Making mini-grids work

Productive uses of electricity in Tanzania

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Photo caption: Productive uses of electricity, Bwisya Village, Ukara Island, Tanzania

Photo credit: Felia Boerwinkel / Energy Change Lab

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Mini-grids could help unlock inclusive growth in remote rural areas, but few proactively stimulate productive uses of electricity, as this often requires resource-consuming actions and expertise. This paper characterises the current mini-grids' industry, taking into account operators' models and strategies. It then focuses on Tanzania, in particular JUMEME, a new and sophisticated private initiative that aims to build energy use and bring a strong added value to rural areas. It ends with recommendations for helping such private actors develop the areas they serve.

Contents

Executive Summary

Clean-energy mini-grids (CEMGs) can increase overall access to energy. They can also foster small enterprises in developing countries' rural areas because they provide power suitable for tools and machines. Private CEMG operators could become catalysts for rural development, not only because they operate sufficiently large assets, but also because:

- They target specific geographical areas and their success often depends on local development;
- They know their regions on a daily and long-term basis, allowing proper follow up;
- Being in the private-sector, they inherently strive to maximize return with limited resources;
- They are locally-based and efficient organisations on which to anchor other public and private development-initiatives.

Nonetheless, becoming such a catalyst depends on economic contexts, regulatory frameworks and CEMG operators' choices. This document, based on current experience from Tanzania gathered through visits, interviews and literature reviews, attempts to assess how well CEMGs can and do serve productive uses of electricity (PUE) and play development roles. We aim to generate discussion among policymakers, funders and rural electrification practitioners who might support CEMG projects in Tanzania and elsewhere.

Our analysis revealed several key considerations:

Operators are developing a range of approaches but there are no common sector-wide definitions or categorisations of CEMG's business models. Most of the current approaches focus (mainly) on cost and risk mitigation. This often means operators reduce the size of their generation assets so their systems only serve households or very low power users. Alternatively, they may target only a narrow set of standardised business customers (for example telecommunication towers). A few build larger plants to sell electricity to specific industries or to feed the national grid. All these approaches protect profitability but are unable or less incentivised to boost local consumption and economies. A more development-friendly approach is where operators install electricity plants that are sufficiently large to stimulate local PUE, and make this segment one of their main target (our case study of JUMEME focuses on one such operator).

While many mini-grids' public communications material say they stimulate PUE, only those specifically targeting PUE for low-income groups are likely to achieve consistent results. Doing so requires complex and resource-consuming actions, such as: identifying economic opportunities, training and guiding local entrepreneurs, offering financial services, sourcing appropriate equipment, developing logistics networks, attracting industries, or opening sales channels. Such initiatives require a comprehensive expertise from operators and imply additional risks that many may consider not worth taking.

Tanzania, the focus of our study, has developed a very effective light-handed regulatory framework for rural electrification, which is essential for encouraging a viable private mini-grids industry. However, regulations alone will not be enough. Additional efforts should be made to support CEMG projects that actively foster local PUE. For example, at present, there are no direct incentives for going beyond households' or shops' lighting, or phone charging needs. Public subsidies offered to mini-grid providers to connect customers do not differentiate between the type of customers or service, so there is less incentive to support a business using electricity for productive purposes: connecting a homeowner with basic domestic needs such as lighting will require less investments, efforts and be "rewarded" the same way. Encouragingly, interviewees told us Tanzania's grants programme is currently being reviewed, and should introduce different grants for different services.

JUMEME: a case study

We present a case study of the JUMEME Rural Power Supply, a joint-venture company that has recently established a mini-grid on Ukara Island, Lake Victoria (in Mwanza Region, Tanzania). Although mini-grids that foster local development are expensive and require much expertise, JUMEME shows a lot of promise. It aims to use PUE as an effective lever to increase revenues and quickly reach profitability. Inensus, a business with considerable expertise in the mini-grid

field, is leading the small group of partners. Their venture is also benefiting from partners' fields of specialisation and careful site selection.

It is early days yet, but this project may be a 'proof of concept' for profitable PUE-focussed rural electrification projects. As such, it provides an interesting case study for similar private CEMG operators wanting to foster PUE. However, as the detailed case study reveals, making such an approach more widely applicable will always require wise actions. There are 'bottlenecks' at every step of local value chains. Simulating PUE means boosting existing activities, fostering new ones, opening sales channels for locally produced goods and attracting the right partners to invest in remote areas.

Issues and Recommendations

Based on the JUMEME case study and our wider research, this paper identifies three main issues and a set of recommendations for stakeholders in Tanzania and other countries exploring rural mini-grids and PUE. These issues and recommendations are outlined below, and are discussed more fully in the conclusion. Addressing them may require much time and resources, but is essential to make PUE a reality within CEMG.

ISSUE 1: There are critical knowledge gaps on mini-grids, productive uses and local agricultural value chains.

- Recommendation 1: Researchers, consultants and their funders should expand and make accessible a literature focusing specifically on Clean Energy Mini-Grids (CEMGs).
- Recommendation 2: International and national development institutions should design more programmes specifically targeting mini-grids in Sub-Saharan Africa and not rural electrification as a whole.
- Recommendation 3: International development institutions should aggregate and make accessible information and case studies on rural activities.
- Recommendation 4: Match-making platforms should bridge the gaps between rural electrification practitioners, rural industries, telco tower owners, and micro-finance institutions.

ISSUE 2: Projects are not adequately incentivised to develop productive uses; they often lack flexibility, and usually cannot afford to develop complex initiatives.

- Recommendation 5: Light-handed regulations are necessary to allow mini-grids to implement essential cost-reflective and flexible tariffs.
- Recommendation 6: Rural electrification regulators should, in partnership with expert development agencies, design specific incentives to push the industry in the right direction.

ISSUE 3: Specific practices and dedicated structures can help foster PUE, and should be shared.

- Recommendation 7: Operators could share knowledge of developing PUE.
- Recommendation 8: Operators should develop efficient partnerships with specialists to foster PUE.
- Recommendation 9: Mini-grid operators should systematically use emerging information and communication technologies to gather data on productive-uses and on the rural economy as a whole.
- Recommendation 10: Operators should also test ICT technologies with the potential to empower rural populations.

1

Introduction: Rationale and Review

This paper attempts to develop insights into the difficulties that may arise when developing productive uses of energy (PUEs) within areas served by private mini-grids, and possible solutions to these challenges.

Following an analysis of different business models and their rationales, we try to define the scope of actions that projects wanting to tackle and stimulate productive energy uses should implement. We then examine the current context of Tanzania's rural electrification sector, its opportunities and bottlenecks.

We focus on the practical implementation of PUE programmes around the JUMEME Rural Power Supply on Ukara Island, Lake Victoria. It is one of the most advanced rural electrification projects we have seen in this regard, associating electrification operations with local development support through business training and agricultural value chain improvement, in an ambitious and potentially scalable strategy.

As well as drawing on JUMEME, this paper is based on a literature review, on interviews performed from France and in Tanzania, and on learning from other projects we visited. Two were implemented by NGOs ACRA and CEFA in Tanzania. Another was Power:On, a start-up launched in Benin in 2015. Another was run by ERA, one of Senegal's private concession holders, operating since 2011.

1.1 What are productive uses of electricity (PUEs)?

Electricity use in rural areas of Sub-Saharan Africa can be split into:

- Domestic uses, within households;
- Community uses, in health centres or schools;
- Productive uses, including small-scale enterprises but also bigger loads such as agro-processing or even more important factories. (IEG/World Bank, 2008; Willcox et al., 2015).

Although domestic and community uses are crucial to rural areas (EUEI & GiZ, 2011), they are not discussed in this paper, which focuses on the potential that electricity, and in particular mini-grids, can offer to productive uses. PUE has various definitions. We consider it simply as a use of electricity that increases income or productivity. In a developing country's rural areas, typical productive uses include services such as sales, restaurants (to power lights and/or fridges), agro-processing (such as milling, grinding, drying and to a certain extent packaging), (drip) irrigation, or manufacturing industries such as carpentry or welding. Our definition also encompasses agricultural activities such as irrigation or wood processing (after EUEI PDF / GiZ, 2011).

Different types of PUE have different economic and social impacts, which also vary between the electricity provider, individual consumer, and whole community. Using energy for productive purposes can:

- Increase a service or production's quality and speed;
- Decrease production costs;
- Produce/conserve additional goods and target new markets;
- Re-localise works previously performed outside the village and increase employment.

So PUE may lead to different types and levels of socio-economic impacts, from the village, region and operator's points of view. It is worth noting that PUEs that have the highest levels of energy consumption do not necessarily create the most important social value. For instance, connecting to the grid a mill that was previously powered by a diesel generator will boost consumption, but will have less economic impact than developing new activities and opening new external markets.

PUEs depend closely on climates, crops, resources, or cultures, and these may vary between regions. For instance, maize- or wheat-oriented regions may need different milling and grinding processes. Energy required for irrigation depends on rainfall and crops. For example in Senegal, peanut cultivation does not necessarily require any water pumping. Our JUMEME case study showed that supporting processing in small-scale fisheries brings varying returns on investment depending on the market value of fish species. Finally, logistics may affect the cost and difficulty of bringing in energy and machines, and make some solutions unviable.

PUEs will also depend on villages' size, wealth, and geographic situation. Hamlets of 300 people are less likely to have a well-equipped carpenter or the range of shops and milling machines that are common in district villages of 2000. So it is clear that PUEs' potential consumption (important to operators), and value creation (important to communities) vary. Addressing such variation at large scales, and learning what works, requires structured and extensive analyses, together with proactive knowledge dissemination.

1.2 Rural electrification and productive uses, a universal goal to unlock economic development

Efforts to improve rural access to electricity has been universally intensified recently, stimulated by an international will to achieve the UN's Sustainable Development Goal n°7: "*Ensure access to affordable, reliable, sustainable and modern energy for all*". This goal has been set as a prerequisite to achieving the others.

Nonetheless, evidence that electricity provision itself leads to income-generation, and thus development, is relatively scarce (Asian Development Bank, 2005; Estache, 2010; Attigah et al., 2013). For a long time, the general belief has been that PUE should emerge naturally as access to electricity is extended. Very few analyses have been conducted to verify this. For instance, the joint GIZ-ESMAP-EU Produse initiative has reviewed literature, launched impact studies in parallel with electrification programmes and concluded that electricity use "*did hardly translate into higher firm profits in a measurable way*", especially in the case of manufacturing activities (Attigah et al. 2013)

Multiple contextual challenges may block such benefits from emerging, including: poor access to markets (Kooijman-van Dijk, 2008), poor access to relevant levels and quality of electricity, inadequate access to finance and equipment, lack of technical/business skills, poor access to physical infrastructure, and problems with less tangible market system links (EUEI & GiZ, 2011). Therefore, some authors and programmes have long proposed bundling access to electricity with complementary development interventions (Escobal, 2005; Grimm et al., 2011).

Energy access may even do social damage in certain cases, especially when inappropriate or oversized equipment is connected, or demand is overestimated, leading to an ***electrification trap*** in which employment falls, prices increase, revenue stagnates and profits fall (see Box 1). Power suppliers should carefully guide entrepreneurs to avoid such issues. Value may also be transferred among actors through ***crowding-out effects***, for example when reducing expenditures on an old product in order to buy a new one. Such effects must be taken into account when assessing the net benefit for a region (EUEI & GiZ, 2011).

BOX 1: POTENTIAL ELECTRIFICATION TRAPS – THE CASE OF CARPENTERS IN NJOMBE REGION

In Njombe region, up in the mountains, ACRA helped a local village business buy a carpentry machine from Italy. Interviewees told us the equipment is very expensive (around TZS3,8 million – €1,500). Such a 1.1kW combined machine requires a sufficient generation capacity, especially to cover peak usage, and an upgraded electricity supply. Moreover, the new entrepreneur needed technical and business training to make the most of his new asset so he could repay the loan and not endanger the micro-finance organisation providing the funds.

The carpenter has seen productivity triple, and can now produce a bed in two days, instead of a week. The quality of his furniture has also improved, so fewer people need to journey to town for such services.

However, there are risks. For instance, if a second carpenter in the village were to buy the same equipment and also increase his productivity and quality, the local market could be too limited to support both businesses (perhaps because road links are poor, or people's purchasing power is too low). That could lead to both businesses failing to make the most of their machines and falling into a typical *electrification trap* of increasing costs and prices but falling profits.

Various researchers have suggested practical frameworks to identify, analyse, support and foster PUE more efficiently. Some provide generic guidelines for identifying and analysing value chains in rural areas (Gouvello and Durix, 2008), others offer methodologies to assess impacts and follow up programme implementation in a dynamic manner (EUEI and GiZ, 2011). Some focus on specific situations, such as Best's 2016 paper analysing fish value chains in Kenya and initiatives trying to stimulate these through rural electrification (Best, 2016). Papers from outside the energy access arena can also provide insights for specific value chains. For example, Match Maker Associates Ltd (2010) produced a very interesting description of the sunflower value chain in Tanzania, which could be used by rural electrification operators. Nonetheless, such case studies are few, and difficult to find.

Several programmes have been recently launched to support PUE and specific actors have developed skills in this domain (see Box 2). New platforms are also providing numerous insights concerning mini-grid deployment (see Green Mini-Grid Help Desk at http://greenminigrid.se4all-africa.org/ and Energypedia at https://energypedia.info/wiki/Main_Page).

Carpenter's lathe in Itundu village, Njombe region (Arthur Contejean)

BOX 2: MAIN PROGRAMMES DESIGNED TO SUPPORT PUE AND MINI-GRIDS

International-scale capacity building programmes have long been supporting SMEs and entrepreneurs to use energy for productive purposes in Sub-Saharan Africa, South East Asia and South America (for example UNCTAD's EMPRETEC capacity building programme). Some recent programmes have progressively targeted rural areas and been run in parallel with rural electrification processes, such as multi-functional platforms with UNDP, the PREMS programme implemented by the ASER in Senegal, or others launched by international agencies (for example ENDEV, UNIDO).

In parallel, some institutions, NGOs and individuals have developed expertise in both electrification and PUE. These include GIZ, Practical Action, Rockefeller Foundation, Energy4Impact (former GVEP), IIED, Renewable World, GRET and GERES, which are all developing and sharing skills at an accelerating pace. Other initiatives (see USAID and GIZ's Powering Agriculture MOOC, or REEEP's Water-Food-Energy Nexus Portfolio) have increased knowledge concerning specific value chains (dairy, fish industry etc.) or technologies (solar pumps, irrigation, cold chains).

