was operating from 2002 to 2004 and received USD30,000 funding from the UNDP and GEF Small Grants Programme. It was managed by a local NGO called Solarnet together with Thananga, a tea growers SACCO. The 40 to 80 Watt systems were first sold through a soft loan with a 15 per cent annual interest

rate and two-year loan period. However, these terms were not low enough for the poorer SACCO members. Therefore the funding was augmented in order to reduce the interest rate to 3.3 per cent and extend the loan period to three years (Jacobson 2004: 184). But between 2002 and 2004, only 150 SHSs had been sold, mainly to rural middle class SACCO members.

Faulu Kenya Deposit Taking Microfinance (FKDTM). FKDTM developed from an NGO to a profit making MFI. It has around 82,000 customers and a relatively wide outreach in the country (Kabutha *et al*. 2007; Mixmarket 2013b). the following information is based on a study on MFI lending portfolios for energy products, funded by United States Agency for International Development (USAID) and the Citi Foundation (Kabutha *et al*. 2007).

Established in 2007, Faulu's energy loan portfolio included liquefied petroleum gas (LPG), SHSs and biogas. SHSs had been sold for USD140-380, with an interest rate of 20 per cent, weekly payments, a repayment period of one year and a loan ceiling of around USD1,430. The energy loan clients were mostly relatively low income groups in urban areas with a small or medium sized business. Faulu Kenya's business model was based on a partnership with a technology provider who installed the system, trained the client and provided after-sales service. By 2007, only 15 SHSs had been sold (although it is not known how many systems have been sold since then). Geographically, Faulu Kenya's service has been limited due to the localisation of technology providers in urban areas which would make a technical service in rural areas too costly. As with many other SHS finance approaches, Faulu faced problems of coordination and accountability regarding technical issues and customer care. Within Faulu, there were no personnel that specialised in energy products. However, the MFI was the direct contact point for customers who expected more information and expertise on the technology from its financial service provider (Kabutha *et al*. 2007: 26-31).

The Kenya Union of Savings and Credit Cooperatives (KUSCCO). KUSCCO was founded in 1973 to serve as an umbrella organization for SACCOs. It operates as a second-tier MFI through SACCOs, which it advises on technical issues, capacity building and product development (Kabutha *et al*. 2007: 33). In 2002/2003 KUSCCO established a department for energy lending which started with its first installations of renewable energy technology in 2004. It received grants, technical assistance, and capacity building through PVMTI, and Shell Foundation's Breathing Space Project for LPG and biogas. By 2007 it was offering energy products in 43 of the 72 districts in Kenya. Similar to Faulu, KUSSCO offered LPG, solar and biogas technology. For its solar products it partnered with the technology provider Chloride Exide. The SHSs ranged between USD425 and USD1,785 with a loan period of one to two and a half years and a loan size of 66.5 per cent of the system cost. From 2001 to 2005 50 SHSs were sold (Interviewee 7; Kabutha *et al*. 2007: 34). KUSCCO offered product loans for SHSs, which could be acquired in bulk from the technology provider, and distributed to them via SACCOs. That means it was not only partnering with the technology providers but also with over five hundred SACCOs. The technology provider only had to deliver the systems and provide technical training to KUSCCO members who then passed on their knowledge to the SACCOs.

However, the partnership constellation and its administrative complexity were part of the reason why the service delivery was very long and complicated, resulting in consumer dissatisfaction and cancellation of loans. As energy loans were not part of its core business, KUSSCO was facing difficulties with the complexity and time intensity of loan offers (Kabutha *et al*. 2007: 33-40). Furthermore, Chloride Exide lacked capacity and their networks were not designed for the national distribution of the technology. Therefore, installations faced delays, taking sometimes up to several months. When the loan started, the technology was often not yet installed. Similar problems had been faced by Faulu and KWFT. 'Product loan was the direction that everyone was taking […] but MFIs had no expertise on the solar product' (Interviewee 7).

Kenya Women Finance Trust (KWFT). The KWFT is a deposit taking MFI which mainly offers loans to low-income female entrepreneurs and has around 280,000 borrowers (Mixmarket 2013c). It initiated a renewable energy programme funded through the Shell Foundation Breathing Space Fund.

> The Fund seeks to create an innovative and commercially viable model for provision of finance by banks and micro finance institutions to small energy enterprises and consumers in Kenya. (KWFT 2013).

It offers LPG for cooking as well as SHSs through a private partnership. During its pilot phase, KWFT installed 250 PV systems. By 2010 the project had already been mainstreamed as a core product line (Kariuki and Rai 2010; KWFT 2013). However, the project has faced several challenges. The products that KWFT was first offering turned out to be of low quality, which led to customers returning the product. KWFT has changed PV suppliers twice and is currently looking for a new supplier. It also experienced a lack of technicians in rural areas and delay with PV installations, as technology providers did not have enough outreach to rural areas (Kariuki and Rai 2010: 15; Interviewee 7). Currently, KWFT is still offering its Clean Energy Loan Products and, according to Interviewee 7, it is also starting to test PAYG finance schemes for RETs (Interviewee 7).

4.1.3 Main barriers of past finance approaches

On the basis of the above, three main types of barriers can be identified that were faced by past finance approaches: access to finance; customer support and after-sales service; and cooperation among technology and finance providers. These are examined below.

Access to finance. Realising access to finance through these past schemes was a major restriction. This was either caused by high interest rates, driven by high transaction costs, especially in relation to lending to rural customers with high distances to customers in Kenya dispersed population and weak infrastructure (Interviewee 4). The exclusiveness of several schemes to certain groups like SACCO members, employees or small businesses further served to reduce access to finance amongst the general population.

Hire purchase facilitates easy access to credits, but only for those whose employers have an agreement with a hire-purchase agency. Hence, access was restricted for people who do not have an employer, or do not have one with a hire-purchase agreement. The approach therefore excludes poor and marginalised households. This is confounded by the high interest rates of hire-purchase arrangements.

Likewise, microfinance projects experienced the problem of reaching poorer parts of the population due to high interest rates. This is emphasized by Michimikuru's subsidised soft loans which were still too high for the SACCO members and had to be reduced to a level that would not be achievable without significant grant support. SACCOs generally have some favourable conditions for loan provision, but lack expertise and resources regarding technologies. The high interest rates and inability to reach dispersed rural populations are one of the main reasons why traditional microfinance has not been successful in providing finance for SHSs in Kenya and other SSA countries (Lighting Africa 2010). Furthermore,

> […] microfinance organizations […] face a number of risks: finding a suitable partner is not easy; as consumption-oriented loans are normally based on credit-worthiness of recipients, mass-scale penetration of energy consumption loans may be difficult; and the risk of non-recovery of energy equipment cost is high.
> (Bhattacharyya 2013: 471)

Interviewees 4 and 6 both identified the high cost of solar loans as one of the main barriers, stating that 'the critical challenge is the high interest rate […] due to high transaction costs of MFIs on the local

level' (Interviewee 4), and that 'the single biggest barrier has been high transaction costs' (Interviewee 6). As a result, the conditions of past finance approaches consistently favoured the rural middle class, many of whom often favoured (modular) cash purchases to avoid the extra costs of loans (Jacobson 2004). Ultimately, Pueyo's (2013: 21) three dimensions of affordability (upfront payment, payment flexibility and total cost) were not addressed.

Customer support and after-sales service. Most of the models and projects were facing problems of unsatisfied customers due to technical issues that could not be, or were not solved. As FIs did not provide solar loans as their core business, they lacked knowledge about the technology and were not able to offer sound customer support due to insufficient resources and capabilities. Instead, FIs depend on the technical knowledge of the technology supplier, but in many cases this was not forthcoming. In the case of KUSSCO, for example, the solar company was not able to provide a good technical service (both in terms of installations and maintenance) due to limited geographical outreach and limited experience in supplying rural areas, resulting in widespread customer dissatisfaction. 'This was a challenge faced across the board' (Interviewee 7). Likewise, in the case of Faulu Kenya, customers expected the FI as their service provider to solve technical problems. When technical support was not forthcoming, customers either had to continue paying their loan, despite a malfunctioning system, or refuse to pay the loan.

Cooperation among stakeholders. The main reason for inadequate customer care and customer dissatisfaction seems to be embedded in insufficiently coordinated allocation of roles within partnerships of technology and finance providers. 'One of the barriers has always been that there is a lack of agreement between the banks and the solar companies and the consumers' (Interviewee 5). This caused issues of accountability, as seen in the cases of ESMAP, PVMTI, Faulu Kenya and KUSSCO.

