Energising local economies

Experiences of solar start-ups in Kenya's small-scale fishing and agriculture sectors

Sarah Best

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About the author

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Cover photo: Woman carries Nile perch landed at Got Kachola, one of the communities where RESOLVE has implemented a community-managed energy hub © Sarah Best

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Contents

Summary

Kenya is a hotspot for renewable energy projects and start-ups serving poor communities. Falling solar prices combined with mobile-enabled payment schemes and remote monitoring technologies are making products more affordable. While the rapid growth in solar home systems and solar lanterns is a huge step forward in terms of meeting people's household needs, a typical 50-watt solar system is not enough for catalysing rural jobs and incomes in a significant way. People have many unmet productive energy needs, such as for welding, irrigating crops, storing food or running a computer.

Energy providers have a keen interest in the productive uses of energy (PUE); as their customers' earnings and demand for power increases, so does the economic viability of an energy service. At the same time, leading energy institutions are increasingly saying energy access targets need to be more ambitious. The Global Tracking Framework includes an index on energy for productive uses, as an example of how the debate is shifting (IEA/World Bank , 2015; World Bank 2014).

This paper looks at what is happening on the ground in Kenya, examining six examples of solar projects and start-ups that target productive energy needs in rural and fishing communities not connected to the grid. It asks: what productive energy needs do the projects target, and what barriers prevent communities or customers from using energy productively? How are the projects or start-ups addressing these barriers?

The main focus of the research is the RESOLVE project — a partnership led by Renewable World, a non-governmental organisation setting up community-run solar microgrids in fishing communities around Lake Victoria. There are also five mini-case studies of other ventures targeting similar energy needs, covering:

- More mature, for-profit companies installing or supporting microgrids (SteamaCo, in collaboration with PowerGen)
- Early stage, for-profit business start-ups selling solar water pumps for irrigation (Futurepump and SunCulture)
- Corporate-NGO partnerships which are piloting multi-service solar energy hubs on a not-for-profit basis (Sollatek and Osram/WE!Hub).

Key findings

Understanding PUE opportunities and context

All the projects studied carry out some analysis on the productive-use potential of their product or service. However, none are doing the type of more systematic assessment recommended in good practice guides to assess the best opportunity and strategy for improving incomes – such as by reviewing local value chains, the costs and benefits of energy inputs, and mapping bottlenecks. Energy providers need to tailor their services to a complex fishing trade that involves different economic actors, value chains, energy needs, and unequal power relations across the chains.

It is vital that developers understand the local context. For instance, a donor-recipient mindset in some communities and sticky politics in local fishing groups can make it difficult to set up a community-run energy business. Other important context factors include the seasonal nature of fishing, gender dynamics and long-term threats to the sustainability of fishing livelihoods.

Different PUE approaches: for-profit and not-for-profit

The private sector interviewees felt that productive uses of energy will happen automatically through effective targeting of their customer base, and because the viability of their product or service depended on customers generating income and the means to pay. The strength of this approach is its focus on understanding market demand and economic sustainability, but it is likely to target better-off customers within communities; the 'trickle down' effects of the cases studied are still anecdotal, not proven.

Meanwhile the NGOs involved in RESOLVE, and the partners in hybrid corporate-NGO projects, felt that while some activities happen spontaneously, extra measures are needed to reach poorer customers, create business opportunities and achieve an economic transformation locally. The strength of the NGO and hybrid models is that they can test different ways of reaching poorer customers, or stimulating higher value-added activities than might not happen automatically; but face problems of slowness, navigating community politics and still need to demonstrate long-term economic viability.

Addressing PUE barriers in delivery models and promotional activities

There are many barriers to people using energy to earn a living. The projects are tackling these barriers both in the way they design the core energy service and by taking extra promotional measures.

Delivery model: the two firms selling solar water pumps, SunCulture and Futurepump, have tailored the delivery model to the specific productive-use needs and contexts of their customers. SunCulture has bundled solar pumps with drip irrigation equipment and agronomic advice to offer an integrated service that offers to 'translate' to higher yields – though the service is targeted at more affluent farmers. Futurepump targets mid-tier smallholders, offering a low-cost pump with flexible payment schemes and a local distribution model to make repairs easier and cheaper.

Promotion is quite a mixed picture. All are doing awareness-raising on their product or service; some are testing ways to disseminate and help finance the purchase of electrical equipment; NGOs and hybrid models are facilitating some training on business development or other technical skills, like computer literacy.

Collaborating with different stakeholders

Energy providers cannot drive local economic development by themselves and good practice guidance recommends collaborating with other stakeholders. Collaboration in the projects studied takes various forms:

- **Holistic**: multiple stakeholders working together toward a common goal on poverty-reduction and economic development
- **Narrow**: stakeholders work jointly but with a narrower set of goals, partners and time commitment
- **Market-based**: enterprises, market aggregators or other value chain actors working together to overcome a specific PUE barrier and motivated by commercial ends
- **Not collaborating**: choosing to bringing support services in-house rather than collaborate.

Market aggregators – meaning actors that interact with large numbers of small-producers such as a co-operative or commercial buyer - merit more examination as collaborators. Some of the projects involved local fishing bodies (Beach Management Units) who do face serious governance problems, but also bring resources that may help address barriers in knowledge, marketing or financing that inhibit PUE take-up in fishing communities.

The policy context

The Kenya **policy environment** enables firms to 'just get on with it' without interference. But equally there are few positive incentives that support the types of decentralised energy technologies, like isolated minigrids, which can in theory serve productive energy needs in rural areas. Several interviewees explained that they avoid working with government bodies because they fear getting caught up in bureaucracy and politics; notably, none of the projects are involved with any complementary, government-led or sector-wide or intervention to improve local livelihoods.

Recommendations

The cases studied suggest several priorities for energy practitioners, policy-makers, funders and researchers:

1. **Strengthen collective understanding of productive-use customers and markets**

   Conduct research and host learning events to build knowledge on key sectors, regions or customer segments served by productive energy applications – particularly in fishing and agriculture, where there is experimentation but not much knowledge-sharing.

   Share key findings from PUE market analyses funded with public money (such as donor finance) with wider stakeholders to raise overall sector performance.

2. **Incentivise energy projects to conduct thorough PUE assessments**

   Funders of energy access start-ups and pilots should allocate a budget to help practitioners assess, measure and share data on PUE opportunities and impacts.

   Workable methodologies should be developed which enable small projects and start-ups to do PUE assessments.

3. **Make sure gender is prioritised**

   All stakeholders should follow existing good practice advice to integrate gender into the energy service design, monitoring phases and PUE promotion.

4. **Test out different delivery models and support measures to address PUE barriers**

   As practitioners experiment with different models, stakeholders should record and assess:

   - The different approaches to promoting PUE and their outcomes
   - The quality and impact of specific support mechanisms recommended in good practice guides, like enterprise development
   - The pros and cons of a 'holistic' versus a 'commercially orientated' approach, in terms of poverty and equity impacts, cost-benefits, service viability
   - Whether a community-run models have additional impacts on PUE outcomes compared to a privately-run service.

5. **Be clear about when and how to collaborate with others**

   Project developers should conduct due diligence on partners and factor in the time and costs involved. Collaborators need to have a shared vision and identify the most appropriate type of collaboration for the PUE goal and local context.

6. **Strengthen the policy context for PUE projects and investments in Kenya**

   Government should conduct a policy assessment of barriers and incentives to PUE investments and innovation that specifically targets low-income communities, and address key blockages or uncertainties, such as tariff arrangements for minigrids.

7. **Integrate long-term measurement of productive use impacts into energy projects**

   All stakeholders need to support impact research and workable monitoring frameworks as pilots and projects develop. They should cover aspects such as the distribution of costs/benefits, gender, and the effectiveness of different delivery models and PUE support measures.

1 Introduction

1.1 Rationale and purpose

Scattered along the shores of Lake Victoria are hundreds of small beaches where around a million tonnes of fish are landed every year, worth a staggering USD 550 million in total. Fishing in Lake Victoria provides livelihoods for 40,000 fishers in Kenya, and another 165,000 across the Ugandan and Tanzanian sides of the lake (LVFO, 2013). On a good day fishers, as well as artisanal processors and traders, can earn a reasonable wage. But poverty remains stubbornly high and the long-term prospects for communities are under threat as fish stocks fall due to pollution and overfishing.

What role does energy play in all of this? People want to make 'productive' use of energy (PUE), such as to chill fish to get a better price from buyers. At night, fishing crews use pressurised kerosene lamps to attract fish, yet the kerosene is costly and the lamps break regularly. The lake is a source of fresh water, but communities living around it lack the energy technologies and equipment needed to pump water and irrigate their plots of land. Shops and services, like bars, kiosks and hair salons want electricity to screen films, chill drinks or power a hairdryer. Yet most beaches are several kilometres from the nearest electricity grid line, making it expensive and unrealistic to extend the grid into these communities.

However, alternatives are now beginning to emerge. They include microgrids (see glossary) connecting households and small shops, and solar charging stations, which rent out solar lamps to fishers.

This paper looks at how decentralised (see glossary) renewable energy projects and start-ups in Kenya are addressing the need for energy solutions that help poor people in fishing communities and rural areas to engage in productive activities. **It aims to address knowledge gaps on how to promote productive uses of energy, by capturing and communicating emerging experiences and lessons from new projects that often go unrecorded or take years to share results.**

The main focus is on the Renewable Energy Solutions for Lake Victoria Environment (RESOLVE) project. This is a partnership led by the NGO Renewable World, which is installing community-run solar microgrids in six communities on the northeastern shores of the lake. The paper also presents mini-case studies on five other energy start-ups or projects targeting similar types of productive activities in fishing and small-scale agriculture. These give a sense of the wider state of play and provide light comparisons to the RESOLVE approach. The mini-case studies include companies supporting or installing microgrids (SteamaCo in collaboration with PowerGen), companies selling solar water pumping products for irrigation (Futurepump and SunCulture) and two corporate-NGO partnerships piloting multi-purpose solar energy hubs in fishing communities (Sollatek and Osram/WE!Hub).

Promoting the productive uses of energy is vital. Using energy productively can create jobs and incomes, and make energy investments more economically sustainable — since having an income means people can pay for services (Attigah *et al*., 2015).

The energy sector increasingly recognises the need for policies and investments that go beyond household-level energy; the recent inclusion of a new measure on productive energy use in the World Bank's 'multi-tier' Global Tracking Framework is a good indication of this shift (ESMAP, 2015).[1] The framework, developed for the United Nation's Sustainable Energy for All initiative, aims to improve how we measure whether people have access to energy. The fact that productive uses are included is important because the tracking framework may influence how governments go about implementing the new Sustainable Development Goal to achieve universal energy access by 2030 (Goal 7.1). It may therefore raise the level of ambition beyond energy access for basic household needs.

A big challenge on the implementation side, however, is that there are relatively few, mature or well-known examples of successful productive use energy programmes to learn from.[2] Typically, energy investments have focused on the supply of energy without looking at how to help customers make good use of that service, and it is often assumed that jobs and enterprise growth will happen spontaneously once energy arrives. This may happen to some degree, particularly for low-power activities like mobile-phone charging or shop lighting, or where an investment is targeted at places where there is already considerable economic activity. But many experts have argued that to have a bigger economic impact or reach poorer populations, additional efforts are needed to help customers use energy to increase their incomes or productivity (ESMAP, 2008; Barnes, 2014; Attigah *et al*., 2015).

1 See ESMAP (2015:11–12) and Table ES.6 for a working suggestion of how access to productive energy could be calculated. This conceptualisation-stage report emphasises that the wide diversity of productive activities and enterprises makes it difficult to devise a common metric, so the proposed framework focuses on how individuals access energy for productive engagements.

2 See Attigah *et al*., 2015 for some examples of productive use promotion in the electricity sector.

Part of the problem is a lack of knowledge and incentives within the energy sector. Promoting energy for productive uses takes energy professionals into wider socio-economic development issues they are not familiar with or see as someone else's job. Collaborating is also difficult – for instance between companies and institutions in the energy, agriculture and water sectors – because of each sector's different perspectives and priorities. Another issue is the sheer diversity of productive activities, enterprises and types of energy product or service that could serve people's needs. What type of strategy is relevant for a large-scale rural electrification programme funded by a public utility, versus a privately run microgrid, versus a standalone device like an electric water pump or solar chiller? How might all of these vary across different contexts?

On a positive note, there is more good practice guidance available on how to promote productive uses; particularly noteworthy is the toolkit produced by the PRODUSE initiative on electrification.[3] There is also a flourishing of experimentation and pilots on the ground, particularly in decentralised renewable energy. One sign of this is USAID's 'powering agriculture' prize scheme, which has received several hundred applicants working on clean energy solutions in areas such as irrigation, storage and processing.[4] A key question is: what are these innovators doing to target productive energy needs? IIED has previously produced a literature review on energy access in smallholder agriculture, and held a stakeholder workshop in London to discuss the results. Through this process we identified a real appetite among practitioners to capture lessons from new pilots as they are happening, in order to understand the different approaches being deployed (Best, 2014; Trevalyan, 2014).

1.2 Key questions and methodology

The research focuses on the following questions:

1. What productive energy needs are targeted by RESOLVE and other energy projects/start-ups, and what barriers prevent communities/customers from using energy productively?
2. What approaches are RESOLVE and other energy projects/start-ups taking to address barriers to the productive use of energy? This includes their delivery model and additional support measures.
3. What ideas and learning are emerging from these early-stage experiences that can inform practitioners, policymakers, funders and researchers?

3 See www.produse.org. Productive Use of Energy (PRODUSE) is a joint initiative of the Energy Sector Management Assistance Program, the Africa Electrification Initiative, the EU Energy Initiative Partnership Dialogue Facility and the German Society for International Co-operation (GIZ). It aims to improve knowledge and practice on the topic and has produced the *Manual for Electrification Practitioners* (Brüderle *et al.*, 2011).
4 See the Powering Agriculture website at https://poweringag.org.

This is qualitative research conducted primarily through semi-structured interviews with non-governmental organisations (NGOs), private sector, academic and community stakeholders in Nairobi, Kisumu and communities around Lake Victoria. The author talked to a range of community members at three RESOLVE project sites (Got Kachola, Ng'ore and Luanda Rombo) as well as customers and technicians connected to a SteamaCo/PowerGen microgrid (Rusinga Island) and to the Futurepump irrigation pump pilot (Rusinga Island). The schedule for these interviews is in Annex 1. This was supplemented by follow-up interviews and a project document review after the field visit.

One qualification to make is that the research does not provide a quantitative or economic analysis of the different energy delivery models, or assess productive use impacts for customers. This type of data was not available either because projects are at an early stage and without impacts to report, or because the data is too commercially sensitive to share publicly. Nor does the research provide a thorough review of energy policy and macro-level aspects of the enabling environment, though it does highlight a few policy issues raised by interviewees themselves. Also, as a small research project with a modest budget, we decided to focus in this instance on capturing the experiences of project developers and their stakeholders. IIED plans to do more multi-disciplinary research on productive uses in the future.

1.3 Case study selection

The RESOLVE case study was chosen after Renewable World approached IIED. They are interested to understand how productive uses of energy can be supported, and to compare their approach to other experiences, including more commercially driven models.

There are many aspects to the RESOLVE project that make it an interesting case study with prospects for wider lesson-learning around the lake in Uganda, Tanzania and Kenya; and potentially for Kenya's coastal fishing communities too.

RESOLVE is a partnership, combining NGOs, a private developer and research institutions. Like many rural energy providers, the project is heavily subsidised. There are donor grants to cover capital costs and customers contribute to operation and maintenance costs through paying tariffs. It has been developed with an ambitious and holistic vision to try to transform local livelihoods, and brings in the type of interventions recommended in good practice guides, such as business skills training and links to micro-finance. RESOLVE has opted for a community-managed system, which is a common model in the energy access field — but always provokes questions about whether the conditions exist for long-term sustainability.

RESOLVE is also interesting as a project operating in a highly complex, dynamic and challenging context. The fishing value chain stretches from men and women involved in fishing and processing, living fairly hand-to-mouth, to better off boat owners and traders, then to the large factories in Kisumu and Nairobi who sell to buyers in European markets. The hope is that accessing energy could help people at the bottom of the chain capture a slightly higher share of value addition from this lucrative industry, as well as improve their general living conditions. At the same time, fishing livelihoods are under threat and there is a need to create other jobs and sources of income – which modern energy services could play a role in.

The mini-case studies were selected for their comparator potential as projects serving similar productive needs to RESOLVE (fishing or agriculture) in the same area or a similar context (lake or coastal). They cover a variety of technologies and delivery models, from the not-for-profit to fully commercial (see Tables 1). SunCulture is slightly different from the others as it does not operate in fishing communities and targets better-off farmers, though as another solar irrigation start-up it offers a useful comparator for Futurepump.

Table 1. Case studies by energy needs, technology and ownership

	RESOLVE	SteamaCo/ PowerGen	Sollatek	WE!Hub/ Osram	Future-pump	Sun-Culture
Key energy needs targeted by sector	Fishing Agriculture Services Households	 Services Households	Fishing Households	Fishing Services Households	 Agriculture 	 Agriculture
Technology	Solar Microgrid & energy hub	Solar Microgrid	Solar energy hub	Solar energy hub	Solar water pump	Solar water pump & irrigation kit
Ownership & manage-ment	Hybrid NGO-led, community owned, private sector technology	Private sector	Hybrid Private sector provides technology & pilots with stakeholders	Hybrid Private sector provides technology & pilots with stakeholders	Private sector	Private sector
Objectives & orientation	Community empower-ment, socio-economic development	Profit-oriented Market-driven pricing	Socio-economic development, assessing business opportunity	Socio-economic development, assessing business opportunity	Profit oriented, market-driven pricing	Profit oriented, market-driven pricing

1.4 Report structure

The report is structured as follows. Section 2 sets out key concepts and enabling factors identified as important for stimulating productive uses of energy. These will be used to analyse the RESOLVE and other practitioner experiences. It also briefly introduces key aspects of Kenya's policy context.

Sections 3, 4 and 5 are the main body of the report, focusing on the RESOLVE case study. Section 3 introduces the context of fishing livelihoods and communities around Lake Victoria and the RESOLVE delivery models; Section 4 looks at the energy needs it is targeting and barriers to productive uses. Section 5 drills down into RESOLVE's approach to serving productive energy needs and reflects on the key lessons.

Section 6 provides mini-case studies of other PUE start-ups around Lake Victoria and Section 7 identifies key ideas and recommendations for actors working in this field.

The research has been funded by IIED's Accountable Grant from the UK Department of International Development, and is part of an emerging work stream in IIED's energy portfolio on energy for productive uses.

Who should read this paper?

This paper is for people within and outside Kenya who want to know what type of productive use of energy projects exist and how they are working in practice.

It will be useful for energy access practitioners; those working on improving livelihoods fishing and small-scale agriculture that lacks access to modern energy; and conveners, knowledge organisations, funders and specialist policymakers who want to understand or communicate learning on the topic.

2

Global lessons on energy for productive uses

Decentralised renewable energy could help address poor people's productive energy needs; and also target productive activities that can make decentralised energy more viable, as it generates the means for customers to pay. There are good practice recommendations on how to address demand and supply-side barriers, particularly for electrification projects. Key elements are PUE assessments in the planning phase, targeted promotional activities toward customers and a supportive enabling environment.

2.1 Defining terms

Productive use of energy (PUE). Energy access is understood here as access to energy supply and equipment that is affordable, adequate, reliable, safe and targeted at people's actual needs.[5] There is no universally accepted definition of 'productive uses of

5 IIED takes a technology-neutral approach to access. While recognising the important role of renewable energy, IIED believes the full energy mix should be considered for poor communities, depending on what is most appropriate. The examples in this paper are solar energy applications.

energy'.[6] When this paper refers to 'productive uses' it is in the sense of uses of energy that directly increase incomes or adds value to goods and services — such as motorised pumps for irrigating crops, or electricity enabling a shop owner to charge up customers' mobile phones. It may involve upgrading existing economic activities or creating entirely new businesses (Brüderle *et al*., 2011). This report contains examples of both.

