



# A study of mini-grids in Tanzania and Madagascar:

the productive use of energy and the impact  
of improved energy access on rural communities



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### **The ACP-EU Energy Facility (<http://energyfacilitymonitoring.eu>)**

This discussion paper is one in a series of discussion papers based on experiences from the ACP-EU Energy Facility (EF).

The EF was established in 2005 to co-finance projects on increasing access to modern and sustainable energy services for the poor in African, Caribbean and Pacific (ACP) countries, especially in rural and peri-urban areas. 173 project proposals have been granted co-funding from the EU for a total of 0.4 billion euros; 50% of the total project-budgets of 0.8 billion euros.

The projects have been, and are being, implemented in the period 2007–2021 with 90% of projects completed in 2019. The projects cover a wide range of technologies:

Electricity grid-extensions in rural and peri-urban areas, hydro-powered mini-grids, solar and hybrid-solar mini-grids, stand-alone solar solutions for businesses, households and public institutions, portable solar equipment mainly used for lighting, clean energy solutions for cooking such as improved firewood and charcoal cook stoves as well as biogas, biofuels for electricity generation, and capacity development of public institutions in the energy sector.

**Among the 173 Energy Facility projects, 57 are directly related to SDG3 improving Good health and well-being and SDG4 Quality education.**

*Danish Energy Management (DEM) has been granted the contract of providing technical assistance for the monitoring of the EF projects in the period 2011–2019. This discussion paper is based on information and data gathered during this period as well as current research and experience from other development interventions.*

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## Executive Summary

The unique **value proposition of decentralised mini-grids** is to provide grid quality electricity to clusters of end users that are not large enough to justify the cost of grid extension. In rural areas, the trajectory of demand growth is gradual, meaning that achieving commercial viability does not happen in the short term timeframe of 2-5 years that development financiers are operating within. Therefore, in order to proactively drive progress, project developers are promoting the Productive Uses of Energy (PUE) to improve **financial viability**.

This study analyses the achievements made in six mini-grid projects supported by the **ACP-EU Energy Facility** in Tanzania and Madagascar to understand the increase in PUE and the impact that energy access has had.

### SDG impact



SDG1: Mini-grid access has **improved the quality of life for 70%** of the communities that have been connected to the mini-grid in Tanzania and Madagascar. A quarter of households reported that they had more **disposable income**, which was primarily spent on food and school fees. Twenty percent of households reported an improvement in **health services**.



SDG5: As users of energy, women value **convenience** and lighting for studying, as well as the **time saved** from travelling to charge mobile phones. Women entrepreneurs report being **empowered** to provide additional services dependent on electricity and an **enthusiasm to expand** their businesses, despite a self-reported lack of knowledge or finances.

The primary roles of women in productive uses are in the **service sector** and auxiliary functions. **Only one third of the 32% of businesses owned by women have total autonomy** over their business. On the other hand, energy access has led to increases in prostitution and **child gambling**, particularly in Tanzania.



SDG7: The introduction of electricity access to the six projects areas has resulted in a **97% reduction in the use of kerosene** and **89% reduction in the use of battery powered**

**torches**. Solar home system usage reduced by 90%, indicating that the quality of light and convenience is valued cost.

**Commercial consumers** generally consider **electricity to be affordable (76%)** however the cost of electricity was a **burden for a significant proportion of households (between 40 and 87 %)**, which is linked to the tariff structure. The application of service charges is a particular constraint as they are applied even if consumption, and therefore activity, is low.



SDG8: The workforce of the MSMEs interviewed had **increased by 2.5 times**, which they attributed primarily to a more diverse portfolio of activities to meet local demand, and increased revenue. The opportunity to become self-employed was valued, both due to the independence to determine how much time was spent on which activities but also due to a **better income per hour of work put in**.

### Promoting productive uses

The conversion of existing businesses from **diesel to electric-powered motors** is a low hanging fruit. As long as the **tariffs result in lower overheads** on energy, business owners are prepared to invest. The most **efficient approach to ramping up PUE** is for the project developer or other company to invest directly in establishing a productive activity.

The local micro, small and medium enterprises have seen a significant **improvement in turnover** by between 65 and 252%, the latter being in agricultural processing. MSMEs reported greater **product diversity** (62% of businesses), a broader **customer base** (59% of businesses), and **longer opening/ working hours** (55%) as having benefited their operations. The additional revenue has allowed businesses to **procure appliances, increase their stocks, and pay for family expenses**, particularly food and school fees.

The uptake of appliances can be facilitated by **pay-as-you-go financing**, although users were still able to source appliances where this was not provided. However, difficulties in ensuring **appliance maintenance and repair** can lead to payment default.

## Selected drivers, barriers and recommendations for promoting PUE

### Recommendation:

*Feasibility studies should include a holistic assessment of and identify the best approach to commercialising, up-scaling production, addressing access to markets and partnership for implementation.*

The availability of natural resources that feed into a **value chain**, such as timber, food crops or sunflowers, has facilitated the mechanisation of a previously manual processes and establishment of ancillary businesses processes. There is potential to do this to a greater extent, for example through irrigation, provided the conditions allow for it, such as water levels and distance to the fields, etc. However, this is **resource intensive** and is **outside most project developers' domains**, relating more to rural agricultural development.

### Recommendation:

*Financial products need to reflect the start-up phase of a business with low profit margins and seasonality of income generation in the economy.*

**Access to finance** to procure equipment is undoubtedly **an enabler**, particularly for those with businesses that were businesses with a low turnover or new businesses, as they may not have the capital to invest in appliances. The poor access to appliances also means that there is a **lack of competition** in the market. The **terms and conditions** on which project developers provide the loans and the repayment plan can influence whether businesses are able to generate the cash flow to repay the loan.

### Recommendation:

*There is a balance to strike between cost-reflective or flexible tariffs and affordability. Subsidies may be needed until economies of scale to be reached.*

The **affordability of the tariffs can drive productive use**. The approach of accelerating the uptake by adopting low tariffs and therefore achieving scale has facilitated commercial activity where applied. On the other hand, the **comparatively** higher tariffs and standing service charges applied by some operators are considered to be burdensome. MSMEs complained that **PUE activities in rural communities are not restricted to daylight**, highlighting the trade-off between energy access and demand management.

### Recommendation:

*Develop partnerships with experts in incubating rural businesses and organisations providing skills development.*

MSME development requires a long-term investment of a variety of actors. Identifying those with the business instinct that are able to **adapt and innovate is key**. The support provided should be given by entrepreneurs that have run their own businesses, and must be **relevant to the way in which rural business is run**, i.e. less focus on formalised accounting and instead working with the entrepreneur using their own methods and logic.

### Recommendation:

*To mainstream gender equality, encourage and sensitise men to support women in achieving their goals.*

The gender interventions have focused on building the capacity of women, facilitating access to finance and establishing businesses. However, their success has been strongly influenced by the men in their community. Therefore, to change attitudes, it is critical to **sensitise and encourage men as enablers** for women to generate an income. This applies also to the internal staff of the mini-grid operators.

### Recommendation:

*Providing rural energy access covers multiple sectors. Therefore, the design process should reflect the variety of skills needed (social, agricultural, infrastructure, business development, etc.) to guide project developers on where it is best to invest efforts.*

Electricity provides a pull factor to an area, specifically if the tariff is attractive. This can work in combination with push factors to motivate businesses to relocate. In Mufindi, the **reliability of the energy supply, combined with the restrictions** put on production in another area made Mufindi a better option, closer to the source of raw materials. However, a significant barrier to greater development is the poor **road infrastructure** and, in some areas, the **mobility of the community**, which limits the degree of social cohesion and economic growth.

# 1 Introduction to the study

The ACP-EU Energy Facility has made a valuable contribution in providing the testing ground for many of the innovative solutions that are being offered today to enhance energy access in rural, off-grid communities. The United Nations' (UN) Sustainable Development Goal (SDG) 7 (to provide affordable, reliable, sustainable and modern energy for all by 2030<sup>1</sup>) sets an ambitious challenge. It is estimated that 600 million people are living without access to electricity in sub-Saharan Africa, predominantly in rural areas, and this is expected to increase by 2040.

The core theory of change of SDG 7 is that the access to electricity will facilitate economic and social activities that improve the quality of life for rural households and vulnerable groups. Off-grid electricity access poses a particular challenge for national governments due to the cost of extending the national grid, the low population density in rural areas, and the logistical challenges of constructing and servicing electricity installations. Since 2007, the ACP-EU Energy Facility has supported 25 mini-grid projects in 27 countries in sub-Saharan Africa that aim to provide electricity where grid access isn't feasible. The total installed capacity ranges from 4 MW to 60 kW, mainly based on solar PV and hydropower.