From the FI's point of view, a key problem relating to product specific loans is the need to depend on a technology partner due to a lack of in-house knowledge and capacity (Interviewee 5 and 7).

> The idea to have specific loans for solar products has been something that the banks have not been interested in […] Hire-purchase was much more successful because it was tied to specific products.
> (Interviewee 5).

KWFT had to change the technology provider several times because of the low quality of products. Furthermore, within the PVMTI project the problematic cooperation between competitive FIs involved in one project led to project cancellation.

4.2. New finance approaches

As the analysis above demonstrates, past finance approaches were subject to a number of common problems relating to outreach to poorer populations and the coordination between technology providers and FIs, which in turn resulted in insufficient customer support. The failure of these approaches left a gap in consumer finance for solar products which now seems to be being filled by new approaches based on innovative RTM technologies and business models based on flexible mobile payments and vouchers. In Kenya there are now around six companies offering payment plans for SHSs based on RTM and PAYG and several companies are currently trying to establish other PAYG finance schemes for SHSs and SPLs (Pueyo 2013; Interviewee 7). The companies offering PAYG operate a one-stop-shop model, meaning they provide both technology and finance (Ballesteros *et al*. 2012: 9). In this section we introduce case studies of three existing models of these approaches in Kenya, M-KOPA, Mobisol and Azuri. In each case the business model is introduced, followed by an overview of the technology and how the approach emerged. The key actors involved are then summarised, followed by an assessment of how the model differs from traditional finance approaches. Each case study concludes with a summary of the key enabling and constraining factors that can be identified.

4.2.1 Case studies of pay-as-you-go finance approaches

M-KOPA

Business Model

The M-KOPA approach is similar to other PAYG schemes, it borrows the model of prepaid electricity from the electricity sector and prepaid airtime from the mobile industry. Payments are made via M-PESA (Kenya's mobile banking system), and M2M technology allows for real time monitoring and control (Hughes (2013); Pueyo 2013). M-KOPA was initiated in 2009 and launched in 2011. Since mid-2012 it has provided customers with a small SHS from the technology provider, d.light. The PAYG payment scheme allows customers to distribute payments for the system over several months up to a total of one year. Customers pay KES2,500 (USD28.50) as a deposit and the remaining KES14,400 (USD165) via instalments by SMS, using M-PESA. After completing the payments, customers own the product outright. The system can be purchased in a shop from one of the current 700 M-KOPA dealers. Through a certain commission payment schedule retailers are encouraged to find customers who can pay for systems. The package includes an instruction manual which enables customers to install the system by themselves. Before it starts operating, they have to call the customer care team which explains the terms and conditions. Afterwards the system gets switched on and provides electricity for five days. Subsequently, customers have to purchase credits to keep the system working. A daily minimum of 40 KES (ca. USD0.34) is required to make the system run for 24 hours. The whole amount has to be paid within one year, but the payment frequency and period is flexible. In April 2013, 10,000 customers had signed up with M-KOPA. By the beginning of August 2013 more than 25,000 had been registered and approximately 1,000 new customers are registered each week (Interviewee 1; M-KOPA 2013; Moore and Hughes 2013; Bloomberg 2013).

Technology

The system comprises a solar PV panel from a Chinese manufacturer, a battery, three lights and a phone charging station. M2M technology is integrated in the system, which connects it with a central control station. SHSs are registered in the network, making it possible to see when they are on and off, how quickly the battery is charging, and if the panel is in the right place. It enables M-KOPA to turn the system off if the customer has not paid. The M2M management system controls charges, the status of the device and keeps a record of payments. It also sends messages to customers' phones if they are running low on credits. Customers can call a help line and ask questions about the device. The technical team can check all performance related issues remotely on the systems and see which part is working or not working. If the technology is not working, a customer brings the system back to their dealer who replaces it and sends it to M-KOPA for repair and maintenance (Interviewee 1).

Emergence of the model

The idea comes from a mobile payments background. Nick Hughes, the founder of M-KOPA, also founded the mobile money service M-PESA. He wanted to develop new innovative business models based on mobile payments with small instalments and recognised the opportunity to deliver clean and affordable lighting to poor people - one of the biggest needs of the Kenyan market: '[…] the problem is how do you get a customer that is on very low income to pay for some good quality equipment?' (Interviewee 1).

To realize the idea, M-KOPA started with a trial phase in order to test different payment plans. It received funding from the Shell Foundation:

> […] We know the guys who run Shell Foundation, we know that they were interested in the new emerging market energy business models and asked if they would fund this idea […] Shell Foundation gave money for a trial phase with 300 customers for very small lighting systems. From that came the idea of what is now M-KOPA
> (Interviewee 1).

Apart from public funding, M-KOPA has a revolving debt fund. A consortium of organisations provide the company with working capital to buy the equipment. After testing out different models, M-KOPA recognised that a certain amount of up-front payment is necessary to create a sense of ownership that makes the customer pay and feel responsible for the system:

> The deposit price is high because we want customers to make a commitment. During the pilot and trial phase we were testing the quantity for the deposit until we found the right amount to find good customers. Size of the deposit is one of the most important factors (Interviewee 1).

Small amounts of minimum instalments have been chosen based on the cash flow and low budget of the customers. KES40 is less than the average spent on kerosene per day by a target household, which accounts for around KES50 per day.

M-KOPA did not emerge from a technology provider or a finance provider perspective. Instead it takes a service provider perspective, delivering a technology and a payment plan to meet the need for clean and affordable lighting. It did not originate from the motivation to replace traditional consumer finance for SHSs but through the identification of a social need and interest in testing out new business models based on the success of mobile money services.

Actors involved in the emergence and development of M-KOPA

The Shell Foundation continued to give grants after the trial phase. Further funding came from the African Enterprise Challenge Fund (AECF) which encourages private sector engagement in pro-poor business models. M-KOPA won a competition which provided them with a repayable grant with zero interest rate. These resources were used for marketing and some capacity building for adding more people to the team. After the trial phase M-KOPA created a business and sold parts of it to an impact investor called Grey Ghost Ventures who invest in innovative emerging market technologies. Another actor involved is the UK Department for International Development (DFID) which is working to identify which other products and services could be offered using the same model. The M2M technology comes from the provider Eseye. Another major actor is Safaricom, the leading mobile network operator in Kenya which operates M-PESA. Some of the M-KOPA shops are also Safaricom shops and their brand is used for marketing purposes. Interviewee 1 states that '[…] they are an important brand element for us for getting customers' trust in the system'. Also, the dealers as a 'motivated sales force' are an important component in the distribution of the technology: 'In rural areas retailers tend to know everybody personally; their job, income, where they live. We're using the local knowledge of those retailers to find good costumers' (Interviewee 1).

Difference to traditional microfinance and hire-purchase approaches

> For hire purchase there exists a different tax system as well as other laws and regulations, which, for example, would allow to us collect the units if customers are not paying. The main difference to microfinance and hire purchase is seen in the payment rate and time: for loans you usually have to make repayments at certain dates and certain amounts […] The difference with us is that we allow the payment size and frequency to be entirely at the customer's choice. There is no complexity as with microfinance. Also with hire-purchase you have to make a certain payment or you have to make a payment every week, we don't have that rigidity […]ease of use and flexibility of payment are the big difference. (Interviewee 1).

Enabling and constraining factors

Interviewee 1 states that the major constraining factor is to get working capital in order to purchase the equipment.

> Regular main stream commercial organisations like a bank would be sceptical because of the new technology, the emerging market and the business model which is not yet well enough proven. This is when organisations like DFID and Shell Foundation come into play. We need those types of organisations who are willing to take the risk to allow innovation to happen.
> (Interviewee 1)

Interviewee 1 didn't identify and laws or regulations that were either helping or hindering the project.

Mobisol

Business model

Mobisol was created in 2010 and has been operating since 2011, mainly in Tanzania, Kenya and Ghana. As a first step, customers are informed about the product either at a central selling point or by local marketing agents through village presentations. Interested customers then go through a due diligence process to assess their ability to pay and a suitable system size via questionnaires and an energy game, adapted to the customers' educational background. Customers choose a system and extra items like additional lamps and pick it up at a service hub. At the service hub a video is shown that explains the technology and its function, customers sign the contract and make a down payment of 10 to 20 per cent of the system price.