Decentralised energy. Our focus is on decentralised energy, a term which encompasses minigrids or microgrids (see glossary) supplying electricity into a small distribution network as well as standalone systems providing mechanical, thermal or electrical power. All the examples in this paper use solar energy, with the microgrids also using diesel as a back-up.

The reason for focusing on decentralised energy is that while grid-based electricity provides the higher power loads often needed by small businesses and industry, the costs of extending the grid to rural areas are often prohibitive, requiring off-grid alternatives. The International Energy Agency (IEA) estimates that to achieve its goal of universal access to electricity, 70 per cent of the rural areas that currently lack access will need to be connected using minigrid or small, standalone off-grid solutions (OECD/IEA, 2011).[7] Decentralised energy is therefore a large part of the solution to energy access, making it critical to understand how these investments can be shaped to stimulate income generation and poverty reduction.

Energy delivery model. This term is a concept increasingly used by practitioners to describe the combination of core technology, finance and management needed to supply energy to users. A successful delivery model is adapted to the wider enabling environment, for example, government policy and tax regimes; the socio-cultural context, such as the local skills base and social cohesion; and additional support services, like skills training for customers (Wilson *et al*., 2012).[8] In discussing how projects address productive use needs and barriers, the paper sometimes distinguishes between adjustments made in the 'core' delivery model on one hand and 'additional' PUE promotional activities on the other. This follows the convention of good practice in literature on electrification which tends to highlight PUE promotion as additional to a standard electricity supply programme. However, as the case studies show, in practice

6 Focusing on the electricity sector, the World Bank-administered Energy Sector Management Assistance Program defines 'productive uses' as "uses of electricity that support any activity that will generate revenue to the user" (ESMAP, 2008:14), while a manual co-authored by GIZ defines productive uses of electricity as "agricultural, commercial or industrial activities that involve electricity services as a direct input to produce goods and/or provision of services" (Brüderle *et al*., 2011:13). A discussion on productive uses of energy on the knowledge platform energypedia provides examples of other definitions — see https://energypedia.info/wiki/Productive_Use_of_Electricity.

7 Within all rural areas requiring decentralised energy to gain access to electricity, the IEA estimates that 65 per cent of the share will be via minigrids and 35 per cent through small, standalone off-grid solutions (OECD/IEA, 2011).

8 See also Bellanca and Garside (2013) for more information on energy delivery models.

the boundaries are blurred: promotional activities like 'awareness-raising' could equally be considered marketing functions core to the delivery model itself.

2.2 Barriers to productive uses of energy

Rural electrification has been a staple of development interventions over decades, carrying high expectations for stimulating local economic and social development. Yet in a key 2008 report by the World Bank-run Energy Sector Management Assistance Program (ESMAP), the authors conclude that rural electrification programmes — both on- and off-grid — have often failed to achieve any lasting impact on people's livelihoods in rural areas (ESMAP, 2008). There are several reasons for this, but a key one has been the energy sector's myopic focus on supplying connections and kilowatt hours, rather than aiming to impact on rural customers' revenue-generating activities. The authors conclude that productive activities will not happen spontaneously and additional interventions are needed on the other side of the meter to convert a connection into a thriving enterprise or new job (ESMAP, 2008). Other reviews of the topic have a similar perspective (Fishbein, 2003; Finucane *et al.*, 2012).

"In general, contrary to the use of electricity for lighting and domestic appliances, its adoption for production does not happen on its own or rapidly. This reality makes it important to include activities in rural electrification projects that address barriers to and encourage the adoption of electricity for income generation" (Finucane *et al.*, 2012: 7).

The literature highlights several demand and supply-side barriers. There is a heavy focus on electricity (on- and off-grid) but many of the challenges identified are likely to apply to thermal and mechanical technologies, such as improved cookstoves used by informal food sellers or small restaurants.

Demand-side gaps relate to:

- **Awareness and knowledge by small and micro-business, households and farmers** on how to use new-found electrical and motive power for profitable enterprise. This may include a lack of knowledge on market opportunities (particularly for products based on additional processing), technology options (the types of electrical tools that could be used and their availability) and cost-effectiveness of energy service or new equipment.
- **Technical, business and financial management capacity** among local small and micro-businesses, households and farmers. For instance, local people may lack the skills needed to manage the energy supply (if community-level management is required) or run a viable business enabled by new energy and machinery inputs.
- **Financing the energy, productive tools and equipment**. Energy customers with sparse financial resources struggle to pay for energy services or the equipment that

makes new energy services worthwhile. Local lending institutions may be unwilling to lend, fail to understand new clean energy technologies or not lend enough (in the case of micro-loans) to cover more expensive equipment powered by modern energy services, like a grain mill or cold storage facilities. The interest rates lenders set are often unaffordable for poor customers.[9] And in rural areas, people's incomes often vary over the year in line with the harvest, so it can be hard to make the regular payments associated with monthly bills or loan repayments.

- **Access to markets for additional or new products produced or services offered as a result of new electrical, heat or motive power**. Local producers need access to markets if they are going to benefit economically from the increased production or quality of their goods; yet many other supply chain bottlenecks beyond access to energy stand in the way, such as poor quality roads.

In small-scale agricultural and food production, there are underlying challenges which make it difficult to increase incomes and productivity. This includes problems in the supply chain, market linkages, variability in income stream, production risks (weather, harvest failure, stock depletion), low productive volumes, access to information and transport links. The levels of trust and strength of relationships between producers and buyers vary greatly across different value chains, which may lever or limit opportunities for small producers to access technology or upgrade.[10]

Constraints on the supply-side include issues such as:

- **Energy providers' understanding of rural markets**. This may be particularly relevant for a large utility, which may not have the offices, staff or partners needed to gain a deep understanding of user needs and the local social-cultural context. Even small and medium-sized companies and NGOs involved in energy provision may lack understanding of the local context if they are new to the market or lack staff presence.
- **Energy providers' service is based on least-cost supply**, rather than delivering maximum development benefits to customers.
- **Insufficient co-ordination with complementary services**, such as agriculture extension services, transport, water supply, microfinance and information and communication technology (ICT) services. Energy providers may have poor linkages with other, non-energy institutions. They may not see it as their responsibility to make

9 Interviewees in Kenya commented that loan interest rates can be around 20–30 per cent – making it difficult for users to buy more expensive energy technologies and related equipment for productive activities.
10 One agricultural expert interviewed for the research explained how in some sectors, such as the tea, coffee and diary sector in Kenya, there are well-established channels for buyers contracting with smallholders and outgrowers. In others – such as the sugar cane sector – even where there are contracts setting commitments to buy and sell at a certain price between producers and buyers, these commitments may not be observed. Where trust and relationships are high, these value chain relationships could be used to help introduce new technologies or provide supporting services, such as consumer finance.

the connections, particularly if they are commercial entities. Equally, the supporting infrastructure may not be present at all.

- **Service quality in rural areas poor or inconsistent**, with interruptions and voltage drops in the case of electricity supply, or insufficient maintenance provisions so technical problems are left unresolved. Consumers overloading off-grid systems can also be a cause of blackouts. Poor reliability will inhibit take-up and use of energy by households and enterprises.
- The **policy, finance and institutional environment** is not conducive to rural development, business development and decentralised energy services (Fishbein, 2003; ESMAP, 2008; USAID/ARE, 2011; Finucane *et al*., 2012; Brüderle *et al*., 2011; Best, 2014, Willcox *et al*., 2015).

As the last point suggests, there are broader constraints in the enabling environment which hold back the expansion of rural or decentralised energy solutions *in general*, and this will have a knock-on effect on productive use applications. These barriers include the lack of affordable financing for entrepreneurs and customers and the high cost/low return of serving rural areas due to problems of geographical remoteness, customer poverty, low density populations, weak infrastructure or political interests which favour urban over rural populations.

Some energy products and services targeting productive uses may also require specific policy incentives to encourage investment. For instance, for solar water pumps, the level of import duties or subsidies provided to competitor products like diesel will affect the economic viability of the business provider.

2.3 Designing energy services to promote productive uses

The barriers identified also point to how energy projects and services could be better designed to target and promote productive energy use. There are different ways of categorising the types of project design and intervention strategies,[11] and this paper highlights three broad areas:

- PUE assessments and planning
- Promotional activities with communities and customers
- Improving the enabling environment.

11 In a review of government and development programmes for electrification, Attigah *et al.* (2015) identify five different approaches for promoting PUE: 'electrification plus'; call for proposals; application-centred; PUE financing; cross-sector.

Most of the good practice guidance studied, such as the PRODUSE manual (Brüderle *et al.*, 2011), is targeted at developers and utilities carrying out grid extension or minigrid projects. However, the principles still appear relevant to smaller projects and standalone products, albeit on a smaller scale and budget.[12] The report will repeatedly refer back to the following interventions to understand to what extent the RESOLVE project (and other pilots and start-ups) have used them:

Assessments and planning

1. **Undertake assessment to understand PUE opportunities in the target area(s).** An initial feasibility assessment will help to understand demand, willingness to pay and identify the broad PUE opportunities and objectives. This should be followed by a more in-depth analysis of the productive use applications by type of economic activity. A lean version would only look at existing activities in the area/target customer base (such as cost savings from replacing diesel with solar), while a more systematic version would include the potential for new businesses to be created. Some technologies will automatically require a decent assessment of PUE. For instance, a minigrid requires higher levels of productive energy demand compared to a microgrid concentrating on lighting, if it is to raise sufficient revenue to cover its costs.

   The type of systematic assessment recommended by PRODUSE is focused on outcomes for users, not just the economic viability of the service. It includes an examination of the relevant value chains that local producers supply or could supply, the role of energy inputs versus other bottlenecks in those value chains, and cost-benefits of investing in energy services as a way to increase value addition. The cost-benefit analysis could include aspects such as production volumes and costs, consumer prices, employment creation and incomes. Some analysis of the distribution of costs and benefits across different groups is also important, particularly where a project has specific social objectives in mind (such as reaching lower income groups) or negative impacts may arise (such as job losses from automation) (Brüderle *et al.*, 2011). Including a gender analysis can help pinpoint the differential opportunities/constraints for men and women to benefit.

   The whole exercise aims to pinpoint exactly which user groups and activities are best to target (given likely resource constraints) and help set clear objectives in terms of how this will reduce users' costs, increase their productivity or catalyse new businesses opportunities.

2. **Select sites or market segments to serve, on the basis of criteria indicating possible untapped opportunities and enabling conditions**. Key criteria would include the existence of adequate physical infrastructure, complementary investments

12 See Brüderle *et al.* (2013) for projects disseminating efficient biomass appliances for productive uses such as baking.

(smallholder productivity programme), support services (agricultural extension) and micro-enterprises with potential to increase energy consumption for productive uses and strong NGOs or local organisations active in rural development.

3. **Identifying and linking with complementary services, sectors and programmes**. The assessment process also requires a mapping of relevant stakeholders to see who might be able to support the productive uses of energy. The scale and type of linking may vary:

   - One level is a larger-scale, deep integration with projects and investments led by government or the private sector in other sectors, such as local economic development, roads, ICT, rural development, agriculture or water supply.
   - Another level is 'lighter touch' and focused on identifying actors who can play a supporting role on PUE promotion, such as a business association that might assist with awareness-raising and enterprise development (see points 5 and 7 below).

   Practitioners have observed that given the different perspectives, incentives and knowledge of different stakeholders, the larger-scale cross-sectorial approach can be difficult to pull off. For instance, an integrated rural development plan can make good theoretical sense but sometimes lack the resources, sustained political support or enabling environment to be delivered effectively.[13]

Promotional activities with communities/customers

4. **Build community awareness and involvement from an early stage.** This stretches from basic information provision (on the PUE opportunity, appliances, the costs of the service) to local stakeholders' active involvement in the development of new energy services so these are aligned with the local context and thus sustainable over time. It could include, for example, radio or poster campaigns, community meetings, engagement with trusted leaders, exposure visits, user testing of pilot products or designing the service to fit with community development objectives.

   Many energy practitioners report that communities are more motivated to adopt new technology when they see their neighbours or other communities use it successfully. Developers could choose sites with this potential for a demonstration effect in mind, and invest in communicating experiences locally in order to spread knowledge about how energy could be used productively and encourage wider take-up.

5. **Facilitate training for enterprise development and other technical skills.** Enterprise development can be targeted at specific micro, small and medium-sized

13 This was a recommendation that came out of discussions among practitioners who attended an IIED workshop on energy for productive uses in smallholder agriculture, April 2014. See www.iied.org/calling-all-energy-agriculture-experts-meet-talk-collaborate.

businesses who demonstrate particular potential for value-addition, or it may be be more generalised to the local community. Trainings cover basic financial literacy (how to apply for a loan, book-keeping) or specific business management skills (marketing, business planning). These type of business development services could be outsourced to NGOs or other agencies with relevant experience. Other types of technical advice might relate to the selection and use of specific pieces of end-use equipment (welding machines, efficient light bulbs) or training in particular skills in the sector targeted for new energy inputs, like food hygiene standards.

6. **Facilitate access to finance to purchase equipment.** This might involve fostering relations with banks, micro-financing institutions or savings co-operatives for suitable loan products to finance energy products, appliances, and other related investments, such as purchasing inventory. Where resources permit, it may involve government or a financing institution establishing a specific fund or loan product for PUE applications.

7. **Promoting standalone energy technologies and end-use appliances.** There are two different elements to this:

   - Improving the availability of end-use appliances, such as computers, refrigerators, oil presses or grain mills. One way to do this might be by encouraging energy providers or existing shops to offer PUE appliances on a cash or credit basis. (This is relevant to microgrids and solar energy hubs in the case studies).
   - Creating/expanding a market for a standalone energy application, like a solar irrigation pump. It involves all the usual steps in designing an energy delivery model plus some of the promotional activities mentioned. This includes gauging user needs and market potential; assessing the technical and financial viability of the technology; testing and demonstrating with users; creating awareness and stimulating demand; working out supply chain and maintenance provisions; and developing a payment or financing scheme to make it affordable for customers.

Improving the enabling environment

8. **Address specific policy and institutional constraints** for energy technologies that can be used for productive activities, such as pricing, subsidisation, tariffs, permitting, duties and feed-in arrangements. Projects also need to be politically informed – for instance, prioritising areas where there will be sustained political commitment to a PUE investment.[14] The enabling environment can be extended much wider than energy. It might include examining barriers and levers to poverty reduction in the end-use sectors targeted. For agriculture this might mean government

14 This was a recommendation that came out of discussions among practitioners who attended an IIED workshop on energy for productive uses in smallholder agriculture, April 2014. See www.iied.org/calling-all-energy-agriculture-experts-meet-talk-collaborate.

investment in extension services or incentives for rural banks to lend to small-scale farmers at affordable interest rates.

9. **Widen targets and performance indicators** set by governments or funders toward energy providers receiving funds to include productive use impacts. Donors, public funders or social impact investors with a poverty reduction remit can measure or set targets that go beyond energy supply to include the uses of energy, customers' revenues, production increases or incomes. Rural electrification plans could integrate PUE for poor, rural communities into the targeted objectives, outcomes and approach (Attigah *et al*., 2015; Best, 2014; ESMAP, 2008; Finucane *et al*., 2012; Brüderle *et al*., 2011).

Having outlined the barriers and interventions that could support productive uses of energy, the final part of this chapter briefly introduces some features of the Kenya policy context relevant for the case studies.

2.4 Policy context

Nearly four in five Kenyans do not have access to electricity (77 per cent) and a similar share of the population depends on solid fuels for cooking (84 per cent).[15] As is the case globally, this is particularly a rural problem: 93 per cent of rural dwellers in Kenya do not have an electricity connection compared to 42 per cent of their urban counterparts (IEA/World Bank , 2015).

Some aspects of Kenya's policy framework positively support increased access to energy. For instance, Kenya has a dedicated budget for rural electrification, clear assignment of institutional responsibilities, and runs energy access programmes. Recognising that the grid will not reach everywhere, the regulatory framework also allows for private sector electricity provision through minigrids and standalone systems (Willcox *et al*., 2015). The Kenyan government's decision in 2014 to exempt imported solar products from VAT was welcomed by some industry representatives, who see this as critical for keeping prices affordable for poorer customers.[16] And several of the private sector representatives interviewed for this research said that an entrepreneurial culture, a growing renewable energy scene and a government that does not interfere excessively in the market makes Kenya attractive for energy start-ups.

15 There is no universally agreed-upon definition of energy access, and it can be a challenge to determine how best to capture issues such as its quantity, quality, adequacy and affordability. These figures come from the SE4ALL Global Tracking Framework, which is based on existing global household survey questionnaires. Electricity access is defined as "availability of an electricity connection at home or the use of electricity as the primary source for lighting". Access to modern cooking solutions is defined as "relying primarily on non-solid fuels for cooking", such as gas or electricity (IEA/World Bank 2015).

16 See this statement by the Global Off-Grid Lighting Association: www.gogla.org/wp-content/uploads/2014/05/GOGLA-Industry-Opinion-on-VAT-and-Import-Duty-Settings-for-Off-Grid-Lighting-Products-and-Solar-Home-Systems-Adopted.pdf.

However, there are also barriers and gaps in the enabling environment worth highlighting. A review by Pueyo (2015) concludes that, notwithstanding the targets and rhetoric on energy access, the main thrust of Kenya's policy and public investment is on large-scale, on-grid electricity generation and connection for economic growth.[17] This has a productive use dimension – but more in terms of guaranteeing an electricity supply to commercial and industrial users than to people living in poverty. And although the government recognises that there is a role for off-grid solutions, practitioners claim that in general decentralised supply – particularly minigrids or microgrids, which could be a key technology solution for productive activities – does not enjoy much active government support (Willcox *et al*., 2015).

Some of the criticisms of policy by minigrid and microgrid developers include:

- A lack of clear rules and permissions allowing operators to set tariffs higher than grid tariffs, which is needed to cover the higher costs of rural supply (see Box 1)
- Lack of explicit provisions for smaller off-grid providers for new feed-in-tariffs and planned net metering arrangements in Kenya's 2015 Energy Bill
- The absence of a grid extension master plan or rules around what happens when the grid arrives in a village, creating uncertainty and risks for investors (Wilcox *et al*., 2015; author interviews).

Though it was not discussed in depth, interviewees for this research also mentioned some policy barriers to standalone energy devices, particularly in relation to product quality standards. In the off-grid solar sector, customer confidence has been dented by negative experiences with low-quality products, improper installation and poor customer service arrangements. The Energy Regulatory Commission and the Kenya Renewable Energy Association (KEREA) have been acting to resolve these problems. For example, solar vendors must be licensed by the regulator; and KEREA are training up solar technicians and developing a voluntary accreditation standard for suppliers, technicians and vendors. While the example given refers principally to lighting, the same issues of a gap in standards or implementation affects new technologies designed for productive purposes (solar water heaters, dryers, night fishing lanterns, and irrigation pumps).

In summary, the general barriers to using energy for productive purposes are well known; there are many recommendations for addressing them which we can use to examine the actual experience of RESOLVE and the other case studies. A glance at Kenya's policy context suggests a rather mixed bag: it does not impede the types of projects and start-ups studied in this paper in a major way, but equally it is not pro-actively incentivising the

17 In its Vision 2030, the Kenyan government set out its aim to transform itself into a newly industrialised middle-income country, envisaging average growth rates of 10 per cent per annum. The strategy sets out a series of flagship projects – such as ICT parks and iron and steel smelting – which are energy-intensive and key drivers for the government's plans to increase generation capacity by 5,000 megawatts between 2013 and 2017 (Pueyo, 2015).

type of decentralised solutions that could help stimulate productive uses of energy in rural areas.

In the next chapter we move from macro to micro to examine the local context of fishing communities targeted by the RESOLVE project, and the key aspects of its design model.

Box 1. Are variable tariffs for minigrids and microgrids more affordable?