In rural areas, the trajectory of demand growth is gradual, meaning that achieving commercial viability does not happen in the short term timeframe of 2-5 years that development financiers are operating within. Therefore, in order to proactively drive progress, project developers are promoting the Productive Uses of Energy (PUE) to increase the intensity of electricity consumption, stabilise the daily load profile, reduce the levelised cost of electricity (LCOE), and improve financial viability.<sup>1</sup>

This paper analyses six of the projects in 11 selected villages supported by the ACP-EU Energy Facility in Tanzania and Madagascar to understand the degree to which the productive uses of energy have developed and the impact that energy access has had on the quality of life for rural households and the lives of the women in the area, specifically considering SDG 1, 2, 5, 7 and 8.

The six projects that were studied were supported by the ACP-EU Energy Facility between 2007 and 2019 and are summarised below. Eleven villages were visited during the field work.

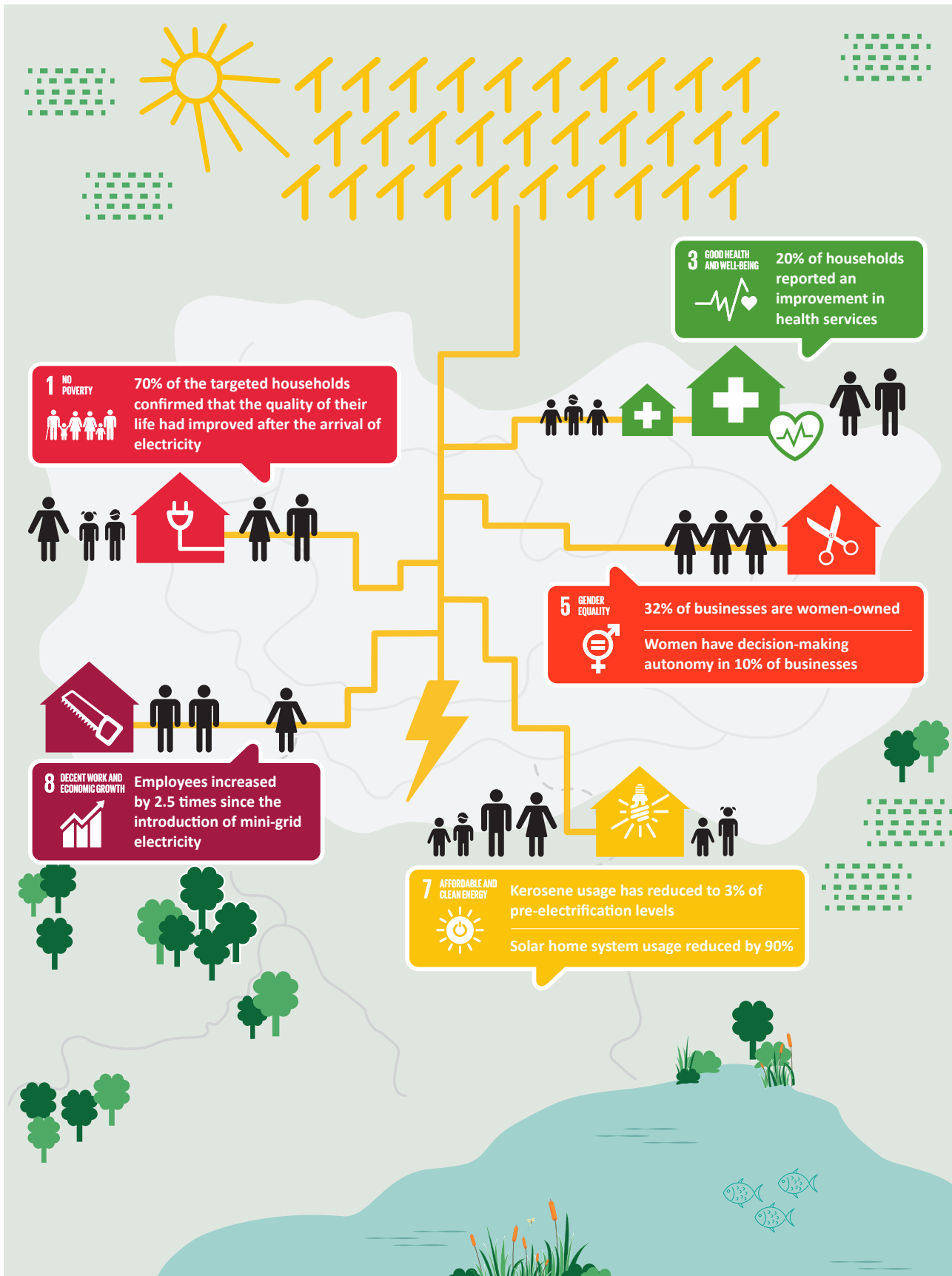
Table 1: List of projects studied

| Operator                          | EU Project                            | Country                 | EU grant contract holder | No. of households interviewed | Energy source | Installed capacity (kW) | No. of connected customers | Population   | Grid connected |
|-----------------------------------|---------------------------------------|-------------------------|--------------------------|-------------------------------|---------------|-------------------------|----------------------------|--------------|----------------|
| Rift Valley Energy (RVE) Mufindi  | Mwenga 4MW Hydropower                 | Tanzania                | RVE                      | 200                           | Hydro-power   | 4,000                   | 4,100                      | 265,829*     | Yes            |
| Mawengi Hydropower Limited Njombe | Mawengi Hydropower                    | Tanzania                | ACRA                     |                               | Hydro-power   | 300                     | 1,600                      | 9,083*       | Yes            |
| Jumeme Bwisya                     | Micro-power Economy Tanzania Roll-out | Tanzania                | Inensus                  | 194                           | Solar PV      | 60                      | 315 (237 active)           | 13,141*      | No             |
| ECOGEMA Sahasinaka                | Program Rhyviere                      | Madagascar <sup>2</sup> | GRET                     | 80                            | Hydro-power   | 60                      | 254                        | circa 21,000 | Yes            |
| SM3E Tolongoia                    |                                       |                         |                          | 76                            |               |                         | 310                        | 17,000       |                |
| Tany MEVA Amboasary               | PHEDER                                | Madagascar              | PHEDER                   |                               | Hydro-power   | 50                      | 180                        | 15,000       | No             |

\* Based on 2012 census data (source: Tanzania National Bureau of Statistics)

<sup>1</sup> World Bank (2019) Mini Grids for Half a Billion People : Market Outlook and Handbook for Decision Makers. ESMAP Technical Report; 014/19

## Key SDG impacts





## 2 Summary

The introduction of electricity access to the six projects areas has resulted in a **97% reduction in the use of kerosene and 89% reduction in the use of battery powered torches**. Solar home system usage reduced by 90%, indicating that the quality of light and convenience is valued over the cost of electricity. The most common use of electricity in the home is for entertainment. Seventeen percent of households are operating a business from home. Most of these businesses are retail and food outlets but a number reported more intensive uses, such as mills. **Commercial consumers** generally consider **electricity to be affordable (76%)** however the cost of electricity was a **burden for a significant proportion of households (between 40 and 87 %)**, which is linked to the tariff structure. The application of service charges is a particular constraint as they are applied even if consumption, and therefore activity, is low.

Mini-grid access has **improved the quality of life for 70%** of the communities that have been connected to the mini-grids in Tanzania and Madagascar. A quarter of households reported that they had more disposable income, which was primarily spent on food and school fees. **Twenty percent of households reported an improvement in health services**, reflecting the introduction of surgical procedures and laboratory testing in local clinics due to the reliable electricity. Few communities have street lighting and communal water pumping, primarily due to the absence of local institutional structures that can effectively manage the collection of a public tax for these services.

Women perform a significant role as energy users but also in delivering services in the community. As users of energy, **convenience** and the lighting for **studying** were named as the most significant benefits, as well as the **time saved** from travelling to charge mobile phones, formerly done in neighbouring villages. Women entrepreneurs report being **empowered** to provide additional services dependent on electricity and an **enthusiasm to expand** their businesses, despite stating that they **do not have the knowledge needed** to take advantage of the opportunities.

Of the MSMEs interviewed, the primary roles of women in productive uses are in the service sector, for example, grocery shops, guesthouses, hairdressers, and food outlets. The representation of women in the supply chain also include auxiliary functions to the male denominated business segments, such as fish drying or catering. Only one third of the 32% of businesses owned by women have total autonomy over their business, illustrating that culturally, decision-making is primarily taken by men or jointly.