The rest of the money is transferred to Mobisol's pay bill[3] account via monthly instalments across a maximum of 36 months, depending on the system size. It is a PAYG model but bound to a specific payment day. An short message service (SMS) reminds the customers of their pay day. If customers cannot pay the system switches off. However, they are not directly in default. The payment plan allows for a yearly grace period of one month per year. Likewise, customers get discounts when they pay off the whole system before the 36 months. Those customers who have seasonal incomes like farmers, are advised to make larger payments at times when their incomes are higher. The distribution of the product is bound to areas with local technicians that have been previously trained by Mobisol. They install the system and do maintenance work. A 36-months after-sales service is included in the price. Mobisol now counts approximately 250 customers in Kenya, 50 in Ghana (with Toyola) and 700 in Tanzania. Installation of 10,000 additional systems was planned for 2013 (Interviewee 3; Mobisol 2013a; Mobisol 2013b).

Technology

The system includes a three-year warranty and contains free maintenance and remote monitoring. The system comprises a panel of 20, 60, 120 or 200 Wp. The smallest option can light two rooms and charge four mobile phones per day. The biggest system powers multiple lights, consumer appliances such as a laptop, TV, or a refrigerator and charges up to ten mobile phones simultaneously. Mobisol focuses on larger systems as the complementing technology is relatively expensive compared to the decreasing prices of solar PV modules.

A GSM modem is included in the solar controller, sending technical data from the panel and battery via an aerial to a web-based database. The M2M technology allows potential maintenance problems to be addressed remotely and the system can be locked if payment is overdue. The local technicians are informed of any problems by the maintenance system and repair the system on site if necessary. Apart from the M2M electronics which come from Germany, all other components (panels, batteries and cables) are imported from China. In Arusha (Tanzania) the technology quality is assessed and the technology components are put together (Interviewee 3; Mobisol 2013a).

Emergence of the model

[3] An M-PESA service which allows bills to be paid via mobile phone by entering a note to payee, the business and account number of the billing company

Mobisol's founder Thomas Gottschalk was involved with a solar taxi initiative[4] as a mechanic. During this time he realised both the potential of solar energy and the need for electricity around the world, especially SSA-countries. He also met people who could help him realize his idea. As he knew about solar PV technology as an engineer and about the potential of mobile technology, he decided to build up a business model based on mobile payments to provide rural households with SHSs.

At the beginning of 2011 Mobisol was searching for an appropriate business model and intensive on-site research was done by its founders to assess the baseline situation and needs that could be met by SHSs (Interviewee 3; Hollmann *et al*. 2013:, 13). They realised that the technology was already widespread, '[…]in Kenya, any village where we went, no matter how isolated, had at least one solar PV system, but the knowledge on it seemed to be limited' (Interviewee 3).

During that field research Mobisol realised that there are very different customer groups, which led to the decision to provide different sizes of SHSs. Furthermore, they recognised that the cash flow of rural populations did not allow them to buy a high quality system or a sufficiently large system and that people were sceptical about the technology due to the high number of damaged devices. Furthermore, they found that the expenditures on phone charging and kerosene for lighting accounted for around USD15 per month, which is in line with Lighting Africa's estimates (see Lighting Africa 2012b).

Mobisol prioritises products which have good quality and last for longer, as buying an SHS is a large investment, although they recognise that 'there has to be a compromise between good quality equipment and affordable technology' (Interviewee 3). Through after-sales service and maintenance the system's life-time is supposed to be optimised.

Actors involved in the emergence and development of Mobisol
Grants and loans were received from AECF and the German Entrepreneurial Development Cooperation (DEG) to build up the model's structure and provide working capital. Some networks helped with knowledge exchange. In particular, the SE4ALL energy access practitioners' network[5] was supportive in helping to get feedback during workshops. Similarly, the Alliance for Rural Electrification (ARE) helped Mobisol to participate in different workshops. Mobisol also took part in the German Federal Ministry of Economic Cooperation and Development's (BMZ) BoP Sector Dialogue workshop which aimed to help develop inclusive businesses. The workshop provided ideas as to how to enhance the supply chain (Hollmann *et al*. 2013: 13).

Vodafone was one of the first contacts to assess the feasibility of the approach and to identify target countries where mobile banking had already been set up. Mobisol also works with local partners. One is Kampuni ya Kusambaza Teknolojia (KAKUTE) Ltd. in Tanzania, a hybrid of a private company and an NGO. Another is Sustainable Community Development Services (SCODE) from Nakuru, Kenya, a similar hybrid organisation. These partners helped develop marketing strategies and customer education, identifying pilot customers, building up customer trust, translating documents and opening a bank account. Mobisol already had established contact with MicroEnergy International, a consultancy specialising in energy access, with whom they collaborated during the development and implementation of the pilot phase and worked with to refine the business model (Interviewee 3; Mobisol 2013b).

Difference to traditional microfinance and hire-purchase approaches

[4] http://www.solartaxi.com/
[5] http://www.sustainableenergyforall.org/events-outreach/practitioner-network

Mobisol had already done research into issues of traditional microfinance for SHSs in Kenya, focusing on technology performance and maintenance service (Lindner 2010). This knowledge helped the start-up to develop the payment plan:

> Within traditional microfinance, SHSs are distributed via MFIs. The example of Grameen Shakti in Bangladesh, providing both technology as well as finance, is often praised as a successful model of micro-financed SHSs. In SSA however, such a model does not exist.
> (Interviewee 3)

Under traditional approaches in Kenya, technology and finance was provided by separate actors, MFIs providing finance and technology providers the SHS. This led to problems of responsibility regarding repair and maintenance and customers not knowing whom to contact in case of system failure. 'Mobisol works differently as it is a technology provider who overtakes the job of an MFI' (Interviewee 3).

A traditional microcredit works in ascending amounts within loan periods in order to assess the credit worthiness of a customer, starting with a small amount which would not allow for acquiring an SHS. Eventually in their fourth credit period they could afford an SHS. Mobisol directly gives out credits for SHSs to customers. Hence, the customer's credit worthiness is largely unknown. This risk is partly mitigated by incentivising their payment through locking the system.

The period of 36 months is also different to former microfinance approaches for SHSs in Kenya. MFIs had seen SHS loans as business loans rather than loans for consumer goods, expecting customers to start a business and therefore set the period to a maximum of 12 or 18 months. In such a short period of time it would be difficult to pay off a system through savings on alternative energy sources. Furthermore, Mobisol does not have loan officers who would tell the customers to pay, as this is done solely via the mobile payment system and the SMS service. The flexible payment plan with a grace period has been adapted from the microfinance sector (Interviewee 3).

Interviewee 3 questioned what they perceived to be a widespread belief in the usefulness of MFIs in the context of development needs relating to energy services:

> There existed and partly still exists a belief that any MFIs could help reaching last-mile customers due to their already existing customer network and knowledge […] MFIs are often still seen as the one institution which can save the under-developed world [...] without considering that MFIs do not have capacities to diffuse cook stoves or SHSs.
> (Interviewee 3)

Enabling and constraining factors
According to Interviewee 3, an enabling factor for the development of the model has been finance through new green sustainable energy social investment funds, which was not available five years ago. Another enabling factor was the removal of import taxes of around 20 per cent on solar products by the Kenyan Government. However, all products have to be labelled with 'solar' to qualify. Mobisol had to wait four months to get aerials through customs, as they were initially not recognised as being part of a solar product.

One uncertainty is taxes on mobile banking transactions. In Uganda the Government realised the revenue opportunities and put taxes on any transaction. This is making mobile banking much more expensive and slowing its diffusion. It is not certain yet if Uganda will remove the taxes due to lobbying, or if other governments will adopt such a policy. 'These are some risk factors which are difficult to estimate' (Interviewee 3).

In Kenya, Mobisol faced a problem due to the strategic partnership between M-KOPA and Safaricom which renders some Safaricom services exclusive to M-KOPA. For instance, information on network coverage is limited to M-KOPA. Furthermore, Safaricom could not provide Mobisol with a toll-free hotline (Interviewee 3).

Azuri

Business model

Azuri's PAYG model differs slightly from M-KOPA and Mobisol as it uses scratch cards instead of mobile payments. Azuri emerged through the UK based start-up Eight19 and had its first deployments in 2011 in Kenya. Customers pay a small amount to have their system installed, typically around USD10. The amount of the down payment can vary and it determines the subsequent payment period. Customers purchase scratch cards once a week, which are validated via SMS. Scratch cards cost around US$1.50 a week, less than the amount which would be usually spent on kerosene and phone charging (Ashden Awards 2013). Customers then type the code from the scratch card into the unit and switch on the systems for one week. After an average of 18 months they have paid the system off and own the product. 'It happens quite often that people miss out a few days or a week, but that is not a problem' (Interviewee 2). Azuri's business model comprises an 'energy escalator' which enables customers to increase their system's size. After completing the payment for one system, customers can decide if they either keep the system or keep on paying for a certain time to get a bigger system.