Grid tariffs are low but connection costs are high

There is a fixed tariff schedule for customers of Kenya Power, the state provider of grid electricity that also runs a number of minigrids. The tariff in Kenya is 2.5 Kenyan shillings (KES) per kilowatt hour (kWh), or USD 0.02, for the first 50kWh of consumption – which is a "lifeline" tariff ensuring poor consumers can afford a basic amount of electricity - and KES 12.75 for up to 500kWh (USD 0.12). For small commercial users, the rate is KES 13.50/kWh (USD 0.13). For the connection fee, Kenya Power charges KES 35,000 (USD 350) per customer. Although subsidised, this connection fee is still around three times the monthly household budget of people living below the poverty line, making it unaffordable for many, and a reason why people do not connect.

Privately run minigrids set higher tariffs but lower connection costs

SteamaCo is one of the companies interviewed as part of this research and a RESOLVE project partner. It typically charges around KES 150/kWh to KES 500/kWh (USD 1.65–5.5), depending on usage. The company argues that these costs are comparable with what customers already spend on alternatives like a diesel generator (micro-enterprise) or kerosene (household). They add that by setting higher tariffs they are able to reduce up-front connection charges to a nominal amount (around 10 USD), so it is more affordable for poor customers.

Regulatory uncertainty on variable tariffs for mini/microgrids

While the law allows private operators to propose higher tariffs, developers say that this is a regulatory grey area for them. Minigrids below 50kWh are said to largely operate under the regulatory and licensing radar, and there is also a perception that regulators are likely to reject the tariff proposals submitted. Interviewees suggested the government is reluctant to move away from Kenya Power's uniform tariff out of concern that private operators may exploit people and set overly high prices. In response, developers say that their rural customers are willing to pay higher prices and the reason utilities have not been able to electrify rural areas quicker is because the uniform tariff is too low to cover costs. They point out that privately run systems do not benefit from the cross-subsidy arrangements that are allowed in the grid system (between rich and poor customers, urban and rural).

One interviewee commented that private operators who set variable tariffs are not pursued by regulators as their numbers are too small to make it worth the effort, though this will not be tenable as the sector grows. Another felt that regulatory uncertainty around tariff rules may be putting off investors.

Sources: Author interviews; Energy Regulatory Commission, 2015; Pueyo, 2015; Osawa and Telep, 2015.

3

Introducing RESOLVE and the Lake Victoria fishing communities

The RESOLVE project aims to improve and diversify local livelihoods through installing community-run solar microgrids in six communities around Lake Victoria. It targets the need for the productive use of energy in fishing, local services and agriculture. RESOLVE has to tailor its energy service around a complex local context and PUE barriers including: fluctuating incomes; environmental and health problems; patchy collective organisation; gender inequality; a lucrative but complex fish trade; and asymmetric power relations across the value chain.

3.1 Context for RESOLVE: fishing livelihoods under pressure

The RESOLVE project is led by Renewable World,[18] a UK-based charity working with local organisations in Nepal, Kenya and Nicaragua to support affordable renewable

18 See www.renewable-world.org. Renewable World was set up by the UK's renewable energy industry in 2007 to act as a link between the European renewable energy sector and energy-poor communities around the world. It works with social enterprises and NGOs to support projects in small-scale wind, micro-hydro, PV solar and biogas.

energy projects for remote off-grid communities. It provides funding, capacity-building and technological expertise. RESOLVE is a three to four-year project that started in 2012. It had a public launch in June 2013 and the grant period for implementation ends in May 2016.

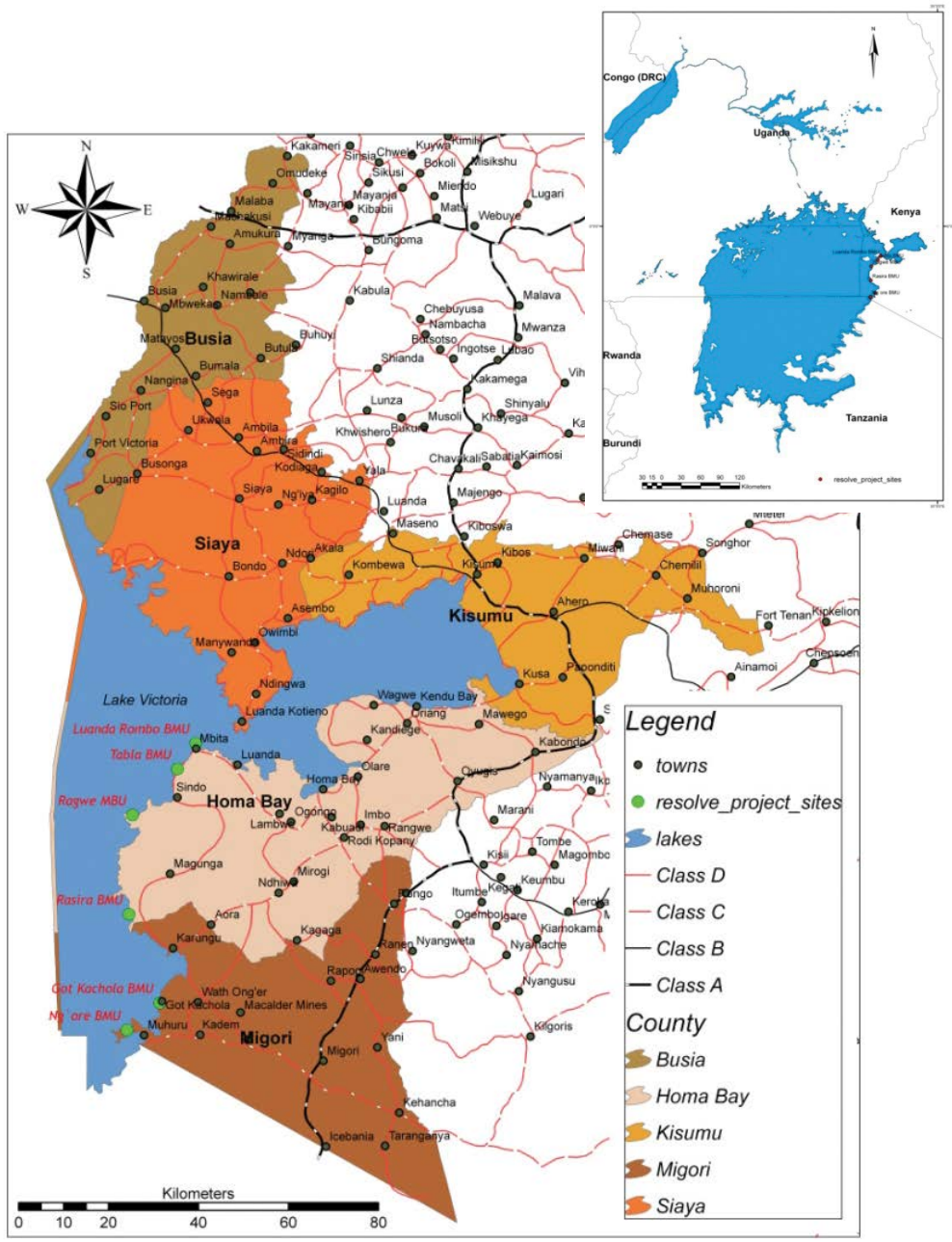
The goal of RESOLVE is to improve health, education, incomes, and crop production in six communities around Lake Victoria through constructing microgrids run by a community-based organisation (CBO). The CBO manages an energy hub as a not-for-profit community enterprise, supplying electricity for homes, fish-chilling and small enterprises; and selling other energy-related services from the hub, such as solar lantern charging. RESOLVE's role is to assess local needs and site-readiness, install the power production systems and conduct training in the community on how to run the energy hub and use its services.

The communities are located in the counties of Homa Bay and Migori on the northeastern shores of Lake Victoria. Lake Victoria is the second largest lake in the world after Lake Superior in Northern America, and is shared by Tanzania (52 per cent), Uganda (43 per cent) and Kenya (6 per cent) (LVFO, 2013). Figure 1 shows the location of the six RESOLVE sites: Luanda Rombo, Got Kachola, Ng'ore, Rasila, Ragwe and Tabla.

The conditions in the area where RESOLVE works are challenging. Around 45 per cent of people in Homa Bay and Migori counties live below the poverty line (Commission on Revenue Allocation, 2011).[19] One study of fish workers in Lake Victoria found 64 per cent lived below the poverty line (Olale and Henson, 2012). Literacy rates and educational attainment are lower than the national average and in most of the communities where RESOLVE works, the norm is to drop out of education after primary school (Odada *et al*., 2015).[20] Many people suffer from poor health linked to HIV and the presence of waterborne diseases (diarrhoea, cholera and typhoid) caused by drinking untreated water from the lake. HIV rates are 27.1 per cent in Homa Bay and 17.2 per cent in Migori, which is significantly higher than the national average of 6.1 per cent (UNICEF, 2013a and 2013b). HIV prevalence is common in fishing communities, and some argue that it is connected to the culture that has grown up around the fishing industry (Fiorella *et al*., 2015). Roads and transport links are very poor, which is a barrier to people selling and buying goods, both within and outside the fish business.

19 Poverty rates in Homa Bay are 44.1 per cent and in Migori County 46.7 per cent. This is very similar to the national average of 45.9 per cent. The data are from the 2005 Kenya Integrated Household Baseline Survey.
20 There is some variation between the sites. In four of the communities, around 60–80 per cent finished their education at primary school, although in Ragwe and Tabla, 38 per cent had completed secondary school, and in Ragwe 6 per cent had completed university (Odada *et al*., 2015).

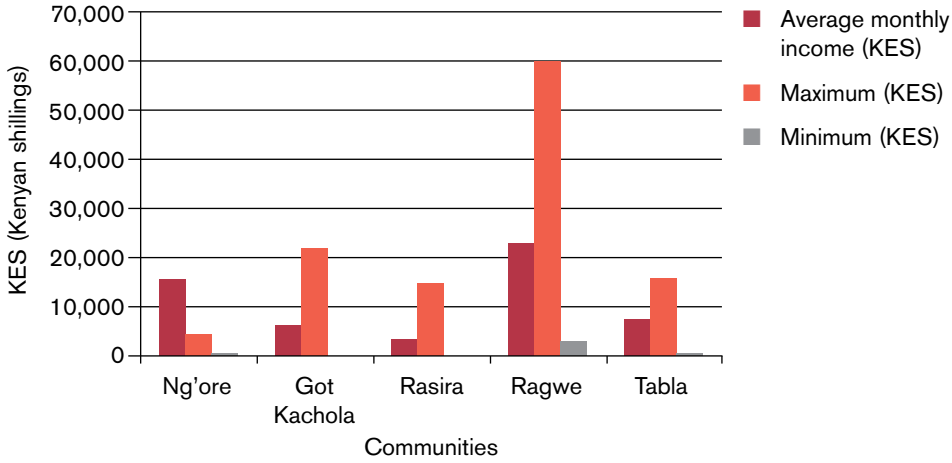
Figure 1. RESOLVE's sites in six communities around Lake Victoria



Source: Odada et al., 2015.

The fishing sector is hugely important for people's livelihoods. RESOLVE's baseline survey found that most households in the communities mainly depend on fishing for their income or on a mixture of fishing with some farming (Odada *et al*., 2015). The average household income was KES 11,115 per month (USD 110) for a typical household size of six people, though Figure 2 shows that income levels vary considerable between the different communities.

Figure 2. Total household monthly incomes across five RESOLVE sites



In general, men do the fishing and own the boats, while women are more involved in processing and selling fish catches destined for local markets (Olale and Henson, 2012). Other activities related to fishing include supplying wood and nets, constructing boats, and transport. Local farmers, shops, vendors, video halls, restaurants and hotels in the villages also depend on the trade, as people use their earnings from fishing to buy their goods and services.

Fishing is important not just for these communities, but the region and country as a whole. The Lake Victoria Fisheries Organization (LVFO; see glossary) estimated that in 2012 there were about 40,000 fishers and 13,000 boats on the Kenyan side of the lake (LVFO, 2013). Kenya's fisheries contribute an estimated 2 per cent of the country's gross domestic product (LVFO, 2013). Across the three countries (Kenya, Uganda, Tanzania), the value of the catch at beach level is estimated at more than USD 550 million with an export value of USD 260 million (LVFO, 2013).

The sector has undergone tremendous transformation, from a local-based subsistence fishery prior to 1960 to a commercialised sector today. Fish production from Lake Victoria grew exponentially in the 1970s and 80s, closely linked to the introduction of Nile perch to Lake Victoria and the development of lucrative export markets to Europe and other parts of the developed world.

However, fishing livelihoods are also under threat because of unsustainable fishing practices. Fish catches have drastically declined and many species are close to extinction (Ogello *et al*., 2013). There are many causes of this, including intensive, non-selective fishing; catchment vegetation degradation; industrial and agricultural pollution; the introduction of exotic species (Nile perch); and gaps in the regulatory framework and weak enforcement fishing bans (Ogello *et al*., 2013).

A 2012 assessment by the provincial planning office, Nyanza, is reported to have found that 65,000 people had lost some income due to reduced earnings from fishing, and expected another 100,000 people to be affected in the following two years (IRIN, 2012). As fishers lose their jobs, others who depend on them will be impacted too. Finding ways to diversify livelihoods and manage fish stocks sustainably are priorities for the sector. Agriculture has been identified as one option, since communities usually own small plots of land (*shambas*) and the lake provides a good freshwater resource close at hand that could be used for irrigation.

3.2 RESOLVE partners and delivery model

Renewable World's main partners for RESOLVE are local NGOs Osienala[21] and FASCOBI, and a private company, SteamaCo (formerly known as ACCESS: Energy).[22] All three partners work around the lake and have offices in the main city, Kisumu. RESOLVE also works with researchers from the University of Nairobi for its baseline assessments and monitoring work. At the beach level, RESOLVE works with local leaders to establish community-based organisations and engages with the Beach Management Units (BMUs), which are government-community co-managed entities designed to manage fishing activities around the lake. See Annex 2 for an overview of RESOLVE partners.

The main components of RESOLVE's energy delivery model include:

- A **solar or wind microgrid with diesel generator back-up**. The systems are intended to produce 10–12 kilowatt hours (kWh) of electricity per day, enough to supply electricity to nearly 50 households and micro-businesses, depending on their usage and distance from the hub.
- A **community-owned and managed system** in each community, governed by a new community-based organisation, known as a Renewable Energy and Auxiliary Project (REAP). Each system is intended to be run as a community business, selling energy and energy-related services. The REAP CBO[23] owns a microgrid and central energy hub (see glossary) which manages the distribution network and anticipated

21 See www.osienala.org.
22 See https://steama.co.
23 The paper uses the term REAP and CBO interchangeably to refer to the community-based organisation established by RESOLVE to own and manage the energy system.

spin-off businesses, like solar lantern sales/rental and phone charging. The REAP is intended to be economically self-sustaining, but with a not-for-profit approach, with profits to be invested in projects which support economic development, the welfare of its members, and the wider community. Membership is open to all for a small fee, with management roles decided through elections and equity and governance criteria (such as female representation).

- **Microgrid installation by a private sector provider** (SteamaCo). Related equipment (such as a water tank) is installed by a local handyman or by community members.
- **Remote monitoring technology** by the SteamaCo 'bitHarvester' (see glossary) to monitor the grids' technical performance and customer payment in real time via cloud-based software. Renewable World currently monitors performance and payments, although this role will be handed over to the CBO.
- **Infrastructure and capacity-building financing** through a £268,000 grant from Comic Relief (USD 386,000), with **user connection fees and tariffs** to cover the costs of connection, operation and maintenance. The initial connection fees and tariffs were set in line with SteamaCo's charges for microgrids elsewhere around the lake: KES 2,500 (USD 25) for the connection fee and a basic rate of KES 140 per kilowatt hour (USD 1.4). The REAP CBOs will have to adjust these according to the costs of operations, maintenance and expansion, as the connection fee is below cost price, and includes a top-up subsidy for the first users connected through the grant. The project has experimented with microfinance loans to enable users to pay for connection fees and invest in equipment.
- **Customers pre-pay** for their electricity using the mobile money system Mpesa, which is widespread in Kenya. Customers pay into the REAP CBO bank account via a web-based payment scheme for small and medium-sized businesses, Kopo Kopo.[24] The whole system is designed to remove the cost and conflicts that arise when community members collect payments in person; help with financial sustainability, as people can only use the electricity when it is paid for; and provide control for customers, who top up when they have the funds.
- **Community engagement** by RESOLVE partners to raise community awareness, assess and build demand, and select viable sites.
- **Training** community members to manage the energy hub as a community business and in **productive activities** that electricity could support (crop production/ irrigation).

24 See http://kopokopo.com/#bo-intro-wrapper.

- **Maintenance.** The CBO is to manage maintenance, though who carries it out is yet to be defined. Keeping SteamaCo on a retainer fee is one option, although RESOLVE considers training up local technicians to be more affordable.
- **Partnering with the local Beach Management Unit** to rent land for the hub and establish fish-chilling activities. RESOLVE pays for the refrigerator, giving it to the CBO, which hands over its management to the BMU. The BMU charges members to use the chilling facilities and associated electricity charges. A memorandum of understanding addresses any potential conflicts that might arise between the Beach Management Unit and the community-based organisation, and limits the BMU's representation in the management of the CBO.
- **Liaison with local government** for building political buy-in and community interest, and undertaking formal registration procedures.

3.3 State of progress

At the time of the field research in January 2015 the first community engaged by RESOLVE, Luanda Rombo, had had its energy hub installed — but faced severe delays in connecting customers. This was because of governance problems in the community together with changes and gaps among core staff within Renewable World and Osienala (see Sections 2.6.3 and 3.3). All the other sites were in the earlier, pre-construction stages of baseline surveys, community engagement and establishing a new community-based organisation (see for details of each site). By March 2016, which is shortly before the official end date of the project, RESOLVE still faced problems in Luanda Rombo, but had progressed significantly elsewhere (see Box 2 on milestones).

Box 2. Project outputs achieved by March 2016

- Six microgrids installed
- Six operational community based organisations to manage the energy hub, each with a legally recognised constitution and their own KopoKopo bank accounts
- 51 households connected, with total connections expected to triple within one year
- Online metering, payment and billing system established and CBO bank accounts integrated with SteamaCo online billing system
- Cash flow accumulated for operations and maintenance
- Training completed for CBO committee members in governance and leadership, financial literacy, and enterprise training
- Productive energy use has begun: eg four sites using freezers for fish chilling.

Source: Author interviews.

4

RESOLVE: Understanding productive energy needs and barriers

Having set the broad context and approach in Section 3, this section examines our key questions: What productive energy needs does RESOLVE target, and what barriers prevent communities/customers from using energy productively? It also looks at how RESOLVE has carried out the PUE needs and opportunity assessment.

4.1 Productive energy needs targeted by RESOLVE

The communities where RESOLVE operates are off-grid; the nearest grid connection can be up to 20 kilometres away. For lighting, people typically use candles and very occasionally small solar panels or lanterns; while for cooking, they use woodfuel and charcoal. The energy situation in RESOLVE sites are standard for the region: a cross-country survey by LVFO found that in 2012, only 8 per cent of landing sites on Lake Victoria were supplied by electricity, 1 per cent had working cold rooms and 18 per cent had drinkable water; by contrast over 90 per cent had mobile phone network coverage (LVFO, 2013).

