GREEN MINI-GRID
HELP DESK

KeyMaker Model fundamentals

Mini-Grids as a tool for inclusion of deep rural communities into domestic and international trade

Nov 2019

INENSUS ENERGY4IMPACT ACCELERATING ACCESS TO ENERGY SUSTAINABLE ENERGY FUND FOR AFRICA SUSTAINABLE ENERGY FOR ALL AFRICA HUB AFRICAN DEVELOPMENT BANK GROUP

KeyMaker Model fundamentals

Mini-Grids as a tool for inclusion of deep rural communities into national and international trade

Authors

Nico Peterschmidt
Senior Mini-grid Expert

np@inensus.com

Dr. Tatiana González Grandón
Energy Economist

tg@inensus.com

This report was developed under the Green Mini-Grid (GMG) Help Desk for the Sustainable Energy for All (SE4All) Africa Hub, hosted by the African Development Bank (AfDB) and funded through the Bank's Sustainable Energy Fund for Africa (SEFA). This report was reviewed by:

Jeff Felten and Brendan Coleman, AfDB

The authors would like to thank the following mini-grid and rural electrification experts for constructive discussions and feedback during the various development stages of this report:

Vivien Barnier and Andrea Cabañero, Inensus GmbH

Photo credits: Inensus GmbH

Referencing:

González Grandón T. and Peterschmidt N. (2019) "KeyMaker Model Fundamentals: Mini-grids as a tool for inclusion of deep rural communities" Green Mini-grid Se4all Africa, AFDB.

Table of Contents

List of Figures, Tables and Acronyms

Acronym	Definition
CAPEX	Capital Expenditures
KMM	KeyMaker Model
kWh	Kilowatt hour
MG	Mini-grid
MSME	Micro, Small and Medium Enterprises
OPEX	Operation Expenditures
PUE	Productive Use of Electricity
TR	Total Revenue

Executive Summary

The KeyMaker Model is an approach to enable rural manufacturing and to successfully trade goods from underprivileged, deep rural areas of developing countries in competitive national and international markets. By decentralizing manufacturing and opening these trade options for rural communities, considerable cash-flows may be channelled into deep previously unelectrified rural areas leading to accelerated rural development and increased living standards, while opening new input sourcing options for industries. Electricity supply from mini-grids for local processing of goods is the **Key** to open these trade options, the mini-grid operator bringing in the required management capacity for the trade business is the **KeyMaker**.

Deep rural communities face numerous disadvantages when competing with peri-urban producers of goods: The long distance to the trading hub, time-consuming and costly transport, as well as lacking management, logistics, accounting, trading, controlling and engineering capacity on site. So far, only highest value products like precious stones, rare metals or tropical hardwood have made their way from deep rural areas to the national or world market, usually with little benefit to the local communities. The KeyMaker Model relocates stages of processing and creates a trade channel for the next level of value goods from deep rural areas like fish, meat, preprocessed organic food, minerals, etc. under strong participation of the local community.

However, relocating stages of a manufacturing industry to rural areas is not necessarily economically feasible. Fortunately, the KeyMaker model systematically harvests synergies between the operation of the mini-grid and the management of the trade business, sharing costs among the two business strings to achieve Economies of Scope in a bi-product company (electricity and KeyMaker good generation and distribution).

The success of a KeyMaker model depends on four main factors:

1. The qualitative superiority of a KeyMaker good based on local natural resources (water, soil, lake, minerals, climate) that create a significant advantage over producing the same product at a different location. That is, significantly increasing product quality.
2. The precision of the design of a local (pre)-processing stage using mini-grid electricity to drastically reduce transport costs of the product.
3. The degree of economies of scope between the two business strings (electricity and KeyMaker product).
4. The quality of integrating business processes into the local community’s life patterns and existing socio-economic structures to maximize product supply.

Governments may use the KeyMaker Model to include not only rural communities into the larger national economic cycle but also to attain fast rural electrification using solar mini-grids commercially viable and thus scalable. To achieve this, policymakers may provide benefits to investors into KeyMaker projects through tax incentives, adequate import duty regimes, and tight collaboration between various ministries.

1 Introduction

Economic inclusion of Deep Rural Areas using the KeyMaker Model

Products from deep rural areas of developing countries often do not find their way to the urban trade hubs, where large consumption results in reasonable commercial margins for the rural population. Instead, products from deep rural areas are just sold locally. Excess goods like fruit and vegetables perish instead of generating income, keeping the rural production structures on a vulnerable level. In contrast, relocating gradual industrial production capacities in rural areas while establishing trade channels from rural regions into the urban-hubs could direct considerable cash-flows into rural areas. Consequently, this may not only change the local production structure, but also the rural development could be accelerated, rural living standards could improve, social well-being could rise, and the rural population could become more resilient to climate change and related effects. If job opportunities in rural areas resulting from this trade and rural economic development arose, migration to the cities and potentially even to industrialized countries could be reduced.

At the same time, many developing countries belong to the fastest growing economies in the world with rapid increases in the percentage of the middle-class population. These changes the consumption patterns in the domestic economy. More fish and meat are consumed. Clothes are purchased more frequently. More solid houses are built and higher quality furniture is demanded. More people buy processed goods in the supermarkets instead of fresh ones at the local market. As domestic industries prepare their response to the new demand, they require additional quantities of raw materials as inputs. These are often sourced from abroad and imported instead of being sourced from domestic resources, as in many cases, international vendors are better connected to the national trading system than small producers of the same product in domestic deep rural areas.

The reason for the goods from deep rural areas not finding their way to the trade hubs is usually two-fold. On the one hand, rural communities lack the management, accounting, controlling and logistics expertise and related organizational structures to enter into serious contracts with large wholesale off-takers. On the other hand, the long geographic distances between deep rural areas and metropolitan trade hubs together with poor transport infrastructure render rural goods expensive, low quality and thus uncompetitive when arriving at the hubs.

The KeyMaker Model in one sentence:

Reduce transport costs and **increase product quality** through local processing with **mini-grid electricity**, to achieve **economies of scope** between the mini-grid and **product trade** business to facilitate linkages between rural and urban centres, as well as to outperform metropolitan or international competitors.

This cleft between rural and urban markets and their production capacities, in developing countries, can be sealed by the KeyMaker model! The KMM model utilizes synergies between the operation of mini-grids used to supply electricity to rural communities and the trading of goods produced in deep rural areas. The mini-grid is the Key to opening the trade channel; the mini-

grid operator is the KeyMaker. The KeyMaker fills all the gaps in local management and logistics expertise with its professional company staff to set-up a small-scale rural industry. In this industry, rural goods are pre-processed using electricity locally. However, the model is profitable when the decentralization of pre-manufacture procures to reduce the transport costs while enhancing the quality of the product when arriving at the urban trade hub. As explained in detail in **Chapter 3.1**, the model is profitable when it generates Economies of Scope by operating a Bi-Product Company and thus reducing costs on both ends: the electricity and the KeyMaker goods business strings.