Since the beginning of the century, more and more international actors have specifically targeted mini-grid development. The Clean Energy Mini-Grids High Impact Opportunity group, developed within the frame of the UN's SE4ALL programme, has managed to aggregate many mini-grid partners in order to improve national and international regulations, develop and share knowledge, advise on business model designs and develop visibility to help financial access. The Green Mini-Grid Help desk, launched in September 2016 and designed by Inensus and Energy4Impact (both partners in the JUMEME project), is a gateway to an exhaustive list of resources for mini-grids. An increasing number of public institutions, such as the GIZ or the UK's DFID, are today supporting mini-grids across the world, in particular in Tanzania (see Annex 3).

More and more publications appear on the subject, and focus on regulatory aspects, such as the Minigrid Policy Tool kit, (RECP et al. 2014) or From the Bottom Up (Tenenbaum et al. 2014), and the more recent Policies And Regulations For Private Sector Renewable Energy Mini-Grids from IRENA (2016).

The Rockefeller Foundation, a private not-for-profit organisation, has designed large scale programmes to support mini-grids and PUE in India. Research institutes, the IIED being one of the most active, are also trying to gather precise knowledge on mini-grids in order to improve practice and visibility.

However, few programmes are taking place in parallel with deployment of new privately operated grids. Private business models are relatively recent and do not yet account for much of the industry. One programme we know of that tried to support PUE strategy in Senegal through a top-down approach in parallel with establishing concessions for rural electrification operators has not been implemented as successfully as expected. Although mini-grid companies and their impact funds' websites emphasise delivery of economic impact, it appears that often only a few shops, mills etc. have actually been connected.

Additionally, when reviewing the literature, we could not find much about specific issues related to integrating PUE within independent CEMGs, nor much that studied private operators' business models, rationales, incentives, field issues or potential revenue streams.

The belief that PUE may arise automatically is slowly disappearing, and most of the projects in preparation or on-going are now mentioning PUE as a core target (see Box 2, UNEP / SE4ALL 2015), but there is a risk that programmes to foster PUE may fail if financial and regulatory incentives are too low, or if practical and relevant case studies are not disseminated.

1.3 How CEMGs could help drive local economies and rural development

Although the practical experience of private CEMGs targeting PUE is quite limited, the approach does have promising potential. In our view, CEMGs represent both crucial vehicles for rural electrification and important long term development partners.

- CEMGs' success depends on economic development in geographically limited areas that operators know well. As the fixed costs of developing CEMGs can be high, operators need to maximise their sales, and are thus inherently keen to serve various types of customers simultaneously, acting as entry points for supporting multiple value chains. Because of their local knowledge, CEMG operators offer opportunities to better understand and tackle the local socio-economic issues.
- Being private actors, CEMG operators inherently need to maximise return from limited resources (and indirectly impact, as both are closely linked). Where their financial return does depend on new PUE, they can foster faster development. JUMEME provides an interesting example of this aspect.
- They operate as a long term and constant presence, facilitating proper follow up, support and monitoring of their development roles. Moreover, they use innovative technologies (including smart meters) that offer interesting data on loads, consumption levels and patterns etc. These data can have multiple uses, including: developing a stronger understanding of activities (for example seasonality, or revenues); adapting programmes to emerging situations; providing remote SMEs with access to finance (based on productive consumption track records); and sizing new mini-grids more efficiently so that generation assets are tailored to actual needs.

These characteristics make CEMGs local actors with whom other public and private initiatives can be anchored, thereby potentially increasing the efficiency of public programmes, NGOs, micro-finance institutions, agri-business, rural services etc.

Some recent initiatives show that integrating support for PUE within CEMGs is becoming an important concern. The ARE (Alliance for Rural Electrification) recently published a document providing summarised case studies and a set of recommendations (Lecoque and Wiemann, 2015). Identifying "*a real appetite among practitioners to capture lessons from new pilots as they are happening*", Best (2016) provides an interesting case study about the NGO Renewable World and Steamaco in Western Kenya, serving fishing communities. Best and Garside (2016) also examined ACRA, CEFA and JUMEME in Tanzania. The Rockefeller Foundation has just launched a dedicated Micro-Enterprise Development initiative (in partnership with the Society for Technology & Action for Rural Advancement (TARA) to specifically support PUE integration within its mini-grid oriented Smart Power India Program (Shared Value Initiative and FSG 2016). Power Hive, a private mini-grid operator in Kenya, displayed some optimistic data on the share of productive uses within revenues in a recent presentation (Power Hive, 2015).

2

Integrating PUE within Mini-grid Business Models

2.1 Private Clean Energy Mini-Grids: a characterisation

Rural electrification in Sub-Saharan Africa was initially managed in a centralized way by state-owned utilities through grid-extension, and sometimes with the support of NGOs. But it is now increasingly being addressed through largely decentralized solutions implemented by independent private actors. These solutions have become cheaper and more efficient over the past two decades, due to overall cost reductions and innovations such as systems for collecting payment via mobile phones and remote monitoring technologies. These innovations have reduced non-payment risk, made credit management easier, allowed predictive maintenance, quickly located technical problems, and last but not least have permitted extensive data analyses to ensure future generation assets are the optimum size. Private companies, thanks to business models improvements and/or specific regulation frameworks, have been able to penetrate and operate in some countries, particularly in Eastern Africa.

Decentralized Clean Energy Mini-Grids (CEMGs) are one of the many solutions to electrifying rural areas. In terms of the level of power made available and cost, they fit between fully standalone solutions/solar home systems (SHS), and national grid extensions. Unlike SHS, mini-grids provide energy to multiple customers, while still being an isolated asset and therefore having to manage generation and sales of electricity, i.e. supply and demand challenges, at the same time. They are centralized assets from the village perspective but decentralized from the national grid's perspective. Such solutions can provide energy at an aggregated level, with higher loads, but require much more technological adjustments to the context. For example, unlike SHSs, which are mainly sized for individuals' lighting and phone charging needs, mini-grid operators have to take into account various load and consumption patterns.

According to the IEA's World Energy Outlook 2010 (IEA, 2010), over 40 per cent of access to electricity in 2030 will be most economically delivered by mini-grids, serving at least four different types of customers in parallel (IEG and World Bank, 2008):

- **Rural households**, whose consumption is usually lower and more easily predictable, and consists of a few lamps, and additional appliances such as TVs, radios and in certain cases fridges, depending on wealth;
- **Community customers**, such as health centres, schools, or water pumps that have specific but recurrent needs;
- **Anchor customers**, including potential nearby industrial plants, water infrastructures, telecom towers, or even national grids, that have specific requirements too, and usually require more formal partnerships;

- **Productive uses**, such as shops, millers, carpenters, or tailors. These productive uses include a very wide range of activities, whose exact requirements depend on many contextual factors. This makes the electricity use patterns less predictable than household consumption.

These four different categories of customers will have different willingness to pay, depending on their uses and budgets, while requiring different types of infrastructures, depending on the appliances they have to connect, how much they consume, and when. Table 1, taken from the Mini-grids policy toolkit, and using the SE4ALL model (RECP, 2014) outlines energy access services, going from tier 0 (no power supply) to tier 5, and the minimum technology needed to serve the needs in each tier.

Mini-grid companies are increasingly defining different risk/revenue/cost strategies and building more precise business models. Until recently most were characterised according to energy sources, ownership (utility, hybrid, private or community operator models (see RECP et al. 2014) or broadly considered as Distributed Energy Service Companies (DESCOs) (see Bardouille and Muench, 2014), but none of this gives insights concerning strategies and business choices.

Brix Pedersen (2016) characterised models into four broad categories, depending on technologies and generating power, before subdividing these according to ownership issues. Here, we discuss and develop her classification, showing the various strategies at stake. We believe it is also important to highlight Power Purchase Agreement grids (PPA), which depend on an up-front contract between the operator and a buyer (in the case of Tanzania, the national utility).

- **Pico-grids**, including **Low Cost DC Grids**, going from 0.5 to 5 kW, provide the simplest viable and replicable solution (comparable with SHS), supplying energy mainly to households, which are more predictable and require less power (for example the companies Devergy in Tanzania, Mesh Power and Mera Gao Power in India). They reduce demand risks by consistently developing small scale business models with easily predictable consumption patterns.

Table 1: Summarising the different characteristics of energy access services, from the Mini-grids policy toolkit

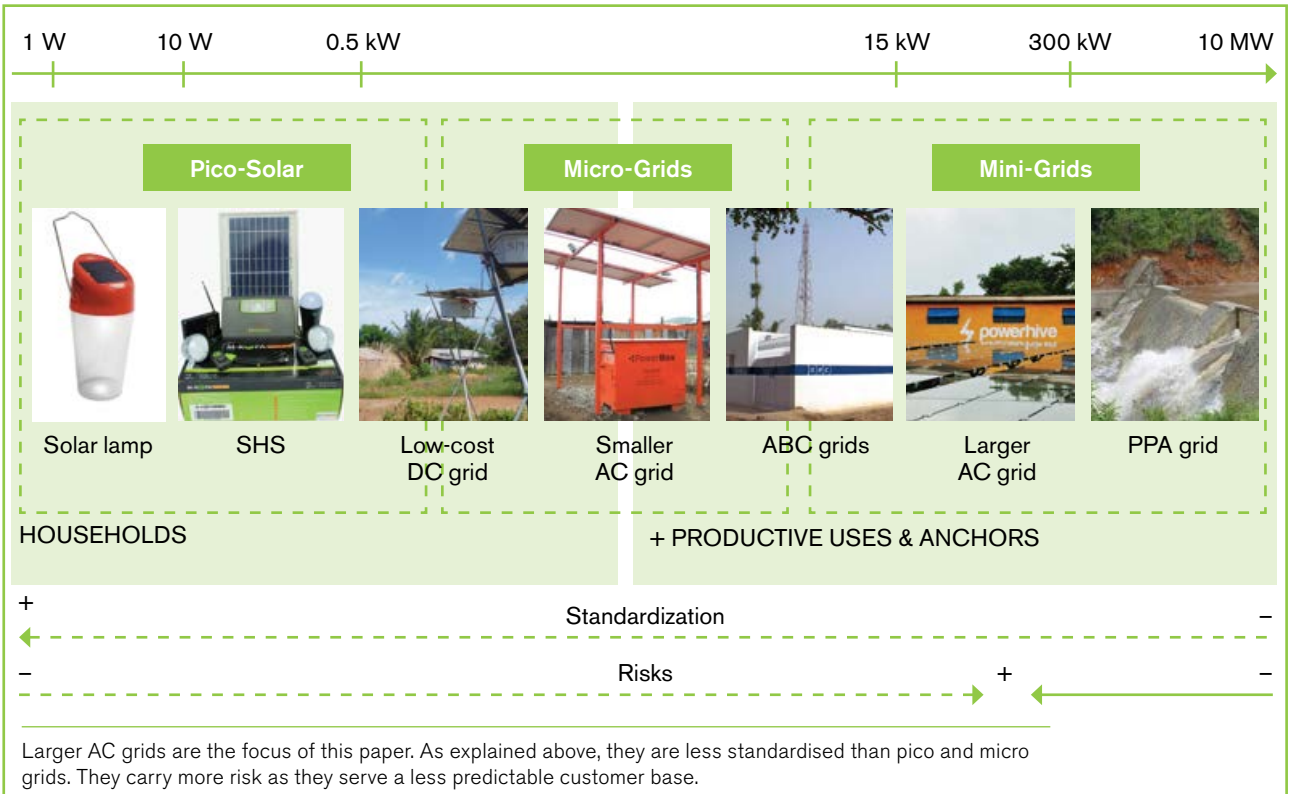
ENERGY ACCESS ACCORDING TO GLOBAL TRACKING FOR SE4ALL	NO	BASIC		ADVANCED		
Attributes	Tier-0	Tier-1	Tier-2	Tier-3	Tier-4	Tier-5
Services		Task light AND phone charging	General lighting AND television AND fan	Tier-2 AND any low-power appliances	Tier-3 AND any medium power appliances	Tier-4 AND any higher power appliances
Peak Available Capacity (Watts)	–	> 1W	>20W/50W	>200W/500W	>2,000W	>2,000W
Duration (hours)	–	> 4 hrs	> 4 hrs	> 8 hrs	> 16 hrs	> 22 hrs
Evening supply (hours)	–	> 2 hrs	> 2 hrs	> 2 hrs	> 4 hrs	> 4 hrs
Affordability	–		✓	✓	✓	✓
Formality (legality)	–			✓	✓	✓
Quality (voltage)	–			✓	✓	✓
Indicated minimum technology		Nano-grids/ Micro-grids, Pico-PV/ Solar lantern	Micro-grids/ Mini-grids, Rechargeable batteries, Solar home sytems	Micro-grids/ Mini-grids, Home systems	Mini-grids AND grid	Mini-grids AND grid

Source: RECP et al. 2014

- **Small (standardised) AC grids**, between 0.2 and 15 kW, which are increasingly integrated into containers, to reduce logistics and manufacturing costs. These also tackle households and a few easily predictable productive uses (PowerCorner, Steamaco, Rafiki Power, all in Tanzania, are good examples, and all source their equipment from the same partner: PowerGen). Standardised AC grids, may require light handed regulations with easy approval processes so they can scale quickly and reduce initial development costs. They may also benefit more from output based aid (such as grants based on the number of connections, independent of the quality of the service). They need a strong local availability of efficient appliances to ensure demand, as they focus on quantitative results and cannot afford too much effort on developing logistics networks.
- **ABC grids** (Anchor-Business-Community grid models, which prioritise those three income streams in that order) partner primarily with anchor customers to ensure a certain level of sales. Given the variable size and type of anchor customers, an ABC strategy may lead to small or big grids, and more or less replicable projects. An ABC model puts the focus on serving less risky customers. Therefore, some PPA grids and larger AC grids could be labelled ABC grids. However, in practice most ABC grids we have observed seem to be the fruit of previous and long term-relationships, as in the case of Rift Valley Energy, which is a subsidiary of an agri-business, or OMC Power and Linksoft, which are specialised energy service companies for telecom towers. Such actors could benefit from linking mechanisms such as matchmaking platforms to help newcomers find partners more easily, and thus accelerate rural electrification. In addition, they may need technical support to design and build appropriate assets (especially for hydropower). Nonetheless, It is important to note the ongoing consolidation process following the massive adoption of telecoms tower-sharing practices (see http://www.towerxchange.com/). This makes partnerships with private mini-grids less interesting for telecom companies, who may now prefer to work with a few specialised Renewable Energy Service Companies (RESCOs). Nonetheless, we have noticed that these tower RESCOs are eager to become CEMGs themselves, or at least sell energy to specialised customers.
- **Larger AC grids**, going from 15 to 300 kW, try to capture the overall consumption of specific localities/districts in remote areas that are often hard to connect to the national grid. This business model was the focus of our investigations (JUMEME is our prime example). This category sometimes blurs into ABC grids and also PPA grids (next) as many AC grid developers look to the ABC model and opportunities to feed anchor customers or the national grid (Brix Pedersen, 2016). For example, CEFA and ACRA will soon begin to feed into the Tanzanian grid. However, in general these grids sit somewhere between the pico and standardised small AC grids on one hand, and the larger ABC models on the other. They must start with highly efficient and proven technical systems, business models, and strong financial support. JUMEME, for example, was launched by the German company Inensus, (http://www.inensus.com/). They may exhibit some of the risk-mitigations strategies explained above, but target a region's overall consumption and in particular rely on PUE, generally resulting in riskier models. Because PUE often increases more slowly than expected, these grids may need to develop strong partnerships with NGOs and value chain consulting companies (such as E4I & Excel Hort in the case of JUMEME, see below). Links with consolidated agribusiness and distribution actors may be needed to bring agricultural product processing back to the locality (generating PUE) or to access external markets more easily. Inensus is currently advocating for 'match-making platforms' that could help connect rural electrification developers and agricultural value chains experts. Partnership with anchors such as telecom towers can also be a way to decrease risks. Since PUE potential varies with regions, depending on local agricultural resources, as well as infrastructures, these grids may focus on specific resource rich areas (with cash crops for instance) that are far enough from the main grid to ensure long-term cash flows and to lower the risk of a sooner-than-expected national grid arrival (Share Value Initiative and FSG, 2016). Indeed national grid arrival presents these grids with considerable risks. Their R&D process is longer and costlier than smaller grids, while their generation assets are less flexible and often lack specific business-to-business PPA contracts. This makes them unable to compete with the low national tariffs. Consequently, they require clear frameworks and laws concerning tariffs and national utilities' arrival.
- **PPA grids**, above 300 kW are a bigger type of ABC model. They focus on the least risky customer of all – the National Grid. Supplying small businesses and households is more of a sideline. Tanzanian examples include Rift Valley Energy, and future projects from CEFA and ACRA.