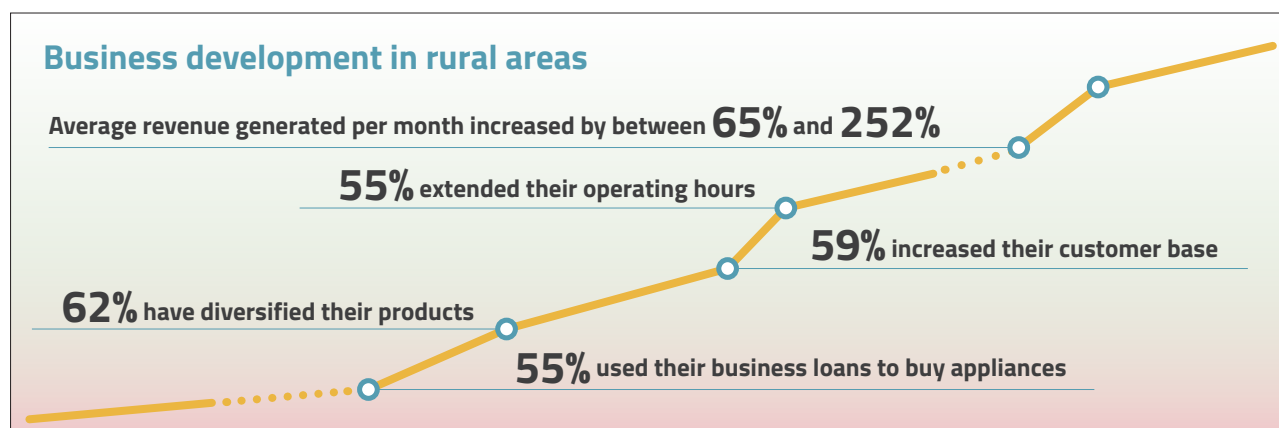
**Mainstreaming** gender in energy access projects also applies to the mini-grid operators. This not only means in terms of job creation for women, which is limited, but also **within project developer organisations in working with women** entrepreneurs, specifically in light of the expanded role project developers and operators are taking in developing productive uses.

A negative effect of electricity access for women is the longer opening hours for bars, which has increased the **prostitution and child gambling**, particularly in Tanzania. Violence against women and girls was not reported to have increased. Therefore, avoiding these effects should be incorporated in project design, similar to the road infrastructure sector.

In terms of the creation of jobs, the workforce of the MSMEs interviewed had **increased by 2.5 times**, which they attributed primarily to a greater diversity in their activities to meet local demand, and increased revenue. **A greater proportion of men** had benefited from increased employment, rather than women, primarily due to the nature of the businesses, which mostly require heavy labour performed by men (e.g. welding and carpentry) or few staff (e.g. retail and tailoring). On a community-wide level however, the situation had not changed. This however may be linked to the nature of work in a rural setting, where individuals participate in many, varied income-generating activities and few are employed on contracts.



### 3 Main Findings



#### 3.1 Productive use of energy

The productive use of mini-grid electricity has manifested in the villages studied in four ways:

1. The conversion of diesel-powered motors to electricity
2. The creation of an anchor load (business) by the utility
3. Movement of new or existing businesses into the area to take advantage of the local resources
4. The establishment of new businesses in the local community

The majority of MSMEs owned electricity consuming equipment before the arrival of electricity, particularly agricultural processing machinery. Of the MSMEs interviewed, 39% sought a loan and of these, 55% used the money to buy appliances. In general, the interest rates ranged between 5 and 24% per annum, although micro-financing institutions (MFIs) in Madagascar can apply a rate of between 30–36% per annum.

The conversion of existing businesses from diesel to electric-powered motors presents an opportunity for project developers. As long as the tariffs result in lower overheads on energy, business owners are prepared to invest, provided the conversion is made to efficient motors or newer mills, such as hammer mills. However,

some businesses are price sensitive on the basis that profit margins are typically quite low, depending on the products. The role of government is important in ensuring consumer protection but also in providing subsidies so improve affordability, similar to the principle applied to the national grid.

Identifying a significant off-taker is the main battle for mini-grids that need to be self-sustaining, i.e. without being reliant on the feeding into the grid and covering operating costs. The investment in local production by project developers themselves is an efficient approach and does de-risk the investment in the mini-grid by providing the utility with a predictable revenue stream that supplements the revenue from electricity. However, this requires that there is potential for productive activity based on a locally available resource, which is not the case in all villages. This approach is also resource intensive for project developers, requiring a diverse skills set.

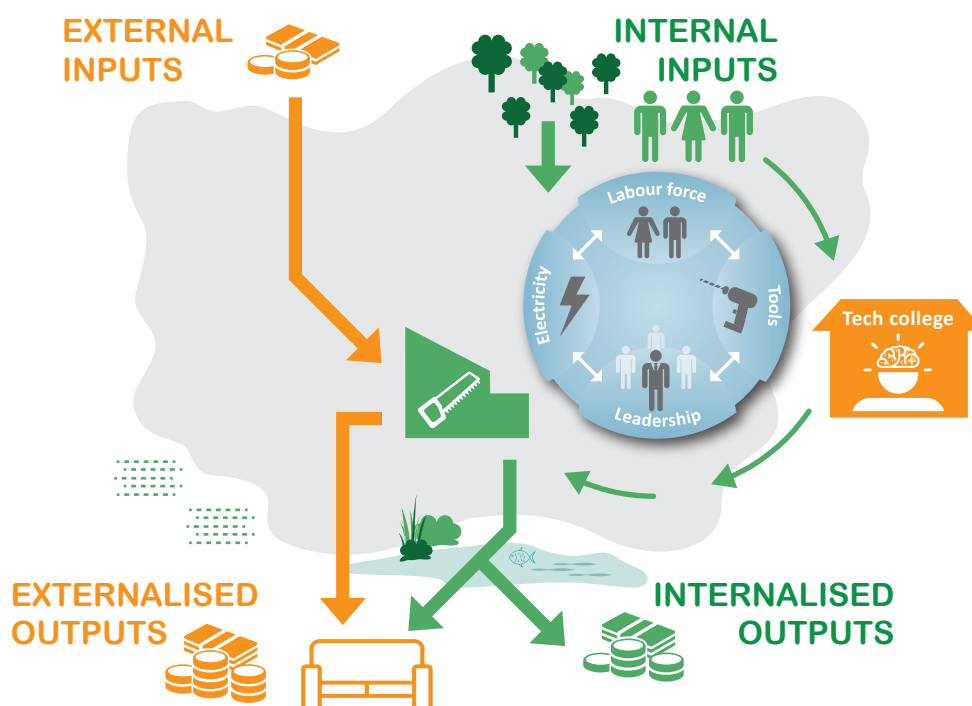
External investment into establishing an SME in the area has had a significant impact in Igoda, Tanzania. The draw of electricity and reliable power led to a new “business park” being built by a single entrepreneur, including a sawmill, mill, a banking agency, a hardware shop and a mattress shop, creating 36 jobs in one business. The pull factors, such as low tariffs, reliable power, proximity to raw materials, skilled labour, etc., are attractive facets for SMEs that tend to locate nearer towns and where the grid is generally located.

### External investment with limited endogenous growth

The introduction of electricity provides the basis for business development in the village. In the case of Igoda, served by Rift Valley Energy in the southern highlands of Tanzania, a sawmill set up operations to take advantage of the proximity to the timber plantations. As a result, an “influx” of non-residents moved in to provide the sawmill with skilled labour. The manager explained that the lack of skill within the village requires that he seeks staff that already have the skills from other regions. Training local staff was not considered to be a viable option as they tended to migrate again out of the village. An induced effect of the arrival of new residents was that a local farmer reported that his sales of agricultural produce had increased because the migrants did not own land in the village and therefore were not able to grow their own food.

The benefits of this new industry for local villagers was limited to auxiliary functions: renting of homes, provision of food and services (e.g. hairdressing, banking services, etc). While this is of course positive, the lack of skills within the village to provide the services required is a lost opportunity that would provide for more significant income generation, increased job prospects for the youth, and more money circulating in the “internal” economy.

Figure 1: Importance of skilling local labourers up to provide human capital to businesses



The mobility of the local community in Bwisya is also a constraint to developing the human capital and knowledge to develop a skilled labour force. Over 90% of the residents of the village have lived there for less than ten years. The islanders report migration and transience as having affected the availability of credit on the island. This may be expected as the primary economic activity is fishing, and fisherman reportedly move between islands frequently.

Table 2: Comparison of revenue generation per month before and after electricity

| Segments  | Average amount earned before electricity (EUR) | Average amount earned after electricity (EUR) | Increase in % |
|---|--|---|---------------|
| Entertainment & accommodation (bars, restaurants, guesthouse)                 | 254.43   | 419.81  | 65%           |
| Retail activities (Kiosk, shops)  | 191.93   | 342.39  | 78%           |
| Material processing (welding, timber processing, brick making, carpentry etc) | 53.15  | 97.06   | 83%           |
| Dairy (production and processing)   | 134.66   | 269.33  | 100%          |
| Garage and spare parts  | 169.62   | 339.24  | 100%          |
| Other services (barber shop, computer/IT, Advisory etc)                       | 137.59   | 313.58  | 128%          |
| Other   | 70.68  | 212.03  | 200%          |
| Food processing (milling, grinding, extraction etc)                           | 64.63  | 227.38  | 252%          |
| <b>Grand Total</b>  | <b>125.86</b>                                  | <b>260.14</b>                                 | <b>107%</b>   |

In general, local MSMEs reported an increase in their revenue as a result of access to electricity. The average revenue generated per month increased by between 65% and 252%. MSMEs in the food processing segment saw the highest increase. Two-thirds of businesses are re-investing their additional income in their business.