Within recent years, mini-grid companies have experimented with what is now called the KeyMaker Model and gained sufficient experience to describe, in **Figure 1**, the KeyMaker Model mechanics.

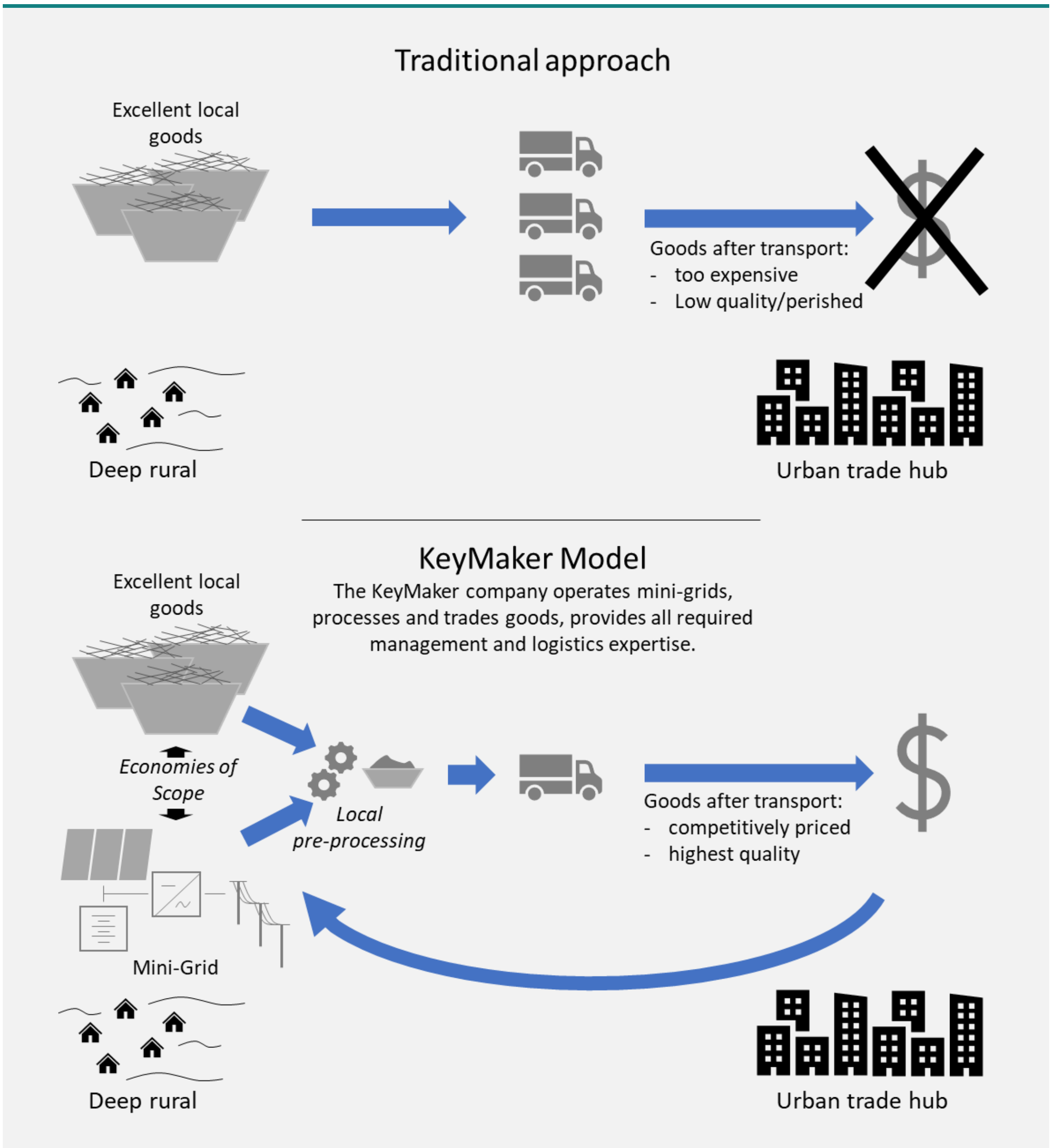


Figure 1: *The KeyMaker Model compared to traditional approaches of including rural areas into national trade. Local processing of goods and Economies of Scope under the KeyMaker Model overcome the shortcomings of the traditional approach, finally including goods from rural areas into the national economic cycle.*

1.1 Description of the KeyMaker Model

The KeyMaker Model enhances a mini-grid company to expand from generating and offering one service -electricity- together with another complementary pre-processed good in two different markets. As usual, the mini-grid company operates, distributes, and retails reliable electricity in the rural village or local market. On top of that, the mini-grid firm opens a second business line, where it self-manufactures local raw materials and becomes a supply-chain manager of a local-resource product to be offered in a regional or national external wholesale market. This way, the mini-grid operator sets up a stable and profitable mini-grid business while making larger profits further downstream.

To manage the supply-chain, the mini-grid firm purchases the local product at bulk (any quantity that the small manufacturers offer). In this way, the mini-grid operator becomes a reliable off-taker with good prices from the small farmer's perspective. Next, the mini-grid operator further locally pre-processes the raw material using the common infrastructure (land, licenses and mini-grid electricity) into a manufactured KeyMaker product. Because the community is usually financially constrained, and the Mini-grid operator is interested in increasing his/her profits, the KeyMaker product cannot be sold within the saturated local market (i.e. the rural community). Instead, the mini-grid operator can make use of the logistics, management and financing expertise of its labour capacity and ship the complementary good to an off-taker in an external market (i.e. a nearby big city).

Tilapia KeyMaker business

The solar mini-grid operator JUMEME in Tanzania collects Tilapia from fishermen on islands in Lake Victoria, cleans and deep-freezes the fish on site using its mini-grid electricity and delivers the frozen product to a whole-sale off-taker in Dar Es Salaam. In early 2019, JUMEME delivered 1 ton per week of its Tilapia, which is among the freshest and largest available in town. JUMEME is rolling out the model across all its mini-grids on islands in Lake Victoria aiming at a delivery of 1 ton per day.

More information on this case can be found in **Chapter 4**.