Figure 1 summarises the different types of mini-grids. It shows how very small grids may be similar to standalone products, such as a solar home system or lamp, in terms of their capacity and customer base.

Figure 1: A characterisation of mini-grids



Larger AC grids are the focus of this paper. As explained above, they are less standardised than pico and micro grids. They carry more risk as they serve a less predictable customer base.

Of course, our characterisation of grids is a simplification. Private projects do not necessarily arise from economic rationales. Often people simply decide to build a plant and serve a locality or region, convinced by their own business plans. Alternatively, they may want to secure the best resources first (as with hydro resources in Tanzania). Others have primarily social or political objectives. CEFA, an Italian NGO operating in Tanzania, built its first dam to power activities that were part of a rural development programme in Southern Tanzania. The locally owned company created has now become an important private actor in the area. And both CEFA and ACRA see grids serving multiple villages as non-political governance tools (Best and Garside, 2016).

Additionally, characterisation is dynamic, and usually each model is adapted to a specific area. An increasing number of companies are thus exploring multiple models. Companies such as Ruaha Energy or Virunga Power in Tanzania are developing a portfolio of various types of CEMG. Some NGOs like CEFA are switching from a community based to a private approach. Mini-grids business models may also have other features, such as integrated water access (as with RVE.SOL), or may take 'productive uses only' strategies (as does the NGO GERES ,which is developing a concept of grid exclusively targeting village activities).

Energy Kiosks are another effective model, and partner with a local entrepreneur to sell different products or services in the village (lamps, phone chargers, printers). They are an important but under-supported segment of energy access (See Knobloch and Hartl, 2014 for a first benchmark). Still, some actors (including SolarKiosk) are designing disruptive models that could prove to be very efficient, providing a wide range of additional services to the community, such as Wi-Fi.

2.2 The challenges of developing PUE alongside Clean Energy Mini-Grids

Serving productive uses of energy is seen by some as a key characteristic and advantage of the emerging mini-grids industry (Knuckles, 2016). Until recently, addressing PUE has been difficult. Diesel generators may not be cost-efficient to run when consumption levels vary strongly, and before low-cost and pre-paid smart meters emerged, managing consumers was tricky. In contrast, CEMG now offer great possibilities for powering high-consuming activities during the day since they often have very little variable cost compared to diesel powered grids (switching on a diesel generator the whole day to power only a few local activities with

varying consumption may prove unviable). Nonetheless, addressing consumption peaks, usually at nightfall, still requires either costly storage capacity or diesel back-up.

Firms tackle PUE in many ways. However, our impression is that commercial websites make strong claims, but the real scale of PUE impacts might be limited or very varying. For instance, connecting a few shops and a barber in a village is very different from supporting and training profitable welders, or developing local value chains, but both might be presented on the same level as targeted PUE. Part of the problem is that developing PUE involves addressing the many challenges that prevent rural entrepreneurs from launching businesses and running them effectively. By compiling research made by Best (2016), Willcox et al. (2015) and Kooijman-van Dijk (2008), and drawing on our own experience, it appears that certain actions are required in rural Sub-Saharan Africa:

- **Areas attempting to grow PUE first need a structured and extensive assessment** of economic potential (main activities, access to infrastructure);
- **Sufficient reliable power must be provided**, i.e. generation assets, and sometimes also batteries, must be enlarged, especially when connecting motor-based activities;
- **Power companies must be able to set adapted customers' tariffs** that reflect costs and willingness to pay, potentially allowing cross subsidization between customers (this is when a customer with higher means, such as a business, is charged higher tariffs per kWh, subsidizing indirectly the lower tariffs charged to poorer customers);
- **Links must be created with other actors** such as agro-businesses, to build on complementary skills. Analysing the local agricultural value chains for ways to improve productivity can be a good way to increase revenues and allow more advanced electricity sales and impact. If the electricity supplier does not have sufficient skills or time to address such needs, partners are needed;
- **Awareness raising** is needed to help inhabitants understand how they can use electricity; this may require the help of NGOs or locals with a connection to the community or knowledge of the field;
- **Capacity building and micro business development support (BDS) is needed** to help newly connected and future entrepreneurs to run their business properly, ensure optimum use of machines and avoid failures such as falling into an 'electrification trap' (see Box 1);
- **Entrepreneurs need increasing access to finance** to invest in assets or build working capital. This may require partnerships with micro-finance institutions or the use of new mobile finance solutions;
- **Previously unavailable appliances** may need supplying in the area.

3

Tanzania: Regulatory Environment and Rural Economy

With only 15.3 per cent of its people having access to electricity, falling to 3.6 per cent access in rural areas (See World Bank Open Data), Tanzania has one of the lowest electricity access rates in the world. The difficulty in reaching landlocked rural areas and the lack of links between industries make the overall situation particularly challenging. Nevertheless, the government is developing an advanced and innovative rural electrification regulatory framework incentivising private mini-grids (including those based on productive uses). Tanzania's renewable resources available for rural electrification are almost unlimited (RECP, 2015). The main source of renewable energy is hydropower in the Southern mountain regions. The country's total additional hydropower capacity is estimated at 4,000 MW. Small hydropower (< 10MW) potential capacity is estimated around 480 MW, and is seen as a particularly interesting way to expand rural electrification. However, hydropower generation assets can be highly vulnerable to droughts, and they are only available in specific areas. Fortunately, Tanzania also has considerable solar energy resources, in particular in the centre of the country, with around 4–7 kWh/m^2/day available. Tanzania's grid-connected PV resource is estimated at 800 MW, with off-grid areas offering even more. In some areas, wind and geothermal resources appear promising for grid-connected plants; but further assessments are needed.

3.1 Tanzania's main mini-grid projects

In Figure 2 and this discussion we present the main private projects our research detected. This list is not exhaustive, because it is difficult to find accurate data on current projects. Many new projects have been launched recently (and have not yet scaled up or proved their feasibility or profitability). This trend reveals the attractiveness of the Tanzanian landscape and the shift towards private projects within the emerging mini-grid industry.

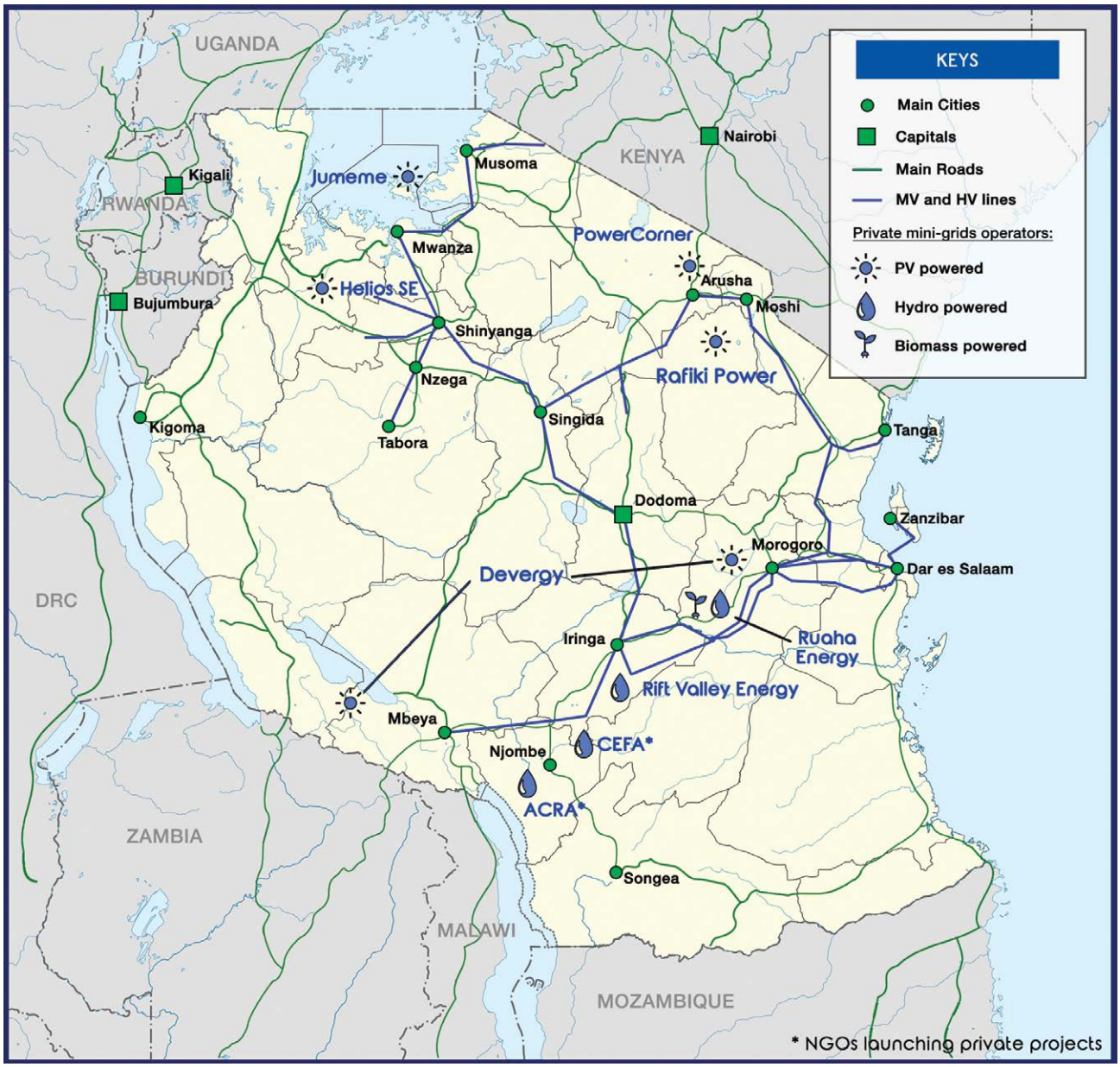
Rift Valley Energy built its one and only 4 MW hydropower plant in 2012, in order to power the parent company's tea factory and sell electricity to TANESCO (the national utility company), while connecting nearby villages. This big scale project has been made possible by Tanzania's facilitating regulations regarding connection and sales to TANESCO.

Two NGOs, **ACRA** and **CEFA**, are also acting on these regulations and increasing the sizes of their projects to be able to sell electricity to TANESCO and then secure revenues. An interesting trend is that both NGOs are willing to develop private projects, financed through private funds (Best and Garside, 2016).

Many other small-scale private energy suppliers have recently been launched. The oldest we could find, **Devergy**, was created in 2010, and has until now mainly developed small scale solar DC grids of less than 5 kW. **Rafiki Power**, owned by E.ON Off Grid Solutions, launched its first project in 2014 and has ambitious plans to scale up quickly, implementing standardised solar AC grids with a minimum capacity of 6 kW. **Ruaha** launched its first project in 2015. This business intends to develop off-grid hybrid biomass/PV projects using technology developed by **Husk Power** in India (which alongside **Redavia**, is a partner in the business). Ruaha also plans utility-scale hydro projects selling to TANESCO. **JUMEME** only became operational on Ukara Island at the beginning of 2016, launching its first hybrid PV/diesel plant. Meanwhile, **Helios SE** should be launched in 2017 near Mwanza, and **Power Corner** has recently commissioned its first small AC grid in Arusha region and intends to scale quickly within and out of Tanzania, as part of ENGIE's strategy to increase its footprint in the energy access industry.

In general these actors are competing for the most interesting areas (lower levels of poverty, higher population densities, specific natural resources).

Figure 2: Main private mini-grids operators in Tanzania



3.2 Light handed regulations: benefits and limits

3.2.1 Well-designed rural electrification regulations assist projects developers

Tanzania's energy sector has been the target of various institutional programmes providing funds, but also technical support, to help design a proper framework. (See Annexes 1 and 3). TANESCO, the state owned power utility, has undergone progressive decentralization and privatisation. In particular, Independent Power Producers (IPPs) have been progressively allowed to participate in the generation process by feeding the national grid, and by distributing power, allowing the integration of mini-grid operators (Gökgür et al., 2005).

Current government bodies comprise EWURA (the Energy and Water Utilities Regulatory Agency), created in 2006, which is in charge of approving independent projects, their tariffs, and designing regulations; and the REA (Rural Electrification Agency), created in 2007, to finance rural electrification projects and manage grid-extension programmes. The Ministry of Energy and Minerals centralises all the initiatives, and is responsible for defining the strategies followed by the different bodies. It has recently published an Action Plan and Investment Prospectus in the frame of SE4ALL support, setting out the different steps needed to achieve access to electricity goals, and also publishing the Energy Supply Industry Roadmap 2014–2024 and the SREP investment plan (see Annex 4).