Indigo is available in Kenya as well as Uganda, Tanzania, Ethiopia, Rwanda, South Sudan, Zimbabwe, South Africa, Sierra Leone, Cote d'Ivoire and Nigeria and is planned to be extended to other SSA countries. In March 2013 the company counted more than 20,000 customers in all project countries. In Kenya, Azuri currently has around 3,500 customers (Interviewee 2; Pueyo 2013: 10-11; Leiber 2013).

Technology

Currently two system sizes of 3 and 10 Wp exist but a third of 40 Wp is in development and another 80 Wp system is planned for the future. The entry level system provides power for two light bulbs and a phone charger. The largest system would be able to power devices like sewing machines. Payments are monitored through RTM technology. Diagnostics of the systems, like electricity generation and use, are collected by local distributors in the field (Pueyo 2013: 10-11; Azuri 2013).

Emergence of the model

Azuri emerged from the recognition that solar power is commercially very effective but not affordable for many people in Africa.

> It was about building a new business and we effectively identified a market of relatively low income consumers and we think we found a product which is suitable for that customer base (Interviewee 2)

Actors involved in the emergence and development of Azuri

Azuri received grant funds from USAID and also from AECF. It also collaborated with investors, to get working capital. Azuri also entered into partnership with a variety of other organisations in Africa, but does not have any partnership with a mobile operator. On a local level, Azuri works with distributors who have a comprehensive understanding of the market. 'Local partners are at the front line of distributing, installing and servicing customers, supported by the training and guidance from Azuri' (Pueyo 2013: 11). The partners help Azuri to understand local customers' capacity to pay.

Difference to traditional microfinance and hire-purchase approaches

According to Interviewee 2, some important differences exist compared to microfinance. However, despite exhibiting awareness of such differences, the company claim not to have consciously assessed former finance approaches:

> The main difference is that we don't have a legal agreement with the customer […] We use technology a great deal. Unlike microfinance, we don't need to have lending circles and weekly meetings so the cost of cash collection is much lower […] We did not pay any attention to former finance approaches […] we just started from scratch and we took it from the point of view of what customers required rather than what people have done in the past.
> (Interviewee 2)

The recognition that customers cannot spend capital and are risk averse regarding new technologies are the main motivation for the business model:

> […] they want the risk to be taken away from them. So the service aspect as opposed to a product is very important from that point of view. The second thing that matters to them is the flexibility of payment.
> (Interviewee 2)

Enabling and constraining factors
As the finance for the business is raised outside of Africa, local access to working capital is not relevant.

> There are a few enabling factors like grants and awards, and a lot of constraining factors, like getting working capital for unusual products in emerging markets. This problem is being faced within all countries of operation.
> (Interviewee 2)

In Kenya, the lack of import duty taxes on solar products is an enabling factor. Interviewee 2 stated that in other SSA countries, the duty can be as high as 20 per cent. In some countries only whole systems would be free of duty, making it very expensive to put product parts together locally.

4.2.2 Key barriers to new finance models
The case studies above suggest that new finance approaches face different barriers to those faced by the design of past finance approaches. The two most obvious barriers seem to relate to up-stream finance in form of equity and working capital and uncertainty regarding governmental laws and regulations.

Equity finance and working capital. Companies have to be able to deliver the technology according to demand. Hence, they have to buy in bulk but retrieve the investment only after long periods of time. Therefore, the enterprise has to have access to equity finance and working capital (Ballesteros *et al*. 2012: 10). Particularly at the beginning, capital costs are a major obstacle. This is also emphasised by Pueyo (2013) in her review of several RTM-based PAYG models:

> Finance for initial capital costs is one of the main challenges for […] business models where the energy service providers provide credit to their customers by remaining owners of the systems until full costs are covered through several instalments. All the suppliers identified through our inventory are small, young and with low capitalisation. They face the so called 'valley of death', or gap in financing between […] grant funding […] and commercialisation.
> (Pueyo 2013: 22)

Public-private partnerships can help to overcome that barrier, but access to such resources remains limited:

> […] it is clear that grants are still required to support the proof of concept of business models and support innovation. To date, we have found a very limited number of donors or investors capable of delivering the capital required to support wide scale trials and innovations.
> (GSMA 2013: 36)

As the interviewees indicated, intensive trial phases were necessary to test down payment and instalment amounts. At that stage in particular, angel investors (who provide capital for start-ups), and grants are needed. Public funding could be channelled via results-based financing for business models that prove financially sustainable after a certain time period. At later stages debt is required to meet working capital needs along the value chain (GSMA 2013). As stated by Interviewee 1, fund raising for working capital is difficult because commercial FIs estimate the risk of financing a new product in an emerging market as being too high. 'Working capital is now the bottle neck – before it was demand and distribution' (Interviewee 4). It is probably due to the emerging interest in funding 'green' markets in developing countries that funding for socially oriented energy enterprises is available at all.

Governmental laws and regulations. According to the interviewees, there currently aren't any laws or regulations in Kenya that act as a disabling factor for their businesses. However, political instability causes uncertainty about the future. Interviewee 4 reported that Kenya's new government is considering re-introducing duty tax for products currently subject to exemptions, which would include the duty free solar products. Due to the solar sector's strong presence in Kenya and the Government's commitment to kerosene reduction (via the 'Kerosene free Kenya' flagship initiative), there may be sufficient commitment from the Government to avoid any obstacles for solar lighting (Interviewee 4) , but it still represents a risk. Another issue is rooted in the relatively young mobile money sector. Interviewee 3 pointed to the possibility that the government might raise taxes on M-PESA transactions, as has happened with Uganda's mobile money service.

5. Comparative analysis of past and new consumer finance approaches

In this section we use the operationalised analytical categories from SNM to compare past and new finance approaches. As well as facilitating comparative analysis, this section also serves to demonstrate the usefulness of SNM in the analysis of finance approaches. Key terms from SNM theory are italicised to make it clear how an SNM approach contributes to the analysis.

Protective space

In many of the past finance projects and approaches, *active shielding* took place in the form of donor funding and support by international organisations. Hire-purchase agreements, however, did not emerge through active shielding. Instead they benefited from *passive shielding* through utilising established lending models. Through this they were able to fill a gap that microfinance was not able to fill. However, the reported success of hire purchase for SHSs was only temporary, probably due to the restricted loan access and high interest rates.

New finance models are also supported through donor funding:

> There has been a tremendous growth in the donor driven support for energy access within the last five years. Donors have created the foundation, so many companies have been built on patient capital and grants provided by donors […] Donors are excited by the new toys, the new technical solutions
> (Interviewee 5)

This highlights the importance of donor funding in nurturing a protective space for energy enterprises to experiment with new finance models. As indicated by interviewee 1, without public funding, M-KOPA would not have been able to conduct sound trial phases, as commercial banks were not willing to take the risk. Interviewee 3 also points to the opportunity provided by the recent 'green growth mainstream'. This can be seen as a form of *shielding* by making use of this new international development *expectation,* which is articulated, for example, in the SE4All initiative.

A shift in donor funding can therefore be identified from proactively initiating and supporting microfinance models for SHSs, towards the occasional support of new technologies and inclusive business models. However, it might not always be easy for new businesses to access resources that lead to the development of financially sustainable models (Koh *et al*. 2012; Pueyo 2013). In the case of M-KOPA, personal contact already existed with the Shell Foundation which was likely to have been significant in facilitating the access to funding. It's not clear whether future businesses will be able to access the same support. It may well be that the protective space provided by donor funding could be removed once business models have been proven, a market for PAYG products has become well established and commercial banks and more investors have been attracted to the market. In this sense, the protective space provided by donor funding can be seen as critical to reducing the risks associated with investment in new technologies and new business models.

Experiments and learning

The early donor supported finance models can be viewed as *experiments* that aimed to learn lessons and build a basis for future finance approaches. It seems that at least between ESMAP and PVMTI some form of experience exchange took place. However, finance approaches were repeating each other's mistakes in terms of after-sales coordination between the FI and the technology provider. Some overall learning, however, seems to have taken place. The reduction of transaction costs and the need for lower interest rates to reach poorer parts of the population appears to be widely recognised but could not be overcome by microfinance approaches (Interviewees 4; 5; 6).