Figure 2 depicts **the KeyMaker value chain**. The first branch of the Mini-grid firm offers, as usual, electricity to a rural community, and on a second branch it buys pre-processed input raw materials to local small-scale manufacturers, then the KeyMaker further manufactures the good (to a certain stage) using electricity-reliant machines. After the KeyMaker good is ready, the developer also transports it to the closest biggest city, where it is sold to an external off-taker. In this way, the Mini-grid developer produces electricity and processes goods locally, but distributes electricity in the local market (rural community) and distributes KeyMaker good in an external market (peri-urban market).

Mini-grid business models had been concerned primarily with a single-product output: electricity. Although the existing models may be economically viable, these are neither scalable nor attractive investment opportunities to induce high amounts of private capital to cover the market needs. In contrast, the KeyMaker Model applies bi-product output theory and employs it for the mini-grid sector. The result is a profitable business model, which not only removes barriers to electricity access but also promotes small-scale rural industrialization.

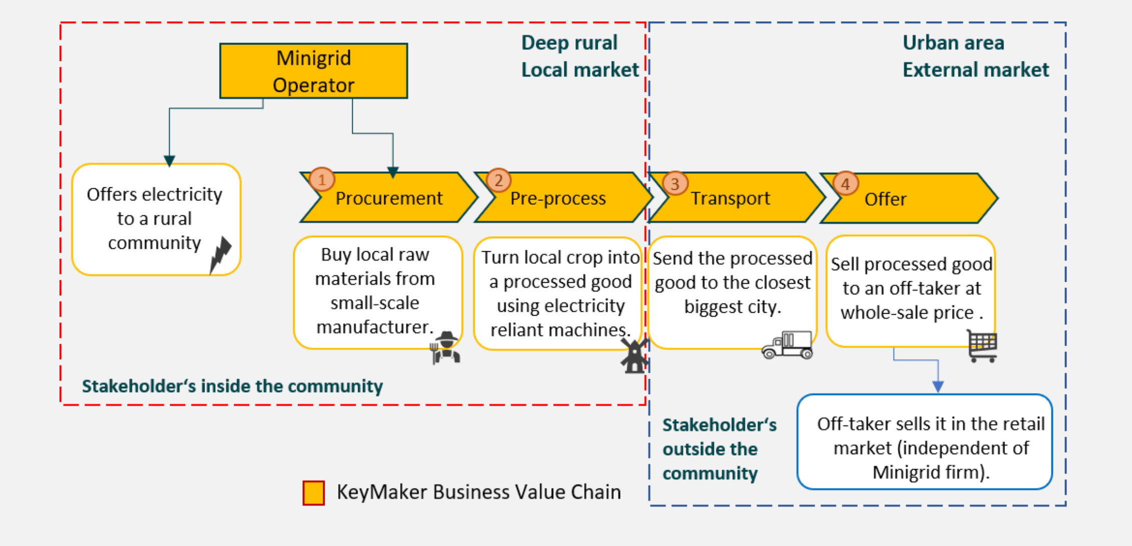


Figure 2: *The KeyMaker value chain.*

To successfully enter these low-income markets, it is crucial to understand the economic activities of the rural customers of a mini-grid to leverage the strengths of the existing market environment and overcome the weaknesses.

Mini-grid developers have long been searching for business models that are highly profitable and may finally allow for large-scale capital flow into mini-grid electrification. Although, mini-grids are considered a *High Impact Business Opportunity* by donor organizations and governments, so far, nowhere in the world a scalable model for private sector mini-grid roll-outs has been put into practice and proven to work in the long run with reasonable returns for the private investor matching the risk profile of a mini-grid investment. Therefore, the interest of investors is limited and capital for the mini-grid sector is rare. The KeyMaker Model is one of the most promising options for mini-grid developers and operators to finally boost revenues and financial returns of their business to levels that attract large amounts of first market capital. All of this is becoming possible as mini-grids are being more and more standardized and require less specialized expertise from the operator thanks to the following aspects. Mini-grid components are becoming plug-and-play and thus easier to maintain. Professional companies offer turn-key mini-grid project implementation, including project development, installation, and commissioning services. Operation of the technology as well as the fully automatic sales procedure via mobile money can be monitored and managed remotely through dedicated software. At some point, the standardization may reach a level where domestic industry feels encouraged to secure its input supply in terms of goods from rural areas through investments into KeyMaker Models, including mini-grids. National pension funds may be interested in joining hands, especially on the infrastructure part.

The local community is at the center stage of the KeyMaker Model. It can barely be considered a beneficiary only; it is rather a trade partner at the beginning of the value chain, as well as a customer of electricity (see **Figure 2**). Communities that live in un-electrified areas usually have primary production economies (like agriculture, farming, crafts, embroiders). Since they have typically traditional practices of production or growth of certain natural resources, they have gathered specialized knowledge around the handling and processing of raw materials. In the case of small-scale farmers, for instance, they adequately grow crops to manage the weather or pest risks. They know their land, soil, water flows, seasons, weather quite well. Thus, they can handle their fields and harvest very efficiently.

However, small-scale manufacturers, in general, lack the expertise of supply-chain management, marketing, information technology, networking and related logistics to selling consumer goods through multiple channels of distribution outside the community to earn a high-profit margin. As experience indicates, following access to mini-grid electricity, some electricity-reliant small businesses may appear. Yet, the great majority of these small enterprises sell their products or services exclusively to locals living directly on the production site or a few sell products on nearby main roads. But virtually none of them sells products regionally or nationally. Communities may be ready to accept and shape the transformation process that the KeyMaker Model requires or not. One of the advantages of the KeyMaker Model over conventional ways of exploiting natural resources in developing countries is that the ownership of the access to the natural resources lies with the community members instead of with e.g., a concessionaire. This facilitates negotiations between the community and the KeyMaker on eye level. As a result, the community has a strong say in any development going on in their area. The KeyMaker should not dare acting against the community's interest as this may endanger its relationship with the community and thus, its business. A well-designed KeyMaker scenario requires relatively little change from the community initially. Change can come over time when the community experiences success and decides to swap ancient habits practised to mitigate risks that may not apply anymore for more efficient production practises. This may e.g. apply to the habit of each individual having multiple sources of income and thus not being able to concentrate fully on one activity (see Banarjee, 2011).

Pineapple KeyMaker business

The hydro mini-grid operator Zengamina in Zambia operates in an area with excellent pineapples. Zengamina's sister company Zambesi Pineapples collects the fruit, processes them to dried fruit using Zengamina's mini-grid electricity, packages and brands it and sells the product to wholesale off-takers in Lusaka. In 2019, the company introduces pineapples juice as a new product.

More information on this case can be found in **Chapter 4**.