Following the Electricity Act of 2008, Tanzania's government decided to take the path of light-handed regulations. It aimed to foster rural electrification projects by reducing long due-diligences processes and giving operators more flexibility when building their business models. Accordingly, EWURA has developed an exemplary Small Power Producers regulatory system (Tenenbaum et al., 2014, and see summary below). Small Power Producers, or SPPs, are those with a generation capacity of 0.1 to 10 MW. Standardized Power Purchase Agreements and Guidelines were designed to stimulate SPP development, and these projects were authorised to sell electricity directly to consumers with excess sold to TANESCO (Tsakhara, 2015).

But while SPPs have been widely developed, only a few bigger IPPs have been established. One challenge is the tariffs proposed to IPPs: currently the government sets its tariffs without considering the production costs, making investment unattractive for big private actors.

Tanzania's Small Power Producer (SPP) regulations summarised:

- SPPs with a generation capacity below 1 MW do not need any licence from EWURA and must simply have their projects registered by regulators (Tenenbaum et al., 2014);
- SPPs are allowed to set the tariff they desire, and can set different tariffs for different customers (sometimes termed 'cross-subsidisation') (EWURA, 2016). SPPs ranging from 100 kW to 10 MW, must have their tariffs approved by EWURA; but projects generating below 100 kW do not need tariff approval. However, if more than 15 per cent of customers complain, EWURA has the right to review tariffs set by these SPPs (Tenenbaum et al., 2014);
- A feed-in-tariff system has been developed to facilitate electricity sales to TANESCO, either through the national grid or one of the mini-grids managed by the utility (Tenenbaum et al., 2014);
- Standardized Power Purchase Agreements have been designed to ease the process of connecting SPPs to the national grid. These are particularly adapted to mini-hydro, wind and biomass power projects (Tenenbaum et al., 2014);
- Grants have been provided through TEDAP (Tanzania Energy Development and Access Project). These are now coming to an end, but will be replaced soon (Tenenbaum et al., 2014):
  - A grant covering up to 80 per cent of the pre-feasibility study costs has been available. The last 20 per cent must be paid by the developer, and the maximum grant is US$100,000
  - A performance grant of US$500 is given to operators for each new connection of a customer using renewable energy sources (be it to a mini-grid or a standalone system);
- In 2005, the government exempted solar products from the 20 per cent VAT;
- For systems below 100 Wp, TEDAP reduced the consumer costs by subsidising 2$/Wp per system sold (Hansen et al., 2015).

These light handed regulations and associated grants are a major step that has encouraged development of private mini-grids. They have let businesses start with reduced risk and use legally backed initiatives to test rural electrification fundamentals. Some then turn to different impact and revenue oriented strategies. Virunga Power, for instance, is a rural electrification operator currently launching projects in Kenya and Tanzania. Its generation will initially be connected to the national grid, so the company can assess consumption

patterns of households and local SMEs without risk to revenue. However, the longer term goal is to switch to completely off-grid AC programmes, according to CEO Brian Kelly.

Similar favourable regulatory frameworks are now being designed and implemented in a few other innovative African countries, including Rwanda and Nigeria. Some of the frameworks provide increased 'visibility' on when national (or privately owned regional) grids might arrive. This is important because these initiatives can totally destroy local private mini-grids by supplying cheaper electricity, and by facilitating land acquisition for the new operators. Readers seeking more detail on private renewable energy mini-grids' regulations throughout the world will find a comprehensive and very recent publication from IRENA (2016) provides a strong update to Tenenbaum et al (2014).

3.2.2 Potential improvements to foster more PUE

Our study finds that although Tanzania's light regulations favour certain types of mini-grid business models, they are not yet incentivising projects to focus on their service and social impact, nor to address the barriers preventing PUE development.

The regulations seem to mainly favour projects that are cheap and that can scale quickly, connecting many households. A major example is the performance grant, which depends on the number of connections, making no distinction between type of customers reached or services delivered. Similarly, allowing only mini-grids below 100 kW to set their own tariffs may encourage operators to limit their sizes, and thus to limit the number of PUEs connected. Small solar projects are exempted from environmental assessments on a case-by-case basis, which reduces complexity and transaction costs and also encourages businesses to stay small.

Government grants are apparently being reviewed as TEDAP ends, and will be replaced by another programme managed by the Renewable Energy Agency, and financed by development agencies SIDA and DFID. The new programme is currently being designed, and will set different subventions in support of the energy access service mini-grid projects offer. As yet, no definitive framework has been made public. Nonetheless, we believe that such tools, incentivising projects to improve their offer, is the way forward to ensure a reliable and good electricity supply to rural areas through the private sector.

At the other end of the spectrum, bigger plants connecting to the national grid are already offered many benefits. Indeed, hydro-plants operators in the south seem to be all going in the direction of grid connection to ensure commercial viability. ACRA and CEFA are both increasing the size of their projects, to be able to sell a part to the national grid and secure their revenues. While commercially sensible, this means projects are less incentivised to simulate PUE in order to secure revenues, especially since tariffs to local customers are set much lower when connected to the national grid, and businesses have only recently started thinking about stimulating PUE. For example, Rift Valley Energy, which is selling the vast majority of the electricity it produces to the national grid and a tea processing factory, sees the share of revenues from villages connected reduced only to a tiny amount.

To sum-up, Tanzania's light regulations are, in our opinion, essential but not sufficient to stimulate mini-grids that primarily serve local areas and develop PUE. Fostering such grids needs more investment and research. Businesses considering a reliance on PUE face additional risks that are not directly balanced by any regulatory or financial rewards, since these have so far been more directed towards projects targeting low-income household consumption.

3.3 Tanzania's rural economy: bottlenecks and opportunities

3.3.1 The rural economy

Tanzania's rural non-farm economy is limited, representing only 10 per cent of employment (Reardon 2010). Figures reported by the World Bank (World Bank, 2007), based on a Rural Investment Climate Survey performed by Tanzania's National Bureau of Statistics, records that 86 per cent of household cash income comes from farming and notes most rural inhabitants are smallholders dependent on rain-fed agriculture. This makes them highly vulnerable to climate, competition and the price fluctuations that emerged after the agricultural liberalisation of the 1980s (Skarstein, 2005). It also means agricultural seasonality strongly influences all rural businesses' sales, supply of raw materials and workforce (World Bank, 2007).

Clearly, rural households face income insecurity, making it more difficult to create and run non-farm businesses. Of the few that exist, most are self-employed entrepreneurs. Often, they are aware only of limited possibilities, and mainly imitate what they see in their village or nearby. This can easily result in a market with high offer but very limited demand. The World Bank reports in the same paper that 57 per cent of rural businesses are in wholesale, 21 per cent

in rural services (personal services, hotel, restaurant), 19 per cent in production (mainly manufacturing and agro-processing, ie carpenter, miller, or welder), and 0.5 per cent in financial services.

However, Tanzania's tremendous agricultural resources constitute opportunities to stimulate the rural economy and even develop further exportable products. Major food crops are maize, cassava and paddy, with maize being by far the most cultivated. Other important crops are sorghum, rice and banana. The main exported crops are cotton, tobacco, nuts and coffee. (African Economic Outlook, 2016).

Because of varying rainfall, irrigation provision and productivity, there are important inequalities between regions. Southern and western areas have high food self-sufficiency levels. Northern regions have a particularly good climate suitable for horticultural crops. Good access to roads and airports makes production for export crops an attractive proposition here. Central and northern regions have high potential for milk production (Promar Consulting, 2011). Lake Victoria's region is of course rich in fish.

3.3.2 Limits and leverages for stimulating the rural economy

Resources are under-used. Today only 22 per cent of Tanzania's arable lands are harvested (95 000ha of 440,000 ha in total, Promar Consulting, 2011). Yet productivity could triple with fertilisers, irrigation and better management (Promar Consulting, 2011), which could eventually stimulate the rural economy, particularly agricultural processing, and so drive PUE. Tanzania is currently importing agricultural products that could be produced locally (for instance sunflower oil). Additionally, developing exportable products such as fish, tea or coffee in certain areas could also be a basis for PUE within rural electrification mini-grids.

Despite rural Tanzania's strong dependence on growing food, a shift is beginning. Rural households are increasingly getting income from rural non-farm activities. Reardon (2006) notes both pull factors (eg local demand for non-farm products) and push factors (eg risk alleviation strategies) that imply a willingness/need to engage in the non-farming economy.

Nonetheless, given disparities in agricultural and renewable energy resources (see https://www.reeep.org/tanzania-2014) in addition to the poverty and electrification levels mentioned above in 3.1, we believe that a strong competition will emerge among CEMG operators for areas with the highest economic and energy potential. This raises an important question for policy makers. Should access to these resource-rich areas be left to evolve, or should policy-makers carefully match resource-rich regions to the most promising projects through tenders?

Limited access to financial capital is a serious constraint. It forces potential entrepreneurs to gather funds from informal lenders, from their vulnerable agricultural activities and/or from their relatives. They rarely have access to formal credit, and when they do, they often lack the skills needed to use it and find the cost very high as well as the lending timescales too short. On the other hand, Microfinance Institutions and local bank interventions are hindered by very high transaction costs and repayment risks (due to seasonality of agriculture but also to population dispersal) relative to the amounts proposed. Nonetheless, financial cooperatives known as SACCOS (Saving and Credit Cooperative Societies) have been developed. The World Bank (2007) reported 1870 SACCOS across Tanzania, offering share capital, loans and grants. Certainly, Tanzania has interesting options that could help entrepreneurs buy equipment. Indeed, CEFA, which has been involved in rural electrification for more than 30 years, is now launching bigger projects with consolidated private actors. They created a successful community-based company to manage their mini-grid and also run agricultural and social projects. CEFA formed a local SACCOS (we were able to interview the manager), which they financed with a TZS 20 million long-term revolving loan (around US$ 9,000). This fund helps farmers get inputs or fertilisers and supports local entrepreneurs. It has gathered 320 members and is still working on expanding and on training local people about the responsibilities a loan brings.

Lack of managerial and accounting skills restrict local businesses. The entrepreneurs we interviewed (mainly carpenters, millers and welders) in the villages electrified by ACRA kept no books, even five years after having launched their business. They had no figures concerning sales or expenses that could indicate successes or failures. However, this lack is also a lever. Building entrepreneurial skills will foster PUE, and if project developers follow up the businesses they support they can gather valuable data.

Itundu village in the Njombe region (Arthur Contejean)

Infrastructure is another crucial factor. The village location, and proximity to other villages, towns or roads is pivotal in offering access to finance, markets, and even education. Tanzania's poor road coverage stops rural businesses reaching external suppliers and markets easily. Each year, heavy rains still isolate around 40 per cent of the communities that do have road access. For example, in ACRA's area in the South, driving 100 km to reach the nearest town (where inhabitants were getting petrol and raw products) takes 4 hours and is impracticable for two to three months during the rainy season.

Dominant activities pose a further constraint. On Ukara Island, for example, the economy depends largely on fish revenues, and their fluctuations hugely influence all other economic activity.

Social structure may also be playing a role. In contrast to Tanzania, Kenya's demand for rural electricity came partly from an already-established rural middle-class that had emerged thanks to high agricultural productivity and an entrepreneurial culture. This agricultural middle class is almost invisible across much of Tanzania. At the same time, Tanzania's socialist history may be slowing the development of a dynamic private business culture. (Hyden, 1975).

Poor links between CEMGs and other industries are another factor limiting rural economies: but improving such links offers a potential lever for success. Inensus, for example, has called for a new matchmaking platform, because informal messages shared through local Chambers of Commerce have not proved as efficient as expected. Inensus CEO Nico Peterschmidt says the objective of such a platform would be not only to "attract industries into rural areas" but also to open "sales channels for rural products". The Alliance for Rural Electrification (an industry association) has been designing tools to foster partnerships (see their Match-Making platform http://www.ruralelec.org/matchmaking-platform). Other organisations, such as the Match Maker Group (http://www.matchmakergroup.com/), and AgriInsight (http://agriinsight.com/) could also anchor such initiatives. A "Value Chain Wiki" accessible on MicroLinks' website (https://www.microlinks.org/using-value-chain-development-wiki) is collating valuable insights and case studies. Regional

NGOs such as One Acre Fund also remain important actors. A strong ecosystem is emerging in neighbouring Uganda, where the European Union has launched its first 'Small Agribusiness Fund'. Panafrican start-ups are being launched to improve logistics and certification processes (FarmForce, Traceability, Metajua) or provide (working capital) finance mechanisms to agricultural small- and medium-sized businesses.

Links between ICT companies and CEMGs are similarly limited. This is in contrast to the links between ICT companies and SHS distributors, which have been rapidly strengthened, as illustrated by GSMA's reports. There are numerous formal partnerships such as between Mobile Telecommunication Networks (MTN) and Nova Lumos in Nigeria, but also more recently between Orange and Engie-backed SHS companies in Western Africa. In these relationships Mobile Network Operators and SHS companies have built on reciprocal benefits. SHS increases mobile money adoption, decreases phone charging costs and eventually increases average revenue per user. Meanwhile, Mobile Network Operators (MNO) provide strong distribution networks and payment solutions.

Creating such links between MNOs and CEMGs in Tanzania seems difficult given the lack of organisation of the mini-grid industry, and the lack of incentives from MNOs. However, recent innovations such as "mAgri" tools are providing opportunities for remote farmers, fishermen and livestock herders to participate and integrate into markets. Different organisations and projects such as ICT4AG, FeedtheFuture & Agrilinks (USAID), E-agriculture.org, GSMA, Connected Farmer Alliance and Agritools disseminate useful news on those developments.

3.3.3 Key messages for mini-grid operators in Tanzania

Our anaylsis suggests a few key messages for mini-grid operators:

- Given the potential synergies, **operators wanting to stimulate PUE should try to develop local agricultural activities, and create opportunities to build bigger assets**. For example, JUMEME and E4I are currently trying to expand fish processing activities, thus using the local resources. However, creating these synergies may require mini-grid operators to perform value chain analyses that are not part of their usual core competencies.
- **Stimulating local agricultural activities will also create a virtuous circle of rising local standards of living and rising demand for PUE.** However, such indirect impacts may take time to arise.
- **Mini-grids operators should favour dynamic areas with existing resources that have a minimum access to infrastructure such as roads.** Ideally, sites should already have activities that could be connected directly to a mini-grid, but also other activities with longer-term potential. Operators should assess nearby villages to understand how the regional economy works and if the neighbourhoods could constitute a viable market.
- **Operators should avoid supplying many similar activities, which can produce a market with high offer but inadequate demand**.

One thing is certain: the energy-agriculture nexus in Sub-Saharan Africa, and especially in Tanzania, is evolving quickly and only innovative actors will remain competitive.