**The most significant benefits to MSMEs** has been the diversification of their products and services (62% of MSMEs reported this), the increased customer-base (59% of MSMEs interviewed), and the extended working hours (55% of MSMEs interviewed). Energy costs are considered to be affordable for 73% of the MSMEs in-

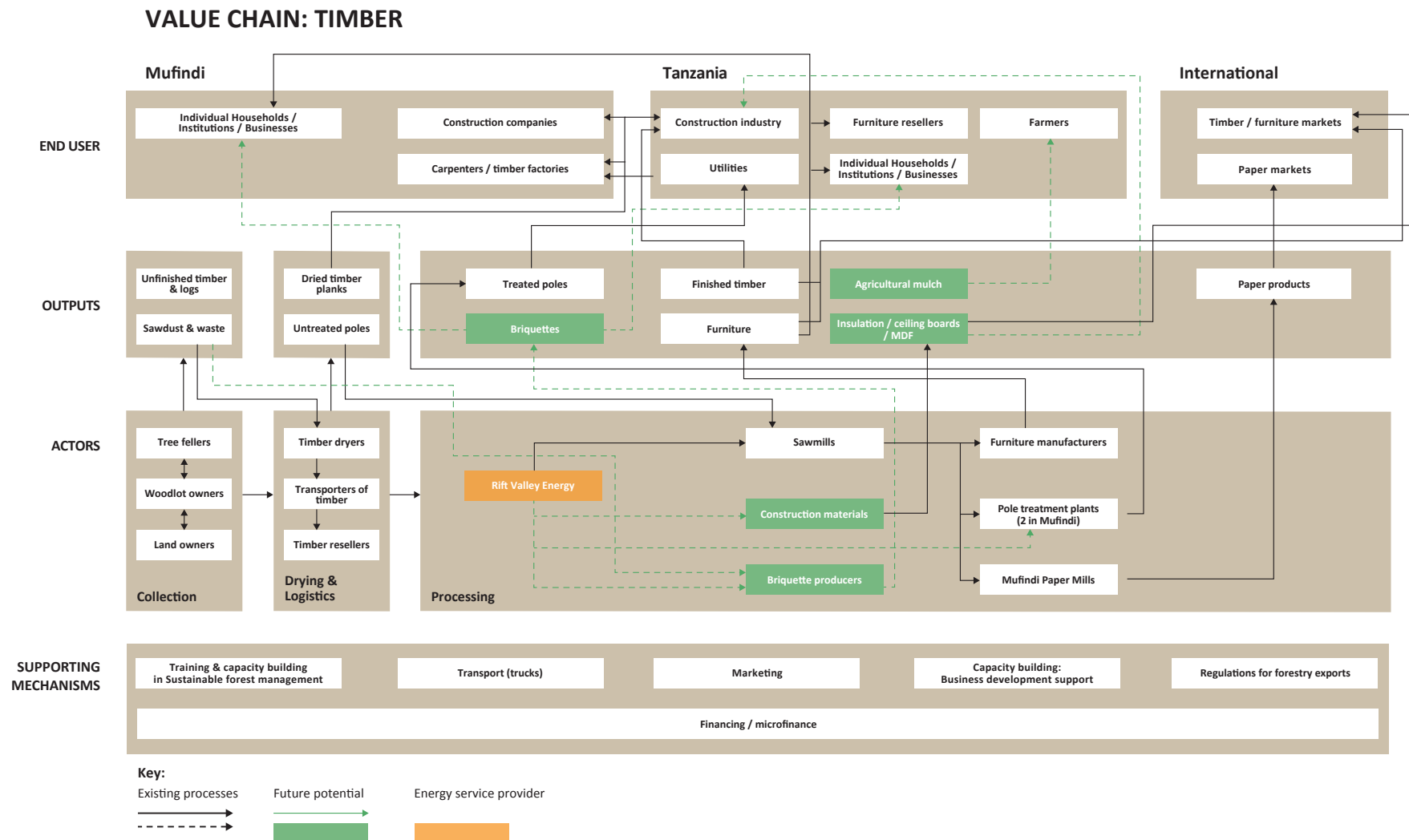
terviewed however, 63% of the customers of JUMEME's mini-grid reported that the cost of electricity presents a significant burden. Demand management strategies have constrained the ability of MSMEs to respond to demand and grow their businesses in a context that does not operate on a time-of-day schedule.

Taking a value chain approach to economic activities may potentially reveal opportunities not only in the direct provision of a product but in the commercialisation of by-products. Three such value chains are described (timber, rice and sunflower oil) that apply to the project sites visited in both Madagascar and Tanzania.



## Timber production

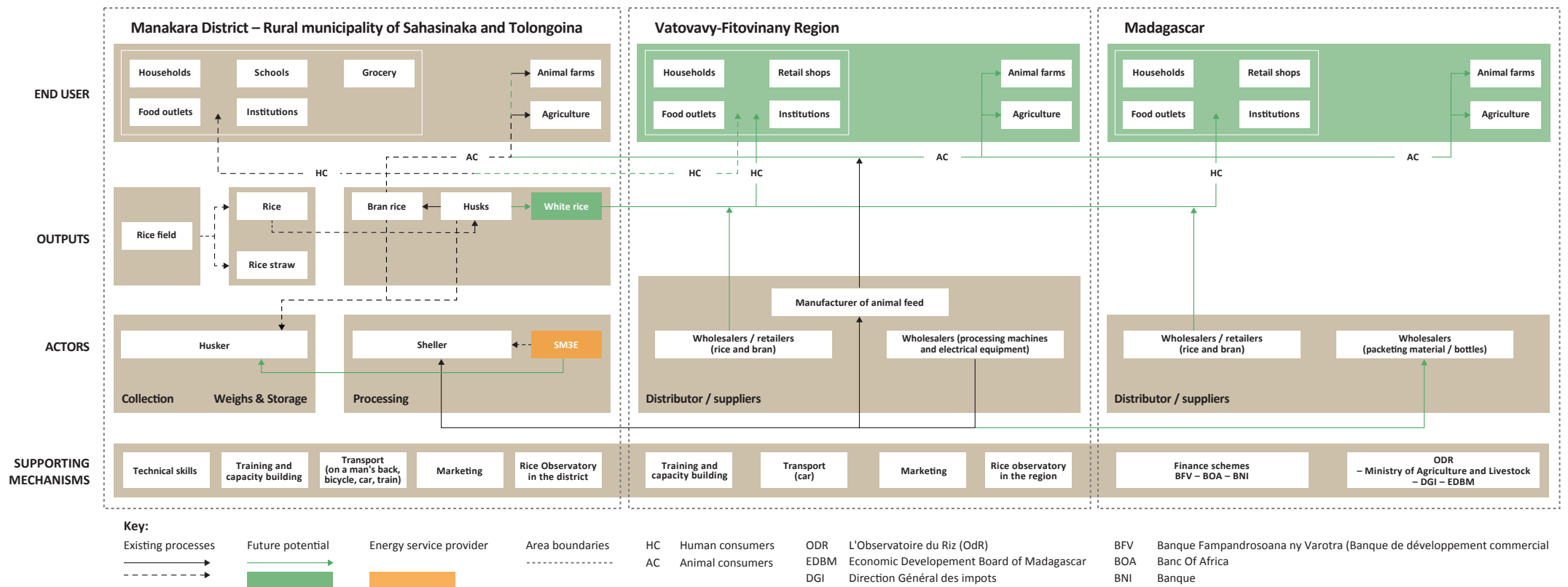
The timber production value chain is relatively well developed in Tanzania for large-scale production. There are opportunities to encourage smaller-scale sawmills to both provide services locally that reduce the costs of transporting timber to sawmills further afield, and to expand on their services, incorporating furniture production, and additional products based on the by-products of production, such as insulation and ceiling boards, briquettes, which would have a local appeal to replace charcoal, and agricultural mulch. RVE is working with smallholder timber producers to develop this value chain.



## Rice production

Rice is being grown in all three sites studied in Tanzania (Mufindi 467 ha, Ludewa 661 ha), and Tologoina in Madagascar. The rice is primarily consumed locally at present despite that there is potential to market further afield. Rice that is transported outside of the area is not processed. There is an opportunity to increase local production through irrigation, processing and packaging for consumption within the region or further afield. The right level of investment in marketing and transporting the product would be required. Consideration would need to be given for quality control and food hygiene standards. Rice husk could be sold as a by-product for animal consumption.