At the end, it is the government, which by shaping the framework determines if and how this new instrument, the KeyMaker Model will be able to transform deep rural areas of developing countries. Policymakers in developing countries are facing the challenge of providing equal opportunities to all their citizens. The KeyMaker Model may be a unique opportunity for policymakers to establish electricity supply services/infrastructure while including the communities into the national economic cycle channelling cash-flows into rural areas and facilitating local development at the same time.

This document explains the KeyMaker Model in three layers of complexity. The present **Chapter 0** provides a survey on the general concept of the KeyMaker Model using simple terminology and low degree of complexity. **Chapter 2** dives deeper into the description of the building blocks of the KeyMaker Model. Formulas are introduced that may help determine whether a KeyMaker opportunity can be profitable or not. The formulas may also be used to fine-tune the design of certain building blocks in a KeyMaker opportunity. **Chapter 3** analyses the KeyMaker Model from a scientific, economic perspective, considering the KeyMaker Model as a model for a Bi-Product company that generates Economies o Scope. In **Chapter 4**, existing KeyMaker projects are scrutinized along the theory developed. Subsequently, additional theoretical KeyMaker opportunities are introduced to provide practical guidance in what a successful KeyMaker project may look like. **Chapter 5** summarizes how governments can support and regulate KeyMaker Models.

1.2 Evolution of mini-grid business models for rural electrification

Mini-grids have experienced an improvement with respect to their operational models beginning from community-based models. Under this model, a donor installs a system in a community, hands it over to the community and lets the community run the system after comprehensive training. The operating sustainability of this model depends on the complexity of the system technology and the local expertise of individuals operating the system. Donors commenced undertaking this model since 1960s using diesel generators or small-hydro mini-grids. With the advent of solar PV and affordable battery technology, donors are trying to hybridize diesel mini-grids. Yet, this increases the challenges for local operation.

A derivative of the community model which, gained serious traction in some Asian countries in the 1990s, is the cooperative model. Under this approach, a cooperative operates one or several large mini-grids using a professional management structure, just like a private company, but with closer relationships to the community and customers. In this case, tariffs are subject to cross-subsidization from city customers.

More recently, since 2007, there was an involvement of the private sector operators who partially invest in the systems and try to amortize their investment through the collection of electricity tariffs. High electricity tariffs are the result of the low electricity demand in rural communities together with high demand for customer management and service. These further decreases demand. The private mini-grid operators are trying to tackle these challenges by standardizing technology and management approaches and hoping that economies of scale will take the model to break-even.

From 2011 onwards, some private operators started targeting Productive Users as electricity customers under the so-called ABC model. The users are structured into three groups: Anchor Customers (A) like factories, large farms, lodges, hotels, large hospitals or telecom towers; Business Customers (B) like mills, metal and wood workshops, local irrigation schemes, commercial ice makers, tailoring workshops and battery hiring businesses; Other Customers (C) like households and small shops, stationaries, barber and hairdresser shops or public institutions. The A customers get the most attention and an individually tailored electricity supply contract. B customers get tariff structures that meet the need of the respective type of business. Load and demand management approaches are used to shift demand towards hours of high availability of low-cost electricity. C customers are offered a standardized service and tariff, which is designed to reduce O&M costs to the minimum.

The ABC model integrating telecom towers as A customers have improved the profitability of mini-grid systems and in some cases has resulted in a projection that suggests a profitable business after a long amortization period of typically 7 to 12 years. Although this model may be economically viable, it is not generating investment opportunities attractive enough to acquire the amount of capital required for larger mini-grid roll-outs and often still depends on subsidization of at least the distribution assets of the mini-grid system.

Around 2017 some mini-grid companies start developing additional businesses around their own electricity supply systems. These are designed for profit-making of a magnitude which is much larger than the profit-making potential of the pure mini-grid business, but which would not be possible without the mini-grid business. This model is called the KeyMaker Model. The whole idea of the KeyMaker Model is structured around the idea of unlocking markets or supply chains by providing reliable electricity using mini-grids together with all other services required to set up a reliable product trade business. The local community profits from increased cash-flows into their local economy. The KeyMaker Model may be the first model that becomes scalable on a pure private sector basis or at least under a PPP structure. Instead of looking for solutions to make mini-grids profitable, the KeyMaker Model looks for problems that the mini-grid can be the solution for.

2 Success Factors and Building Blocks of the KeyMaker Model

The aim of a KeyMaker is to outperform urban competitors that produce the same goods closer to the trading hub. Its strategy is to reduce transport cost and increase product quality through local processing with mini-grid electricity while reducing costs through Economies of Scope between the mini-grid and product trade business to maximize his margin. **Figure 3** depicts the cost structures of KeyMaker businesses vs. peri-urban producers of the same goods. The first two columns show two cases where no margin is achieved. In the first column, there is no pre-processing made in rural areas. The second column depicts the case in which the pre-processing stage of the raw material is too energy-intensive (kWh per processed unit output) and although transport costs are cheap, there is no margin left to compete with peri-urban processing. The third column illustrates a successful KMM, where optimal pre-processing is achieved to decrease transport costs.