While RESOLVE targets both domestic and productive energy needs, this report is concerned with the latter. The main productive energy gaps and needs targeted by RESOLVE are:

- **Fish chilling or freezing**. Fishers and boat owners want electricity and refrigeration facilities to chill or freeze their fish when it is landed, since fish is highly perishable. A lack of cold storage facilities weakens the fishers' bargaining power with the traders they sell to, who do have cold storage. Freezers can also be used to make ice, which fishers or traders can use while fishing or taking fish to market.
- **Fishing lanterns**. Fishers use kerosene lanterns when fishing at night. The lanterns float on small platforms and attract flies, bringing fish to the surface. Kerosene, however, is expensive, polluting (because of spills) and hazardous. The fact that kerosene lamp glass is fragile and has to be replaced regularly, particularly when lake conditions are choppy, adds to boat owners' costs (see Box 3).
- **Lighting and other low-level power needs in micro-enterprises**, such as shops, hotels, video halls, hairdressers and other businesses. Typical applications could include mobile phone-charging, televisions, fans, fridges and hairdryers.
- **Water pumping and purification**. Farmers need to pump water from the lake to irrigate small plots of land. Villagers do not have a clean water supply and many people drink polluted water from the lake. They need energy and equipment to pump water, using tablets or filtration to purify it. RESOLVE considers this a productive use of electricity, envisaging that the hub will sell water to people locally.

A core aim for RESOLVE is to increase people's incomes. Figure 3 shows how the project partners describe the connection between introducing new energy services and improving local livelihoods.

RESOLVE has identified these productive energy needs through:

1. **Existing knowledge and advice** from partners familiar with the local context
2. **Secondary data** from related studies and projects, such as a market assessment on alternatives to fuel-based lighting for night fishing in Tanzania (see Box 3 on night fishing)
3. **Including relevant criteria in the site selection**, for instance to test whether a community appears to have an entrepreneurial culture
4. **Carrying out community baseline surveys** on household attributes, energy sources and uses, income, health, access to information and communication, and BMU capacity
5. **Holding community meetings** to identify existing business activities, potential new business activities and sources of finance to start a business.

Box 3. Night fishing: replacing kerosene with LED lighting

Many of the 12–18 million artisanal fishers in the developing world fish at night, using pressured kerosene lanterns to attract small fish, like sardines and herrings, to their nets. Across Lake Victoria (Uganda, Tanzania, Kenya) there are approximately 30,000 fishers on 8,000 boats employed in night fishing, each using about four lanterns per vessel.

A study from Tanzania found that night fishers spent 35–50 per cent of their take-home pay on lighting costs (fuel plus lamp maintenance) and that similar catches could be obtained with battery-powered light-emitting diodes (LED) lighting systems, while eliminating fuel costs.

The analysis showed that a single kerosene lantern costs USD 40 in upfront costs and USD 50 a month for maintenance and fuel. These costs are divided equally between boat owner and crew. According to the researchers' calculations, an LED-based electric fishing light could decrease the monthly costs to about USD 7.30 and thus increase fishers' profits by 30 to 40 per cent. This could be a significant cost saving. In Tanzania alone fishers spend about USD 70 million per year on fuel and lamps (Lake Victoria, Lake Tanganyika, Zanzibar, and the ocean coastline).

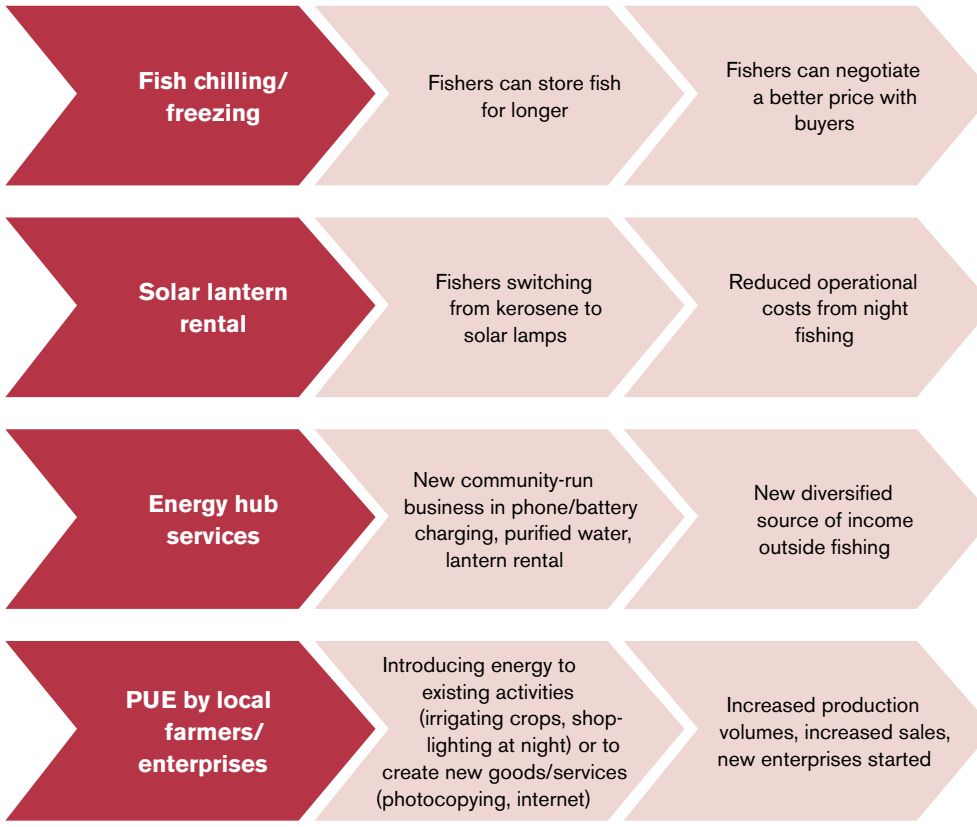
The authors conclude that while the market potential is strong, the technical performance of LED lights and batteries needs to be improved so they are durable enough to withstand fishing environments, provide sufficient brightness and last the whole night.

Source: Gengnagel et al., 2013.

RESOLVE assessed the PUE opportunities (4 and 5 above) after the sites were selected and with the technology parameters already decided. Annex 4 provides details on ideas from community members about local PUE opportunities.

There are PUE needs in the communities specifically not targeted by RESOLVE. For example, fishmongers selling into local markets often preserve and process fish by smoking or frying it, and the stoves they use to burn biomass are linked to unsustainable fuel consumption and health problems. There are other initiatives in the region aiming to encourage the take-up of more efficient stoves (Muok and Amakobe, 2013).

Figure 3. Channels between RESOLVE energy services and local livelihoods



Sources: Author interviews and data in Odada *et al*., 2015.

4.2 Understanding PUE in context: energy and the fishing value chains

Good practice guides on PUE, such as the PRODUSE manual (Brüderle *et al*., 2011), recommend using a value chain perspective to help clarify the economic objectives of a project. It asks: which sectors, sub-sectors, enterprises and groups are being targeted? How will introducing new energy services help to achieve the objectives of increasing production and reducing costs? What other bottlenecks may lie in the way, and what complementary measures will help overcome them?

Beyond the assessments described earlier, RESOLVE has not conducted an in-depth study or value chain analysis (see glossary) of the PUE opportunities for particular sub-sectors targeted by the energy hub. It is beyond the scope of this study to fill that gap; it is in any case hard to find good data. However, highlighting some of the key features of the fish value chain will help other developers to understand the context, and think about how this might affect the design and impact of RESOLVE and similar projects.

There are two main markets for the Lake Victoria fisheries:

1. **Export markets for industrialised processed fresh and frozen Nile perch fillets.** These are the highest value fish and mainly sold to Europe, but also other markets such as Israel, Australia, the US and Japan.
2. **Domestic markets for fresh tilapia, artisanally processed fish (Nile perch, tilapia, *omena*) and feed-grade *omena*.**[25] Fresh tilapia is the most widely consumed fish in Kenya. Artisanally processed fish include fried Nile perch skeletons, fried, smoked and sun-tried tilapia, and sun-dried, feed-grade *omena*. Processing is vital because of the lack of local cooling facilities. Feed-grade *omena* is sun-dried in poor hygiene conditions, which is why it can only meet animal feed-grade quality standards (Hempel, 2010).

The communities targeted by RESOLVE supply to both these markets, depending on which species are more prevalent locally.

For both markets, fishing is small-scale or artisanal.[26] Fishers use wooden sailing boats and canoes, and catch fish with nets, lines and traps (see Box 4). An increasing number of fishers use boats with outboard motors, though few are using more high-tech equipment, such as hygienic fish holds. Trawling was banned in the late 1990s due to its environmental impacts (Otieno, 2011). *Omena* fishing takes place at night, which is relevant for the RESOLVE project because of its efforts to address the lighting needs of night fishing.

25 *Omena* is the local name in Dholuo for the silver cyprinid, a small silver fish approximately five centimetres long, unique to Lake Victoria. It is called *dagaa* in Tanzania and *mukene* in Uganda.
26 There is no fixed definition of a small-scale fishery, and 'artisanal' and 'small-scale' are often used interchangeably. See Blackmore *et al.* (2015: 14, Table 3) for a typology of small-scale fisheries.

Box 4. Who are the fishers?

People often use this term to include all people involved in any aspect of fish harvesting, though in fact there are distinct groups. The first category is the boat and gear owners who often do not participate in the actual fishing but lease out their boats and gear. The second category is the fishing crew, which includes a boat operator who directs the boat in water and its operation. There is also a boat manager who may or may not be part of a fishing operation, but who is responsible for selling fish and paying crew members.

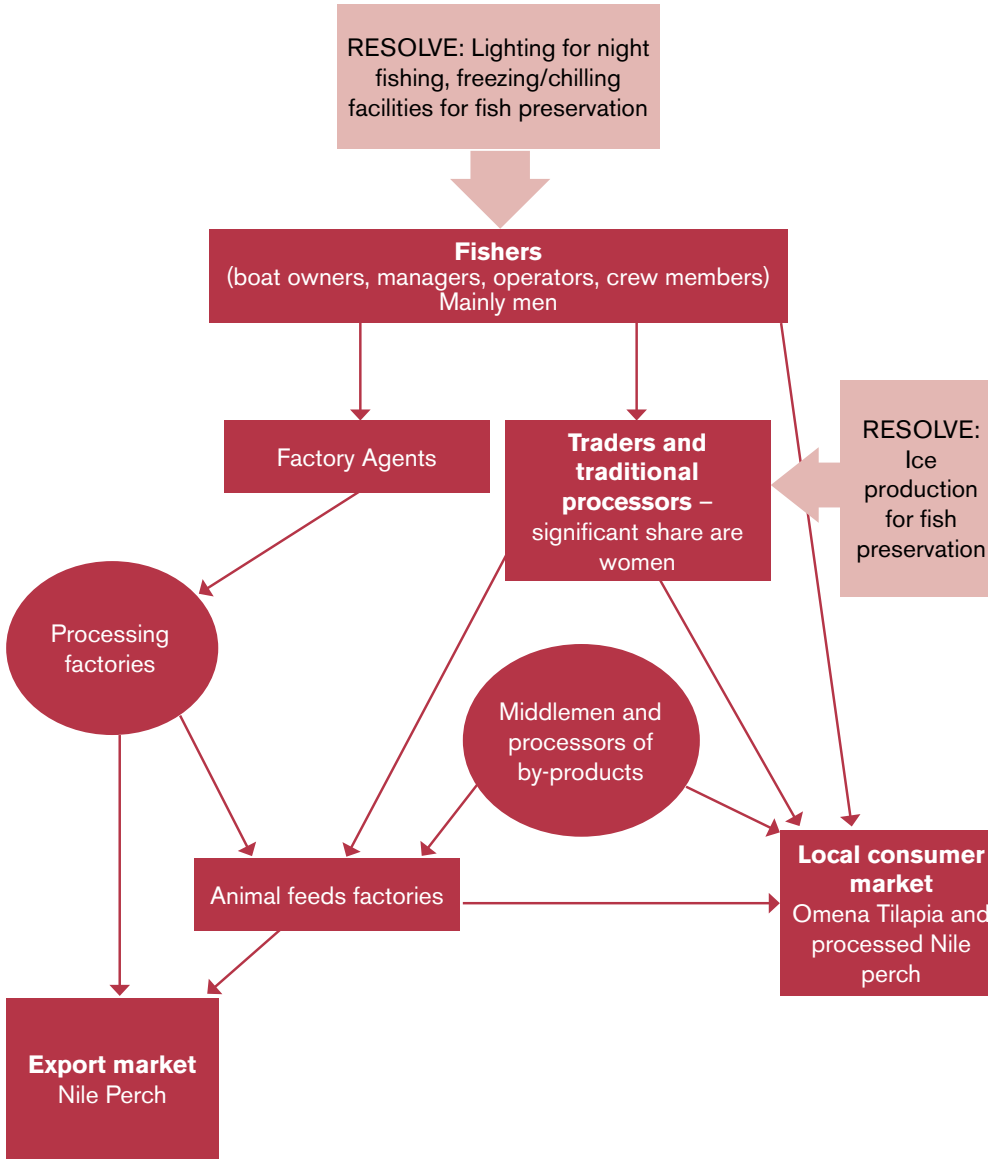
Fishers usually get paid by receiving a share of the proceeds after deducting expenses. For instance, the boat owner takes 50 per cent of the income from fish sales, and the crew members share out the remaining half among themselves. In some cases the boat owner might retain all the proceeds for six days while the crew takes the proceeds for the seventh day, or the boat owner pays crew members a regular wage.

Sources: Omwega, 2006; author interviews.

Abila (2003; 2007) has described the two types of value chain for the Kenyan Lake Victoria fisheries. Beyond production, the chains differ significantly in terms of the actors, governance and incomes earned. Figure 4 identifies some of the key actors and highlights segments targeted by RESOLVE.

1. The export-oriented Nile perch value chain is highly formalised and regulated because of the need to meet international food standards. The fishers sell their Nile perch at the lakeside to middlemen ('fish agents'), from where it is transported to factories in Kisumu and Nairobi, and onwards to the export market. These middlemen may be company agents or independent agents. Company agents are contracted by the fish factory, who also provide them with an insulated fish truck equipped with ice to keep the fish chilled. Independent agents sell fish to the factory of their choice, without a binding contract, and use their own ice truck or hire one from a factory. For Nile perch, the factory will agree on a price with an agent in advance of supplying fish, and the agents negotiate their own price with fishers.
2. The domestic market involves more informal trading relationships. The fishers supply fish to women or men traders at the lakeside, who then sell the fish in the nearby market or to second-level middlemen, who transfer it to other rural markets or to distant urban markets. This channel also has a traditional fish-processing sub-sector. Most of the processors and traders sell their fish within 20 kilometres of the source and will transport it to a market 2–3 days a week, spending the other days seeking supplies and processing fish (Abila, 2007).

Figure 4. Fish value chain in Kenya



Source: Adapted from Abila, 2003.

It is hard to come by robust or recent figures showing how value addition is distributed between different actors. Abila (2007) notes that in the artisanal chain, processors and traders' incomes vary widely between individuals, market sites, types of activity, season and so on, making it difficult to have an accurate picture of income and costs. The studies available focus mainly on Nile perch and broadly agree that most of the value is captured by factories and foreign retailers, that agents take their cut, and that at the production end, boat owners take a greater share than the fishers hired to bring in the catch.[27]

Certainly there is a strong perception that the fishers and boat owners are unfairly squeezed compared to other players in the chain. RESOLVE partners interviewed for the research repeatedly stated that the lack of chilling facilities — combined with poor market information — leaves fishers in a weak bargaining position. They described how agents wait around for hours after the fish is landed, forcing the fishers to sell at a low price before the fish starts to rot. Fishers' and boat owners' incomes might also be under pressure as fish stocks fall: with the decline of landed quantities of Nile perch, fishers need to invest more effort and go to more distant places than before, raising their costs (Hempel, 2010).

> *"The case which touched me is when these factories [agents] come in the morning and they find the fish there. They have not provided any chilling facility but they wait for fish until around two or three o'clock. Fish which is worth around 300,000 Kenya shillings, they [fishers] will sell it for about 5,000 because these people are desperate. There is nothing they can do – they have nowhere to store this fish." — RESOLVE partner.*

What does this snapshot of the fish value chain add to our analysis? It shows that the energy needs targeted by RESOLVE are feeding into two quite different value chains, with different actors, relationships, rules and — probably — distribution of income, all of which could shape the outcomes of providing new energy inputs. It also prompts more questions that RESOLVE could examine as part of its impact assessment, and are relevant to other developers targeting the fishing sector. For example:

- Will buyers pay higher prices for chilled fish, or source them elsewhere?
- Within communities, who is going to benefit and who might lose out in terms of costs, profits and jobs — boat owners or fishing crews, male fishers or female processors, those supplying export or domestic markets, consumers or producers?
- How will kerosene sellers respond to the adoption of solar lanterns?
- Are there bottlenecks within the value chain that stand in the way of upgrading?

27 A study of Tanzanian Nile perch export value chains to Europe found that the retailer receives about 60 per cent of the value, processors and export sector 10–15 per cent, agents about 5 per cent and fishers 15 per cent. The fishers' share is comparable with what Icelandic fishers receive for cod fillets or US farmers for their products (Hempel, 2010). A study of Kenya's Lake Victoria fisheries suggested that Nile perch agents paid fishers a price in the range of 50–75 per cent of the price they get at the factory gate, which agents argue reflects transportation costs (Abila, 2003).

Now that we have identified the PUE needs targeted by RESOLVE, and placed them within a wider chain of trading relationships, the next part of this section moves on to the barriers that might stand in the way of people using energy productively. Data limitations mean that this focuses on general barriers identified by RESOLVE stakeholders rather than specific bottlenecks within particular value chains.

4.3 Barriers to PUE and strengthening livelihoods

There are several reasons why it is difficult for local people to increase their earnings or diversify out of fishing, and these in turn represent barriers to the productive use of energy. There are also social, cultural and institutional factors which have a big bearing on how a project like RESOLVE stands in the local community, particularly in terms of the acceptance and success in establishing community-run business to run the energy hub. Table 2 lists some of the main livelihood constraints for people working in small-scale fishing, processing and trading.

Table 2. Livelihood constraints for artisanal fishers, processors and traders

Fishermen (boat owners and crews)	Processor-traders (artisanal)
Irregular, fluctuating incomes, low incomes for some	Low and unreliable fish supplies, fluctuating prices
Lack of access to credit	Lack of credit or savings facilities
Lack of savings culture or savings facilities	High transport costs because of poor infrastructure
Poor infrastructure (roads, electricity)	Decreasing sources of wood fuel for smoking
Lack of cold storage facilities (ice, cold rooms)	Lack of quality standards for domestic market
Lack of organisation for purposes of improving bargaining power	Asymmetric bargaining power linked to gender inequality
Lack of skills for alternative livelihood or business management, including lack of agricultural skills	Lack of skills for alternative livelihoods or business management, including lack of agricultural skills
Inadequate post harvesting handling facilities or skills for fish handling	Inadequate post harvesting handling facilities or skills for fish handling
Insufficient social infrastructure (schools, health) and susceptibility to HIV and other diseases	Insufficient social infrastructure (schools, health) and susceptibility to HIV and diseases

Sources: Abila, 2007; author interviews.

Many of these constraints look similar to the typical demand-side barriers to PUE identified earlier (Section 2.2), such as the gaps in skills, finance and market access. While it is beyond the scope of this study to investigate all of these constraints, I want to highlight three areas where non-energy factors might help or hinder the take up of PUE and shape the outcomes of RESOLVE. These are: gender, access to finance and local governance.

4.3.1 Gender

The RESOLVE project wants to give women a voice in their communities and see them benefit economically. The organising power of women appears quite varied across the different communities and women are concentrated in particular economic activities. There are also some quite complex gender dynamics in parts of the fishing business:

- **Organisation and leadership.** Many of the leadership roles in community institutions, like the Beach Management Unit, are held by men. At the same time many communities have active women's groups, such as the Mtakatifu Women's Group in Ng'ore (involved in fish processing) and the Super Farmers and Emmanuel in Luanda Rombo (involved in farming/poultry rearing).
- **Economic activity.** The position of women in the fishing business has changed with the growth of a commercialised sector: in the Nile perch export market and industrial fish packing plants, men are dominant, and women largely excluded. Women do, however, play an important role in drying and selling *omena*, tilapia and low-value Nile perch into local markets (Fiorella *et al*., 2015). Outside of fishing, women are also very involved in cultivating small plots of land (*shambas*) and in local services, such as vegetable vending or tailoring.
- **Gender relations in the fish trade.** One practice which may play into how benefits are distributed is 'fish-for-sex' (*jaboya*). This takes place between women traders and male fishers, whereby women exchange sex for preferential access to fish.[28] It has been described in many countries and exists in Lake Victoria, though it is not clear how widespread it is in the sites targeted by RESOLVE. For the region as a whole, there is some evidence that declining fish stocks are perpetuating the practice. With fewer fish, there is stronger competition among women traders and sexual exchanges help secure their supply. Whether perceived as exploitative or a livelihood strategy, *jaboya* is linked to a very vulnerable sub-population in communities (Fiorella *et al*., 2015).