4

JUMEME Case Study: A practical example of a PUE-Oriented Business Model

The JUMEME business model gathers most of the latest innovations and findings in the field of rural electrification through mini-grids. It also integrates PUE as a core feature, addressing many of the hurdles preventing households from starting viable economic activities. This case study shows that it is possible for private projects to implement such initiatives, and that, if implemented wisely, they seem to be an effective way to maximize a mini-grid project's revenues and reach profitability while also having an important social benefit.

4.1 A private model maximizing the impact of electricity for local people while optimising commercial success

The first JUMEME mini-grid was launched at the beginning of 2016 on Ukara, an island of 37,182 inhabitants located on the Lake Victoria. A modular 60 kWp solar plant, a 33 kVA diesel genset and a 240 kWh battery bank have been installed near Bwisya, the major village of the island. A three-phase network allows a high quality service to households and SMEs. By February 2017, 249 connections had been established in Bwisya, the only electrified village at that point. The strategy is to upgrade the existing plant powering Bwisya to 90 kWP and extend the connections to one nearby village. Then the operator wants to start building, in March 2017, two other independent power stations of 50 kWp and 60 kWp to connect the six other villages of the island.

JUMEME is a joint venture between Inensus, St Augustine University of Tanzania, TerraProjects and RP Global. Each offers expertise in different fields. Established since 2005, **Inensus** has been one of the first private clean energy mini-grid operators in Africa, and is building on this long-term expertise. Through the company Enersa (Energie Rurale Sahélienne) that Inensus founded in Senegal in 2010, a tariff model was developed offering prepaid electricity 'blocks' (setting a power limit and a fixed authorised amount of electricity over a set time that might or might not be used). In JUMEME, Inensus have mixed this with "Pay-as-you-go" features (PAYG – meaning you pre-pay for a set amount of power, buying in increments that match one's cash flow) to allow customers more flexible consumption patterns. Austrian companies **RP Global**

and **TerraProjects** are specialists in renewable energy investment and project management. **St Augustine University of Tanzania** is a local university providing skilled human resources, helping train future business people, and serving as anchor in the region.

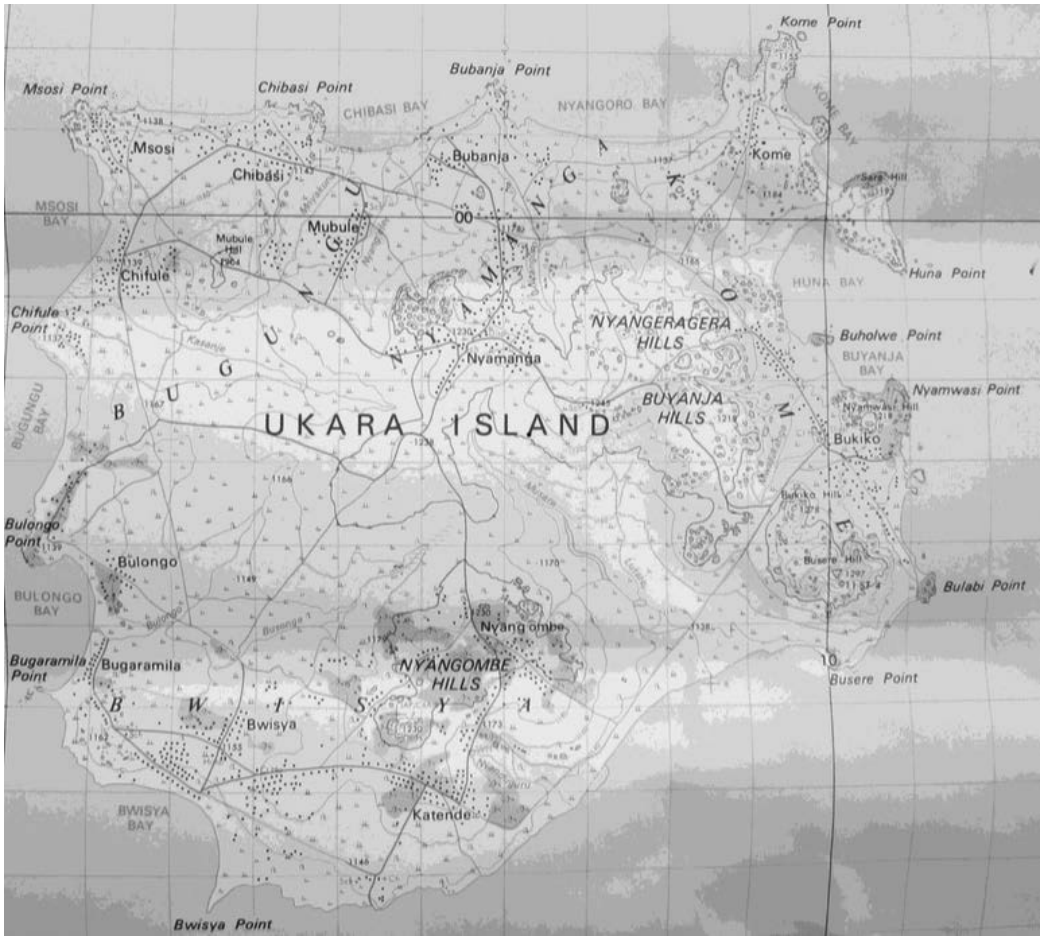
JUMEME is also partnering with **Energy4Impact (E4I)**, formerly the Global Village Energy Partnership (GVEP), an expert in developing energy businesses in East Africa. E4I is responsible for stimulating entrepreneurs and attracting investors. **Excel Hort Consulting**, another partner, is based in Uganda and brings expertise in developing and improving agricultural and agribusiness value chains in the region. It is responsible for analysing local agricultural production, identifying opportunities, and aggregating and training interested farmers.

As a private company based on real equity, JUMEME needs to reach profitability quickly, and this requires fast-growing demand from households and other PUE. The joint venture optimises how different partners work together by centralising core financial, commercial and technical management of the project through JUMEME, while building strong connections between partners and dividing practical tasks and analyses according to partners' expertise. Interviewees told us JUMEME intends to develop this model further and scale quickly, by expanding into four other clusters in other parts of the region: two on other islands and two on the mainland.

The project has a budget of 16m euro, of which about half is financed by private investments. The rest is covered by grants, including, 7.4m euro from the EU through the ACP EU Energy Facility. Smaller grants are provided by the Energy and Environment Partnership (Southern and East Africa), the Sustainable Energy Fund for Africa (managed by the African Development Bank), the Overseas Private Investment Corporation (OPIC) and the Global Climate Partnership Fund (GCPF) (Nolan, 2016).

Thanks to Tanzania's facilitating regulations for SPPs, JUMEME has been able to set up semi-variable PAYG tariffs that mean households, SMEs, and industrial loads are charged differently at different times. For example, businesses pay less for power in the day than at night. Incentivising business use during the day helps to balance energy demand with production.

Figure 3: Map of Ukara Island



4.2 Maximising PUE development

As Fredrick Mushi from Energy4Impact explained, JUMEME's strategy is to make the project viable by serving very small businesses and also larger projects. The idea is to increase power consumption while improving local living conditions in ways that will eventually indirectly increase households' electricity consumption even further. In other words, local household consumption alone is not enough to ensure AC mini-grids' viability, so businesses that function during the day are an important revenue stream that should also stimulate local growth and eventually indirectly boost revenues from households.

However, productive uses of energy do not necessarily appear by themselves. So JUMEME is simulating them as described below.

4.2.1 Assessing the area's potential

JUMEME chose Ukara island because it offers opportunities to mix electricity services and economic development in an area inaccessible to the grid. Population density is relatively high compared with other rural areas in Tanzania, at 463 inhabitants/km^2 (National Bureau of Statistics, 2012 survey). This means the costs of expanding the network to neighbouring villages are relatively low. And because Ukara is an island, there is no immediate risk of national grid arrival.

Importantly, the island offers many agricultural and economic opportunities for productive uses of electricity. For example, rice is already grown here. JUMEME intends to implement a project connecting farmers with organisations funding water pumps for rice irrigation. Fostering PUE this way should stimulate productivity and electricity sales. Another example is fishing. Although reaching Ukara by ferries from Mwanza (Tanzania's second largest city) takes around six hours (reached by crossing a bigger island, Ukerewe), important fish resources have pushed fish factories to connect the island directly to Mwanza with their own boats.

In fact, there are existing transportation routes that are used to import many everyday life products to Ukara. Inhabitants and shop owners can get food and consumer goods twice a week from a big market on a nearby island. These resources offer a basis from which to build future transport infrastructure which will encourage PUE.

Ukerewe island, Tanzania, on the way to Ukara (Arthur Contejean)

4.2.2 Raising awareness among the population

In order to improve communication and local integration, JUMEME has set up a Village Power Committee, which is in charge of discussing the latest decisions and news related to the electrification project with the population. JUMEME has also launched promotional events and door-to-door communication campaigns to improve customers' understanding of electricity's potential. The company expends a lot of effort in explaining how tariffs are organised, and how financing options can develop.

Overall, JUMEME has created a close relationship with the local population. The company has a shop selling appliances in the middle of Bwysia, the most important village. Staff from JUMEME, Energy4Impact, and Excel Hort are almost always around. For example, E4I staff regularly monitor newly connected entrepreneurs' activities, and know them personally. During our visit, Excel Hort's project manager (who was born and raised on Ukerewe Island) was conducting meetings and interviews with farmers to develop more knowledge on their social organisation and to raise awareness about opportunities such as solar pumps. The idea was to analyse the possibility of creating groups to coordinate farmers' access to what they see as expensive machinery.

4.2.3 Linking complementary skills

According to Nico Peterschmidt, aggregating too many partners adds complexity and increases an organisation's coordination costs. To avoid this, the project centres on JUMEME, and Inensus chose to partner with companies it already had relationships with.

- **JUMEME coordinates and is in charge of the business**

  JUMEME runs the general organization of the project. As well as designing, installing and operating the plant, JUMEME is the main manager of commercial, financial and technical aspects. Concerning PUE stimulation, JUMEME organises market analyses, financial modelling support, and short term loans targeted to interested entrepreneurs. It also supplies engineering support to help connect or adapt machinery.

- **Energy4Impact is taking care of the business support**

  E4I's mission is to identify, support and monitor local businesses. Initially, they stimulated existing small businesses. They have been incentivising entrepreneurs (millers, carpenters, welders etc) to connect businesses and invest in new machines, with financial support directed through a local SACCOS. Additionally, E4I has been assessing the potential for new small businesses, for example an egg incubator and a poultry farm. E4I's objective in Bwysia is to connect at least 50 local entrepreneurs, through tailor-made training, advisory services and long-term mentoring. When we visited the project in May 2016, the company was providing energy to more than 35 small businesses (some of which were newly created). E4I is also helping entrepreneurs to select energy efficient tools and to develop markets.

  E4I's second strategy is to try to develop bigger industrial activities in order to increase wealth creation and energy consumption at a higher scale. E4I has identified local investment opportunities (see Annex 4) and, in late May 2016, held a 'JUMEME B2B Forum' in Mwanza to showcase opportunities to potential investors. They want to attract businesses willing to test new investments that fit with the mini-grid, such as a fish processing factory and drying racks (see later). Some businesses have recently been launched, such as a bakery, an ICT centre, and a poultry farm that can produce 3000 chickens per month.

- **Excel Hort Consulting (EHC) is in charge of agricultural aspects**

  EHC is responsible for all the agriculture-related business development aspects. Its role is to analyse the island's agricultural value chains, find gaps that electricity can bridge, and form Smallholder Farmer Groups to increase access to finance and to boost coordination. EHC intends to provide equipment, such as irrigation pumps and fish dryers.

  Over the longer term, EHC also plans to train farmers, improve their practices and help them diversify into tomato, carrot, and spinach production.

4.2.4 Building capacity and guiding entrepreneurs

As the business skills of local entrepreneurs is low, training programmes, advisory services and mentoring conducted by E4I are key to improving the viability of local small businesses. Training covers four topics: management methods, basic bookkeeping, administrative works (registrations and certifications), as well as productive and effective uses of electricity.

4.2.5 Increasing access to finance

JUMEME is also building links with local and rural banks, SACCOs and MFIs. The company has a project to raise demand for electricity by fostering new businesses that use new machinery. Within the project, JUMEME monitors interactions between customers and microfinance institutions.

To encourage initial take up, JUMEME helped the first businesses with discounts and favourable terms, on a first come first served basis: entrepreneurs only had to pay 10 per cent of the equipment cost upfront (this

was progressively raised to 50 per cent), and a grant covered a further 46 per cent of the purchase price. In addition, entrepreneurs were offered a one-month trial, allowing them to use electricity for free. During this month, Jumeme assessed the business' consumption and adapt its prices. However, this initial incentive scheme has now ended and such subsidies are no longer provided in Bwysia.

In May 2016 E4I initiated an agreement with Ukerewe SACCOS (a Tanzanian micro-finance cooperative) to help extend financial services to other productive users of electricity. These users are working with the project team (JUMEME, Excelhort and E4I) and will be introduced to the SACCOS with a view to becoming members. E4I also decided to guarantee certain loans to help reach entrepreneurs who do not qualify under the existing MFI criteria, and thus finance a part of the losses that SACCOS may face when lending to those borrowers.

4.2.6 Providing a reliable and sufficient power

JUMEME has ensured that its plant will be able to offer enough electricity to supply different uses. For example, when batteries are full during the day and excess energy is available, inverters increase the AC frequency of the distribution network. This is detected by smart meters, which then activate deferrable loads (ie loads where the timing is not critical), such as water pumping for irrigation.

4.2.7 Setting cost-reflective and adapted tariffs

Tanzanian regulations have authorised cost-reflective tariffs, allowing JUMEME to charge higher prices than those set by TANESCO's networks (though JUMEME prices have not yet been approved by EWURA). Tariffs charged are still lower than the cost of using local diesel generators, and bundling them with financing options and services offered makes JUMEME's power attractive to businesses looking to improve their activities.

JUMEME has designed its responsive tariffs after collecting data on entrepreneurs' energy consumption patterns. As solar PV systems generate very cheap energy during the day compared with evening and night (when power must be taken from batteries), daytime power prices have been set around one quarter of evening power prices for entrepreneurs. This incentivises usage patterns that even out potential demand peaks in the late afternoon (TANESCO does not have this flexibility due to regulation constraints). In the end, powering a mill or a solar pump is not much more expensive than it would be through TANESCO if a grid connection were available. Meanwhile, no household connection fees are required upfront: these are financed by the company, with the cost recouped through electricity bills.