New finance models have recognised the opportunity to decrease costs by the use of technologies that enable real time monitoring and controlling as well as mobile payment. The three companies represented in this study were aware of the problems of traditional solar loans. However, according to the interview answers, only Mobisol actively built on that experience by taking into account previous research on problems of micro-financed SHSs. Nevertheless, even implicit recognition of past problems can be seen as a base on which to build new approaches, implying *second-order learning* in the form of changes relative to previous assumptions and explicit attention to a different way of doing things.

All start-ups were conducting trial phases which helped them to test and modify assumptions about consumer needs and capacity to pay. This can be seen as new *first-order learning* in relation to these different approaches to finance that built on the *second-order learning* above. The inadequacy of loan amounts and payment terms that many of the past models were facing indicates that former finance models did not follow the *assumption* that payment rates have to be linked to local costs of kerosene and phone charging as part of common energy consumption practices. In other words, they did not sufficiently take into account *consumer needs and behaviour* around solar electricity and lighting. In this sense, the *second-order learning* of new finance approaches can be seen as particularly significant.

It seems, however, that each enterprise was doing the same kind of research, which indicates that little knowledge exchange between them was taking place. It is yet to be seen whether their *experiments* with new business models will lead to an overall *learning effect* through the communication of experiences between each other which would benefit the whole niche. Their will to share experiences seems to be limited, probably due to issues pertaining to competitiveness. This feature of free market based donor supported interventions seems to be somewhat inadequate, as public grants should not serve a single business but rather the establishment of a whole market for affordable SHSs.

Actor-networks

As part of the *nurturing* process that enables the development of innovations, interactions and networks can be seen to have been established via past finance approaches, although there are questions as to the extent to which these were well aligned enough to properly nurture the niche. Interaction within previous finance models took place primarily between development agencies as well as local FIs. Within the *protective spaces*, however, *intermediating work* between the actors seemed to have been weak. For instance, many partnerships between FIs and technology providers were lacking in coordination and exact distribution of tasks, which led to accountability issues and client dissatisfaction. This might indicate that donor funding is not necessarily sufficient to facilitate a *protective space* if it is not coordinated well. Many of the comments by the interviewees also indicate that the *networks of actors* have been insufficiently aligned. Even though many partnerships between technology and finance providers evolved they failed to work in ways that clearly defined roles.

Another problem seems to be rooted in the complexity of such networks:

> All the actors - technology and finance providers and donors - have a different view of what the consumer wants and come up with various solutions, whereas the consumer just wants a simple thing; which is cheap electricity.
> (Interviewee 5)

Knowledge exchange took place within donor based networks, but was promoted less once donor support phased out and finance was mainly offered by private businesses:

> After the donor driven projects, businesses started offering product loans […] they were doing their own thing and there has not been much knowledge sharing […] It should have been done differently. If there is no sharing of information on how to mitigate risks and why energy loans are

> so expensive, it is difficult to reduce the high interests rates of around 25 per cent and to solve the problems that finance providers were facing. This should be changed.
> (Interviewee 7)

Interviewee 7 suggested that KEREA could take over the task of linking all relevant players in relation to technology and finance provision for solar lighting, as KEREA has access to all practitioners in the market and could find 'best matches'.

New business models partly overcome the barrier of finance and technology *interaction* as they provide both services as one-stop-shop models. Furthermore, actors from different backgrounds, like the strong mobile money sector, are now active within the SHS niche which might indicate a form of niche *empowerment*. However, *knowledge exchange* between the enterprises remains an issue, as described above.

Workshops, such as those indicated by Interviewee 3, would have the potential to bring *experiences* and ideas together. Likewise, Lighting Africa could facilitate the diffusion of lessons learned from the new business models. The organisation is acknowledged by several interviewees as a helpful platform of knowledge exchange, mainly in the field of SPLs, but with evidence which is also important for the area of SHSs (Interviewees 4; 5; 6). 'Lighting Africa is an important network at the pico level. They have workshops which enable technology and finance providers to meet and identify opportunities of collaboration' (Interviewee 6).

Interviewee 4 indicates that:

> GOGLA wants to do a study on all finance options available. Research is coming, but slowly. This is a critical role of networks [...] because many actors in the arena are repeating each other's mistakes. It is crucial to facilitate the sharing of information, promoting good practice and documenting case studies on what has worked and what hasn't […] and to bring all actors together and generate more interest from investors.
> (Interviewee 4)

This indicates the need for *broad and deep networks*, involving many committed stakeholders to overcome barriers that past finance approaches were facing. It also emphasizes again the need for knowledge exchange.

<u>Institutions</u>
Regarding governmental *laws and regulations*, interviewees did not indicate many constraining or enabling factors. An enabling factor has undoubtedly been the removal of import duty on solar products as indicated by Interviewee 3. Accounting for *consumer behaviour* around solar electricity seems to have been less prevalent among previous finance approaches. The three dimensions of affordability, upfront payment, payment flexibility and total cost, have not been sufficiently accounted for. Loans were created which did not reflect the consumers' payment behaviour.

The strategy of new finance approaches is to provide payment schedules which are tailored to consumers' cash flows, enabled through widely established mobile phone use:

> The concept is relevant for how they live their lives: They buy things in small amounts because it's the way their cash flow works, they cannot afford the up-front cost. This is true of washing powder, food […] It's not that they don't have money, it's that they have small amounts and their income is very irregular. (Interviewee 1)

Mobisol goes even further in that it tries to adapt to the low education level of low-income customers. It promotes customer education, taking into account people's ability to receive information, for example though games, videos and a user manual with comic drawings.

The PAYG enterprises can therefore be seen to be adapting more to consumer behaviour. Nevertheless, it is not yet clear how far they will reach poor populations. For instance, the start-ups assume an expenditure on kerosene that is prevalent among wealthier rural populations. Hence, their target group is located amongst these populations. As Interviewee 3 states, the current RTM technology used is too expensive to be applied for smaller and cheaper SHSs.

Expectations and visions

As many actors are involved in the provision of finance for SHSs, different expectations and visions can be identified across these actors. Most of the past finance providers had the *expectation*, that the major constraint to the uptake of SHSs is the lack of access to adequate finance, and that they could make profit by providing that finance:

> The expectation of finance institutions is to get into that market as a penetration strategy, to diversify the portfolio and to have a quick win, as there is demand for this product and this loan... but it has not always worked out as the loans are very expensive.
> (Interviewee 7)

Likewise, technology providers hope to expand the market for their products through financing.

As mentioned above, international development organisations and donors seem to have shifted their vision from a belief in microfinance as a market catalyser towards the need for capacity building. Recently there has been a stronger focus on supporting energy access and making finance available through the private sector. Hence, support of socially oriented private enterprises seems to be prioritised.

The Government seems to have established a supportive policy environment for actors providing finance for SHSs though 'Kenya Vision 2030' and 'Kerosene free Kenya'. According to Interviewee 4, Kenya is the only country in Africa who has a flag-ship commitment for the eradication of kerosene for lighting. Its commitment gives investors and companies confidence that policies will not change within the next five years. 'It is as simple as the promise, "I won't touch solar lights within the next five years"' (Interviewee 4). In this way the expectations and vision of the government are likely to be perceived as aligned with the interests of actors seeking to expand the solar market in Kenya, providing a powerful impetus for engagement from investors.

New PAYG finance providers have the expectation that they can reach a larger part of the population by offering clean and affordable electricity. All three start-ups shared the expectation that clean and affordable electricity access can be achieved by offering a payment plan that is based on baseline expenditure patterns. Their emergence and development might be influenced by and dependent on the expectations and visions of international development organisations and the Kenyan government's commitments.

5.1. Limits and risks of new finance approaches

In many ways the analysis above suggests that new finance approaches tend to address many of the barriers of past approaches. However, interviewees point to the fact that their success in terms of financial sustainability remains to be proved (Interviewees 3; 5; 6). Regarding access to finance, an improvement can be identified as costs have been lowered and flexibility and ease of payment facilitated. New finance models therefore seem to have a higher potential to enter the kerosene-based regime by trying to adapt to consumer behaviour in terms of payment.

All three companies interviewed aim to provide a whole service rather than a technology, and try to take the risk associated with that new technology and the investment away from the customer (Interviewees 1; 3; 4). However, the M2M technology they apply is still relatively expensive to be used for cheaper pico-systems which might reach the poorest households. There is also not yet sufficient experience on the performance of the RTM system. Some interviewees mentioned cases of abuse (Interviewees 4; 7). Receiving information on the system only through mobile network signals is also a new approach, so might encounter technological issues if, for instance, the network is down.