28 *Jaboya* relationships appear to be quite diverse and have been understood in different ways – from women as victims, as entrepreneurial, or in search of mutual support and small luxuries. However perceived, *jaboya* is linked to the most vulnerable, and raises their risk of HIV infection. The women who practice it appear more likely to be uneducated, poor, food insecure and possibly widows/female household heads (Fiorella *et al*., 2015).

"You will meet more women than men in the fishing industry. They don't go into the lake but are the ones that dry the fish, take them to market and all that. Women are pivotal. Even in our farms we will be providing water at the shambas, where at the farm level the ratio of women to men is 90:10." RESOLVE partner.

We can speculate that these factors may have a bearing (positive and negative) on women's prospects for benefiting from the energy hub. For example:

- Likely male dominance of leadership positions in the energy hub could lead them to prioritise interests of men over women
- The special focus on night fishing and fish freezing/chilling could benefit those involved in fish harvesting (men) more than fish processing (women), or non-fish activities like farming. It may also tilt the uneven bargaining power between male fishers and women traders/processers, unless the latter get access to chilling facilities as well.
- Alternatively, energy for fishing could have positive secondary effects on women's livelihoods as fishers earn and spend more locally in enterprises run by women. Energy for irrigation could also have a positive impact on women.

Mary Ochola uses a small solar lamp in her shop in Got Kachola. Electricity from the microgrid could power lighting, to extend opening hours, and a fridge to stock cold drinks

Box 5 highlights the challenges faced by RESOLVE in addressing gendered needs and dynamics.

Box 5. Gender and productive uses of energy: Mtakatifu Women's Group (Ng'ore)

A dynamic women's co-operative in Ng'ore has recently opened a new building for processing fish, but where will it get the energy for lighting and fish chilling?

The Mtakatifu co-operative was originally set up as a response to the declining fishing business; people needed to find other income sources to cushion the losses. Earning more money to support their children and grandchildren is a big priority.

Thirty-five women are involved, paying KES 50 to join, and the group has its own savings account. Some male community members support the group. The co-operative's first venture was to acquire some land and start farming tomatoes, though that ran into financial problems. The current plans involve starting a fish farm and, using funds from The Lake Victoria Environmental Management Projects II and the World Bank, they have built a building for processing fish. They have also bought a boat for fishing, owned jointly by the group.

The women know their energy-related priorities: fish chilling, lighting (for processing fish at night) and producing purified water to bottle and sell. However, the new building is located at a distance from the beach where the RESOLVE hub is built; and the centre may require more power than the microgrid can produce. It is likely that Mtakatifu will have to find power from another source.

Source: Author interviews.

4.3.2 Access to finance

The affordability of the energy services and equipment for RESOLVE communities is critical for service take-up and use. While there are financial barriers, the situation on the ground is more nuanced than a simple analysis of 'poverty plus lack of credit'.

Several RESOLVE partners interviewed for the research saw local people's inability to manage finances well and the lack of mainstream financial institutions serving these communities as real blocks to people setting up new businesses or buying equipment. Problems with financial literacy are well documented: many studies on fishing communities highlight the contradiction of fishers earning relatively good incomes, particularly given rising Nile perch prices over several years, but nevertheless remaining poor (Van der Knapp, 2006). Part of the problem appears to be an absence of a saving culture and tendency to spend earnings on drink, sex or the small consumer products available in the villages, together with a lack of savings mechanisms (Van der Knapp, 2006.) Also, some researchers have suggested that because fishers can earn money on a daily basis (during the fishing season), they are reluctant to diversify: alternatives like agriculture pay only after crops are harvested and sold (Ogello *et al*., 2013).

Pendo: A women tailor hopes to use electricity to power an electric sewing machine

At the same time, financial barriers do not apply equally to all groups in fishing communities. For instance, boat owners are found to be more likely to use their income from fishing to develop other enterprises (Van der Knapp, 2006). And focus group sessions by RESOLVE identified that there are many non-formal sources for start-up finances in the communities:

- Table banking (a social revolving fund among friends; see glossary)
- Personal savings (including selling livestock)
- Support from children
- Funds from government (Women Enterprise Fund, Youth Enterprise Development Funds, Uwezo Fund, Kenya Women Fund)
- Retirement benefits
- Loans from a co-operative society
- Loans from friends and relatives
- Income from fishing or selling agricultural produce from gardens/farms
- *Harambee* (community pooling together for development) (Osienala, 2015).

4.3.3 Governance

A third key contextual factor is the organisational and governance capacity in fishing communities, which is particularly important for RESOLVE because of its model of a community-run hub to sell energy services. RESOLVE's experience has been quite varied across the communities, ranging from mismanagement and challenging community politics to competent and committed individuals or organisations.

There are many important institutions locally, including the Fisheries Department, traditional chiefs, local government, NGOs and community-based organisations. A key one for RESOLVE is the Beach Management Unit (BMU), which is present on every beach and intended to include everyone involved in fisheries — such as boat owners, boat crew, traders, processors, boat builders and repairers, net repairers and others. They are quasi-governmental organisations and their stated purpose is to work with government and other stakeholders in managing fishery resources and improving the livelihoods of the community members.[29] The problem is that in some of the communities the BMUs are poorly managed and get taken over by a few powerful individuals. In a perceptions survey carried out by RESOLVE, householders across four of the sites ranked their local BMUs as having 'low' capacity across areas such as record-keeping, leadership, management, participatory decision-making, information sharing and conflict resolution (Osienala, 2015).

Initially RESOLVE had intended the Beach Management Units to manage the energy hubs (as they do for Sollatek), but problems with BMU members at the first site, Luanda Rombo, led to a change in tack with a decision to set up entirely new community-based organisations (REAPs). The BMU remains important because of their economic and political clout locally, and within RESOLVE they still control the fish chilling facilities.

Another governance issue reported by interviewees is the high level of NGO activity in the region, which has contributed to a 'hand-out' culture that is difficult to cut through. Local people are used to subsidised or free products and services, and this creates challenges for an NGO-led project like RESOLVE in terms of persuading people to pay for energy services or to manage these in an economically sustainable way. There is also cynicism locally around the long-term commitment of some NGOs whose projects end abruptly when funding runs out; as well as recognition that such projects can be vulnerable to being manipulated, taken over or undermined by local political interests.

A final characteristic of the fishing communities worth mentioning is the mix of permanent and migratory populations, insiders and outsiders. Some fishers travel between communities while others are stationary, and some boat owners are local while others join from outside as investors. Although no study has been made, we can speculate that this could have implications for local acceptance, benefit and management of new

29 For more information on the formal role of Beach Management Units see www.lvfo.org/index.php/bmus/10-beach-management-units-bmus.

infrastructure or technologies. On the one hand a mixed social make-up may reduce trust and interest in collective organisation or planning, while on the other, the fact people get exposure to new ideas outside the village and bring in additional resources may encourage the take-up of new products or practices.

To conclude this chapter, RESOLVE is targeting a range of productive energy needs that do reflect the priorities of local people, and partners have done some assessments to back this up. However, by probing a little into the fishing value chain we can see there is some uncertainty around who will benefit and by how much. We have seen there are reasons to think that the arrival of electricity in fishing communities might not lead to the spontaneous flourishing of new economic activities or to upgrading existing ones. Some of these are very consistent with the typical PUE barriers found elsewhere (skills, resources, infrastructure), but some are very specific to the area, like the savings culture among fishers or the politics of fishing bodies. The discussion also showed we should be wary of jumping to quick conclusions about the barriers that exist. Fishers might not be good savers, but do have access to several sources of finance locally; women might not hold decision-making positions, but the types of work they do could benefit from the energy hub, directly and indirectly.

All this reinforces the idea that to promote PUE, energy services and promotional activities have to be designed bearing in mind a complex set of relationships, incentives and wider social, economic, cultural, political and environmental factors. The next chapter moves on to our second key question, of how RESOLVE is trying to address barriers to PUE in their delivery model and support measures.

5

RESOLVE: addressing PUE needs and barriers

RESOLVE is trying to address PUE needs and barriers through its core energy delivery model based on community ownership and additional support measures. It has used the type of promotional activities recommended in good practice, such as awareness-raising, finance support and training. It is too early to assess how effective these are, but a number of useful lessons are emerging.

5.1 Catalysing enterprise through a community-owned delivery model?

The RESOLVE partners interviewed for this research gave different reasons for why RESOLVE chose a community ownership model. At the most basic level, it is the Renewable World approach. Some interviewees argue that it creates additional benefits for communities, over just paying for an energy service run by an independent entity. They expect managing the hub will build people's capacity to run their affairs and their business skills.[30] The NGO and academic participants also expressed concern that a wholly private-sector model could end up excluding poorer community members by setting tariffs at unaffordable rates.

30 The CBOs' constitution includes an objective "to initiate sustainable development projects for the improvement of the living standards of the community members through the use of renewable energy" (Got Kachola REAP constitution).

As stated earlier, initially RESOLVE intended the Beach Management Units to have a central role in managing the energy hubs, but problems of poor management and a conflict of interests where this was trialled at the first site, Luanda Rombo, led to a change in RESOLVE's approach (see Box 6).

Box 6. Community-owned energy: early stage challenges

In Luanda Rombo, a key BMU official was appointed as site manager for the hub on behalf of the newly established CBO. A villager was also employed as an agent to run the hub services: selling cold drinks and mobile phone charging; providing meter readings; and turning the lines on or off when customers' Mpesa credit was topped up or expired. However, the site manager – also a customer of the hub – was not paying his bills. It was reported that he would put pressure on the agent not to cut his line, or even let himself into the hub and switch it on himself. The partners also encountered poor financial management. Records were not being kept properly so it was unclear how much money the CBO was making, who was looking after the money or was really in charge. Some community members complained about the lack of transparency or fairness with the CBO selection process itself.

Partners have learned from Luanda Rombo and adapted their approach in other sites.

Sources: Author interviews; Access: Energy (2013).

The main changes adopted by RESOLVE are:

- **More rigorous site selection**. Four of the original beaches selected were changed after it was assessed that other sites were better organised and scored more strongly in terms of entrepreneurial culture, willingness to pay and experience of running other development projects.
- **Stronger focus on governance**. The REAP community-based organisation in new sites is required to establish robust governance structures *before* the microgrid's construction starts and the connections are made. The BMU is no longer the entry point, and the CBO constitution prohibits BMU leaders also heading up the CBO. RESOLVE also retains a right to nominate three out of ten leadership posts for a defined period of time.

One of the main lessons for RESOLVE is that the process of building a CBO to run the energy hub is difficult and takes a long time. Interviewees explained that this challenge was exacerbated by changes in Renewable World staffing and capacity gaps in one of the partners' organisations (see Box 7).

The process of building the CBO involves explaining and getting buy-in to the concept, electing people to positions, agreeing the purpose and governance functions, drawing up a constitution, supporting the group in getting registered with the Department of Social Services, establishing a bank account, and training the CBO members in financial management and dispute resolution skills. Success is very dependent on finding existing

Box 7. Partnership capacity and coordination

Interviewees raised various capacity and co-ordination challenges within the partnership.

Key staff at Renewable World left the organisation shortly after the project was launched, creating a management vacuum for a period. The NGO Osienala is recognised as having good local knowledge, but at the time of the field research was perceived by some partners to be falling behind on delivery. The private sector partner, SteamaCo, was performing its role of carrying out site assessments and installing equipment, but had pulled back from its close engagement in RESOLVE following the challenges at the first site (see Box 6). From the company's perspective, problems in the community management model, the phasing of activities, partner engagement and communication were taking up too much management time.

Despite the gains that come with collaboration, this experience also shows what kind of hiccups can occur. This shows the need to conduct prior due diligence to ensure partners have the right capacity and are sufficiently joined-up around the vision, approach and roles.

Source: Author interviews.

Women drying fish at Luanda Rombo'

leaders in the community who can drive the process forward. The constitution for the CBOs is also a critical mechanism for ensuring that the hub is managed well. It includes provisions around responsibilities, auditing procedures, membership fees and annual meetings. The constitution also requires some female representation on the leadership committee; this is a tactic by RESOLVE to try to strengthen women's voices in the project.

The field visits for this research confirmed how important the quality of community leadership is for speed and success in implementing a community-run model. For instance, Ng'ore appeared to have a number of dynamic individuals in leadership roles, with vision for how to develop the community and the role of its energy hub. In Got Kachola, on the other hand, there was still some uncertainty over the relationship between the CBO and

the BMU, and the steps to registration – despite RESOLVE partners stating that several sensitisation meetings on the topic had already taken place.

In general, the partners were more optimistic about the four new sites; progress there has been more rapid and smoother there than in the earlier phase. One partner said: "In the new sites I am not seeing challenges [in building community ownership] because we have really taken a lot of investment in terms of the registration and trying to make them understand what the project is all about."

However, the company involved, SteamaCo, had a slightly different perspective: it had proposed a more radical shift from a community-managed hub to one overseen by the community, but managed independently (see Box 8). This proposal was not taken up by RESOLVE, though all interviewees agreed that the community-run model has its challenges. One partner described how they try to pitch their project to communities as 'doing business' – rather than an aid project – with RESOLVE providing 'start-up capital' and training for a new energy enterprise.

Box 8. Community-private sector partnership model: an alternative?

Following problems at Luanda Rombo, SteamaCo proposed amending the CBO-managed model. A competent individual in the community could be employed by the CBO on a professional basis to run the energy hub and its services. The CBO would retain overall ownership, decision-making (for instance over what productive activities to invest in) and pay for maintenance, but the day-to-day management would be outsourced.

SteamaCo argued that the culture of receiving handouts made it difficult to establish a business-orientated CBO in Luanda Rombo, and that the incentive structure was not working. For instance, "the idea of collectively saving money as a CBO does not confer as much impetus to look after the equitable day-to-day management of activities as we had hoped". In other projects, SteamaCo has pursued a privately owned model (see Section 5).

Sources: Access: Energy, 2013; author interviews.

It is too early to draw conclusions on the relative merit of RESOLVE's community-run model versus a more private-sector approach in terms of PUE outcomes. This discussion does, however, point to the need for deeper comparative analysis in the future.

5.2 Promotional activities to support PUE

RESOLVE has tested several promotional measures to address gaps in community members' knowledge, financial resources, financial skills and access to end-use equipment, such as freezers. This holistic intention is in line with good practice; although the partners have come up against some knotty problems, for instance in sourcing suitable end-use equipment. See Annex 5 for a summary of PUE interventions.

Community awareness-raising. RESOLVE has done a lot of awareness-raising about PUE opportunities through community meetings, surveys on energy use and focus group discussions. This forms part of the engagement work needed to get the community-run model off the ground, and appears to be more extensive than the work a privately run microgrid would do on its own (see Section 6). There is also potential for RESOLVE to raise awareness of their experiences beyond the communities they work in, since one of the partners, Osienala, runs a local radio station and another partner (staff at the University of Nairobi) has good government and policy connections. It is part of RESOLVE's vision that a successful project could demonstrate what is possible and encourage replication by others.

Skills and enterprise development. Osienala has carried out four-day financial literacy training courses with community members at the project sites. Training has targeted the energy hub committee members and a number of new or existing local enterprises served by the hub, such as barber shops, shops offering battery charging, and a youth-run computer centre (in Ng'ore). The course covers issues such as book-keeping, business planning and controlling hub finances. Some partners expected training to be done on agricultural production (drip irrigation, seed selection, organic manure). However, by early 2016 the agricultural component had yet to get off the ground. At Luanda Rombo, the women farmers' group plots were too far from the hub site to be served by it; although there was still an intention to introduce water pumping and irrigation in another community, Ragwe.

Financial support to pay for energy services and end-use equipment. RESOLVE is addressing financing constraints; first, through the delivery model itself, as customers pre-pay for their electricity using the mobile money system. This may go some way to addressing the problem of irregular fishing and agricultural incomes, and gives customers more control over when they pay for and use electricity. Second, RESOLVE has asked communities themselves to identify potential funding sources that are already available (see Section 4.3.2).

A third measure that RESOLVE has tested is microfinance. In Luanda Rombo, RESOLVE worked with KIVA ZIP (see glossary), an online crowdfunding platform, to provide loans to customers worth KES 10,000. The idea was that customers would use the loan to pay for connection fees and wiring (initially KES 2,500) and make investments that would start or add capacity to their energy-enabled business (such as stocking a shop or purchasing electric hair clippers). While people did pay back the loan, there have been teething problems. The first borrowers in Luanda Rombo did not use the loan for the purpose intended by RESOLVE (the connection fee). This required a re-think of the process; one idea was to start involve the CBO in approving loans. A more fundamental challenge is

that KIVA ZIP closed its Kenya operations during late 2015.[31] RESOLVE still considers some kind of financing mechanism as necessary to get over the connection cost barrier faced by poorer community members and to help customers buy appliances. At the time this research was published Renewable World staff were identifying the options.

Promoting energy-related equipment. RESOLVE's main focus on the equipment side is fishing. The BMUs at four sites have received two freezers, paid for by the Comic Relief grant.

- **Cold storage at the BMU**. One freezer is located at the BMU, which offers overnight storage services for their members. The BMU has explored different charging models, but the current approach is to charge a flat fee (KES 250) for one person to hire the whole freezer for a night, with electricity costs paid on top of that. RESOLVE estimates that this is the best way to ensure the freezer is used to capacity and expects that within two years the BMUs will generate sufficient revenue to buy another freezer.
- **Ice-making by local shops**. The other freezer is leased to a local shop-owner who uses it to make ice to sell to local traders; the traders use the ice to preserve fish being transported to local markets. This was an innovation proposed by the communities themselves. The BMUs earn KES 1,000 a month from leasing the freezer.

No impact studies have been conducted yet, although one recognised challenge is the small freezer size – a drawback for villages specialising in large fish. One partner estimated the units could only store about four Nile perch.

Landed fish without cold storage - Got Kachola.

31 For KIVA ZIP's explanation of why it closed its Kenya operations see https://zip.kiva.org/blogs/200.

RESOLVE has also worked to source solar lanterns for night fishing, and to explore how this can be developed into business for the hub. By reviewing other experiences and consulting local fishers, the partners identified a number of obstacles. These included insufficient battery longevity, low durability, the time and distance involved in recharging; and competition with kerosene sellers, who charge for fuel used after the fish are landed, rather than upfront recharging costs (Osienala, 2015; Gengnagel *et al*., 2013). At the time of publication, RESOLVE had identified an appropriate lantern and was awaiting quality assurance approval from Lighting Africa.[32] The staff also decided that rather than renting lanterns the hub should sell them, working in collaboration with a microfinance provider.

Linking with complementary services, sectors and programmes. The project is cross-sector in the way it combines an energy technology provider with NGOs knowledgeable about fishing and agriculture, and brings in additional players, such as microfinance institutions. This collaboration is at a very local level; what RESOLVE has not done is deliberately design the project from the beginning in concert with a higher-level investment or programme. The field research did identify complementary investments underway, such as the Lake Victoria Environmental Management Programme,[33] which has funded new buildings for weighing, storing or processing fish in Ng'ore and Got Kachola.

One issue raised by the interviewees is that higher-level engagement at an early stage can be risky, particularly where it touches political interests. RESOLVE had done a very visible public launch, which involved key local decision makers and the media. On the one hand this garnered interest, but on the other it raised expectations significantly. This made RESOLVE more vulnerable to criticism and a wavering of support — among partners, the community and political allies — when delays and problems arose at the first site.