### VALUE CHAIN: RICE



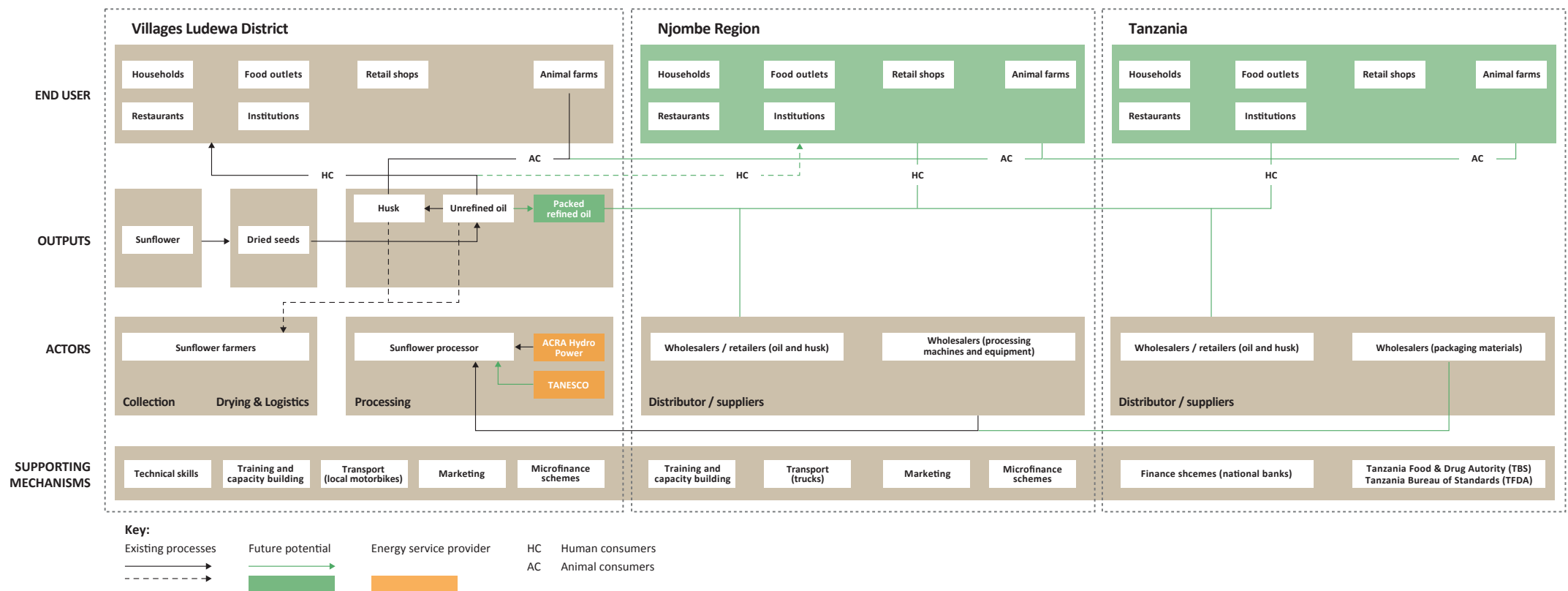
## Sunflower oil production

The market for sunflower oil within the southern corridor is well established and absorbs more than 75% of the sunflower oil produced in the Southern Highland regions. However, the majority of oil is consumed in its unrefined form. Therefore, only a relatively small percentage is today traded outside the region. Local consumers are able to purchase unrefined sunflower oil in the following ways:

- from farmers who have paid for the processing of their crop,
- from local traders who have purchased from farmers and paid for the processing,
- from processors who have bought either the seed or oil from the farmers,
- from retailers who have bought the oil from processors or traders, or
- from farmer/community groups who own processing equipment.

The opportunity exists to refine the oil and package it for local, regional or national consumption, as well as sell the husk as an input into the animal feed industry.

## VALUE CHAIN: SUNFLOWER PROCESSING





There is the potential for other value chains to be developed, such as perishable farm produce, although consideration needs to be given to the proximity of the markets to be accessed, the logistics of transporting goods given the poor road networks, and the need for a cold chain where applicable. Refrigeration for food preservation which is more common in Madagascar, could be developed to reduce food wastage but this requires the MSME to source finance to invest in stock, in appliances that have significant storage capacity, and in marketing.

Working with existing businesses is more effective than supporting new businesses. Business development support (BDS) is resource intensive and was provided in Tanzania to the projects studied. However, the approach to BDS does not seem to have left a lasting legacy, due to the relatively short period over which BDS was provided and the time required for local MSMEs to develop skills and get started. **The practical experience of those providing BDS, as well as the tools and techniques adopted with BDS need to be relevant** to how rural businesses operate.

**The tariff structure that governs mini-grids is crucial to the PUE.** Different approaches have been adopted by project developers:

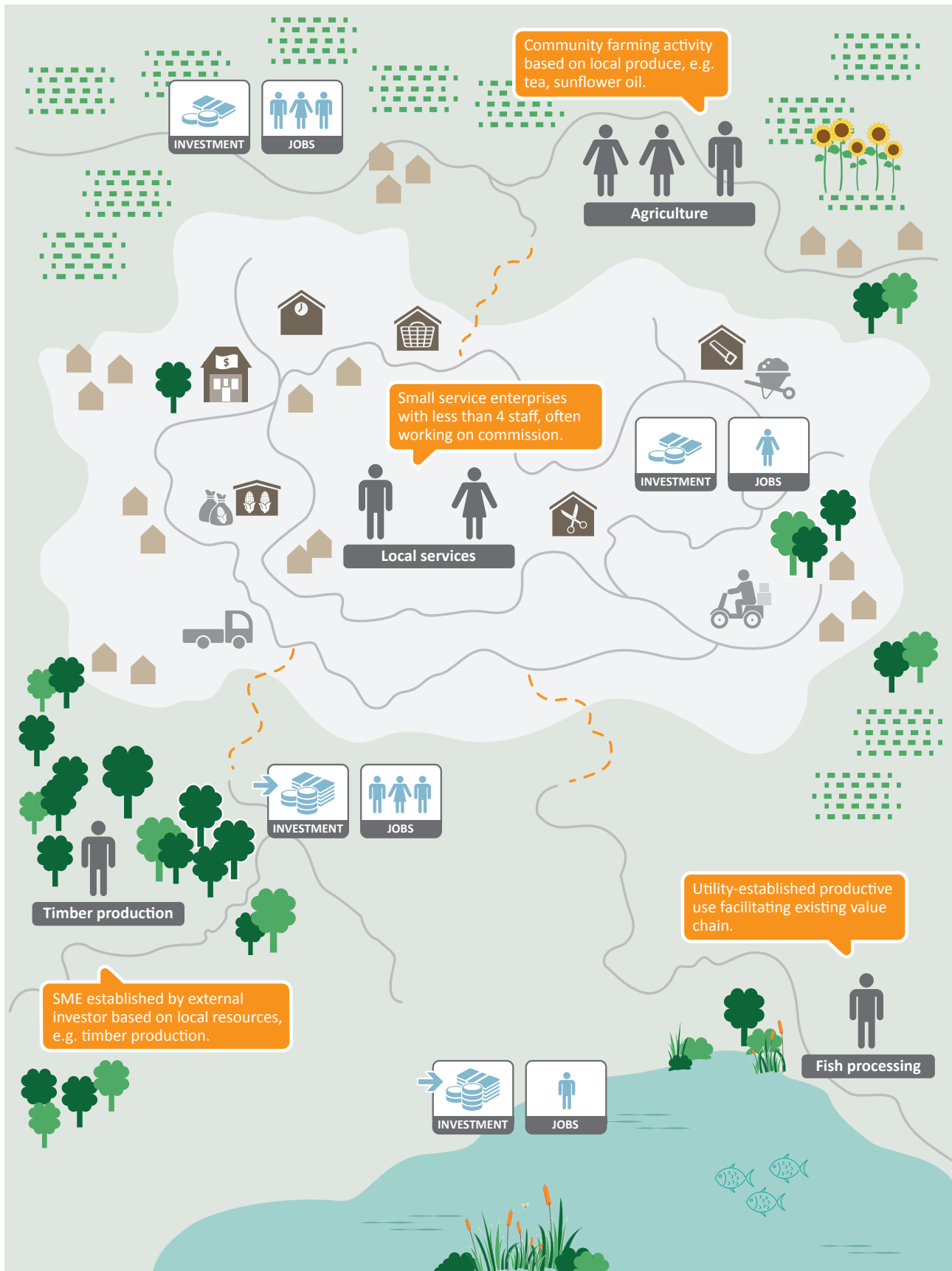
- i) to keep the tariff low to encourage uptake until scale can be achieved or,
- ii) to charge a cost-reflective tariff from the outset, particularly for technologies that are more expensive, such as solar PV, and rely on private investment.

Both models require significant subsidies and the investment per kWh generated differs according to the energy source. However, price sensitivity for rural users is a key factor that should be taken into consideration in the design, as it directly affects the viability of the customers' business, and therefore commercial viability of the mini-grid. Structuring tariffs needs to take into consideration seasonality, and the burden of placing weekly or monthly service charges that do not reflect actual consumption, and therefore business turnover. The regulatory framework has a role to play in protecting consumers and holding mini-grid operators to account however this has to be balanced against the business case for rural, and particularly off-grid, energy access.