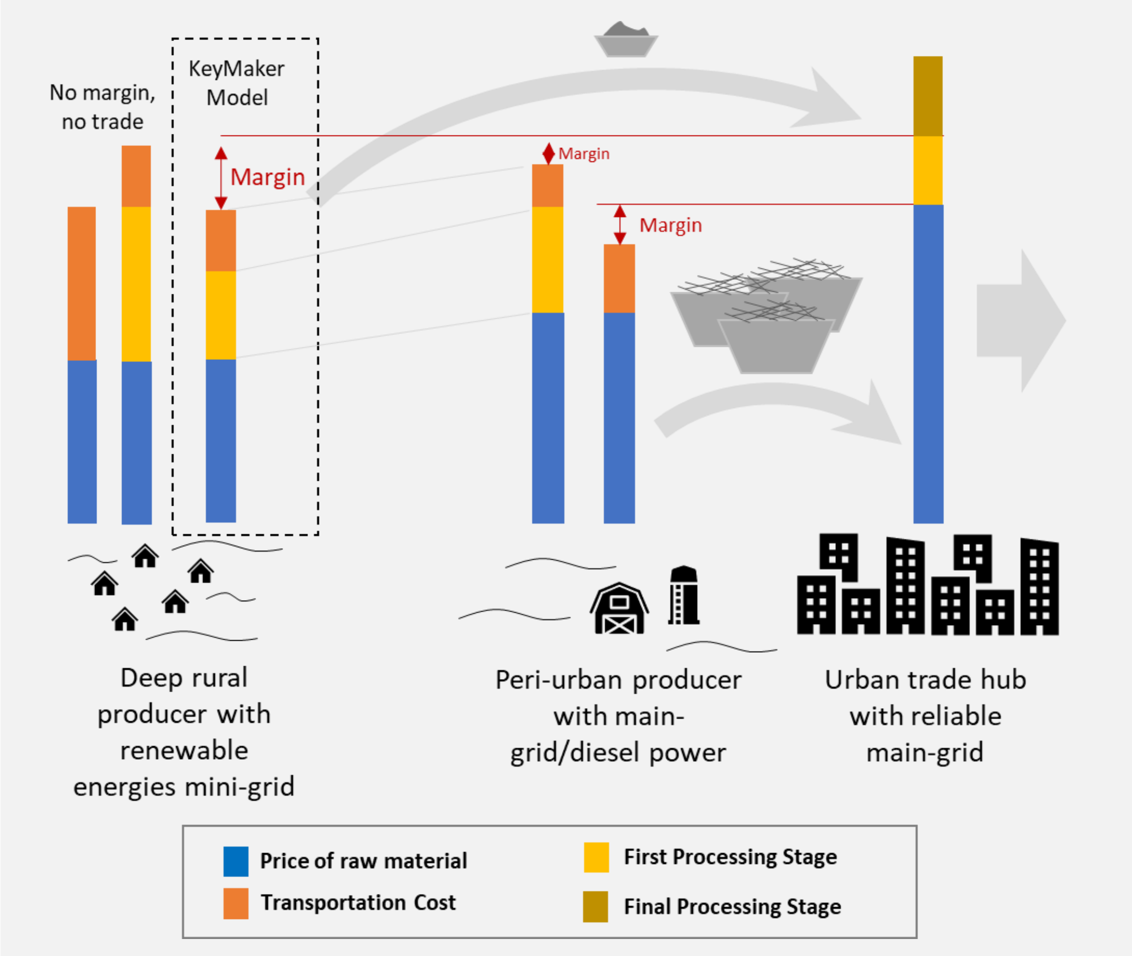


Figure 3: *Cost structures and competitive advantage of KeyMaker businesses. The columns the cost compositions that occur in the various value with and without local processing. The deep rural product becomes competitive thanks to economies of scope achieved from optimal use of electricity from Mini-grid for the processing stage and reduced transport cost.*

A deep rural trader who tries to bring bulk un-processed products to trade hubs will have a hard time, as the transport cost eats up all its margin. A peri-urban producer of the same good has much lower transport cost as the distance to the trade hub is shorter and probably transport infrastructure is more developed. Thus, the peri-urban producer can make a margin on that trade and be the sole supplier to the trade hub. Even advantageous natural resources and low labour cost leading to lower prices of the goods in deep rural compared to peri-urban areas typically do not make up for the disadvantage on the transport side.

The cost structure changes as soon as the KeyMaker comes into play. Local pre-processing of goods using mini-grid electricity reduces the weight and volume of the goods which minimizes transport cost. For many processing activities like cooling, deep freezing, etc. reliable electricity is of more importance than cheap electricity. Mini-grids supply electricity reliably but at a higher cost. This together with the usual lower labour cost in deep rural areas and the cost-sharing potential with the mini-grid electricity business (Economies of Scope) in deep rural areas leads to processing cost in KeyMaker Models that are lower than processing cost in peri-urban areas.

In many peri-urban areas, main-grid electricity is available but not reliable. Diesel generators balance the remaining demand. The total cost of electricity in a peri-urban area may be depending on the reliability of the main-grid be not too far from mini-grid electricity prices. Therefore, peri-urban areas would probably not succeed when copying the KeyMaker approach based on lower-quality natural resources. Depending on the balance between fixed and variable cost on the processing side, the wholesale off-taker at the trade hub would probably rather buy the pre-processed good (in case of high variable cost) or the unprocessed (in case of high fixed cost) one. Only if the pre-processed good from deep rural areas has a specifically high quality, the off-taker will buy the deep rural good at an attractive margin. This is where the excellent natural resources and local expertise in deep rural areas required to make the KeyMaker Model work, come into the picture again.

After all, under the KeyMaker Model, the deep rural community can finally benefit from its advantageous natural resources and the local expertise developed around these resources and deliver goods to the trade hubs channelling cash flows into the community. Even though decentralized, local pre-processing of goods is generally less efficient and more expensive than centralized processing in large factories, the decentralization of processing steps under the KeyMaker Model can succeed in an economically efficient market.

Table 1: *Assumptions of cost structure figure and prerequisites for successful KeyMaker businesses.*

Deep rural producer	**Peri-urban producer**
Excellent natural resources	Reasonable natural resources
Low labour cost	Mid-range labour cost
Reliable but high cost mini-grid electricity	Unreliable main-grid + diesel backup
Smallholder producers	Semi-industrial producers

When designing a KeyMaker scenario, the developer needs to run comprehensive analyses and take numerous decisions. These can be structured along the building blocks or success factors of the model as explained below. They shall guide the developer in taking his/her decisions in a way that turns the KeyMaker scenario into a commercial success. **Figure 4** depicts the building

blocks of a successful KeyMaker Model as parts of a building. The superiority of natural resources over resources at other sites and the local experience in generating excellent goods from these resources is the foundation of the building (block 1). Block 2 is the design of the pre-processing stage with the aim to drastically reduce volumes and weights of goods to be transported to trade hubs reducing transport cost and at the same time conserve goods to maximize product quality. These building blocks are complemented by the structure of the management, incl. O&M, accounting, controlling, logistics, etc., its efficiency and the company's relationship with the local community and its people which are customers and vendors to the company at the same time (block 3). Each of the blocks is described in detail below. If all these three building blocks are well-arranged, they support Economies of Scope, which requires certain management approaches. Economies of Scope are the prerequisite of the successful operation of the mini-grid as well as the goods processing and trading business under one company roof. How to reach Economies of Scope will be explained in **Chapter 3**.