After-sales service is provided differently by the three PAYG suppliers. It is not yet clear the extent to which these alternative approaches will address the shortcomings of past finance approaches in this sense. M-KOPA also relies a great deal on technology to assess system functioning. It is yet to be seen if that can replace on-site operation and maintenance.

As one-stop-shop models, the enterprises do not face coordination problems like those prevalent within technology and finance partnerships. They interact with international organisations as well as with local partners and connect the emerging mobile phone market with the SHS niche. Although they seem to build sound networks within their business models, so far their knowledge exchange seems to be limited. Associations like KEREA and programmes like Lighting Africa as well as workshops could play an increasing role in the diffusion of lessons learned and best practices.

Research strengths and limitations

The anecdotal information from interviews and donor funded studies on past and, especially, new finance models clearly constitutes a limitation of this study. The new models are too recent to be able to evaluate whether their potential for providing better finance for SHSs will be confirmed. A robust impact evaluation of finance models would be necessary in order to draw conclusions on their effectiveness. Despite this lack of information, the SNM lens enables a qualitative analysis by focusing on the salient features of both past and new schemes.

One reason for the lack of peer-reviewed literature on consumer finance for SHSs in Kenya is rooted in the limited information and data on market share of different financing options. As reported by the interviewees, this is mainly due to competition among actors. It clearly shows the limitation of this research and the need for further research.

Applying the SNM in the context of developing countries is novel and challenging. This research faced similar limitations to previous applications of SNM in the context of developing countries. The identification of a regime as defined by socio-technical transition studies is problematic, as no large scale incumbent technology exists. However, the flexibility of the theoretical framework allows for a conceptualisation adapted to the specific research context, given that the research object and the framework's operationalisation are well defined. In the context of this paper, the SNM concepts helped to structure the analysis and the socio-technical transition perspective allowed for a better understanding of past and new finance approaches beyond the technocratic concept of barriers.

6. Conclusion and policy recommendations

The adoption of a socio-technical perspective in this paper, operationalised through an SNM analytic approach has facilitated a number of insights into the failures of past finance approaches and the potential of new approaches to overcome them. This has been particularly useful in moving beyond traditional, technocratic 'barriers' or 'SWAT' type analyses to draw attention to the social practices that access to SHSs facilitates. This also allowed an understanding of finance for SHSs in the context of what, and the ways in which, people currently pay for these services (e.g. for kerosene or batteries). In this way a number of weaknesses of past financing approaches were identified. Firstly, access to finance has been limited with very few parts of the population able to access it (e.g. employees of companies with hire purchase schemes). High interest rates, resulting from high transaction costs, made access for low-income members of the population difficult if not impossible. Secondly, after-sales service and customer support were often inadequate resulting in widespread customer dissatisfaction and often refusal to repay loans. Thirdly, a lack of coordination between actors from the technology and finance sectors caused delays and issues of accountability, linked to weak customer care.

The analysis suggests that new finance approaches have the potential to address the failures of past finance approaches in a number of ways. They provide wider access to finance as they are not restricted to certain groups or requirements. Furthermore, their payment plans are adapted to match the customer's existing expenditure on relevant energy services. Coordination between finance and technology providers is not necessary as both services are provided within the one-stop-shop models. Moreover, the three enterprises analysed in this study emphasise the provision of a service rather than a technology, allowing them to better attend to the needs and practices of potential users. However, these new models also face barriers in terms of accessing working capital and an uncertain policy environment. They are also not yet able to reach the poorest strata of society.

Building on these strengths and weaknesses, the SNM based analysis above points to a number of relevant policy recommendations for better fostering the potential of new finance approaches to support more widespread uptake of SHSs in Kenya. So far, new PAYG business models are being supported through occasional donor funding and loose government commitments. This support might be strengthened through stronger commitments by the Kenyan government, nurturing market expectations and reducing the risk posed by political instability. More coherent support from international donors would also be helpful in this regard, helping to foster the protective space required for the SHS niche to compete with mainstream energy practices. It would also be useful to link the provision of donor grants to a requirement to share experiences gained during trial phases in order to nurture both first and second order learning within the niche.

An in-depth market study would help to avoid resource intensive research by single energy enterprises. Thorough market research has to be undertaken in order to understand customers' income flow, their spending on energy and their capacity to pay. Hence, international development assistance could be oriented towards needs assessments of the market and helping to establish political frameworks and infrastructures to facilitate further innovation. For instance, as the PAYG schemes are based on a novel application of M2M technology, it would be helpful to further test the strengths and weaknesses of the technology and to support further research and development into its cost structure, with a focus on how it might be applied within smaller systems. These smaller systems are of critical interest in terms of meeting the needs of the poorest households which may require adapting the technology to pico-systems and SPLs.

Finally, the analysis points towards the critical role played by actors who foster networks and share information. Many of the weaknesses of past approaches and potential limitations of new approaches might be overcome by better fostering networks of relevant actors across the whole of the niche, from

technology providers, to financiers, to mobile communications companies, to entrepreneurs, to consumers. An organisation like KEREA might take on such a role, perhaps nurtured from the broader perspective that the new Kenyan Climate Innovation Centre might play. This highlights a central role for government and donors in supporting the actions of such organisations in capacity building activities across the SHS niche and beyond.

7. References

Acker, R. H. and Kammen, D. (1996) 'The quiet (energy) revolution. Analysing the dissemination of photovoltaic power systems in Kenya,, *Energy Policy*, 24.95:81–111

Ashden Awards (2013) 'Case study summary: Azuri Technologies, Africa', http://www.ashden.org/files/Azuriwinner.pdf (Accessed 25 November 2013)

Asif, M. and Barua, D (2011) 'Salient features of the Grameen Shakti renewable energy program', *Renewable and Sustainable Energy Reviews*, *15*.9: 5063–5067

Azuri (2013) 'Indigo products', avialable at http://www.azuri-technologies.com/indigo/products/ (Accessed 2 August 2013)

Ballesteros, A., Norford, E., Nagle, T., Yonavjak, L. and Alzner, S. (2012) *Implementation strategies for renewable energy services in low-income, rural areas*, Issue Brief, Washington DC: World Resources Institute

Bawakyillenuo, S. (2012) 'Deconstructing the dichotomies of solar photovoltaic (PV) dissemination trajectories in Ghana, Kenya and Zimbabwe from the 1960s to 2007', *Energy Policy*, 49: 410-421

Bazilian, M., Onyeji, I., Liebreich, M., MacGill, I., Chase, J., Shah, J., Gielen, D., Arent, D., Landfear, D. and Zhengrong, S. (2013) 'Re-considering the economics of photovoltaic power, *Renewable Energy*, 53: 329–338

Berkhout, F., Verbong, G., Wieczorek, A J. (eds) (2010) 'Socio-technical experiments in Asia – a driver for sustainability transition?' *Environmental Science and Policy*, 13.4: 261-338 (Special Edition)

Berkhout, F., Verbong, G., Wieczorek, A. J., Raven, R., Lebel L. and Bai, X. (2010) 'Sustainability experiments in Asia: innovations shaping alternative development pathways?, *Environmental Science & Policy*, 13: 261–271.