However, addressing diverse demands from various types of businesses makes revenues uncertain. To mitigate that risk, JUMEME has implemented a monthly subscription, different for each type of customer.

4.2.8 Supplying appropriate appliances

JUMEME is also sourcing appliances and machines itself, and providing these to entrepreneurs. This helps avoid technical issues and control maximum consumption. It also ensures that local businesses invest in effective, adapted, safe and quality equipment.

4.3 Nile Perch and Dagaas value chains

This section of our case study analyses two specific fish value chains present on Ukara island: Nile Perch and Dagaa.

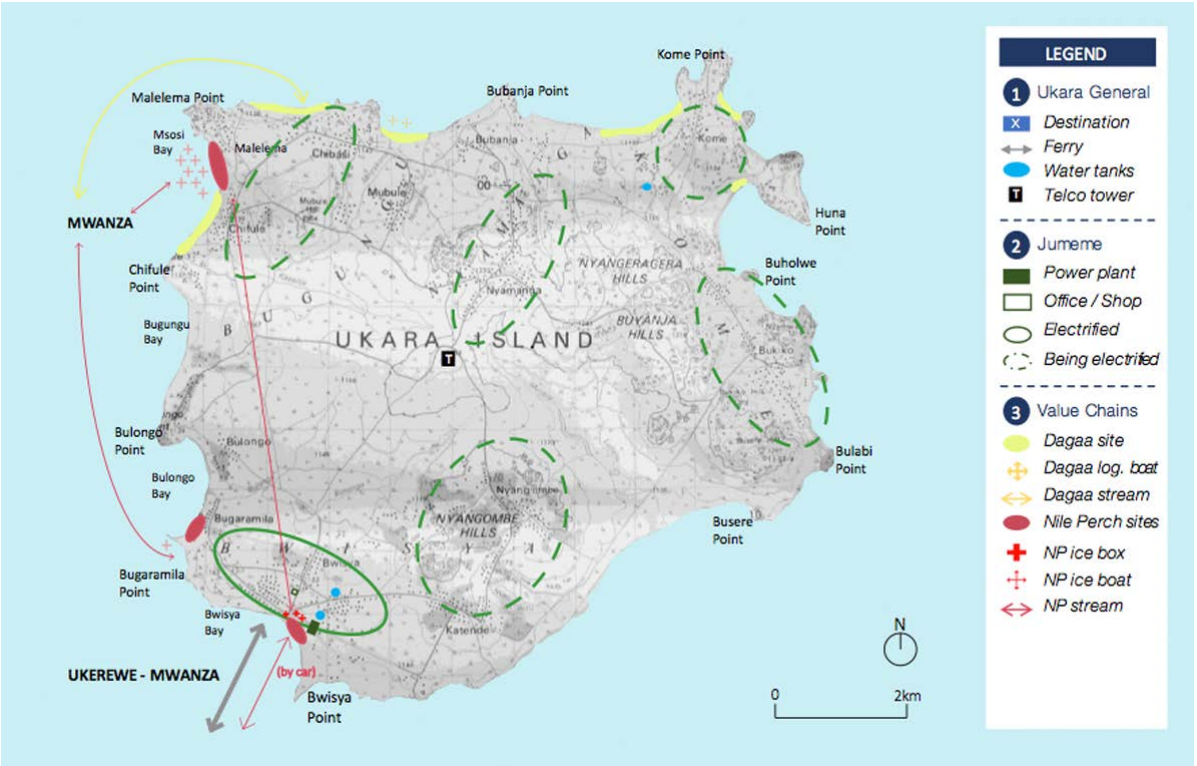
Populations of Nile Perch have been overfished all around lake Victoria. As a result, fishers now also target Dagaas (*silver cyprinids*), which are sold in Tanzanian and neighboring markets. Both these value chains involve fishers and middlemen in Ukara. Fishers, often coming from non-Kara communities, work long hours on the water in risky conditions and have little control over the overall value chain. They usually work for middlemen: boat-owners if fishing for Nile Perch or Tilapia, or camp-owners in the case of Dagaas. These middlemen take half the profit (after recouping the costs of fuel, maintenance, materials and logistics) and split the rest among the fishers.

Dagaa camps are located on flat beaches as fish must be dried right after being caught (Chifule, Chibasi and Kome beaches), while Nile Perch fishing villages are located closer to deeper waters where the fish are found and where refrigerated boats can moor (Malelema, Bugaramila and Bwysia), see Figure 4.

4.3.1 Nile Perch and Tilapia

The whole island catches 20–60 tonnes/year of Nile Perch, of which 70 per cent is sold outside of the island. Tilapia catches are 5–11 tonnes/year, of which 90 per cent is sold outside. Boat-owners sell their fish to local dryers (as seen in Malelema), resellers and restaurants, or to middlemen with whom they have ties (either because they have cooling boxes located in the village, or because they supply ice boats sent by fish factories). Prices depend on fish size. Bigger fish command higher prices as their internal parts, 'Dongo', are valuable when exported to China. Prices are approximately 0–4kg = 4,000 TZS/kg; 5–9kg = 6,000 TZS/kg;

Figure 4: Ukara Map – JUMEME and Fish Value Chains



> 10kg = 7,500–8,000 TZS/kg. Middlemen constitute the only available cold chains and therefore have much power (See the Nile-Perch tilapia current value chain 1, Figure 5).

Besides creating dependency, this lack of local ice supply leads to losing 10–20 per cent of the catches, spoilt before being sold. It also adds costs to the value chain because it encourages boats to overload with ice when leaving Mwanza (bringing higher fuel costs).

Given this situation, JUMEME sees installation of an Ice Block Production Unit as an investment opportunity. Such a unit could add a step in the value chain and thus create considerable value by providing enough ice to avoid fish losses, and by reducing dependency on middlemen (See Annex 4 – Projects Brief). Such a business could help neighbouring islands that are in the same situation. Locally available ice would improve local bargaining power with fish factories in Mwanza. Local ice could also provide raw material for producing local juices, and potentially reduce butchers' losses (and also improve food safety). Of course, this implies increased revenues from JUMEME's perspective.

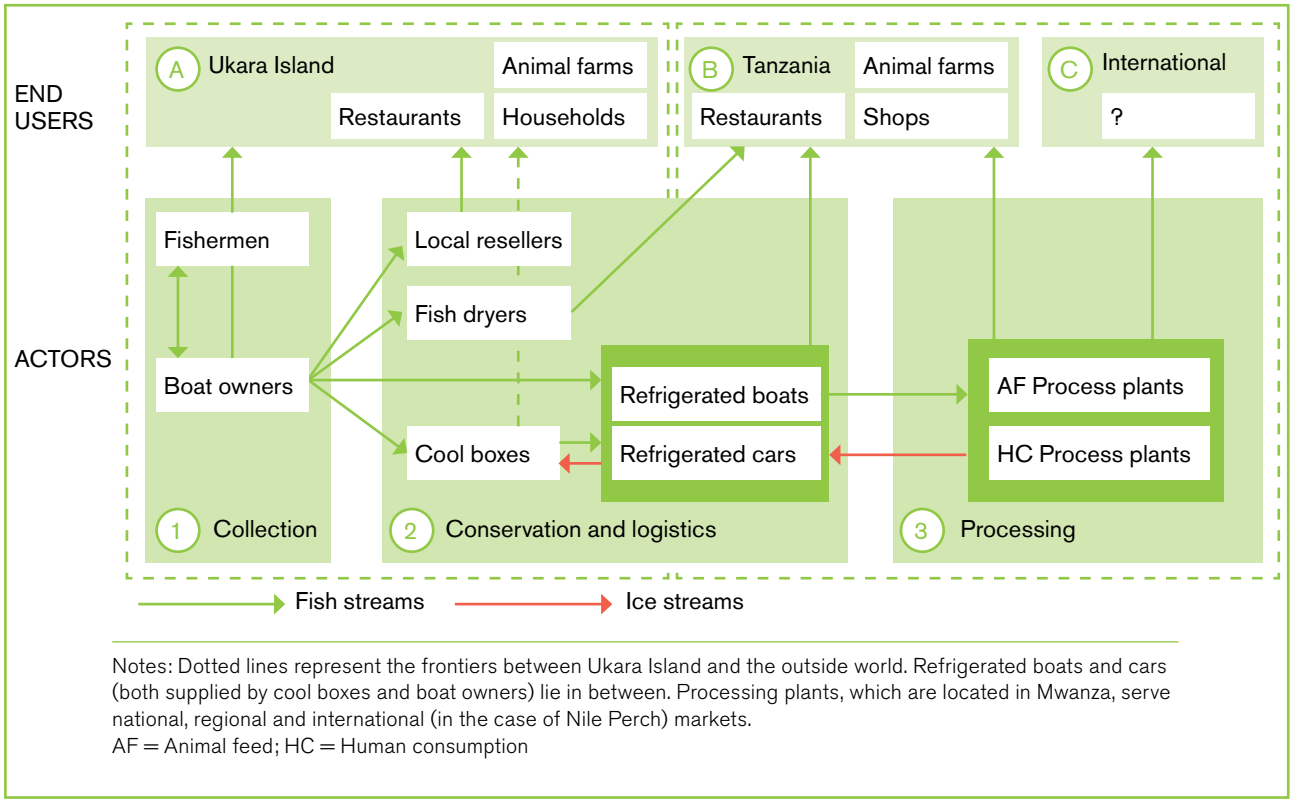
Nonetheless, JUMEME and E4I may face several difficulties. These include identifying people to operate this business; finding the necessary funds to buy equipment; and setting acceptable prices in a market comprising diverse customers with varying willingness to pay. Geographic factors must also be considered. Producing ice depends on availability of drinking water (see Figure 6), while distributing ice is inherently limited.

For cooling boxes, we estimate the potential market may be a maximum of two million TZS/month for enough ice to avoid the current 10–20 per cent fish losses. Ice boats, which probably need the most ice, will need to be convinced to change supplier, and will need to report any such change to their processing factory. Moreover, it could be difficult to sell ice to middlemen who previously got it free from factories. As for juice production and butchers, assessing demand is tricky. It would therefore make sense to start with a small-scale pilot, to define prices, assess actual demand, and convince ice boats.

Another longer term opportunity is a fish processing plant. This would need much more investment and implies great changes at the scale of an island such as Ukara (see Figure 7). In this situation, boat-owners would sell most of their fish directly to the plant. But this would destroy most middlemen jobs, and generate direct competition with down-stream processors. Nonetheless, it would have considerable impact, helping fishermen and locals to capture a higher share of the fish value chain, creating jobs, empowering the community, and reducing dependency on big factories in Mwanza.

A cooling box, located in Western Bwysia (Arthur Contejean)

Figure 5: Nile Perch (and Tilapia) Value Chain 1 – Current situation



Notes: Dotted lines represent the frontiers between Ukara Island and the outside world. Refrigerated boats and cars (both supplied by cool boxes and boat owners) lie in between. Processing plants, which are located in Mwanza, serve national, regional and international (in the case of Nile Perch) markets.
AF = Animal feed; HC = Human consumption

Figure 6: Nile Perch (and Tilapia) Value Chain 2 – Setting and Ice Block Production Unit

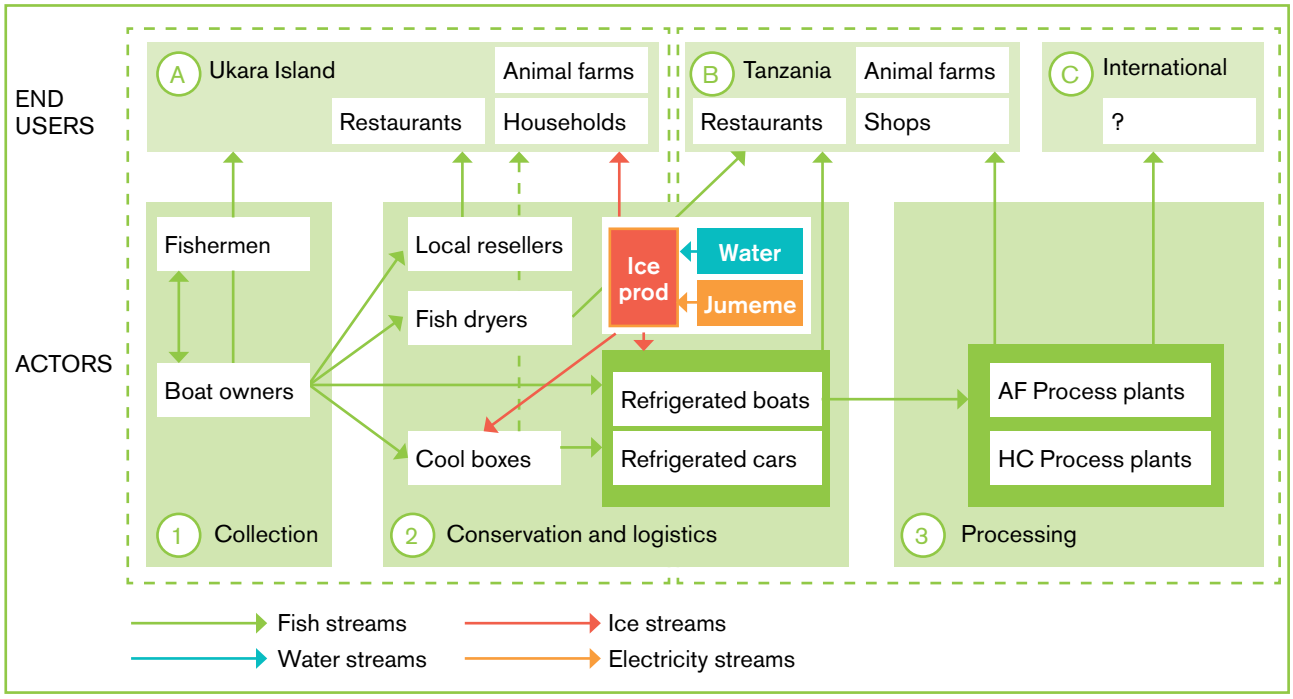
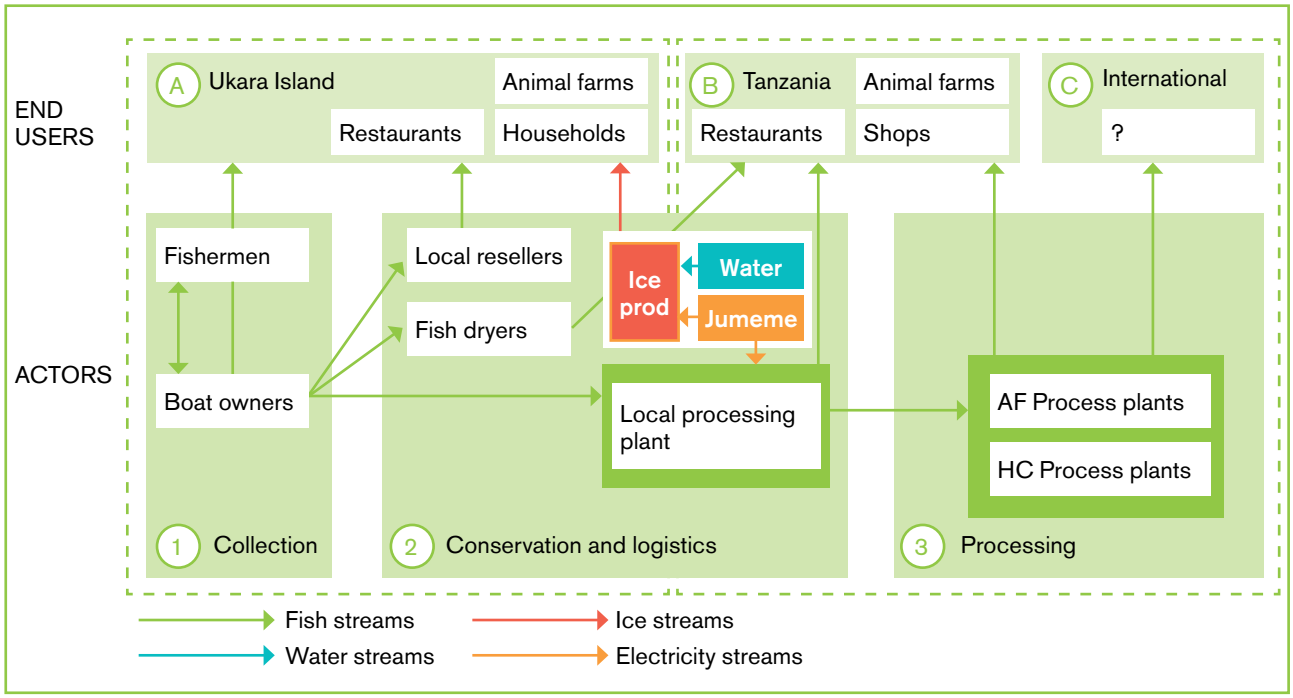