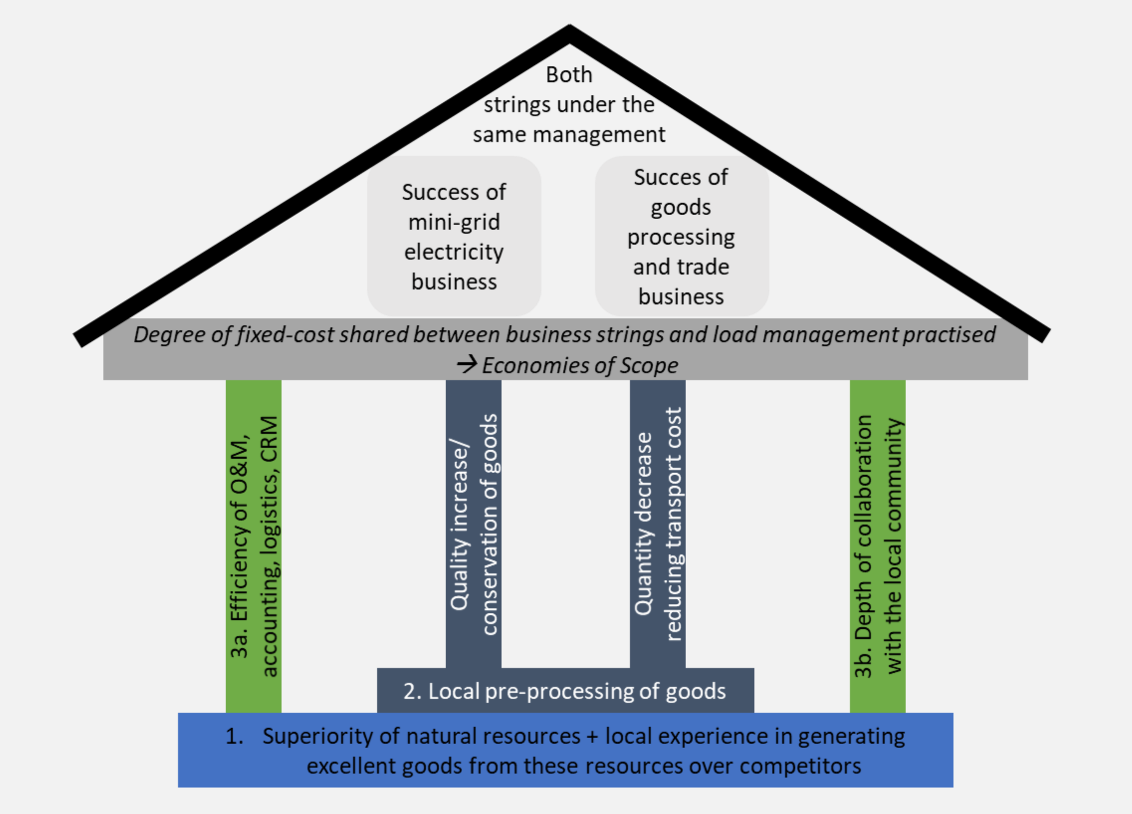


Figure 4: *Building blocks/success factors of the Bi-Product Company under the KeyMaker Model.*

2.1 Block 1: Superiority of natural resources and respective local experience

The superiority of natural resources in the deep rural area selected for a KeyMaker business is the most important selection criterion and foundation for the success of any KeyMaker opportunity.

Deep rural communities with a long history and a growing population, usually have some special characteristic like good soil for certain crops, low-cost water for irrigation, mineral deposits, forests, special climatic conditions, fishing grounds, or similar that attract people to this place. Besides, a community may have developed special expertise in farming, mining or producing artisanal goods using the natural resources available locally for generations. To identify KeyMaker goods, the developer shall focus specifically on these special competences and natural resources in communities. Only where these resources and competencies exist, a KeyMaker business can thrive. To find these special resources and competences, some insight into the national and international markets is required. The hints may be taken into consideration:

- Resources that are unique and cannot be found anywhere else in the country are of special interest. Examples are: Sweetwater fish is only available where the lakes are; Minerals, gemstones, etc. can only be found where the natural deposits are.
- Goods that grow under special rare conditions may be interesting. Some examples are: Crops that require special soil or climate (e.g. wine, coffee, tea); Crops that require a lot of water for irrigation that may be available for free at some places.
- In some areas, some plants that at other places only grow in plantations or greenhouses, grow naturally without the need to establish plantations. This can be a cheap way of accessing these plants: Examples can be forests of precious hardwood; certain fruits.

Finally, any good selected must either be transportable for a low cost or must be of bulk reducing type, meaning that by local processing using mini-grid electricity, the weight and/or volume to be shipped and therefore the shipping costs decrease drastically. **Figure 3** displays the relationships and comparisons to be undergone. These can also be captured in a formula as follows.

Assuming that the price for goods at the trade hub is in equilibrium, the formula to calculate the advantage of KeyMaker products over peri-urban competitors who apply local processing is as follows:

$$A1 = \frac{(C1 + S1) - (C2 + S2)}{C2 + S2} \qquad (1)$$

with

$A1 = Advantage\ of\ KMM\ good\ over\ substitute\ product\ due\ to\ better\ natural\ resources$

$C1 = Cost\ of\ producing\ and\ processing\ the\ good\ in\ peri\text{–}urban\ areas\ with\ weaker\ natural\ resources$

$C2 = Cost\ of\ producing\ and\ processing\ the\ good\ in\ deep\ rural\ areas\ with\ better\ natural\ resources$

$S1 = Cost\ of\ shipping\ from\ the\ peri\text{–}urban\ area\ to\ the\ trade\ hub$

$S2 = Cost\ of\ shipping\ from\ the\ deep\ rural\ area\ to\ the\ trade\ hub$

An A1 of larger than or equal to 0.25, indicates that the KeyMaker good has been well-selected. If for instance, A1=0.25, it means that if manufacture of this good is relocated to rural areas, it costs of production are reduced by 25% than when manufactured in peri-urban areas.

Some external factors around market trends and political influence need to be considered when selecting the resources and sites for a KeyMaker good.

Thus, clearly analyse consumption trends in the market you are targeting. Many developing countries are growing at a rapid pace creating a fast-growing middle-class, requiring products that have not been demanded in such quantities before. These products may become good KeyMaker products.

Some countries protect domestic markets through import duties. As long as you address the national market, you may be protected from international competition if you select a duty protected product. Be aware that the tax and duty regime may change at any time. You may use the time of protection to build your company and increase efficiency in your processes.

In most cases it may be wise to first address a national off-take market before addressing an export market.

2.2 Block 2: The right depth of local pre-processing of goods

In this block, the developer optimizes the depth of pre-processing that under the given constraints provides the maximum commercial advantage over delivering unprocessed material from that same site to the trade hub.