RESOLVE has also not been particularly active in addressing specific **policy or institutional constraints** to productive energy use, apart from liaising with Lighting Africa around solar lantern quality standards. We can speculate that this may be because Renewable World is focused on meeting its project-level deliverables, is relatively new to the Kenya energy scene, and is generally not very active on policy issues.

A final good practice recommendation related to the enabling environment is **for funders/policy-makers to include PUE targets** as a measure of success. The outcomes promised by RESOLVE do include one for "increased incomes as a result of diversification of income generating opportunities" (alongside outcomes on community health, access to ICT and energy hub members' decision-making capacity). RESOLVE has collected some baseline information (on income levels, for instance) which can be used

32 Lighting Africa is a joint International Finance Corporation and World Bank programme that aims to catalyse the market in off-grid lighting. It has developed a series of quality standards and testing methods as a way to protect consumers and increase their confidence in the market. See https://www.lightingafrica.org/what-we-do.
33 See http://lvemp.eac.int/about-us.

for monitoring and evaluation, but project delays mean there is little to assess before the grant runs out.

5.3 Reflections and emerging lessons

With all the hubs now built, Renewable World staff report that some productive energy use is happening. This includes small shops offering mobile phone-charging services and selling ice, the BMU cold storage services, and a new youth-run cyber café. One interviewee speculated that bigger impacts might be felt at household level, because the microgrids are not powerful enough to meet communities' different PUE needs. It is a bit premature to judge what impact the support measures might have on catalysing economic activity; however, we can highlight the lessons reported by partners and reflect on their experience so far.

1. **Thorough and early PUE assessments can help prioritise PUE objectives and support measures.** One of the challenges for RESOLVE is that the project expected many different PUE activities to benefit — from agriculture to fishing — but the available time and resources to address them are limited. The impacts may be less than hoped for, such as freezers not large enough for the villages' needs and the farming plots too far from the hub to be served. It is possible that a more in-depth assessment of the PUE opportunity at the start could have helped RESOLVE to prioritise a smaller set of PUE needs and the interventions to target them. Another important learning from RESOLVE is the importance of applying clear criteria for selecting sites, including the level of community dynamism, leadership and entrepreneurship.

2. **A holistic approach and community model requires time and effort.** RESOLVE is following good practice by combining energy supply with building local-level demand and working with partners to do this. This, alongside the community-run model, means that RESOLVE has had to expend considerable time and effort on community engagement. The delays at the first site also reduced the time available for promotional activities and assessing the outcomes before the grant period ends. It may be worth reflecting on this as part of a wider evaluation. For instance, if the hubs were run by independent agents (as proposed by SteamaCo) could the project partners invest more in productive-use support activities — or would liaising with the agent still incur high transaction costs?

3. **Working in partnership requires due diligence, clear roles and a shared vision.** Given Renewable World's objectives to use energy for better health, empowerment and livelihoods, it made sense to work with partners who have local knowledge or expertise in particular areas. Partnerships are always hard to do effectively and take a long time to build, particularly where organisations are

working together for the first time or have different outlooks – as was the case with RESOLVE. A number of the interviewees commented on the challenges created by gaps in some partners' performance and roles, and conflicting approaches among them (see Box 7). The difficulties of working via the Beach Management Units have also been highlighted. All of this points to the need for good due diligence of partners, clear roles and a shared vision.

4. **Projects need flexibility to experiment with PUE interventions**. RESOLVE has adapted its priorities and approaches as it learns, for instance by changing project sites and distancing themselves from the BMUs when required. While some interventions have not got off the ground, like energy for irrigating crops, unexpected opportunities have emerged, like leasing freezers for ice-making. This suggests projects and funders need to factor in flexibility to experiment and learn.

5. **Long-term monitoring and evaluation is critical.** Finding the resource and impetus to measure impacts is a challenge for many donor-funded projects, where long-term monitoring is not factored into the budget or accepted by donors who want financial closure in shorter time periods. On the current timetable there will be relatively few observable impacts by the end of the project grant period in June 2016, creating limits to the measurement RESOLVE can complete within its funding cycle. It seems highly desirable that RESOLVE partners or Renewable World seek funding for longer-term monitoring and evaluation. RESOLVE can use its baseline data and reports like this to assess impacts over a three, five or ten-year period. Some areas that would be interesting to cover include:

   - Impacts of the energy hub on economic activities specifically targeted by RESOLVE
   - Distribution of impacts across different economic actors, activities (such as night fishing versus processing), men and women
   - Mapping the mechanisms which link electricity to productive outcomes (such as the role of training, microfinance, local resource mobilisation, site selection) including identifying what happens 'spontaneously' and what requires outside support
   - Comparing the community-ownership model versus a private sector-run model, in terms of PUE outcomes.

These reflections conclude the RESOLVE case study. The next chapter places the RESOLVE experience in a wider context by discussing productive use projects and enterprises in the region, agricultural and fishing sectors.

6

Other productive energy projects and enterprises

There is plenty of experimentation around energy services for small-scale fishing and agriculture in Kenya. Private-sector actors are optimistic about the potential to meet productive energy needs through commercial approaches — but require grant money in the early stages to learn about the market. Many start-ups are more focused on getting core aspects of their delivery model right — in terms of pricing, technology, raising funds, maintenance and distribution — than on demand-side support measures. New ideas are emerging on the types of collaboration and pragmatic support that could encourage customers to buy their products or services.

This chapter provides mini-case studies of other projects and enterprises serving the productive energy needs of smallholder farmers or fishing communities. The aim is to shed light on what else is happening in the area and sector, providing light comparisons with RESOLVE and distilling their lessons. Each case study summarises key aspects of the design model, its approach to supporting productive activities, challenges and future opportunities. The case studies include a mixture of privately run companies and hybrid NGO-corporate partnerships (see Table 1 in Section 1), but particularly provides insights on the private-sector perspective. The case studies on SteamaCo/PowerGen and Future

are more in-depth as they involved site visits and meetings with local stakeholders. Table 3 shows how the case studies compare to RESOLVE in terms of the different types of PUE needs targeted.

Table 3. Intended energy uses or services

	RESOLVE	SteamaCo/ PowerGen	Sollatek	WE!Hub/ Osram	Future-pump	Sun-Culture
Fishing						
Fish chilling	✓					
Fish freezing	✓		✓	✓		
Solar lantern leasing, sales or battery charging	✓		✓	✓		
Agriculture						
Water pump for irrigation	✓				✓	✓
Local retail services						
Food, drink, leisure (eg lighting, chilling, cooling)	✓	✓				
Mobile phone-charging	✓	✓	✓	✓		
Internet centre	✓			✓		
Selling ice	✓			✓		
Selling purified water	✓			✓		
Household						
Electricity connection (eg for lighting, phone-charging)	✓	✓				
Solar lantern			✓	✓		

This solar microgrid has capacity for 60 customers. It is designed and built by PowerGen and operated by SteamaCo.

"The people who are using it for light are happy, but there are a lot of ways to get better lighting solutions and microgrids are just one of them. The people who are really ecstatic are the ones running the barber shops, phone-charging businesses, guesthouses and bars. This is enabling them to run businesses they couldn't before because generators were just too unreliable and expensive"— company interviewee.

6.1 SteamaCo and PowerGen

6.1.1 Overview of energy service

This case study covers two companies that often collaborate to install microgrids and related technology for managing the system. SteamaCo is a start-up, for-profit company operating as a technology provider to microgrid developers and operators.[34] Its primary business focus is to lease web-based software, which enables remote monitoring and control of power systems. Their hardware system, known as a bitHarvester, allows microgrid operators to track customer use, use mobile-money payments, control electricity supply and view overall system performance remotely on an online dashboard. As a secondary activity, SteamaCo do microgrid designs for others to build or operate (advising on the design of the power hub, distribution, ownership, customer engagement). The company (formerly known as Access: Energy) was until recently focused on microgrid installation and operation, and still manages several microgrids supplying renewable power (80 kilowatts total) to about 1,000 homes and small businesses in Kenya.

34 See http://steama.co.

SteamaCo's decision to move into a technology provider role was driven by a belief that this is more scaleable, with higher margins over a shorter period. SteamaCo technology currently runs more than 30 microgrids around the world.

The research involved a visit to Mahinga beach on Mageta Island (Lake Victoria) where there is a 4.5 kilowatt solar/wind system with diesel back-up. It had been in operation for 12–15 months and was serving around 43 customers, with capacity for approximately 15 more. The grid is owned by SteamaCo, with a local person employed to manage operation and maintenance tasks. The power system was made and installed by PowerGen, a for-profit microgrid developer and solar installer that SteamaCo collaborates with.[35] For PowerGen, the typical capital costs of a microgrid of this size is about USD 30,000 with a 3–5 year payback time – though the company expects this period to shorten once a project developer has 50–100 microgrids on their books.

6.1.2 Approach to productive uses

SteamaCo's and PowerGen's target market for microgrids in off-grid areas are people using power for productive uses, as these customers are generating the means to pay. This usually means micro-enterprises, though they also connect households. The main types of 'productive use customer' are small shops (lighting, phone charging, drinks chilling), hairdressers (powering clippers or a hair dryer) bars, restaurants, music and video halls (using electricity for lighting, playing videos/football matches on a TV screen, charging for music downloads).

The company's approach to addressing productive uses focuses on the nuts and bolts of delivering a functioning and economically viable energy service. Adopting special measures to support the demand-side constraints on productive uses, or to target particularly vulnerable groups such as women, is not considered within the business remit. The perception of staff is that lots of activity is enabled automatically. The measures used across the two companies that can be seen to address productive use include:

- **Understanding local needs** through regional office presence and conducting a **site assessment** to test current and future demand, and willingness to pay
- Holding **community meetings** at the project outset to raise awareness about the project, possible uses of electricity and to get local permissions (eg renting land)
- **Pricing electricity so it is competitive** with existing alternatives, such as a diesel generator, and affordable for existing micro-enterprises. Tariffs at the time of writing were typically USD 2–5 per kilowatt hour, depending on what bundle a customer buys, plus a very low connection fee of USD 10 which the company recoups through the tariff. Business customers (such as kiosk owners, video hall owners) reported

35 See http://powergen-renewable-energy.com.

spending around KES 500–600 per day. This is similar to the daily fuel cost of a generator, though the tariff has the added benefit of covering maintenance costs. According to one interviewee, the tariff is also competitive compared to kerosene and solar lanterns, which are "easily above USD 10 per kilowatt hour".

- **Using (SteamaCo) remote monitoring technology and mobile payment** platforms to manage costs and risks (e.g. switching off customers who do not pay), improve service quality (spotting maintenance problems early) and provide cheap, flexible pay-as-you-go service (no cost of physical collection, customers buy power when they have money).

Their funders (donors, social impact investors, crowdfunders, private equity) have varying degrees of interest in securing social goals. In the main, funder requests to measure impacts are limited to targets around the numbers of households electrified, rather than economic outcomes of electricity usage.

6.1.3 Challenges

Company representatives acknowledge that the levels of power supported are not sufficient for all local productive use needs. On Mageta, electricity is not used to chill fish, for example. An interviewee also pointed out that the microgrids cannot currently serve the widely used 'Posho Mills' (for milling grain), which are designed to run on diesel motors and would require a significant investment to retrofit them to run on AC power.

The local site manager and customers also reported some technical issues to iron out, particularly when the power supply is switched between solar and diesel (when batteries run low). This creates a power surge, damaging electrical devices.

At a policy level, the lack of clarity on permissions to charge variable tariffs is a worry for operators. SteamaCo and PowerGen have engaged policymakers on universal tariff questions as part of the new Energy Bill.

6.1.4 Opportunities

Company representatives are optimistic about the potential for privately run microgrids to supply energy in remote rural areas and stimulate micro-enterprise. They are more sceptical about interventions that involve the community ownership of energy equipment, believing that customers and funders both prefer these to be run by experts. Equally, they emphasise the limits to what for-profit companies will pay for, in terms of stimulating customer demand or support packages. New opportunities or ideas mentioned include:

- Testing the business model for microgrid operators by **leasing or selling electrical equipment to energy customers**
- Encouraging **microfinance institutions** to help people to buy appliances

Fishing boats at Mageta Island

- Using **data on energy consumption and payment** as evidence for microfinance institutions of customers' reliability, provided data protection rules are complied with
- Exploring electricity supply for **Posho Mills**, as a widespread economic activity and anchor client – focusing first on financing solutions for retrofitting the equipment
- Using the opportunity of **decentralisation** in Kenya to secure future off-grid contracts
- Using data generated to leverage donor resource through a results-based financing mechanism, paying a subsidy for each kilowatt hour of renewable energy sold, for example.

6.2 Sollatek Solar Centers

6.2.1 Overview of Energy Service

Sollatek Electronics (Kenya) Ltd[36] and the Indian Ocean Water Body have formed a partnership to pilot 15 Sollatek Solar Centers, providing energy solutions to the artisanal fishing industry and communities along the Kenyan coast. They use existing buildings and install solar power to offer cold storage facilities for fish freezing, solar lighting, solar lantern rental and phone charging services at non-electrified beaches. The combined installed capacity is approximately 60 kilowatt hours.

36 See http://2015.sollatek.co.ke.

Sollatek is a power and solar products company; the Indian Ocean water body is the managing entity for coastal Beach Management Units in Kenya. The project was funded by a USD 100,000 grant from the US African Development Foundation's Power Africa Off-Grid Energy Challenge, to test demand, viability and affordability of the model. Under this model, Sollatek will own the solar centres for a year, then hand them over to the Indian Ocean Water Body who in turn will oversee a transition to full management by the BMUs. During and after the pilot, local-level BMUs were responsible for day-to-day management of the solar centres. The BMUs will provide performance data for two years to give Sollatek commercial insights. The partners envisage that the income from services provided will be enough to cover the cost of hiring someone to run the centre, and maintenance costs such as batteries.

6.2.2 Approach to productive uses

Some of the key interventions to design and implement the pilot included:

- **Research** on how the local fishing sector works and key actors within it. This included a survey on catches, fish prices, cold storage availability and community knowledge.
- **Subsidised freezers.** Each solar centre had a 225-litre freezer and facilities were offered at a reduced rate of KES 2 per kilo for a 24-hour period, which is lower than the standard charge by fish dealers of KES 5 per kilo.
- **Training** BMU members to run the hub, focusing on solar system management, sales, financial reporting and book keeping
- **Monitoring** the hub's different revenue sources: cold storage, lighting, mobile phone charging and solar lantern rental; and customers' activities. This was used for **financial forecasting** for the first three years to assess business viability.

Research on the fish sector identified significant variety in fish trading relationships — ranging from fishers' co-operatives, who are pre-contracted to single dealers, to ad hoc arrangements, whereby fishers only fish when an independent dealer arrives at the beach. It showed the pivotal role of dealers and the possibility that cheap access to chilling facilities would threaten their margins and control. The research also challenged the team's initial assumptions by showing there was more local demand to rent lanterns for domestic use (such as for children studying) than for night fishing.

Sollatek found that the three-month pilot provided direct access to energy to 10,000 people, which was higher than predicted. The project also achieved a significant positive cash flow for the BMUs and for Sollatek. The amount was however less than expected, possibly because the pilot was run during the low fishing season.

6.2.3 Challenges

- **Local mindsets**. Similar to RESOLVE's experience, Sollatek found a mindset more oriented towards donations than business within many BMUs. In addition, some BMUs are dominated by a few individuals with vested interests, which Sollatek thought could create risks, for instance, of dealer-members taking control to get a 'free service' for themselves or an insider group. The company felt this could be addressed by vetting groups thoroughly; getting the BMUs to submit business plans to show they understand what is involved; and using equipment withdrawal as a sanction.
- **Adapting to seasonality**. The seasonal nature of the fishing industry means potential losses during the low season; other profitable uses of the freezer at these times should be explored.
- **Being flexible**. Flexibility is needed in project implementation — to respond both to complications on the ground, and to innovative business ideas, where these arise.

6.2.4 Opportunities

The pilot produced evidence for two potential commercial opportunities:

- solar product distribution for grant-financed projects
- piloting smaller, more affordable freezers financed by a pay-as-you-go or rent-to-own model. More research is needed on the size of the potential market for freezers.

Other positive lessons the company drew from the experience:

- Communities were more receptive to solar-powered freezing than expected
- Some communities/individuals use their own initiative; women members of one BMU proposed selling ice and frozen juices, benefitting the whole village, not just the BMU members/fishers
- Mainstream energy firms can be incentivised with grant funding to do pilots in low-income markets, as a way for them to learn about the market and raise product awareness. Without funding it would be hard to justify on cost grounds.

6.3 WE!Hub

6.3.1 Overview of energy service

The Water-Energy Hubs (WE!Hub) in Kenya are a collaboration of Global Nature Fund, OSRAM, Thames Electricals Ltd. and Light for Life to establish solar-powered energy hubs offering clean energy products, purified water, communication and training for local fishers, households, small businesses and schools. The project is funded by the Siemen's

Foundation and the European Union and is the second phase of an earlier pilot (O-Hubs, 2008–2010). There are three existing WE!Hubs around Lake Victoria and a further five are planned, with two of the existing hubs located close to where RESOLVE is also operating (Mbita and Ragwe).

The hubs are set up as "self-sustaining, profit-oriented social businesses". Electrical energy is provided by 72 solar panels with a performance of 220 watt peak each. The hub offers several services, of which the lamp rental business is the most important:

- Renting and re-charging OSRAM's battery-operated LED lamps, primarily for night fishing
- Cell-phone charging
- Internet café and computer services
- Training courses on ICT and entrepreneurship (business management, customer service, accounting, financial management, mentoring, ICT skills)
- Purified rainwater that has been treated using filtration and UV lamps.

Customers pay a small fee for accessing services. Each customer has to register at the WE! energy hub and pay a refundable deposit to start leasing the battery-operated lanterns. Solar lanterns are rented out with a deposit of KES 3,000 (USD 30) and charged up at a rate of KES 100 (USD 1) per charge. The project states it follows social business guidelines with fees being at least 30 per cent lower than the equivalent price of kerosene (WE!Hub, undated).

6.3.2 Approach to productive uses

The partners focused on ways to get the social business model working, and – for the private sector partner – to test and promote their lighting products. There are three interesting aspects of their approach:

- **Pay-per-use fee and rental model.** The energy kiosk has chosen a model of renting and recharging over selling lamps. This potentially addresses some cost/risk barriers they believe put customers off from purchasing the lamps or a full solar home system (due to cost or vulnerability to theft). Another advantage is that since products are not exclusive to the customer they can be immediately exchanged for a fully charged one, which avoids long waiting times during recharging.
- **Offering diverse services that meet local needs.** The hubs offer social as well as productive energy services because it is trying to respond to local priorities. An interviewee described these social services as 'an attractor to the hub'. The revenue from the energy services is intended to fund social activities, particularly the training, which is relatively low-cost to put on.

- **Maintenance and disposal.** Repairs, maintenance and end-of-life disposal/recycling are handled at the WE! hubs by technicians trained by the project.

The research identified some anecdotal evidence of impacts:

- Hub operators were doing about 400 charges (batteries, lanterns) per day across three hubs – roughly KES 40,000 per day (or USD 390).
- Estimated cost savings for boat owners by replacing kerosene with solar lanterns for night fishing is in the region of KSH 6–12,000 (USD 60–120) per month (or a 20-day fishing season). The savings come from not buying kerosene or replacing spare parts, since the glass in kerosene lamps breaks easily.
- The hub is apparently stimulating new businesses. It was suggested that one man who uses the hub to recharge villagers' phones is making KES 3,000 per month (USD 30).

6.3.3 Challenges and opportunities

The partners learnt from the first pilot phase (such as the need for awareness-raising and training local people). Some specific teething problems reported include:

- **Pricing products so customers value them.** Initially the solar lantern deposits were set very low, but this encouraged negligence and loss by customers, who in any case would pay much more for a kerosene lamp – so the price was subsequently raised.
- **Addressing distribution blocks through middlemen.** Fishers would not travel to the hub because it was too far from the beach. WE!Hub encouraged the creation of 'middlemen' – villagers who will transport lanterns to the hub by motorbike for recharging on the fishers' behalf.