## Business activities in rural areas



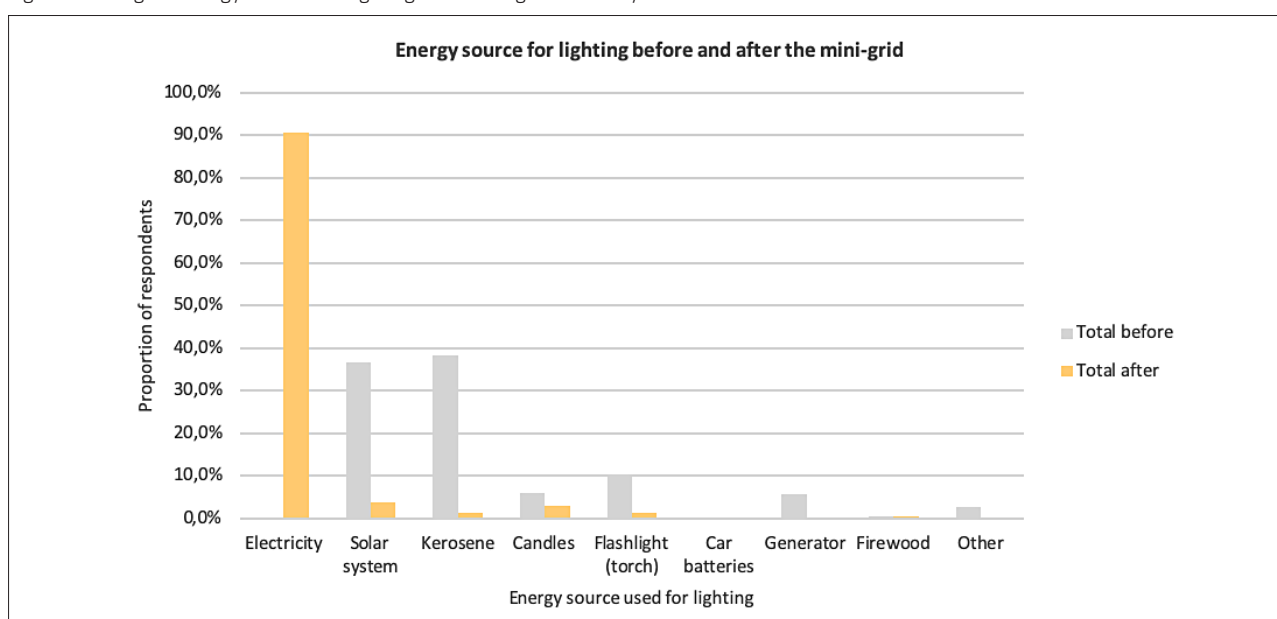
## 3.2 Impact

### SDG 7: Ensure access to affordable, reliable, sustainable and modern energy



The transition to **electricity has displaced the use of traditional energy sources**, such as kerosene and battery-powered torches. This is more pronounced for households in Madagascar, which were more reliant on kerosene lanterns than in Tanzania, where solar home systems were used by 47% of households.

Figure 2: Change in energy sources for lighting after mini-grid electricity



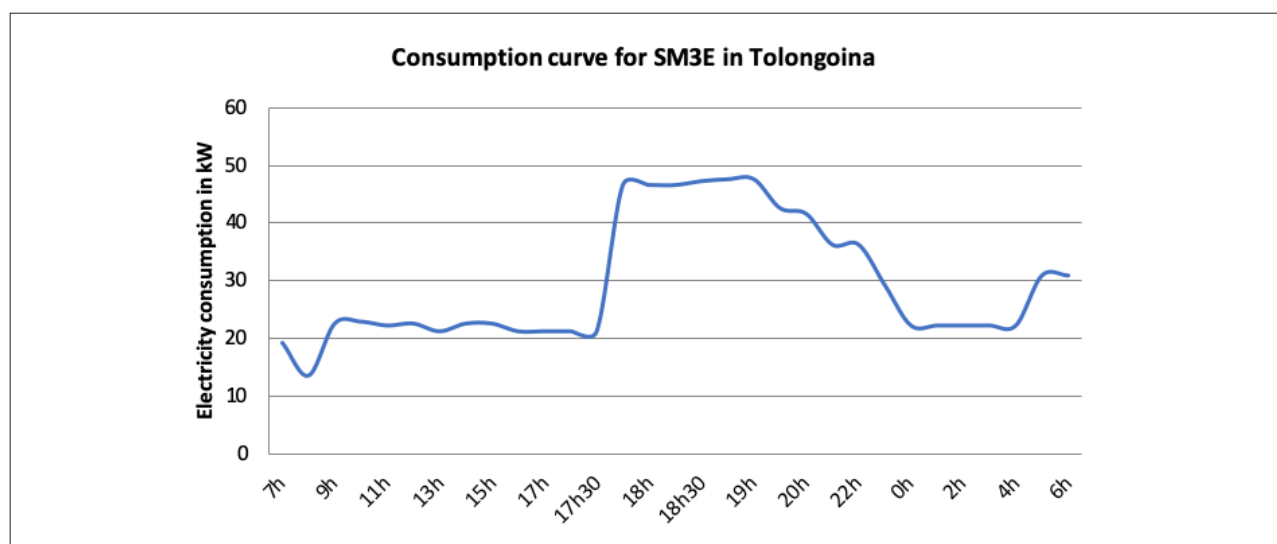
In Tanzania, 17% of households operated a business from their homes, the majority of which are small retail or food outlets. However, 13% of these reported having a maize mill or carpentry/timber processing workshop. In Madagascar, of the businesses being operated by households, 22% are freezing food or cold drinks, 43% have grocery shops and 22% are food outlets. Only one household was operating a mill. In general, **58% of households use their electricity service all day** and 22% use it for between 4 and 8 hours a day. In Madagascar, 76% of users make use of the system all day and for security lighting and refrigeration during the night.



The perceived **affordability** of the electricity is consistent with the levels of tariff being applied. Fourteen percent of domestic customers on tariff of EUR 0.14, reported that they found the cost of electricity to be a burden. This indi-

cates that these households may be very low income, and would likely also struggle to afford traditional fuels, such as kerosene. However, almost 90% of households on a tariff of EUR 1.38 per kWh reported electricity as a significant burden and therefore prioritise their energy needs, indicating that the threshold of affordability has been exceeded.

Figure 3: Consumption curve for Tolongoina customers in Madagascar



The **reliability** of power supply across all projects was generally reported to be very positive. The two projects experiencing grid instability reported that this was due to the link with the national grid, which was not stable and therefore caused instability, or due to maintenance works.



## SDG 1: End poverty in all its forms everywhere

On average, **over 70% of the targeted households confirmed that the quality of their life had improved** after the arrival of electricity. The reasons provided by respondents include convenience and the quality of light. However, indirect effects were also mentioned, specifically the time saved by having access to electricity directly in their homes. Respondents reported that it was no longer necessary to travel to the nearest on-grid town and wait there to charge mobile phones, that chores could be done more efficiently, and activities could take place after dark.

In addition, the availability of reliable electricity resulted in health clinics offering additional services, such as surgical procedures and laboratory tests. The schools in Madagascar reported a **40% improvement in pass rates** since the introduction of electricity, although this could be linked to other factors too.

Seventy-four percent of respondents stated that the increase in revenue generated from productive uses is reinvested in their business. A **quarter of household respondents stated that they had more disposable income** after electricity, which was primarily spent on food and school fees, although it would seem that medical treatment is also a significant cost item in Madagascar.

Despite these very positive effects, there are some **negative consequences** of energy access. Children are being distracted from their studies by TV and some are gambling on slot machines, and there has been an increase in prostitution in the area as bars are able to open for longer hours.



## SDG 5: Achieve gender equality and empower all women and girls

The introduction of electricity has had a significant impact on the lives of women. The increased convenience and decreased time taken to perform routine activities has had a **significant effect on their quality of life**. The time is reportedly used to perform additional chores, both for men and women.

In terms of the supply chain, women have a **customer facing function and occupy the service-oriented roles**, including retail, tailoring, and hairdressing. Even in business segments where women do not have the main role, such as fisheries, they support with auxiliary services, such as drying the fish.

The ownership and **decision-making role of women appears to be limited**, with only 10% of women stating that they have the autonomy to take decisions in relation to their business. However, the cultures in both Tanzania and Madagascar encourage families to work together, which was also echoed by the focus groups. There are specific entry points for women: for example, in terms of access to finance, women tend to seek out loans from cooperatives rather than banks; in terms of representation on local councils, women are engaged in advising on issues that directly affect them.



From the profile of the women entrepreneurs interviewed, they are motivated, ambitious and talented. However, they lack some fundamental capacities to facilitate their entrepreneurial drive. A number of factors have affected their success as entrepreneurs:

- energy illiteracy
- a lack of business management skills,
- the tendency to work in groups that also leads to a risk of discord,
- insecurity that prevents them staying open late into the evening,
- cultural perceptions of women as being disreputable if they operated a business, and
- the failure to maintain repayments during the start-up phase due to poor cashflow.



**Mainstreaming of gender** requires that gender equality is considered at **all levels**, including within the **operators' internal organisation**. As mini-grid operators are required to engage with productive users, and in some cases are providing first line support to women-led businesses, gender equality *within* these companies is not necessarily understood or practiced. The inclusion of organisations such as women-focused private sector organisations to mainstream gender could be explored to a greater extent.