As shown in the introduction to this **Chapter 2**, the main aim of local pre-processing is to reduce shipping cost. Shipping cost can be reduced by:

1. Decreasing the volume. E.g., sunflower seeds take much more space than tanks with liquid sunflower oil.[1]
2. Decreasing the weight of the good to be shipped. E.g., Fresh fruit can be heavy. In contrast, with freeze-dried (lyophilized) fruit, or desiccated fruit, water content inside the fruit is reduced, and the weight is decreased significantly. Ore from artisanal mines can be further refined through local processing, reducing weight.
3. Optimizing packaging and avoiding cooling during shipment. E.g., fresh vegetables like tomatoes need to be packed in boxes to not be squeezed during transport. In addition, they may require on-truck cooling during shipment to arrive fresh at the customers' place. In contrast, tomato paste neither needs cooling, nor box packaging but can be delivered in tanks.
4. Reducing losses in product quality, volume and weight due to shipment of goods. E.g., fresh fish on ice loses water during transport of up to 10 or 20% of its weight, especially when packed densely and squeezed. Frozen fish can be packed densely, drastically reducing shipping cost and losses.
5. Changing the mode of transport. In beef trade, usually, life cattle are brought to the slaughterhouse. If slaughtering and cooling of carcasses is done in rural areas, the carcasses can be shipped instead of the life cattle.

The following formula can be used to derive the advantage of local processing over delivering unprocessed goods from the same side:

---

[1] Local sunflower oil pressing only makes sense if the press cake can be utilized for further processing locally.

$$A2 = \frac{(S1 - S2 + X2 - X1)}{X2 - CL - S2} \qquad \textbf{(2)}$$

with

$A2 \ = \ Advantage\ of\ KMM\ over\ unprocessed\ product\ delivery\ from\ same\ site$

$S1 \ = \ Shipping\ cost\ of\ unprocessed\ good\ \ to\ trade\ hub\ (\ including\ transport\ losses)$

$S2 \ = \ Shipping\ cost\ of\ locally\ pre–processed\ good\ \ to\ trade\ hub\ (\ including\ transport\ losses)$

$X1 \ = \ Sales\ price\ of\ unprocessed\ good\ \ at\ wholesale\ off–taker$

$X2 \ = \ Sales\ price\ of\ processed\ good\ at\ wholesale\ off–taker$

$CL \ = \ Cost\ of\ local\ rural\ processing\ (including\ electricity)$

A2 can take values larger or smaller than zero indicating positive or negative effects of the depth of local processing on the overall Advantage of local processing. **Figure 5** indicates that in most cases there will be a maximum advantage that can be gained with a specific depth of pre-processing. This is what the developer wants to achieve. With less or more depth of pre-processing, less commercial advantage can be generated. With too little depth of local pre-processing, the potential of bulk reduction of the product is not fully utilized and the optimum is not reached. With too much depth of local pre-processing, there are processing steps covered locally that could be performed in a better and cheaper way in a centralized factory while not reducing transport cost sufficiently anymore. If the depth is way too high or way too low, the effect may even be negative.

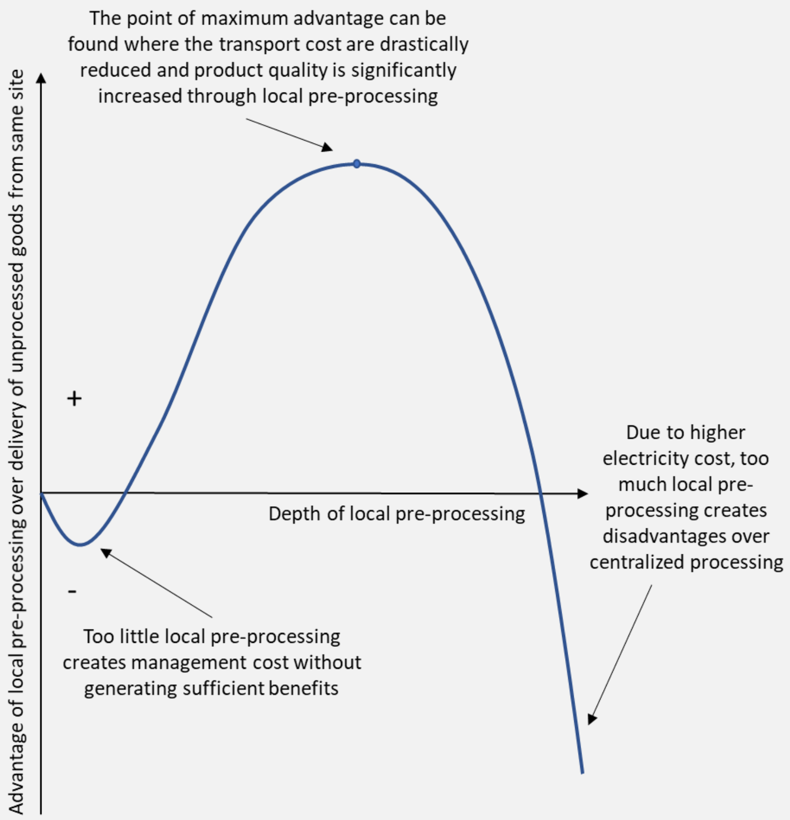


Figure 5: *Effect of various degrees of depth of processing on the commercial advantage of local processing of goods in a KeyMaker Model.*

To find the maximum A2, the developer may run several calculations under varying processing scenarios with respective product sales prices researched.

It is recommended, not to limit the sales volume on the downstream side by creating a brand for the products or even going into the retail market, but to sell at bulk to a wholesale off-taker who takes any quantity that the KeyMaker delivers. This enables the KeyMaker to also purchase any quantities delivered from its vendors in deep rural areas. Only by becoming a 100% reliable off-taker for its vendors, the KeyMaker can establish a sustainable business relationship with a community. Therefore, despite high A2s in scenarios with decentralized retail packaging, going into the retail business is not recommended.

2.3 Block 3: Management of processes and collaboration with the community

The traditional approach of running a deep rural large-scale business is based on a collaboration between the government and the investor. Local communities are usually not involved much in the negotiations as national government interests precede local interests. In the best case, a Social and Environmental Impact Assessment takes care of the local community's interest. In some cases, indigenous local population gets expropriated or even deported with or without compensation. Large businesses like mines, hard wood processors, etc. usually aim at exploiting natural resources in an industrial scale.

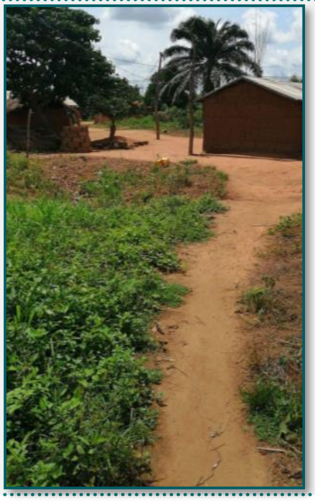
In contrast, the KeyMaker Model acknowledges that the natural resources belong to the local community and that the local community has built up experience and knowledge using these resources over generations. As the community members are the owners of the resources, that the KeyMaker Model builds upon, are electricity customers and vendors of the goods to be traded at the same time, a good relationship between the community members and the KeyMaker is a prerequisite for a successful KeyMaker business. Therefore, other than the efficient delivery of highest quality services on all management, accounting, controlling, O&M and logistics tasks in both, the mini-grid as well as the goods trading business, a number of additional aspects need to be considered when operating a KeyMaker business. Most of these aspects are related to the cooperation with the community.