On the opportunities side, one motive for OSRAM to engage with the pilot was learning about the market for their lighting product. On the basis of the pilots, the company has assessed that there is commercial potential.

6.4 Futurepump

6.4.1 Overview of energy service

Futurepump is a for-profit company established in 2012 which aims to do business-to-business manufacturing, sales and marketing of solar water pumps, selling to local distributors who sell on to customers.[37] At the time of the research, Futurepump was piloting its pump in Rusinga Island on Lake Victoria (close to RESOLVE's site in

37 See www.futurepump.com.

Oluoch Omwoma - Futurepump customer member of Rusinga Island Organic Farmers Association (RIOFA)

Luanda Rombo). It was operating on a business-to-customer basis in order to work out a business model for the pumps' sales, maintenance and after-sales service. The aim is for the Rusinga business unit to become a micro-franchise and, through their learning, to develop a franchise pack that could be rolled out to other distributors – for instance, to companies currently selling Honda or treadle pumps. They had five customers and 100 orders at the time of the research.

With its headquarters in the UK, Future Pump has an office in Kenya and works in partnership with Practica Foundation and International Development Enterprises. Their start-up activities have been funded through grant and Challenge Fund money, provided by bilateral donors and foundations.

The pump is called the 'Sunflower', and is powered by a conventional 80 peak watt solar panel. The panel is detachable (for security) and the pump is portable. It is a piston pump operated by a DC motor, which sits on and turns a flywheel. It pumps from depths of approximately six metres, making it appropriate for extracting water from a shallow supply – hence trialling it with farmers whose plots are close to Lake Victoria. Since water is pumped when the sun is shining, it works best in conjunction with storage tanks and drip systems so that irrigation can be carried out at cooler times of day.

6.4.2 Approach to productive uses

Productive uses of energy is Futurepump's *raison d'être*, and their product is targeted at smallholders for irrigating crops sold into local markets. The following design measures are being tested:

- **Targeted customer base.** Futurepump are targeting mid-tier smallholders, the group between the relatively affluent farmers and subsistence-level farmers (who cannot afford their product). They are targeting farmers selling locally into informal markets and producing higher value crops (tomatoes, kale, coriander), which have short crop cycles and produce multiple crops per year.

- **Simple technology design**. The pump designed by Practica Foundation follows principles of robustness and simplicity, such that most repairs can be done locally. There are no circuit boards or electronics and it is simple to dismantle with a screwdriver.
- **Competitive pricing and flexible payment models**. The pump costs USD 400, in the same price range as a five horse-power petrol pump (USD 300–500). They are experimenting with customer payment models to get over the hurdle of upfront costs, for instance by charging a deposit and allowing monthly repayments (with interest) and providing the flexibility for farmers to pay off more when they have the cash available. They are experimenting with a software platform for automatic SMS billing, alerts and reminders, which Futurepump see as a key tool for achieving scale.
- **Raising customer awareness and linking with complementary initiatives.** Futurepump are working in partnership with RIOFA, the Rusinga Island Organic Farmers Association. The company is establishing a sales, service and distribution centre on land next to a planned demonstration site that RIOFA purchased to showcase organic farming techniques. Demonstration days run with farmers have been important for getting user feedback. Linking with complementary initiatives may be a short-run activity to build product awareness, and staff noted that existing providers, like Honda, sell products without offering supporting services to farmers.

6.4.3 Challenges

A key challenge is the remoteness of rural markets and poor infrastructure, and the impact on distribution, maintenance and spare parts. The company had resisted responding to any order requests outside the small pilot area; this was out of concern that if products are not serviced they would become redundant, leading to a loss of customer trust.

Other hurdles related to policy and finance. While there is enough of an enabling environment to 'just get on with it' in Kenya, the process of getting imported goods in to Mombasa is slow and expensive, and the sector had to lobby hard to get a duty waiver on imported solar products. The company is not currently planning to work with government on a practical project, mentioning risks of politicisation. The time and effort involved in securing donor finance was another general challenge for a start-up.

6.4.4 Opportunities

The company see various potential levers for addressing the challenges of marketing, distribution and maintenance. Some of these are already being tested:

- **Clustering sales, maintenance and training in a controlled geographic area**. Futurepump envisages a hub approach, whereby a local distributor of their product would cluster together a workshop, spare parts store and and training for local technicians. They would limit their sales to within easy distance (a 'motorbike's ride') for servicing. Under this model, replacing a very cheap spare part is cost effective.
- **Farmer-to-farmer sales.** Providing a commission to farmers who recommend the product to others could help address the problem of low technology awareness.
- **Bundling with farmer inputs and services provided by others.** Company staff noted interesting complementary innovations, which could act as distribution channels for the pump and offer farmers a more holistic package. Examples include the growth of Kenyan-manufactured, low-cost drip irrigation systems; low-cost farm inputs packages (fertiliser, seeds, training), such as the USD 100 package offered by the NGO One Acre, which is only repayable after the harvest; and new loan facilities which link finance with agronomic advice, such as the F3Life loans for smallholders offered to farmers following soil conservation practices.

6.5 SunCulture

6.5.1 Overview of energy service

SunCulture is a for-profit company based in Nairobi which sells AgroSolar Irrigation Kits to farmers in Kenya, consisting of a solar-powered water pump and drip irrigation system.[38] The company started in 2012 and launched their first products in 2013. Their target customer base is Kenya's one million or so better-off small-scale farmers producing higher-value vegetables (capsicum, tomatoes, onions, cabbages). This group includes urban dwellers who continue to oversee family farms from a distance ('telephone farmers') and who have the resources to invest. The average cost of the kit is around USD 2,500. The system can also be adjusted to apply fertiliser through the drip system as a way to increase efficiency.

SunCulture intend to be a 'one-stop shop', combining pump and irrigation product sales with training (on the system), after-sales support and agronomic advice (fertiliser use, pest control, organic farming, propagation, seed selection, crop rotation). They also aim to

38 See http://sunculture.com.

provide farmers with access to capital and markets — connecting farmers to banks and domestic and export markets — though at the time of research this was not a focus.

6.5.2 Approach to productive uses

The stand-out feature of SunCulture's approach is the integrated technology and advisory package offered to farmers. This holistic approach grew from the founders' observation of how disconnected agricultural value chain actors were.

According to the company's marketing material, switching from a petrol/diesel or electric water pump could save a typical customer up to KES 20,000 per month (USD 200).

6.5.3 Challenges and opportunities

The biggest challenge has been in changing people's mindsets about the value of testing agricultural technologies and practices that are different to what they are familiar with.

SunCulture is interested in reaching the 'mass market'; but making their existing offer cheaper and thus reaching lower-income farmers is very difficult.

On the consumer finance side, the current customers are sufficiently well resourced to pay for the kit up front. However, the company would like to see financial institutions give more long-term loans to farmers — whether for purchasing their equipment or other inputs — as the current practice of one-year loans is too short a time window.

Overall the company is optimistic about the potential for renewable energy in their target market. They see the movement of funds (private equity and venture capital) for renewable energy to East Africa as a good indicator. From a policy perspective, the removal of value-added tax on solar products has been important — though more could be done to incentivise business, for instance through easing up import procedures to make it more efficient.

7 Conclusions and recommendations

7.1 Conclusions

The paper has examined how RESOLVE and other renewable energy start-ups and projects are addressing productive-use needs of poor rural customers in Kenya. It has asked: What productive energy needs are being targeted and what barriers prevent communities or customers from using energy productively? And what approaches are projects taking to addressing the barriers to the productive use of energy?

Our case studies covered a variety of technologies and services — microgrids, water pumps and multi-service energy hubs — for a range of energy needs in fish harvesting, local services like small shops, and small-scale agriculture.

Understanding PUE opportunities and context

All the projects studied carry out some analysis on the productive-use potential of their product or service, but none are doing the type of more systematic assessment recommended in good practice guides to assess the best opportunity and strategy for creating incomes and local value addition. A systematic assessment would cover, for instance, the different economic activities and value chains; understanding the costs and benefits of energy inputs; and mapping bottlenecks.

It is vital that developers understand the local context. For instance, a donor-recipient mindset in some communities and sticky politics in local fishing groups can make it difficult to set up a community-run energy business. Other important context factors include the seasonal nature of fishing, gender dynamics and long-term threats to the sustainability of fishing livelihoods.

Different PUE approaches: for-profit and not-for-profit

All the case studies involve the private sector in some form, but vary in the degree to which they are commercially or socially driven. At one end of the spectrum is RESOLVE, as an NGO-led consortium with a community-run energy model that seeks to address a range of local livelihood and well being needs. At the other end are businesses like SteamaCo and SunCulture, which focus on private-sector energy delivery services to generate a return and attract private investment. In the middle, the hybrid company-NGO solar hub pilots seek to achieve a mixture of the two.

In general, those in the private sector interviewed for this report feel that productive uses of energy will happen automatically, through effective targeting of their customer base and because the viability of their product or service depends on customers generating income and the means to pay. They are optimistic that their customers can work out how to make money from energy, even in poor communities, and distrust approaches they consider encourage a handout mentality. The companies are, however, less likely to get involved in building local capacity and demand except on a short-term or trial basis; for instance to raise awareness of a new product or to test out a new business opportunity.

An alternative view, articulated by the NGOs involved in RESOLVE, is that while some activities happen spontaneously, extra measures are needed to reach poorer customers; create business opportunities; and achieve an economic transformation locally. RESOLVE has designed its whole delivery model around a productive-use goal by establishing a community-based organisation to run the microgrid and sell energy services. RESOLVE also provides several support measures for users, such as equipment, financial literacy training and links with microfinance institutions. The two hybrid company-NGO solar hubs are doing some similar support activities to RESOLVE but on a short-term basis; and as businesses, the incentive is to learn about the market and commercial opportunities.

The study was not set up to evaluate if one model is better than another, but we can infer:

- The strength of the private sector approach is its focus on understanding market demand and economic sustainability, but it is likely to target better-off customers (and indeed one company is expressly targeting richer farmers); 'trickle down' effects of the case studies are still anecdotal, not proven.
- The strength of the NGO or hybrid models is that they can test different ways of reaching poorer customers, or stimulating higher value-added activities that might not happen automatically; but face problems of slowness, navigating community politics and still need to demonstrate long-term economic viability.

7.2 Recommendations

The following emerging ideas and lessons could inform the priorities of energy practitioners, policymakers, funders and researchers working in this field. Recommendations are summarised in Box 9.

Box 9. Recommendations for stakeholders

Funders and investors

- Invest in rural and decentralised energy, and productive use applications
- Ensure investees use robust PUE assessment tools and are clear on their objectives
- Incentivise and test different productive-use delivery models and support measures
- Assign budget to measure long-term impacts of projects
- Support the use of PUE monitoring frameworks that are workable for enterprises
- Support knowledge sharing of emerging pilots and innovations
- Address finance constraints for enterprises

Knowledge organisations

- Track and share knowledge on different productive-use energy delivery models
- Incorporate value-chain analysis into energy access research
- Conduct sector or local-level research, eg in fishing, horticulture, dairy, retail
- Develop workable frameworks for assessing PUE impacts for use by multiple actors
- Convene knowledge-sharing platforms and conferences on productive energy use
- Investigate policy and finance levers/barriers
- Integrate gender into analysis

Practitioners and enterprises

- Cost and seek funding for research to build in-depth understanding of productive-use customers and energy impacts
- Cost and seek funding for productive-use support measures, additional to core delivery model
- Provide feedback and share learning on interventions to support productive uses
- Explore propositions to combine energy with other services, work with aggregators or non-usual suspects (eg agribusiness)
- Work with researchers/governments to measure long-term impacts of investments

Government and policymakers

- Include productive use targets for low-income populations as part of national policy
- Assess and revise policy frameworks to incentivise decentralise renewable energy (tariffs, duties, standards)
- Improve the wider enabling environment for investment (corruption, import processes)
- Explore how decentralisation might create opportunities for complementary local investments (eg road building)
- Convene events on high-impact sectors where innovation is taking place eg fishery
- Support cross-sector working to maximise links between energy and other sectors (water, agriculture, gender, tourism)

1. Strengthen collective understanding of productive-use customers and markets

It is self-evident that achieving a viable energy service in low-income markets requires a good understanding of the customer base and their context. There is growing market knowledge of the cookstoves and solar lighting sector, but all the case studies showed a lack of depth in stackholders' understanding of markets for productive-use energy applications.

People who depend on agriculture or fishing, and want to use energy to earn more, face a variety of needs, preferences, incomes, barriers, opportunities, risks and costs. All of these are likely to shape the energy delivery model and its chances of success. Some factors may be generally applicable, allowing certain innovations to be replicated. For instance, many interviewees described the need for financing methods that respond to the variability of farmers' incomes over the agricultural cycle, such as flexible customer payment systems or incentives to overcome financial institutions' reluctance to lend to farmers.

However, what this research also showed is that contextual factors alter significantly between particular sub-sectors; an individual's role in the value chains; or particular local contexts. This requires tailored responses in the design of the energy delivery model and support measures. For instance, in fishing communities like those targeted by RESOLVE, the lack of a savings culture may be a bigger constraint to paying for energy services than low or fluctuating incomes. Another example is the difference between Futurepump and SunCulture which are both targeting irrigation needs using solar pumping technology, but have contrasting customer bases. SunCulture's better-off farmers can afford a higher priced product and the extra advisory services, often paying in full, up front. Futurepump meanwhile is targeting less well-resourced farmers and accordingly has a much lower-priced product, designed around principles of local maintenance and allowing customers to pay in instalments.

Recommendations

Funders, researchers and policy-makers should:

- Conduct research and host events to build knowledge on key sectors, regions or customer segments served by productive energy applications – particularly in fishing and agriculture, where there is experimentation but not much knowledge-sharing.
- Share key findings from PUE market analyses that have been funded using public money (such as donor finance) with wider stakeholders to raise overall sector performance.

2. Incentivise energy projects to conduct thorough PUE assessments

While all the projects carry out demand analysis, they do not conduct the type of systematic assessment recommended in good practice guides to assess the best opportunities and strategies for creating incomes and value addition locally.

Depth of understanding is crucial. The RESOLVE case study provided a glimpse of how complex and varied fishing value chains are, reinforced by the Sollatek and WE!Hub case studies. For instance, in the case of RESOLVE we saw how the fish trade around Lake Victoria involves two very different value chains — a more commercialised and formal Nile perch sector selling in international markets, and a more informal, lower-value fish sector for local consumption. These relationships are likely to affect how the costs and benefits of new energy investments for fish chilling and night fishing will play out for different actors.

For projects like RESOLVE, which are explicit in their social objectives, a more thorough assessment could help them to be precise about who their beneficiaries are, to prioritise interventions according to the budget, and to measure outcomes. One reasonable objection is that it takes up a lot of time and resources, but this could be addressed as follows:

Recommendations

- **Funders of** energy access start-ups and pilots should allocate a budget to help practitioners assess, measure and share data on PUE opportunities and impacts.
- **Government departments, researchers, funders or electrification agencies** — and other actors with a public interest role — should invest in developing workable PUE assessment methodologies suited to small projects or businesses, and allocate funds for in-depth PUE research that would support sector-wide knowledge.

3. Make sure gender is prioritised

'Integrate gender' is a standard recommendation — and sometimes risks being seen as token as a result. This research did show some significant factors in fishing communities and value chains that could shape the distribution of benefits between men and women. It asked more questions than it could answer at this stage: for instance, when fish chilling is offered by BMUs (Sollatek, RESOLVE), will women buying fish see their margins reduced or themselves gain access to chilling services? How will farming incomes (where women dominate) be affected by energy hubs? Of all the case studies, the NGO-run project RESOLVE appeared to be the only project thinking proactively about how to ensure women benefitted (in terms of the economic activities targeted, or involvement in energy hub management).

Recommendation

- **All stakeholders** should follow existing good practice advice to integrate gender into the energy service design, monitoring phases and PUE promotion.

4. Test different delivery models and support measures to address PUE barriers

The paper has looked at how projects and enterprises are addressing PUE demand-side constraints, such as people's lack of knowledge or finance.

While good practice guidance (on electrification) tends to focus on 'add-on' support measures, the case studies showed how getting the core delivery model right is just as crucial for practitioners. This covers issues such as design, affordability, distribution, marketing, maintenance, management and ownership. For instance, in the examples of solar lanterns for night-fishing (RESOLVE, WE!Hub) we saw the importance of technical design, battery-charging arrangements, price, and competition from kerosene as factors which all shape fishers' demand for the product.

The private sector and NGO interviewees had different attitudes towards the additional promotional measures. In general, the private sector is more hands-off, seeing productive use as something that arises automatically from businesses targeting their customer base well and customers using their ingenuity. That said, the case studies did provide several examples of companies being active on the demand side – for instance, selling agronomy services (SunCulture), raising awareness with farmers' associations (Futurepump), or thinking about how their customer payment data could help customers secure loans to buy equipment (SteamaCo/PowerGen).

The RESOLVE project and hybrid corporate-NGO pilots are generally more interventionist, for instance securing grant funds to provide training in financial literacy, and subsidising end-use equipment. This is an interesting area, and one that needs exploring further through comparative research based on proper impact data, which are not currently available.

Recommendations

Funders and energy providers should experiment with different models and support measures, tailored to the value chain and local context.

All stakeholders should support research to analyse:

- The different approaches to promoting PUE and their outcomes
- The quality and impact of specific support mechanisms recommended in good practice guides, like enterprise development

- The pros and cons of a 'holistic' versus a 'commercially orientated' approach, in terms of poverty and equity impacts, cost-benefits, service viability
- Whether a community-run model has any additional impact on PUE outcomes compared to a privately run service.

5. Be clear about when and how to collaborate with others

All the good practice guidance recommends that energy providers work with others to address wider economic development issues outside their expertise. The case studies revealed some of the challenges of collaboration, where parties have different outlooks or some partners lack the right capacity. Rather than dismiss collaboration as 'too difficult', the examples underline the need to carry out due diligence on partners and to experiment with a variety of different partnership arrangements. The types of approach identified were:

- **Holistic***:* this is the RESOLVE approach, bringing together different partners for a range of customer supports and common goals for poverty reduction
- **Narrow**: stakeholders work together with a narrower set of goals, partners or time commitment, such as Sollatek's solar centre pilot with coastal BMUs to learn about the market
- **Market-based**: actors work with other value chain actors on a specific bottleneck, motivated by commercial ends, such as Futurepump's idea of working with agricultural input providers to raise awareness of their product
- **Not collaborating**: choosing to bring support services in-house rather than collaborate, such as PowerGen piloting options to lease or sell electronic equipment to microgrid customers, or SunCulture offering agronomy advice alongside irrigation kits.

Farmers, and enterprises that poor people run, usually operate on a small scale; a major limit to their ability to access markets and increase their incomes. Some interviewees expressed an interest in market aggregators – meaning actors that interact with many small-scale producers, such as a producer co-operative or a large commercial buyer. Aggregators could bring some kind of scale, collective organisation or entry point for accessing 'lots of small'. Two of the projects (RESOLVE, Sollatek) have tried this in the fishing sector through the Beach Management Units, although they encountered challenges due to management and governance issues in those bodies. This is another area for further research and experimentation.

Recommendations

- **Project developers** need to conduct due diligence on partners to assess whether a shared vision exists and factor in the time/costs to make collaborations work.
- **Stakeholders** involved in partnerships for promoting PUE should identify the most appropriate type of collaboration for their goals and context.
- **Project developers and researchers** should explore the role of market aggregators as an entry point for facilitating access for small producers to energy equipment and related support.