### Power to the women

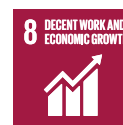
In 2004, Dafroza established her tailoring business. As a mother of four children, taking care of six others that had been orphaned, and with a husband that was seriously ill, Dafroza's drive for success comes from a necessity to support this large family. In 2017, she purchased an electric sewing machine for EUR 149 under the appliance financing scheme offered by JUMEME. Having received skills training from the Small Industries Development Organisation (SIDO), Dafroza was able to put her new skills into practice immediately.

JUMEME's flexibility to accepting the sporadic flow of income on the island meant she was able to repay her loan. As the sewing machine is not energy intensive, Dafroza's electricity bills are manageable.

Dafroza is performing a value-added service embroidering plain materials. By doing this, she is able to increase the sales price on her items by three times. However, the purchase power of the local community is limited. The crack down on fishing regulations has also reduced the disposable income available on the island, and her goods are not an essential.

Dafroza's passion for her work has motivated her to attend a trade fair on a neighbouring island to showcase her products and identify potential stockists for her products on Ukerewe Island and in Mwanza.





## SDG 8: Promote inclusive and sustainable economic growth, employment and decent work for all

The creation of jobs through productive use of energy is evident: **businesses report 2.5 times the number of employees, since the introduction of mini-grid electricity**. The effect has been greater for men than women however and community members report that it is primarily the youth benefiting. In Tanzania, specific mention was made of the migration of labour into communities with electricity, which was confirmed during interviews. The more significant job creation did come from the larger scale investments in local production.

The household survey did not indicate a significant change in terms of jobs status. However, this is primarily due to the nature of work in rural communities. Typically, **individuals perform multiple income-generating activities, layering their sources of income, and in some cases, addressing weaknesses in the value chain by filling the gaps**. This leads to resilience but is also a necessity due to the small scale of the local market. Access to markets outside of the immediate area would potentially improve dynamism but the local infrastructure is very restrictive.

The ability to become self-employed as a result of electricity was welcomed. Those that had given up employed positions indicated that this liberated them and allowed them to earn a higher income. Job displacement was not considered to be a significant concern as the suppliers of traditional fuels began to supply electrical products.



## 4 The Theory of Change

Based on the data presented above, it is apparent that the provision of mini-grid electricity has facilitated socio-economic development in all the villages that were visited. The Theory of Change for energy access projects has broadly held true, although there are nuances in terms of the degree to which the provision of electricity has led to change and in which respects.

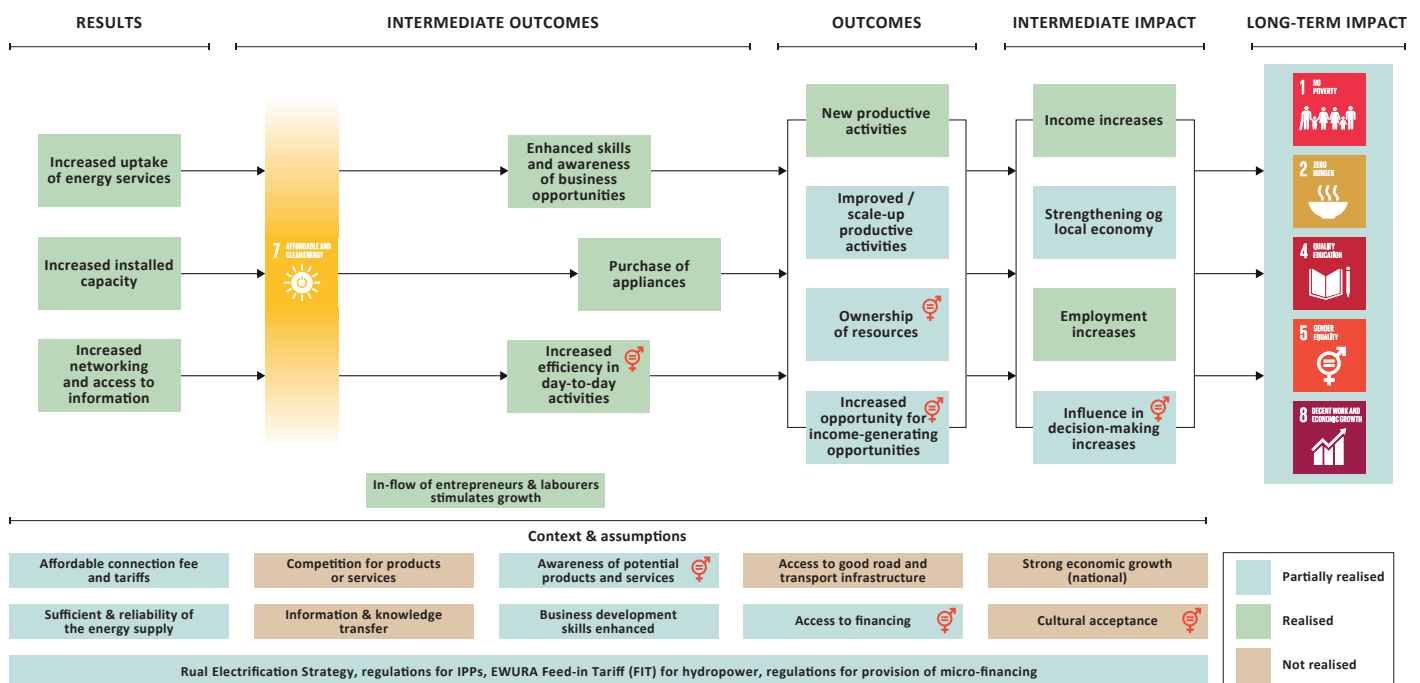
### Intermediate Impact

As described above, there is evidence that the provision of electricity has led to an increase in income, strengthening of the local economy, and employment; the increase in revenue is being reinvested into businesses by two thirds of MSMEs; a quarter of households report an increase in disposable income, which they are using towards food security and education. Seventy percent of

respondents stated their quality of life had improved as a result of electricity.

However, the local economy has only been strengthened to the point where factors external to the provision of energy have constrained further development. For example, the national economic downturn in Tanzania has had a significant effect on the timber industry, reducing demand for one of the main productive outputs. The clamp down on illegal fishing in Tanzania resulted in less money in the local fishing village economy and has had a negative effect on the revenue stream of local fishermen. There was little evidence that the cultural status of women had altered significantly, specifically in terms of decision-making, although there are individual cases where this has occurred.

Figure 4: The revised Theory of Change based on research findings





## Outcomes and intermediate outcomes

The increase in opportunities to generate an income could not be accurately mapped without a baseline. However, the communities indicated a significant increase in the services and businesses available. Additional productive activities have been introduced based on the diversification of products and services. Appliance financing has facilitated the availability of appliances in areas where there is very little competition in the market and appliances are not available in the vicinity.

However, the challenges at this level have related to keeping up payments on financed appliances, poor business management skills, and lack of access to markets with greater purchase power, outside of the internal economy. The poor road infrastructure has a significant influence on this.



## Results

The uptake of energy services has been very successful in three of the six projects studied. For over 70% of commercial users, affordability is not a concern. However, this is not the case with domestic consumers. The other three projects have struggled to bring new customers on board, linked to the cost of connection and tariffs. In addition, there are restrictions in terms of the available installed capacity for productive use and the reliability of supply for two projects. Energy illiteracy and the lack of awareness of how to access financing have presented a barrier to further exploitation of the installed capacity, particularly for women.



## 5 Drivers, barriers and opportunities

The key drivers of the developments in terms of productive uses in the project sites that were studied are:

- Local natural resources
- Availability of grid-quality electricity
- Access to start-up finance
- Affordable tariffs and limited demand-side management
- Skill and capacity
- Adaptation and innovation
- Logistical factors
- Cultural acceptance.

These drivers have worked in synergy in the cases where businesses have succeeded. The availability of natural resources that have lent itself to a **value chain**, such as timber, food crops or sunflowers has facilitated the mechanisation of a previously manual processes and establishment of ancillary businesses. There is **potential** to do this to a greater extent, for example through irrigation, provided the conditions allow for it, such as water levels and distance to the fields, etc. However, this is **resource intensive** and is outside most project developers' domains, relating more to rural agricultural development. It will require communities to become accustomed to irrigating, paying for the water, and recognising the potential this has for increasing profits. **Access to markets** also needs to be facilitated.

**Access to finance** to procure equipment is undoubtedly **an enabler**, particularly for those with businesses that were businesses with a low turnover or a new business, as they may not have the capital to invest in appliances. The **terms and conditions** on which project developers provide the loans and the repayment plan can influence whether businesses are able to generate the cash flow to repay the loan. The maintenance of equipment is also a success factor as it will determine whether the cash flow is consistent.

The **affordability of the tariffs can drive productive use**. Rift Valley Energy's approach of accelerating the uptake

by adopting low tariffs **for grid quality electricity** and therefore achieving scale has facilitated commercial activity. By the same token, the **comparatively** higher tariffs and standing service charges applied by JUMEME are considered to be burdensome, further constraining business operations due to time-of-day tariffs. MSMEs complained that rural communities do not function only during daylight. This is specifically a challenge for solar hybrid mini-grids due to the cost of providing electricity at night and the aim of providing grid-quality electricity 24-7.