Bhattacharyya, S. C. (2013) 'Financing energy access and off-grid electrification: A review of status, options and challenges"' *Renewable and Sustainable Energy Reviews*, 20: 462–472

Bloomberg (2013) 'Shell-Backed Solar Company Bets on Phone Banking for Africa', available at http://www.bloomberg.com/news/2013-03-07/shell-backed-solar-company-bets-on-phone-banks-to-grow-in-africa.html (Accessed 24 February 2014)

Byrne, R. P. (2011) 'Learning drivers Rural electrification regime building in Kenya and Tanzania', PhD thesis, Brighton: University of Sussex

Byrne, R., *et al.* (2012) 'Energy Pathways in Low Carbon Development: the Need to Go Beyond Technology Transfer' in D. Ockwell and A. Mallett (eds) *Low Carbon Technology Transfer: From Rhetoric to Reality,* Abingdon: Routledge

Byrne, R., et al. (2011) Energy pathways in low-carbon development: from technology transfer to socio-technical transformation, STEPS Centre Working Paper 46, Brighton: STEPS Centre

Caniëls, M.C.J. and Romijn, H. A. (2008) Strategic niche management: towards a policy tool for sustainable development, *Technology Analysis & Strategic Management*, 20.2: 245–266

Collins, D., Morduch, J., Rutherford, S. and Ruthven, O. (2010) *Portfolios of the Poor: How the World's Poor Live on $2 a Day*. Princeton: Princeton University Press

Ehrbeck, T. (2013) 'How Financial Innovation Helps the Poor Improve Their Lives', *Huffington Post*, available at http://www.huffingtonpost.com/tilman-ehrbeck/how-financial-innovation_b_3321062.html (Accessed on 28/07/2013)

Geels, F.W. (2002) 'Technological transitions as evolutionary reconfiguration pro- cesses: a multi-level perspective and a case-study', *Research Policy,* 31: 1257–1274

GSMA (2013) 'Service over Technology: Defining the Role for Mobile in Energy Access', Report, Group Special Mobile Association

Hankins, M. (1993) Solar Rural Electrification in the Developing World. Four Country Case Studies: Dominican Republic, Kenya, Sri Lanka and Zimbabwe, Washington DC: Solar Electric Light Fund

Hankins, M. (1996) Lighting Services for the Rural Poor: Test Marketing and Evaluation of 7 Solar Lantern Units in Rural Kenya, Washington DC: World Bank

Hankins, M. (2004) 'Introduction to and Limitations of Solar Photovoltaic Power' and 'Choosing Financing Mechanisms for Developing PV Markets: Experiences from Several African Countries', Chapters 1 and 2 in M. Krause and S. Nordström (eds) *Solar Photovoltaics in Africa: Experiences with Financing and Delivery Models*, New York: UNDP and GEF

Hankins, M. and van der Plas, R. (2000) *Implementation Manual: Financing Mechanisms for Solar Electric Equipment*, Report ESM231/00 of the Joint UNDP/World Bank Energy Sector Management Assistance Programme, July

Hannappel, S., Kranz, T., Link, S., Sahakyan, A., Schwind, M. and Frede, J. (2013) The Potential for Linking Microfinance Practices and Renewable Energy Technologies in Kenya - Exploring the Niche', in M. Schäfer, N. Kebir and D. Phillip (eds) *Micro Perspectives For Decentralized Energy Supply,* conference report, 27 Feb–1 Mar 2013, Berlin: Technical University of Berlin

Hollmann, D., McDermott, M. and Naguib, J. (2013) 'Developing inclusive business models – the BoP Sector Dialogues: how German development cooperation has been advancing the debate on inclusive business', in GIZ (2013) *Value chain development by the private sector in Africa: Lessons learnt and guidance notes*, Deutsche Gesellschaft für Internationale Zusammenarbeit, March: 11-15

Hoogma, R. (2002) 'Exploiting technological niches', doctoral thesis, Enschede: University of Twente

Hope, K. R. (2013) 'Performance contracting as a performance management tool in the public sector in Kenya: Lessons of learning, *Teaching Public Administration*, 31.2: 204–217

Hughes, N. (2013) Unlocking a New Market : Ultra-Low-Cost M2M Opportunities and Barriers to a New Mobile Frontier, M-KOPA, Mobile for Development

Jacobson, A. E. (2004) 'Connective Power: Solar Electrification and Social Change in Kenya', PhD Thesis, Berkeley: University of California, Berkeley

Jacobson, A. (2007) 'Connective Power: Solar Electrification and Social Change in Kenya', *World Development,* 35.1: 144-162

Jacobsson, S., Sanden, B. and Bangens, L. (2004) 'Transforming the energy system: the evolution of the German techological system for solar cells', *Technology Analysis & Strategic Management*, 16.1: 3–30

Kabutha, J., Sengendo, M., Winiecki, J., and Morris, E. (2007) Using Microfinance to Expand Access to Energy Services: The Emerging Experiences in East Africa of Faulu Kenya and Kenya Union of Savings and Credit Cooperatives (KUSCCO), Arlington: The SEEP Network

Kapur, D., Lewis, J. and Webb, R. (eds) (1997) *The World Bank: History (vol.1)*, Washington DC: Brookings Institution Press

Kariuki, P. and K. Rai (2010) Market Survey on Possible Co-operation with Finance Institutions for Energy Financing in Kenya, Uganda and Tanzania, London and Nairobi: Global Village Engergy Partnership (GVEP) and USAID

KEREA (2013) 'About us', available at http://kerea.org/about-us/, (Accessed on 17 July 2013)

Koh, H., Karamchandani, A. and Katz. R. (2012) *From Blueprint to Scale. The case for philanthropy in impact investing*, Mumbai: Monitor Group

Krause, M. and Nordström, S. (2004) Solar Photovoltaics in Africa: Experiences with financing and delivery models, New York: UNDP and GEF

KWFT (2013) Kenya Women Finance Trust Limited wibsite, available at http://www.kwftdtm.com/page.php?id=41 (Accessed on 17 July 2013)

Lachman, D. (2013) 'A survey and review of approaches to study transitions', *Energy Policy*, 58: 269–276

Laufer, D. and Schäfer, M. (2011) 'The implementation of Solar Home Systems as a poverty reduction strategy—A case study in Sri Lanka', *Energy for Sustainable Development*, 15.3: 330–336

Lay, J., Ondraczek, J. and Stoever, J. (2012) 'Renewables in the Energy Transition: Evidence on Solar Home Systems and Lighting-Fuel Choice in Kenya, *Energy Economics,* 40: 350-359

Leach, M., Scoones, I. and Stirling, A. (2010) 'Governing epidemics in an age of complexity: Narratives, politics and pathways to sustainability', *Global Environmental Change-Human and Policy Dimensions*, 20.3: 369-377

Leiber, N. (2013) 'Selling Solar Panels on the Installment Plan in Africa', *Bloomberg Businessweek,* available at http://www.businessweek.com/articles/2013-05-30/selling-solar-panels-on-the-installment-plan-in-africa#r=auth-st (Accessed 2 August 2013)

Lighting Africa (2010) *Solar Lighting for the Base of the Pyramid. Overview of an Emerging Market*, available at http://www.lightingafrica.org/resources/market-res.html, Washington DC: World Bank (Accessed 20 July 2013)

Lighting Africa (2012a) *Policy Report Note. Kenya,* available at http://www.lightingafrica.org/resources/market-res.html, IFC/World Bank (Accessed 20 July 2013)

Lighting Africa (2012b) *Household Lighting Fuel Costs in Kenya*. Market Intelligence Note 2, available at http://www.lightingafrica.org/resources/market-res.html Washington DC: IFC/World Bank (Accessed 20 July 2013)

Lighting Africa (2013) *Lighting Africa – Catalyzing markets for modern off-grid lighting*, available at http://www.lightingafrica.org/, Washington DC: IFC/World Bank, (Accessed 20 July 2013)

Lindner, K. (2010) Certifying Microfinanced Solar Home Systems Used for Business Purposes, Paper, Berlin: Berlin Technical University

Lucas, H., Vinci, S. and Nagpal, D. (2013) 'IOREC 2012: International Off-Grid Renewable Energy Conference. Key Findings and Recommendations', Conference Report, Abu Dhabi: International Renewable Energy Agency

M-KOPA (2013) '25,000+ customers, and hundreds more every day' available at http://www.m-kopa.com/, Nairobi: M-KOPA (Accessed 19 July 2013

Magradze, N., Miller, A., and Simpson, H. (2007) *Selling Solar. Lessons from fore than a decade of IFC's experience*, Washington DC: World Bank/IFC/GEF

Markard, J., Raven, R. and Truffer, B. (2012) 'Sustainability transitions: An emerging field of research and its prospects', *Research Policy*, 41: 955–967

Ministry of Energy (2012) *National Energy Policy, Third Draft*, 11 May 2012, Nairobi: Government of Kenya

Ministry of Environment, Water and Natural Resources (2013) *Memorandum of Understanding,* [online] available at http://www.environment.go.ke/archives/2868 (Accessed on 27 July 2013)

Mixmarket (2013a) *Kenya,* [online] available at http://mixmarket.org/mfi/country/Kenya [06/08/2013] (Accessed on 15 August 2013)

Mixmarket (2013b) *Faulu Kenya,* [online] available at http://www.mixmarket.org/mfi/faulu-ken; http://www.faulukenya.com (Accessed on 15 August 2013)

Mixmarket (2013c) *KWF,T* [online] available at http://mixmarket.org/mfi/kwft (Accessed on 15 August 2013)

Mobisol (2013a) *Mobisol Prepaid Energy,* [online] available at http://www.plugintheworld.com/mobisol/home.html. (Accessed on 11 August 2013)