Figure 7: Nile Perch (& Tilapia) Value Chain 3 – Setting a Local Fish Processing Plant



Such promising but risky innovations pose many questions:

- What exact benefits would such a project have, for the community and JUMEME?
- Is the proposal viable in this remote area? Could it transform Ukara into a regional centre?
- How could investment opportunities be linked together?
- If ownership is not local, would value created (employment mainly, loss reductions, logistics streamlining) be higher than the value destroyed (middlemen), taking into account *Crowding Effects*?
- Is it possible to partner with existing actors, or is it better to enter into direct competition with them?

4.3.2 Dagaas

At first sight, the Dagaas value chain seems much simpler than Nile Perch's on Ukara, as camp-owners dry fish on the beach for one to three days before selling them to external middlemen arriving from Mwanza. Still, from a national and international perspective, "*the chain is a complex web spanning internal and external markets in other countries and involving many thousands of individuals*" (Legros and Luomba, 2011).

According to interviews carried out for this paper in Chibasi and Kome, camp-owners own boats on which a team of five work from 7pm to 6am, preferably during dark-moon periods, using kerosene lamps to lure fish, and for 15–20 days a month (see also Ibengwe, 2010). Catches are variable (usually six months high, and six months low). While providing solar lamps is a component of Resolve's project led by Renewable World on the Kenyan shores of the lake (Best, 2016), Ukara's fishermen did not seem convinced by their potential benefits, claiming they are not powerful enough to attract fish.

Camp-owners split each boat's profit, taking half, and dividing the rest among fishers. They sometimes provide food, and some employees sleep on the beach and dry fish literally on the sand. In some cases, five more employees work on the landing site (Luomba and Onyango, 2012).

Dagaas are sold locally for around 2,500 TZS/kg. This may reflect the current low quality of the fish. Indeed, bigger species of Dagaas that can be found in Lake Tanganyika, and which have less sand in the dried product, sell for 15,000 TZS/kg, according to a middleman we met. Moreover, local Dagaa catches suffer heavy post-harvest value reduction of around 60 per cent (Ibengwe, 2010, and our interviews) due to physical losses and quality reduction caused by poor storage or animal predation. That is equivalent to around $1,139 per fisher per year.

A woman gathering Dagaas in Chibasi Bay (Arthur Contejean)

The dried fish is sold in 80kg bags to middlemen who send them to Mwanza, or Dar Es Salaam (and sell them for 4,500 – 5,000 TZS/kg). Retailers then sell dagaas in various sizes of bags or buckets (from 50 grammes to 20kg) to others who distribute them all around Tanzania and surrounding countries, where they are sold to households or as animal feed. There are also some fairly distant markets. Besides Cambodia and Vietnam (Legros and Luomba, 2011), recent articles mention markets such as Canada and Australia (Kasumuni, 2015), and it seems there may be opportunities in the EU for frozen Dagaas (Legros and Luomba, 2011).

However, economic information on Dagaa fisheries in Ukara are still imprecise, and data would need to be gathered to properly assess how much is captured and by whom.

JUMEME, together with E4I, are proposing to install racks and help local producers packaging dagaas (See Annex 4). Using drying racks could reduce post-harvest losses to 30 per cent by decreasing the amount of fragments, and by limiting degradation from rain and contaminants (sand or grass) (Ibengwe, 2010). The precise benefits of such a project are unclear, and depend on many factors. However, let's consider a simple calculation. One square meter of locally produced racks costs approximately US$10 = 21,000 TZS, and can dry 2 kg per day (Ibengwe, 2010; Legros and Luomba, 2011). Let's assume that a camp owner installs a 10m² rack, for 210,000 TZS, and dries 20 kg/day, and that one boat of five fishers catches 20 kg per day. The new price might vary from 3,000 TZS/kg to 5,000 TZS/kg (4,000TZS/kg being the most probable assumption according to available literature), we can compute potential benefits: see Table 2 illustrating different scenarios. It might only take 14 working days to recoup the investment. Packaging fish in smaller portions, mixed with locally-produced spices, could also add much value. Such a project could create synergies with another investment opportunity identified by E4I – 'Horticulture in Ukara', but the products might be more difficult to transport.

It seems clear that despite uncertainties about markets, investing in racks could make a lot of sense from a camp-owner's perspective, and lead to significant income increases for fishers. Given the lack of precise information, JUMEME and E4I, together with the parastatal Tanzanian company Small Industries Development Organisation (SIDO), are launching a pilot project within Edward Malembo camp. Edward Malembo is the richest person on the island, owning the biggest dagaa camp, which owns 35 fishing boats, 2 transportation vessels and claims to be selling 20 – 100 bags (1.6 – 8 tonnes) per day. Working with a significant business like this may signal the opportunity to other small camp owners. This pilot programme could also be a good way to gather more precise data on operating costs and investments, and much attention should be given to recording data.

Table 2: Installing Racks, Basic Impact on Revenues (authors own)

Scenario: new price / kg	3,000	4,000	5,000
Additional revenue / kg	500	1,500	2,500
Additional revenue / day	10,000	30,000	50,000
Potential increase for fishermen salary / day	1,000	3,000	5,000
Additional revenues for the camp-owner / day	5,000	15,000	25,000
Investment required	210,000	210,000	210,000
Number of working days to recover the investment	42 days	14 days	8 days

JUMEME plays an important role in this opportunity. It is the only consolidated actor operating in Ukara as a whole, and having interest in a local economic improvement. Without such a company, such projects would be handled within short-term development programmes, without longer term incentives. Drying racks, even if successful, would have no direct impact on JUMEME's revenue, but they would increase local revenues and should therefore indirectly boost households' energy expenditures. Producing basic racks locally may also provide work and experience to newly installed wielders, and therefore increase their consumption of electricity. Even if the best solution does not involve electricity directly, it is clear that mini-grids operators can have a cross-cutting impact on agricultural value chains and local economies.

4.4 Overview of JUMEME's role in fostering PUE

Developing Ukara's value chains without anchoring on a mini-grid would probably not be possible. It would be difficult to make links between different activities (for example welders and fish drying racks, fish cold chains and fruit juices), and too challenging to provide extensive consulting services to remote populations.

Fostering value chains serviced by AC mini-grids does seem to require much more effort than might at first be expected. It requires a strong business and technical model that focuses not only on household power supplies but on a range of related issues. This, in turn, requires well organised partnerships: in JUMEME's case with Energy4Impact and Excel Hort Consulting. Doing it alone would be impossible, as would aggregating many small partners, because of the management challenges identified by Nico Peterschmidt.

Fish value chains do offer great opportunities to develop productive uses within Ukara island and to foster the local economy. Nonetheless, this value chain also illustrates risks. Reducing fishers' dependency on middlemen, for instance, would destroy middlemen's jobs. And a fish processing plant could also bring negative impacts to the whole island, by destabilising the existing economy, and destroying partnerships with fish factories.

JUMEME is therefore right to move carefully, using pilot programmes, in order to avoid damaging value chains that are organised as the outcome of years of local activity. Launching pilot projects may also allow operators and their partners to gather more data before scaling up any PUE opportunity, and so avoid failure.

It is too early to be sure of JUMEME's impact on different entrepreneurs (on their costs, price, sales, profit), and therefore too early to judge JUMEME's returns on its efforts to boost local PUE. Most businesses that had been connected at the time of our visit (carpenters, welders, and millers), had not started to pay for their electricity, and were still in a free trial period. Also, some investment opportunities proposed by E4I that has not yet materialized (such as the ice block production) and probably require further feasibility studies. Nonetheless, the recent launch of the bakery, ICT centre and poultry farm how how the project is improving the local economy.

It does seem, from studying JUMEME, that private mini-grids can develop effective ways to maximize revenues and impacts by incentivizing PUEs. Nonetheless, it is also apparent that they need to increase returns as fast as possible, leading them to focus significantly more on direct electricity sales rather than on parallel initiatives that could also help maximize local development. This is understandable for a private electricity operator, and indeed it may prove inefficient for power companies to address activities going well beyond their own expertise. However, support for such activities, where possible, could be a way to improve local economies, thus leading indirectly to more electricity sales – but this is yet to be proven.

Moreover, success of such initiatives may depend on the local situation. Ukara Island seems to be a very particular environment, with important fisheries, high population density, a strong economy and low risk of competition from the national grid. It was clear from our interviews that partnerships were drawing on long-established relationships. So it will be interesting to see if and how other companies and NGOs are able to reproduce such cooperative initiatives.

5

Findings and Recommendations

Providing Business Development Services, access to finance, and training is an important step toward local development, but does not appear to be enough. Indeed, **tackling local value to have a greater impact requires:**

- A **transversal** understanding of the region;
- **Renewed pilots and improvements**, and therefore daily presence, at least at the beginning of the project;
- **Research, comparison and communication** with potential partners;
- **Changing local habits without destroying the existing equilibrium;**
- Developing a clear picture to **take into account crowding effects, and avoid electrification traps**;
- **Balancing** the willingness to generate **revenues** from electricity, and to have a maximized **impact**;
- Tackling issues at **different points of entry,** and **in parallel**.

Moreover, we believe that addressing the following issues will be essential in Tanzania (and in countries taking similar paths) to help operators like JUMEME to address the key challenges they are facing, and to allow others to follow in transforming efficient PUE-focused private mini-grids into a large-scale reality:

ISSUE 1: There are critical knowledge gaps on mini-grids, productive uses and local agricultural value chains.

- *Recommendation 1: Researchers, consultants and their funders should expand and make accessible a literature focusing specifically on Clean Energy Mini-Grids (CEMGs).* Too much of the existing literature is targeting rural electrification as a whole, mixing together Solar Home Systems, standardized DC mini-grids, and different sized AC grids with different strategies and goals. Specific characterisation attempts are emerging, and should be developed further. Before regulations can be designed to stimulate mini-grids that answer development challenges, we must first know what is at stake. New entrants should be able to understand up-to-date models and avoid replicating mistakes. Funders should prioritise projects with significant PUE impacts and avoid channelling resources to those that will have limited impacts on rural economies.
- *Recommendation 2: International and national development institutions should design more programmes specifically targeting mini-grids in Sub-Saharan Africa and not rural electrification as a whole.*

- *Recommendation 3: International development institutions should aggregate and make accessible information and case studies on rural activities.* It is neither obvious nor easy for CEMG to foster products like sunflower oil or fruit juice when limited information is available on national value chains and markets, local stakeholders, best practices, energy needs, necessary equipment, investments and potential impacts. Aggregating existing information could add much value.
- *Recommendation 4: Match-making platforms should bridge the gaps between rural electrification practitioners, rural industries, telco tower owners, and micro-finance institutions.* This could be done through local and national match-making platforms and should be managed by industry associations or local authorities to reduce efforts needed from CEMG operators.

ISSUE 2: Projects are not adequately incentivized to develop productive uses; they often lack flexibility, and usually cannot afford to develop complex initiatives.

- *Recommendation 5: Light-handed regulations are necessary to allow mini-grids to implement essential cost-reflective and flexible tariffs*. In addition, it is important that such regulations are easily accessible and understandable, so that developers do not spend too much time and effort complying with them. Nonetheless, governments have to be careful that those light-handed regulations are well designed to prevent counter-productive competition arising.
- *Recommendation 6: Rural electrification regulators should, in partnership with expert development agencies, design specific incentives to push the industry in the right direction*. In particular, providing different levels of connection-based subsidies to incentivise PUE, and complementary financial tools, such as revolving result-based funds, is vital. Robust research from institutions will be essential to develop well targeted regulations.

ISSUE 3: Specific practices and dedicated structures can help foster PUE, and should be shared.

- *Recommendation 7: Operators could share knowledge of developing PUE.* Researchers' work depends on CEMG operators' willingness to provide more information concerning their projects. Knowledge must be based on concrete facts to allow good practices to spread.
- *Recommendation 8: Operators should develop efficient partnerships with specialists to foster PUE.* CEMGs could act as a significant catalyst for rural development but cannot singlehandedly manage economic development in rural areas. They need support from proficient partners. However, projects should not depend on too many partnerships because these increase costs and decrease decision making efficiency.
- *Recommendation 9: Mini-grid operators should systematically use emerging information and communication technologies to gather data on productive-uses and on the rural economy as a whole.* In the past, remote areas were very hard to understand. Today, smart metering, real-time and connected pre-payment schemes etc open the way for precise analyses. Using these opportunities could help operators optimize the size of their generation assets, while also driving public development programmes.
- *Recommendation 10: Operators should also test ICT technologies with the potential to empower rural populations*. Making mobile/internet agricultural services available could for example let local entrepreneurs discover and access new markets by themselves, lessening the pressure on CEMG operators.