MSME development requires a long-term investment of a variety of actors. Selecting entrepreneurs is a crucial stage that can drive success, identifying those with the business instinct that are able to **adapt and innovate**. The support provided should be given by entrepreneurs that have run their own businesses, and must be relevant to the way in which rural business is run, i.e. less focus on formalised accounting and instead working with the entrepreneur using their own methods and logic.

Energy literacy and skills are low in many rural communities. Assessing the internal and external market potential requires specific skills and knowledge. Where business development support has been provided and new activities established, **formal skills development** has provided the MSME with a strong basis on which to grow, such as tailoring, welding, carpentry, etc. Similarly, the migration of labour from other areas into the village has caused social tension, but has been necessitated due to the lack of skill available in the local youth. Migration into the village provides a development potential/opportunity of the village to become a new "regional centre".

It is not possible to address and control the external factors that serve as drivers or barriers to PUE. One of the drivers for **attracting investment** into local production in Mufindi was the **reliability of the energy supply, combined with the restrictions** put on production in another area that made Mufindi a better option, closer to the source of raw materials. Other barriers to greater development is the poor road infrastructure and, in some areas, the **transience of the community**, which limits the degree of social cohesion.

## 6 Lessons learned

The following specific lessons have been derived from this study and may inform future projects aiming to drive PUE:

| Drivers                                       | Lessons learned   |
|---|---|
| Local resources & identifying a value chain   | <ul style="list-style-type: none"> <li>▪ The challenge of establishing a commercially viable mini-grid highlights the importance of a significant off-taker;</li> <li>▪ Where a significant off-taker is not obvious, an effort needs to be placed in developing the value chain for local resources and productive activities;</li> <li>▪ Developing local value chains is a long-term process. It requires an understanding of community activities, local resources, and the capital to support MSMEs or directly develop new value chains.</li> </ul>   |
| Access to start-up finance                    | <ul style="list-style-type: none"> <li>▪ Project developers are fulfilling multiple roles, including providing credit financing. The risks are high for project developers, particularly due to the lack of resilience of MSMEs operating in rural communities;</li> <li>▪ Access to finance is a significant barrier for MSME growth. The design of the financing scheme is important in supporting MSMEs during their start-up phase, taking into account their cash flow and time to establish a strong customer base.</li> </ul>  |
| Affordable tariffs and demand-side management | <ul style="list-style-type: none"> <li>▪ Reducing connection fees can increase the uptake of services, speeding up the process of achieving scale. However, this does require that financial incentives are available to subsidise connection costs;</li> <li>▪ The technology is a determining factor if the tariff is to be cost-reflective. Price sensitivity means there is a balance to strike;</li> <li>▪ The time-of-day tariffs can be counter-productive, particularly as a number of rural activities take place after dark, when costs are higher for solar PV.</li> </ul>   |
| Skill and capacity                            | <ul style="list-style-type: none"> <li>▪ Project developers are making a significant contribution to boosting rural capacity. However, in order to improve efficiency and effectiveness, partnerships need to be forged with organisations that can drive skills development and access to finance;</li> <li>▪ Local government is a key partner in rural agricultural development due to their role in providing capacity building through extension workers. In addition, local development funds and government-funded skills development organisations can play a vital role. This has not been integrated into project design;</li> <li>▪ Rural MSMEs tend to replicate successful businesses although the degree of quality varies. The formulation of a business is often completed without assistance and is not always linked to market demand. Energy literacy is a barrier.</li> <li>▪ Access to markets is key to MSME development however this continues to be a barrier that rural MSMEs have yet to overcome.</li> </ul> |
| Adaptation and innovation                     | <ul style="list-style-type: none"> <li>▪ Adaptation and innovation is required of the project developer and the end users. The project developers need to adapt to energy use patterns that develop and innovate to stimulate new PUEs. End users need to adapt and innovate based on market demand, which is not always known before electricity is available;</li> <li>▪ Local entrepreneurs that have the potential for growth are exceptional and therefore it is important to identify them and support their development;</li> <li>▪ Where there are gaps in the value chain, entrepreneurs or project developers have taken action to close the gap.</li> </ul>  |



| Drivers            | Lessons learned  |
|--------------------|--|
| Logistical factors | <ul style="list-style-type: none"> <li>▪ The most significant barrier to future development is poor transport infrastructure.</li> </ul>   |
| Gender             | <ul style="list-style-type: none"> <li>▪ Men are key to facilitating the empowerment of women and their buy-in is key.</li> <li>▪ As with all interventions, there are positive and negative effects. Apart from the positive effects, energy access appears to give rise to an increase in behaviour that puts vulnerable groups at risk.</li> </ul>  |
| Sector-wide        | <ul style="list-style-type: none"> <li>▪ Rural development includes multiple sectors which are not coordinating or learning from one another. Without a joint approach, growth is limited;</li> <li>▪ The business case for mini-grids in poor, rural contexts where the load is limited is not adequate to support the business case. Until the cost of technology decreases, consideration should be given to the most appropriate technology and financing arrangements.</li> </ul> |

## 7 Recommendations

The project developers that have participated in this study have **pioneered the promotion of PUE** and on that basis provided a valuable basis to learn lessons. The

following specific recommendations have been derived from this and could be considered in designing and implementing projects that aim to drive PUE:

| Drivers                                       | Recommendations  |
|---|--|
| Local resources & identifying a value chain   | <ul style="list-style-type: none"> <li>All projects should undertake a <b>baseline</b> study of productive uses to ensure that the changes observed can be understood in relation to the situation before electricity arrived;</li> <li>Feasibility studies should include a holistic assessment of all resources in the village and identify the best approach to commercialising and up-scaling production, particularly agricultural, particularly addressing <b>access to markets</b>.</li> </ul>  |
| Access to start-up finance                    | <ul style="list-style-type: none"> <li>Develop access to finance for rural business development that takes into consideration the risks associated with rural contexts. Consideration should be given to <b>guaranteeing revolving funds</b> to reduce the risk to the project developer/ MFI;</li> <li>To reflect the stage at which an MSME is at, <b>stage repayment plans</b> to allow them to establish a cash flow before repaying their loan.</li> </ul>  |
| Affordable tariffs and demand-side management | <ul style="list-style-type: none"> <li>Consider minimising the connection fees, applying for financial incentives where available, to promote uptake;</li> <li>Consider the balance between tariff setting and cost-recovery taking into account the ability-to-pay;</li> <li>Where feasible, reduce limitations on consumption and consider the rural clock.</li> </ul>   |
| Skill and capacity                            | <ul style="list-style-type: none"> <li>Where possible, develop alliances with local government to engage <b>extension workers</b> that can provide long-term advice to farmers on how to make use of irrigation and develop the market linkages that may lead to wider markets;</li> <li>Introduce <b>energy literacy courses and consumer awareness raising</b> on PUE as it relates to current practice, but also encourage demonstration businesses to show how energy can be put to better use, for example with food preservation;</li> <li>Mini-grid operators co-opt partners to provide <b>formal skills training and apprenticeships</b> to improve the <b>quality</b> of work, and therefore broaden potential markets.</li> </ul> |
| Adaptation and innovation                     | <ul style="list-style-type: none"> <li>Consider <b>the selection of businesses</b> very closely and identify local agents of change that demonstrate an entrepreneurialism that facilitate the success of their business, incorporating some form of due diligence;</li> <li>Mentoring and training is provided by <b>entrepreneur networks</b> that can provide practical and patient guidance in the medium term;</li> <li>Encourage the versatility that MSMEs show in closing gaps in the value chain;</li> <li><b>Share information</b> between mini-grid operators to ensure that the future projects build on the existing experience and knowledge.</li> </ul>   |
| Logistical factors                            | <ul style="list-style-type: none"> <li>Solutions to rural development are cross-sectoral and therefore, where possible, planning to improve energy access should be coordinated with road infrastructure development so as to facilitate local development.</li> </ul>   |



| Drivers     | Recommendations   |
|-------------|---|
| Gender      | <ul style="list-style-type: none"> <li>▪ The <b>role of men</b> in influencing the rate of cultural change is critical. When addressing gender, ensure that men are included in awareness raising and in supporting the women and girls in their family to gain capacity.</li> <li>▪ All energy access programmes should incorporate the requirement for project devel-opers and contractors to <b>avoid the negative effects of energy access</b> through aware-ness raising and prevention, similar to what is done in the roads sector.</li> </ul> |
| Sector-wide | <ul style="list-style-type: none"> <li>▪ The <b>dissemination of experience</b> based on the results obtained from these pioneering projects in terms of PUE should be prioritised;</li> <li>▪ <b>Cross-sectoral working is promoted</b>, particularly from rural agricultural development programmes, covering water, sanitation, agriculture, infrastructure;</li> <li>▪ Provide the need for <b>subsidies</b> to the tariff for mini-grids to support the journey to achieving scale.</li> </ul>   |