6. Strengthen the policy context for PUE projects and investments in Kenya

While the paper did not conduct an in-depth assessment of the wider policy and enabling environment, interviewees raised several issues. In Kenya, the policy environment is seen as reasonable in the sense of there being a lively entrepreneurship scene and not too much government interference, enabling firms to 'just get on with it'. However, the lack of incentives for decentralised energy, and regulatory uncertainty over the setting of variable tariffs, are key complaints by minigrid/microgrid developers. It was striking that many innovators rejected the idea of closer collaboration with government bodies on productive-use projects. Kenya's ongoing decentralisation process should be a perfect opportunity to link up decentralised energy projects and start-ups with local development, but it will require committed and effective county administrations to do this well.

Recommendations

- **Government** should conduct a policy assessment of barriers and incentives to PUE investments and innovation that specifically targets low-income communities, and address key blockages or uncertainties such as tariff arrangements for small minigrids.

7. Integrate long-term measurement of productive use impacts into energy projects

Many of the case studies had some baseline data or anecdotal evidence that showed local people were benefitting, or might benefit, from their services economically – for instance, customer savings by switching from kerosene to LED lanterns. But generally the evidence base is patchy, which makes it harder to learn what types of interventions work well and what do not.

The RESOLVE case study highlighted a common problem: donor funds are too small or short-term to gather robust data on the impacts of an energy project. Enterprises will often only invest in data-gathering that directly helps with raising finance or marketing

– such as the number of households electrified – precluding the kind of in-depth assessments that are of value to the sector as a whole. With so many pilots emerging around productive-use energy applications in the rural sector, this is an ideal opportunity for energy funders to make an early investment in long-term monitoring.

Recommendation

- **All stakeholders** need to support impact research and workable monitoring frameworks as pilots and projects develop. They should cover aspects such as the distribution of costs/benefits, gender, and the effectiveness of different delivery models and PUE support measures.

Now is an exciting time for finding energy solutions that help poor, rural people to earn their living. Energy experts know from decades of experience on rural electrification what stops people from using energy productively and have developed guidance on possible solutions. At the same time, pioneers from the private- and non-profit sectors – like the ones studied in this report - are developing innovative technologies, delivery models and partnerships, which could help overcome the barriers to PUE. This is a crucial moment to support diverse experiments, share knowledge and track progress. IIED is planning to build its research around productive uses of energy and we invite colleagues, partners and stakeholders around the world to share their views and experience on some of the key issues and questions arising from this paper. Please contact Sarah Best at sarah.best@iied.org.

Annexes

Annex 1. Author interviews

Energy sector stakeholders and case study interviewees

Organisation	Name	Position	Date
African Centre for Technology Studies (ACTS)	Wycliffe Amakobi	Research Assistant	13 January 2015
African Energy Policy Research Network (AFREPREN)	Stephen Karekezi	Director	16 January 2015
Climate Innovation Center	Edward Mungai	CEO	13 January 2015
EFK Group	Alan Paul	Founder and Executive Chairman	11 January 2015
EFK Group	Myles Lutheran	Managing Director	12 January 2015
Family Support Community Based Initiatives (FASCOBI)	Pastor Gilbert Ang'ienda	Director	19 January 2015
Futurepump	Toby Hammond	Managing Director	7 January 2015
Futurepump	Kinya Kimathi	Kenya Field Manager	16 January 2015
GVEP International	Davinia Cogan	SME adviser	12 January 2015
GVEP International	Gregory Miller	SME adviser	12 January 2015
GVEP International	Shashank Verma	Senior SME adviser	12 January 2015
HiNation	Kristina Linhardt	Chief Executive Officer	22 January 2015
Kenya Agricultural Productivity and Agribusiness Project (KAPAP)	Andrew Dibo	Extension Specialist	13 January 2015
Kenya Renewable Energy Association (KEREA)	Cliff Owiti	Co-ordinator	13 January 2015

Organisation	Name	Position	Date
Kickstart	John Kihia	Country Director	15 January 2015
Osienala	Prof. Herick Othieno	Project Co-ordinator	19 January 2015
OSRAM	Oscar Ominde	Technical Project Manager – Off-Grid Lighting	15 January 2015
PowerGen	Eve Meyer	Chief Operating Officer	28 January 2015
Renewable World	Patricia Mbogo	Senior Regional Project Manager, East Africa	Several: December 2014 – February 2015
Renewable World	Geoffrey Mburu	Regional Programme Manager, East Africa	10 February 2016
Solar Kiosk Kenya Limited	Rachna Patel	Managing Director	15 January 2015
SteamaCo	Dr. Sam Duby	Chief Technical Officer and Co-Founder	23 January 2015
Strathmore Energy Research Centre (SERC)	Prof. Izael da Silva	Director of Renewable Energy	13 January 2015
Sunbelt Energy	Henry Gichungi	Consultant	14 January 2015
SunCulture	Samir Ibrahim	Chief Executive Officer and Co-Founder	16 January 2015
University of Nairobi	Prof. Eric Odada	Professor, School of Physical Sciencies, University of Nairobi	15 January 2015
World Agroforestry Centre (ICRAF)	Rodrigo Ciannella	Programme Officer, Biofuels	14 January 2015
World Agroforestry Centre	Dr. Philip Dobie	Senior Fellow	14 January 2015
World Agroforestry Centre	Dr. Miyuki Iiyama	Post-Doctoral Researcher	14 January 2015
World Agroforestry Centre	Dr. Mary Njenga	Post-Doctoral Fellow in Bio-energy	14 January 2015

RESOLVE project: Customer/community interviewees

Community	Name	Organisation/position	Date
Got Kachola	Enose Ochola	Secretary, Interim Committee for REAP Shop owner/boat owner	21 January 2015
Got Kachola	Ken Ugiro	Chairman, Community Development Projects Forum Boat owner	21 January 2015
Got Kachola	Vitaris Ochere	Area Assistant Chief, local government	21 January 2015
Got Kachola	Patrick Opaza	Fisheries Department	21 January 2015
Got Kachola	Japhethet Odero	Fisheries Department	21 January 2015
Got Kachola	Mary Ochola	Shop owner	21 January 2015
Got Kachola	Lucy	Vegetable seller	21 January 2015
	Pendo	Vegetable seller/tailor	21 January 2015
	Otieno	Vegetable sellers	21 January 2015
Ng'ore	Lucas Ogutu Okoth	Community leader, Ng'ore community	22 January 2015
Ng'ore	Mary Areyo Otieno	Treasurer, Mtakatifu women's group	22 January 2015
Ng'ore	Wilfreda Anango Odundo	Chair, Mtakatifu women's group	22 January 2015
Ng'ore	George Odingo Okoth	Community member	22 January 2015
Ng'ore	Lucas Sobosobo	BMU member, youth representative	22 January 2015

SteamaCo and PowerGen: community/customer interviews

Community	Name	Organisation/position	Date
Mageta Island	Stephen	SteamaCo technician	19 January 2015
Mageta Island	Calisto	Video hall owner	19 January 2015
Mageta Island	James	Kiosk owner	19 January 2015
Mageta Island	Rosalina	Domestic customer/kiosk owner	19 January 2015
Mageta Island	Cynthia	Hairdresser salon owner	19 January 2015

Futurepump: community/customer interviews

Community	Name	Organisation/position	Date
Rusinga Island	Dennis Siroh	Permaculture Research Institute Kenya / Rusinga Island Organic Farmers Association (RIOFA)	23 January 2015
Rusinga Island	Zephania Owuor	Futurepump technician	23 January 2015
Rusinga Island	Oluoch Omwoma	RIOFA member, farmer	23 January 2015

Annex 2. Key organisations involved with RESOLVE

Name	Organisational type	Activities	RESOLVE project role
Renewable World	NGO with headquarters in UK	• Works with local organisations such as NGOs and social enterprises to support renewable energy projects for remote off-grid communities through providing funding, capacity-building and technological expertise • Currently operating in Nepal, Mozambique, Tanzania, Kenya and Nicaragua	Overall project lead, responsible for coordinating and delivering all aspects of design, implementation and reporting Coordinates the partners and project, manages and raises funds
SteamaCo	Private company, Kenya registered	• Previously a microgrid installer and operator (as ACCESS: Energy), SteamaCo is now a technology provider to microgrids • Leases web-based software, which enables remote monitoring and control of power systems. It tracks customer use and mobile money payments, and controls electricity supply. Power operators can view performance on a dashboard	Responsible for providing and installing the hub and the monitoring system (usage, payments) Expected to provide maintenance, paid for by the energy hub users
Osienala (Friends of Lake Victoria)	Kenyan NGO	• Large local NGO working on community conservation and livelihoods around Lake Victoria • Does training, research, advocacy and information dissemination, including through running local radio stations	Delivering community training (financial, business literacy)
FASCOBI (Family Support Community Based Initiatives)	Kenyan NGO	• Local NGO focused on women and children • Works on grassroots initiatives around child protection, counselling, microfinance and social business activities for women, teenage mothers and children, kitchen gardens and farm schools for demonstration	Community liaison and engagement

Name	Organisational type	Activities	RESOLVE project role
University of Nairobi	Academia	• Professor Eric Odada is Professor of Geology and Head of Marine Geology and Oceanography at the School of Physical Sciences. Areas include water resources, climate change, environmental change	Involved in project conception University researchers conduct studies to inform project design and evaluate impacts
REAP (Renewable Energy Auxiliary Projects)	Community-based organisation	• New community organisation established in each community as part of project to manage the village energy hub • Has elected offices, constitution, bank account. Registered with Department of Social Services	Managing community energy hub – responsible for operation, arranging maintenance and managing income Has a formal partnership with RESOLVE
Beach Management Unit (BMU)	Community-based organisation with links to government	• Membership organisation present on every beach. Co-manages beach activities with State Department of Fisheries • Has exclusive management rights over fish landing • Consists of an assembly, an executive committee and sub-committees. Engages all people involved in beach activities (fishers, boat owners, traders) • Provides data on catches and develops co-management plans to ensure sustainable fish management (eg closing areas, restricting fishing gear or number of vessels)	Lease BMU-owned land to energy hub Customer of hub (for fish chilling) Initial responsibility for managing energy hub ended after governance problems at the first site

Annex 3. State of progress across six selected RESOLVE sites (January 2015)

Name of sites	Progress by Jan 2015
Luanda Rombo (visited briefly, no formal interviews conducted)	• Luanda Rombo was the first site engaged for the RESOLVE Project • The energy hub was constructed and there were approximately four electricity connections at the time of visiting • The hub was running some energy-related services – selling cold water and sodas, mobile phone-charging • Serious governance problems around the hub's management were being addressed. Community members had registered a new CBO with the Department of Social Services to manage the hub, officers had been elected and the process for opening a bank account had been started • The CBO was identifying other energy users to connect, eg the BMU • A water tank had been installed and the community was in the process of digging a shallow well to facilitate pumping of water to the two farms being managed by the women
Got Kachola (full day visit)	• The Got Kachola CBO had approached the Department of Social Services in order to get registered. An interim committee was in place. • RESOLVE partners had made several visits to the sites for participatory demand analysis and research
Four new sites Ng'ore (full day visit) Rasila Ragwe Tabla	• The sites were selected in the month of October 2014. RESOLVE partners were engaging the communities to sensitise them to the project, establish the CBOs and elect members to their management teams • Plans were in place to engage the Department of Social Services to facilitate the CBO registration. Ng'ore had submitted paperwork • Participatory demand analysis and stakeholder engagement was being conducted in order to assess what energy system would meet local needs

Annex 4. Productive energy needs identified by communities (RESOLVE)

Community perceptions on business opportunities that could be enabled by the construction and operation of a community-owned energy hub.

Fishing	Non-fishing
• Fish freezing/chilling business • Ice-making for traders/fishers to transport fish to market • Freezing fish innards/bladder to sell to Uganda to produce surgical thread • Increased omena fishing if lamps are available/chargeable at the beach • Omena drying and packing business • Charging solar lamps for night fishing	• Farming using drip irrigation with water pumped from the hub (tomatoes, kale) • Pumping water to be purified and sold • Video and sports entertainment business • Selling ice to soda vendors • Longer hours in hotels, eateries, shops, vegetable vendors (lighting, running small electrical equipment) • New hairdressers/barbers • Security lighting at night • Welding • Carpentry • Stone-cutting • Mobile phone-charging services • Youth-run ICT services (computer, internet, photocopy, typesetting, printing) • Selling ice to soda vendors • Selling/renting solar lights for homes/ businesses

Sources: Author interviews in Got Kachola and Ng'ore; RESOLVE Activity Progress Report (November 2015) by Osienala to identify enterprise demand in Got Kachola, Tabla, Ragwe, Rasira and Ragwe.

Annex 5. Summary of PUE measures adopted by RESOLVE

No.	Areas recommended by good practice guides	Measures adopted by RESOLVE
Assessments and planning		
1	*Undertake assessment to understand PUE opportunities in the target area*	• Assessment based on prior knowledge of partners and reference to other pilots/data for night fishing • Conducted baseline surveys on household attributes, energy sources and uses, income, health, access to ICT and BMU capacity • Community meetings to identify existing/new business activities, sources of finance to start a business, gender needs • No in-depth value chain analysis or market assessment to clarify objectives
2	*Select sites on basis of untapped opportunities and enabling conditions*	• Initial site selection deemed insufficiently robust so criteria strengthened to put emphasis on entrepreneurialism and community leadership
3	*Link up with complementary services, sectors and programmes*	• Little deliberate linking with higher-level programmes at the outset • Efforts to galvanise local political support created overly high expectations
Promotional activities with communities and customers		
4	*Build community awareness and involvement from an early stage*	• Strong emphasis on community awareness-raising and involvement • Energy hub (REAP) constitution sets objective to support its members with livelihood and business information, invest proceeds in member welfare and links with microfinance groups • Community leaders understand the need for training customers, eg what equipment can be run on the power available
5	*Facilitate training for enterprise development and other technical skills*	• Training focusing primarily on financial literacy and governance so CBO members can manage the hub better, with some local enterprises included • Community members interested in training or exposure visits for understanding fish value chains, agriculture (production, value addition and irrigation) and similar energy projects – not conducted by time of research

No.	Areas recommended by good practice guides	Measures adopted by RESOLVE
6	*Facilitate access to finance*	• Addressing through mobile-enabled payment system, community discussions to identify local finance sources and partnering with microfinance providers
7	*Promote standalone energy technologies and end-use appliances*	• Use of grants to purchase freezers for BMUs who charge members for usage / lease the freezer to a local business • Sourcing of quality solar lanterns • Learning lessons from other solar lantern pilots and consulting fishers
The enabling environment		
8	*Address specific policy and institutional constraints for energy technologies*	• Liaise with lighting Africa on solar lantern quality standards • Otherwise not engaged with policy debates, eg pricing, subsidies, tariffs, permitting, duties, feed-in arrangements
9	*Widen targets and indicators set by funders policy-makers to include PUE impacts.*	• Income-generation is one of 4 targeted outcomes but project lacks PUE objectives backed by in-depth analysis • Baseline surveys conducted to capture broad information on income • No clear plans/budget yet for on-going monitoring of PUE after 2016

Sources: Author interviews, Odada *et al*., 2015.

Acronyms and abbreviations

BMU	Beach Management Unit
CBO	community-based organisation
ESMAP	Energy Sector Management Assistance Program
FAO	Food and Agriculture Organization of the United Nations
GIZ	*Gesellschaft für Internationale Zusammenarbeit* (German Society for International co-operation)
IEA	International Energy Agency
KEREA	Energy Regulatory Commission and the Kenya Renewable Energy Association
LED	light-emitting diodes
LVFO	Lake Victoria Fisheries Organisation
NGO	non-governmental organisation
PUE	productive use of energy
REAP	Renewable Energy and Auxiliary Project
RESOLVE	Renewable Energy Solutions for Lake Victoria Environment

Glossary

bitHarvester A technology developed by SteamaCo that enables remote monitoring of energy systems' technical and financial performance. It is an iPod-sized computer attached to the energy hubs that meters and switches customers' power on and off, tracks distribution, power equipment, billing and technology failures, and transmits the information to SteamaCo (or the operator) via the mobile-phone data network. It requires customers to sign up using their mobile phone and to prepay their usage via Kenya's mobile-banking system, M-Pesa. The purpose of the bitHarvester is to meter and control power delivery to users; troubleshoot and address problems, such as dips in battery voltage, before they become serious; as well as identify spare capacity that could be directed to other uses, like water-pumping; and check customers' power usage against their remaining balance. The bitHarvester will disconnect a user's line as soon as their account reaches a balance of zero.

Decentralised energy refers to a system where energy production occurs at or near the point of use, irrespective of size, technology or fuel used. It is distinct to large, central power stations and grid networks, distributing power across long distances (UNESCAP, undated). It encompasses minigrids or microgrids supplying electricity into a small distribution network (see 'minigrids or microgrids') as well as standalone systems providing mechanical, thermal or electrical power. Examples of the latter include diesel generators, solar water pumps or a solar home system. Decentralised electricity generation can be connected to a central grid — for instance a minigrid that feeds into the grid — though all the examples in this paper are isolated systems.

Energy hub (also known as 'energy kiosk') is an approach to provide electricity to low-income households in off-grid regions. The hub produces electricity, usually from a solar panel, and sells it to users through charging devices (lamps, batteries). Some hubs are multi-service stations that also offer services such as retail products (energy and non-energy), entertainment (TV/music) and education (Hartl and Knobloch, 2014).

Kiva Zip is a pilot programme launched by Kiva.org to drive innovations in person-to-person lending. It provides 0 per cent interest loans up to USD 5,000 for small businesses and entrepreneurs who are financially excluded and underserved. These loans are 'crowdfunded' by individual lenders on the Kiva Zip website, connecting entrepreneurs with dozens of lenders. Kiva Zip see lenders as potential 'brand ambassadors' and customers of their business.

Lake Victoria Fisheries Organization is an East African Community institution with constituents from Kenya, Tanzania and Uganda. Its aim is to harmonise, develop and adopt conservation and management measures for the sustainable use of living resources of Lake Victoria to optimise socio-economic benefits from the basin for the three partner states.

Minigrids or microgrids are power systems that feed the electricity produced into a small distribution network to provide a number of end users with electricity on their premises. They are typically off-grid, less than 1 megawatt (minigrid) in capacity and use diesel, renewable or hybrid (combined) fuel sources to produce power. The terms are not universally defined and there is no agreed term distinguishing minigrid from microgrids, though it is generally assumed that minigrids are larger systems.

Table banking is a group funding strategy where members of a particular group meet once a month, place their savings, loan repayments and other contributions on the table, then borrow immediately – either as long-term or short-term loans to one or a number of interested members. Group members often use often use the money borrowed as capital for their livelihood projects, such as buying livestock.

Value chain analysis (VCA). A value chain refers to all the functional activities and actors involved in producing and distributing a product or service, including design, input supply, production, processing, trading, distribution, retail and final disposal of the product after use. There are different purposes and methods for analysing value chains. For instance, in the development sector, VCA has been used to identify: opportunities for smallholders and other marginalised actors to strengthen their economic position and relations with other actors within a chain; options to improve the efficiency and competitiveness of a whole chain; improving the environment (eg policy, institutions) in which chains operate or for specific actors, such as smallholders; and opportunities for innovation or for improving labour conditions (Donovan *et al.*, 2015).

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Knowledge Products

Research Report

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Energy; Fisheries

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How are enterprises and NGOs in rural Kenya addressing poor people's needs for energy that helps them earn a living? This paper looks at what new solar start-ups are doing to promote productive energy use in the fishing, agriculture and service sectors. It asks what specific productive energy needs the projects are targeting – such as cold storage for fish caught in Lake Victoria – and how they address the various barriers that prevent communities from fulfilling those needs. The six case studies include microgrids, irrigation pumps and multi-service energy hubs.

IIED is a policy and action research organisation. We promote sustainable development to improve livelihoods and protect the environments on which these livelihoods are built. We specialise in linking local priorities to global challenges. IIED is based in London and works in Africa, Asia, Latin America, the Middle East and the Pacific, with some of the world's most vulnerable people. We work with them to strengthen their voice in the decision-making arenas that affect them – from village councils to international conventions.

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