Mobisol (2013b) *Mobisol launches optimised version of its SMS-based pay-as-you-go solar home system,* [online] available at http://www.plugintheworld.com/mobisol/press.html (Accessed on 11 August 2013)

Moore, J. and Hughes, N., M-KOPA IPR, LLC (2013) *Transaction Processing and Remote Activation*, Kenya and GB, Pat. 20130185194

Morris, E. and Kirubi, G. (2009) Bringing Small-Scale Finance to the Poor for Modern Energy Services: What is the role of government?, New York: UNDP

Napier, M. (2011) *Including Africa – beyond microfinance*, London: Heron, Dawson & Sawyer

Ngigi, A. (2008) Interview Ashington Ngigi, Managing Director of Integral Power Litd, conducted 21 July 2008

Nique, M. and Arab, F. (2013) *Sustainable Energy & Water Access through M2M Connectivity*, Report, Group Special Mobile Association

OECD/IEA (2011). *World Energy Outlook 2011,* Paris: International Energy Agency

Omwansa, T. and Sullivan, N. (2012) *Money, Real Quick: The Story of M-PESA*, London: Guardian Books

Ondraczek, J. (2013) 'The sun rises in the East (of Africa): 'A comparison of the development and status of solar energy markets in Kenya and Tanzania', *Energy Policy*, *56*: 407–417

Peet, R. and Watts, M. (1993) 'Introduction: development theory and environment in an age of market triumphalism', *Economic Geography*, 3: 227–253

Phillips, J., Das, K. and Newell, P. (2013). 'Governance and technology transfer in the Clean Development Mechanism in India', *Global Environmental Change*, 23.6: 1594–1604

Pode, R. (2013) 'Financing LED solar home systems in developing countries', *Renewable and Sustainable Energy Reviews*, *25*: 596–629

Pueyo, A. (2013) *Real time monitoring technologies for pro-poor access to electricity*, Theme 7, Evidence Report 12, Brighton: Institute of Development Studies

Raven, R. (2005) 'Strategic Niche Management for Biomass: A comparative study on the experimental introduction of bioenergy technologies in the Netherlands and Denmark', PhD thesis, Eindhoven: Technische Universiteit Eindhoven

Raven, R. (2006) 'Niche accumulation and hybridisation strategies in transition processes towards a sustainable energy system: an assessment of differences and pitfalls, *Energy Policy,* 35: 2390–2400

Raven, R. (2007) 'Niche accumulation and hybridisation strategies in transition processes towards a sustainable energy system: an assessment of differences and pitfalls', *Energy Policy*, 35: 2390–2400

Raven, R. and Geels, F. W. (2010) 'Socio-cognitive evolution in niche development: com- parative analysis of biogas development in Denmark and the Netherlands (1973–2004)', *Technovation*, 30: 87–99

Rooyen, C., Stewart, R. and Wet, T. (2012) 'The Impact of Microfinance in Sub-Saharan Africa: A Systematic Review of the Evidence', *World Development*, 40.11: 2249–2262

Schot, J., and Geels, F. W. (2008) 'Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy, *Technology Analysis & Strategic Management*, 20.5: 537–554

Smith, A. (2007) 'Translating sustainabilities between green niches and socio- technical regimes', *Technology Analysis & Strategic Management*, 19: 427–450

Smith, A., Kern F., Raven, R. and Verhees, B. (2013) 'Spaces for sustainable innovation: Solar photovoltaic electricity in the UK', *Technological Forecasting and Social Change*, 81: 115–130

Smith, A., and Raven, R. (2012) 'What is protective space? Reconsidering niches in transitions to sustainability', *Research Policy*, 41: 1025–1036

UNDP (2007) Energizing the Least Developed Countries to Achieve the Millennium Development Goals: The Challenges and Opportunities of Globalization, New York: United Nations

van der Laak, W., Raven, R. and Verbong, G. (2007) 'Strategic niche management for biofuels: Analysing past experiments for developing new biofuel policies', *Energy Policy*, 35.6: 3213–3225

van der Plas, R. and Hankins, M. (1998) 'Solar Electricity in Africa: a reality', *Energy Policy*, 26.4: 295-305

van der Plas, R. and Hankins, M. (2000) Implementation Manual: Financing Mechanisms for Solar Electric Equipment, New York: UNDP and World Bank

Verbong, G., Christiaens, W., Raven, R. and Balkema, A. (2010) 'Strategic Niche Management in an unstable regime: Biomass gasification in India, *Environmental Science & Policy*, 13.4: 272–281

Watson, J., Byrne, R., Morgan Jones, M., Tsang, F., Opazo, J., Fry, C. and Castle-Clarke, S. (2012) 'What are the major barriers to increased use of modern energy services among the world's poorest people and are interventions to overcome these effective?' CEE Review 11-2004. Collaboration for Environmental Evidence, available at: www.environmentalevidence.org/SR SR11004.html (Accessed on 03 July 2013)

The World Bank (2013) *Database,* [online] available at http://databank.worldbank.org/data/views/reports/tableview.aspx (Accessed 20 August 2013)

Yuan, J., Xu, Y. and Hu, Z. (2012) 'Delivering power system transition in China', *Energy Policy*, 50: 751–772

Appendix A: Past Finance Approaches

Categories and concepts of SNM:

A. Protective space or niche
B. Experiments and Learning
C. Actor-networks
D. Expectations and visions
E. Institutions

Interview questions (and the relevant SNM category in parentheses)

1. What have been the main barriers, challenges and opportunities for microfinance and hire-purchase approaches to finance SHSs/solar lighting for consumers in Kenya? *(A)*
2. Can you think of any experiments which exemplify these barriers, challenges and opportunities? *(B)*
3. Which are the main actors involved in the provision of consumer finance for SHSs/solar lighting? *(C)*
4. Are there any key actors, institutions or networks that have helped coordinate finance activities or facilitate communication and learning between actors? *(C)*
5. What do you think are the main motivations and expectations behind the provision of consumer finance for SHSs/solar lighting? *(D)*
6. Do you think that over time, finance approaches have improved? *(B)*

   Did they take into account previous experiences?

   Can you think of any examples?
7. Are there any laws and regulations which have been either facilitating or hindering consumer finance provision? *(E)*

Appendix B: New PAYG Finance Approaches

Categories and concepts of SNM:

F. Protective space or niche
G. Experiments and Learning
H. Actor-networks
I. Expectations and visions
J. Institutions

Interview questions (and the relevant SNM category in parentheses)

8. Please describe the process of the emergence of the project in general terms:
    - When and how was it initiated; and how did it progress through to completion? *(For general understanding of the approach)*
    - Why did it emerge/What was the motivation for its emergence? *(A, B, D)*
9. Please describe briefly how the model works *(For general understanding of the approach)*
10. Which actors have been involved in the development and execution of your model? What role did they play? *(C)*
11. Are there any key actors or institutions that have helped coordinate finance activities or facilitate communication and learning between actors?
12. What are the main differences compared to other kinds of financing like microfinance or hire-purchase arrangements? *(B)*
13. In what ways have you taken into account former experience of SHS consumer finance before designing the model? *(B)*
14. How did you take into account the specific needs of your low-income customers? *(B, F. This question might be redundant if already answered under question 1.)*
15. What do you think are enabling and constraining factors for the provision of finance for SHS/solar lighting? Are there any laws and regulations which were either facilitating or hindering your project? *(E)*
16. What are the next steps of improvement, if any? *(B)*

Appendix C

Available at http://datatopics.worldbank.org/financialinclusion/ (Accessed on 15 August 2013)

Has an account at a financial institution/post office/MFI (composite indicator)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	448	44.8	44.8	44.8
	no	552	55.2	55.2	100.0
	Total	1000	100.0	100.0	

Borrowed money from financial institution in past 12 months

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	101	10.1	10.1	10.1
	no	899	89.9	89.9	100.0
	Total	1000	100.0	100.0	

Borrowed money from employer in past 12 months

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	63	6.3	6.3	6.3
	no	934	93.4	93.4	99.7
	(dk)	3	0.3	0.3	100.0
	Total	1000	100.0	100.0	

Has used a mobile phone to pay bills in past 12 months

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	137	13.7	13.7	13.7
	no	863	86.3	86.3	100.0
	Total	1000	100.0	100.0	

Has used a mobile phone to send money in past 12 months

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	663	66.3	66.3	66.3
	no	337	33.7	33.7	100.0
	Total	1000	100.0	100.0	