Annex 1

Interviewees

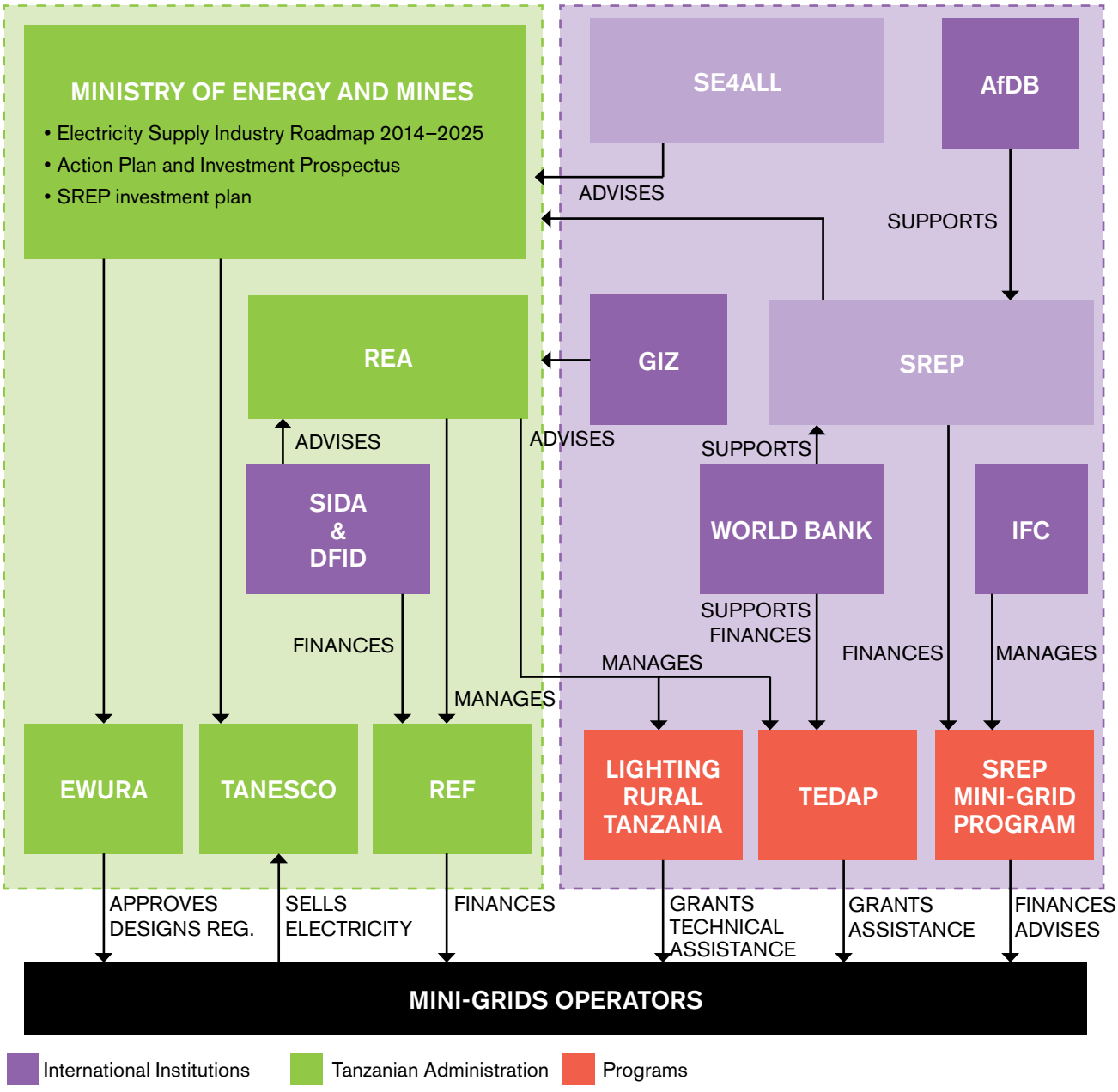
We conducted qualitative interviews for this research from December 2015 to June 2016, with various organisations, both from France and during a visit to Tanzania in May 2016. JUMEME, ACRA and CEFA provided us with much information on their projects, and allowed us to visit villages and interrogate local entrepreneurs. Here is a list of the people we met, as well as their organisation:

ORGANISATION	NAME
ACRA (Tanzania)	Nicola Morganti Davide Ceretti Marco Tancredi Federico Ferrante 15 entrepreneurs in villages Employees from the community based company Lumama
Agence Française de Développement (Tanzania)	Denis Munuve (Tanzania)
Alliance for Rural Electrification	David Lecoque Marcus Wiemann
CEFA (Tanzania)	Jacopo Pendezza Dario de Nicola Director of the community based company Matembwe Village Company Manager of the local partner SACCOS
E.On Off-grid Solutions	Sebastien Rieger Maarten Fonteijn
Energy 4 Impact (Tanzania)	Simon Collings Fredrick Mushi Emilian Msangi
Fondation Energies pour le Monde	Yves Maigne Juliette Darlu
GERES	Benjamin Pallière
GiZ (Tanzania)	Vogel Gerd-Henning
GRET	Julien Cerqueira Benjamin Trouilleux
Helios SE	Rachel English
Hystra	Lucie Klarsfeld
I&P	Elodie Noquet
IFC	Pepukaye Bardouille
IIED	Sarah Best
Inensus	Nico Peterschmidt

ORGANISATION	NAME
JUMEME project (Tanzania)	2 local employees from JUMEME 1 employee from Excel Hort Consulting 10 actors involved in the fish value chain (fishermen, icebox or iceboat owners) and entrepreneurs
Power:On	Tristan Kochoyan
Rift Valley Energy (Tanzania)	Franz Kottulinsky
Rockefeller Foundation	Clare Boland Ross
Schneider	Christophe Pauline Thomas André
SunFunder	Audrey Desiderato
UNEP	Dean Cooper

Annex 2

Schematic of rural electrification programmes and institutions



Annex 3

List of programmes supporting mini-grids in Tanzania

PROGRAM	DESCRIPTION
Green Climate Fund	Established by 194 governments, the GCF is a newly created fund intending to finance the reduction of CO2 emission in developing countries in order to reach the 2°C challenge. In particular, one of its programmes is the "Universal Green Energy Access Program", co-managed by the Deutche Bank, approved in October 2016, and currently constituted of US$301.6 million. It will finance access to green energy, by funding in particular clean energy mini-grids, in Tanzania, Benin, Kenya, Namibia and Nigeria.
SE4ALL	Launched by the UN secretariat, SE4ALL has chosen Tanzania to be one of the first movers in Africa and is supporting the organisation of the sector between public and private actors, in order to achieve three goals quantitatively defined as: "*Ensuring universal access to modern energy services. Doubling the rate of improvement in energy efficiency. Doubling the share of renewable energy in the global energy mix.*" A clear Action Agenda defining the path to achieve those goals, and an Investment Prospectus has been designed.
Energy Access Market Accelerator	SE4ALL, in parallel with the Energy+ Technical Working Group and Accenture Development Partnerships, is developing an Energy Access Market Accelerator, aiming at improving the energy access sector by aggregating market information, coordinating different financial initiatives, and identifying/closing institutional gaps.
Tanzanian Energy Development and Access Project (TEDAP) (Currently being reviewed)	The Tanzania Energy Development and Access Program, which should come to an end soon, has been launched and managed by the Rural Electrification Agency, and supported by the World Bank with co-financing from Global Environment Facility and Africa Renewable Energy Acess. It aims to help develop energy projects. Within the off-grid component, US$23m was aimed at supporting small scale projects, through the two grants explained in part 3.2.1, but also through lines of credit with the Tanzanian Investment Bank, aimed at financing long-term debt (up to 15 years). TEDAP also supported the design of a facilitating regulatory environment.
Lighting Rural Tanzania	Implemented by REA in parallel to TEDAP, this project launched competitive grants (up to US$100,000 per project) to provide technical assistance to innovative rural electrification projects. It is currently implementing the 3rd wave of grants, launched in 2014, with the theme being "Promotion of Micro-Grids for electrification of remote off-grid rural villages and islands in Mainland Tanzania".
The Scaling-Up Renewable Energy Program (SREP)	Tanzania has been chosen to be one of the pilot countries in the implementation of the Scaling-Up Renewable Energy Program (SREP). Supported mainly by the African Development Bank and the World Bank, the government of Tanzania developed a SREP-Investment Plan, aiming at proving the viability of new opportunities for expanding renewable energy. Its objectives are to cut risk and catalyse the creation of more than 100 MW of geothermal power, mainly by the private sector, and to develop a proper enabling environment for such technologies. It will thus provide funding for the riskiest phases, and design risk mitigation mechanisms.
The Norwegian and Swedish Development Agencies (NORAD and SIDA)	NORAD AND SIDA were the main investors in the Rural Electrification Fund managed by REA until 2015. SIDA has developed many capacity building activities to expand operational capacity in REA and Tanzania's Energy and Water Utilities Regulatory Agency (EWURA) and guide them in the design of proper regulations.

PROGRAM	DESCRIPTION
The UK's Department for International Development (DFID)	DFID is currently designing a Green Mini-Grid Program co-financed with SIDA.
The French Development Agency (AFD)	The AFD is mainly involved in extending transmission lines across the country and in grid extension projects. They are also currently designing a SUNREF line of credit facility to finance rural electrification projects through local banks.
The International Finance Cooperation (IFC)	In the frame of the SREP, the IFC has recently launched a programme of US$4m to develop a commercially viable market for mini-grids, and tackle the financial challenges that they face. To find examples of the social and commercial potential offered by those solutions, the IFC intends to "*offer transaction advisory services and support for identification of key risks and potential mitigants for 20–25 renewable-energy mini-grids to directly benefit an estimated 13,750 households or approximately 67,375 people*."
German Corporation for International Cooperation (GIZ)	The GIZ is currently supporting nine micro-hydro projects for the REA, to help them design proper business plans and achieve bankability. GIZ is also advising the REA in a more general way.

Annex 4

Abstract of projects proposed by the E4I (GVEP) for investors on Ukara Island

ICE BLOCK PRODUCTION: OVERVIEW OF THE OPPORTUNITY	
Key project features	• Project description: creation of an operating company in charge of producing ice-blocks in Ukara commercially • Land plot to be awarded for lease • Raw materials – Water – Nylon bags – Ice block machine – Freezer (optional) • Reasonable investment cost • Safe and secure environment for storage
Support available	• District and/or Village Council ensure smooth process for the allocation of land and permits • GVEP provides business, technological and financial training and/or support
Key investment rationale	• Strong local and external demand for chilling drinks and storing fish • Availability of reliable and affordable electricity • Attractive returns • Untapped and sizeable market in Ukara Island and nearby island • Availability of raw materials (water)

DAGAA FISH DRYING AND PACKAGING: OVERVIEW OF THE OPPORTUNITY	
Key project features	• Project description: establishing company dedicated to salting, drying, packaging dagaa fish using solar driers. • Materials needed – Solar drying rack/tunnel/tent – Small 'dagaa' fish – Packaging materials
Support available	• District and/or Village Council ensure smooth process for the allocation of land and permits • EHC, GVEP and JUMEME provides business, technological and financial support
Key investment rationale	• Availability of dagaa fish, approximately 10–30 tons per month • Strong external demand of sand free and hygienically dried dagaa fish • Significant reduction in post-harvest loss • Shorter drying time; drying during rain • Significant higher market price for high-quality dagaa fish

Source :Energy 4 Impact et al. (2016)

Glossary and Abbreviations List

AC grid: Alternative current grid, sometimes associated with a three-phase system. Main standard of grid, can power important loads.

CEMG: Clean Energy Mini-Grid.

DC grid: Direct current grid. Can provide a relatively limited level of service at lower cost than AC grids. New very energy efficient DC appliances are being designed in parallel with the expansion of SHS industry, and these can be powered by DC current.

DESCO (Distributed Energy Service Company): DESCO refers to the new model of private companies which distribute electricity in certain areas. Such a company is selling energy services to its customers (e.g. Solar Home Systems, where the customers pay a certain amount each months for having light and charging phones), associated to their use of the electricity, rather than absolute kWh.

Electricity Trap: A situation in which a business invests in a connection and equipment, but overestimates potential returns, which may lead business failure.

EWURA (Energy and Water Utilities Regulatory Agency): EWURA is Tanzania's regulator of energy and water utilities, created in 2006. It is in charge of designing the regulations and approving projects and their tariffs.

IPP (Independent Power Producer): An IPP is a private and independent power producer generating electricity. They can operate independently in an isolated area, or they can sell a part of their electricity to TANESCO.

Mini-grids: Using different sources of energy, mini-grids are electrical systems that manage electricity generation assets, connecting several households in one or several locations. They can be totally isolated from or connected to the national grid, depending on geographic situations and policy frameworks. In this working paper we consider mini-grids to be any system with a generation capacity of 1 kW – 10 MW.

PAYG: 'Pay As You Go' Process allowing customers to pre-pay for their electricity. Smart meters let customers unlock the use of a certain amount of kWh. Once the amount is consumed, the supply of electricity is locked until some credit is added.

PUE (Productive Use of –here- Electricity): A PUE is an agricultural, commercial or industrial activity that uses electricity services as a direct input to producing goods or providing services.

PPA (Power Purchase Agreement): A power purchase agreement is a contract passed between an operator generating electricity, and a buyer (be it TANESCO, the Tanzanian national utility, or a private company).

REA (Rural Electrification Agency): Tanzania's REA, created in 2007, is the entity in charge of rural electrification. It is mainly financing and designing projects, as well as managing the sector in line with the regulations and laws designed by EWURA.

RNFA: Rural Non Farm Activities

SHS (Solar Home Systems): SHS are standalone systems powering only one household through solar panels. They can provide up to 1 kW.

SPP (Small Power Producer): In Tanzania, a SPP has a generation capacity in the range of 100 kW to 10 MW.

TANESCO (Tanzania Electricity Supply Company): TANESCO is Tanzania's national and public electricity utility, created in 1968. It is in charge of generating, transmitting and distributing electricity through the national grid.

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Mini-grids could help unlock inclusive growth in remote rural areas, but few proactively stimulate productive uses of electricity, as this often requires resource-consuming actions and expertise. This paper characterises the current mini-grids' industry, taking into account operators' models and strategies. It then focuses on Tanzania, in particular JUMEME, a new and sophisticated private initiative that aims to build energy use and bring a strong added value to rural areas. It ends with recommendations for helping such private actors develop the areas they serve.

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