If implemented properly, the KeyMaker Model:

- Encourages the processing of indigenous raw materials.
- Creates additional employment opportunities in the village.
- Creates immediate and steady revenue to some local families.
- Promotes the growth of small-scale industries in rural areas.
- Lowers the spread of the informal sector in the rural areas.
- Fosters national industry as opposed to importing small-scale manufactured goods.
- Can bring about closer relationship between small-rural industries and large-scale urban industries.
- Promotes traditional arts and crafts and thus preserves rural culture.

So far, no fully structured approach towards working with the community under a KeyMaker Model has been developed. However, some experienced based recommendations that can also be verified by common sense can be introduced:

- Do not implement any high revenue opportunity that goes against the interest of the community and keep the community informed about your activities to make sure that your moves do not come as a surprise to the community. Meet the community on eye level.



The effect of reliable off-take of goods on local producers

Citizens in deep rural areas of developing countries are usually smallholder farmers growing various crops in parallel for risk mitigation purposes. The risks are on the agricultural side (diseases like fungi, insects, etc. draughts, mistakes like wrong usage of fertilizer, wrong soil for the crop) but also on the market side (low prices due to low demand or high supply). The farmer knows that by diversifying his/her crops he/she loses efficiency, but he/she does so as the likely result of having a bad harvest with just one crop is death (starving or not being able to pay for medical treatment) of family members.

If the farmer had a reliable off-taker of all his produce, parts of the risk is taken from him/her. As a result, he/she may focus on just one or two crops increasing efficiency.

- Identify high revenue opportunities that create win-win situations instead of competing with existing businesses within the community. Competition with players outside of the community cannot be avoided of course.
- To be successful, the KeyMaker will need strong promoters inside the community. Thus, take your time to set up a solid relationship with the community, identify people you can trust and that are reliable enough for cooperation before you tackle any high revenue business.
- Do not try to impose change. Decades of development cooperation in rural communities suggest that change of behaviour required to create economic impact can only come from within the community in question. Thus, any activity that requires a fundamental change in behaviour to succeed is bound to fail. Instead, you need to pick up any activity that local people would require significant change for, with your own internal team.
- Expect the community only to manage those parts of the value chain that they are used to, have skills and experience in. If new tasks are supposed to be assigned to the community, take it step by step. The change of working with a larger company is already a big change in the community's everyday life. All activities that are not part of the community's traditional activities must be managed and monitored very closely by your company.
- Become a reliable off-taker for your vendors from the community and purchase any quantity of the product that is offered to you. Remember that once you do not buy a product though it has been produced for you, this product probably does not find a market and the vendor and its family will be heavily disappointed or may even be affected negatively immediately (by e.g. lack of cash for staple food, medicine, school fees, etc. creating hunger and despair). This means that also your off-take channel should take whatever you as a KeyMaker deliver. A wholesale off-taker can do this while a retail off-taker may not be able to meet this requirement. Resist the temptation of building bottlenecks upstream and downstream at the same time just to maximize your profit margin.

2.4 KeyMaker Model vs. Productive Use of Electricity Approach

The KeyMaker Model (KMM) is different to the Productive Use of Electricity (PUE) approach. In the latter, the mini-grid firm engages in technical and financial assistance for Micro, Small and Medium Enterprises (MSME) to purchase productivity-enhancing electrical equipment. As shown in **Figure 6a** the maximum output of labour-intensive economic activities increases with acquired machines, and as shown in **Figure 6b**, the Mini-grid benefits from an increase of electricity demand, which shifts its electricity output. However, experience and various studies have shown that expanding electricity access, together with productive uses is not a sufficient condition for enabling income growth and employment generation within a rural community. A report from the World Bank (1995) presents that the benefits from PUE depend fundamentally on the small manufacturer's purchasing power. More recent articles studying the impact of productive use approach from South Africa and Benin (Oakley, D. et. al 2007 & Peters J. et. al 2011) coincide with this stance, additionally highlighting the importance of a sufficiently large market for the small enterprise's output. The lack of positive impacts on the communities' income growth can be explained by the insular nature of low-income societies that cannot afford to consume both the extra output of PU and electricity from the mini-grid. Thus, as shown in **Figure 6**, the changes in production in both enterprises are marginal.

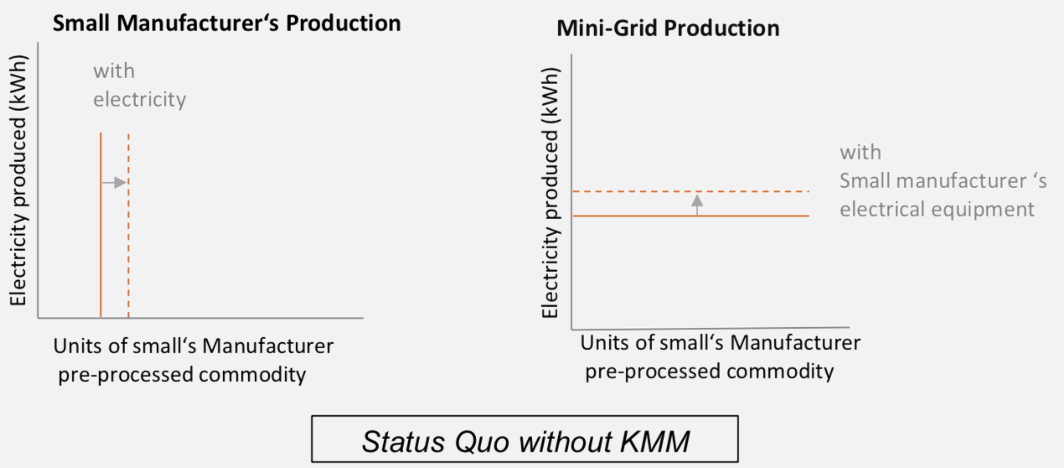


***Figure 6a:** Production frontier of Productive User*

***Figure 6b:** Production Frontier of Mini-grid*

By contrast, the KeyMaker model is an approach where the Mini-grid firm offers two business lines in parallel in two different markets; one offers electricity in a community and offers the locally manufactured good to an off-taker in the external market, i.e. the nearest big city (see **Figure 1**). In this way, the KMM can be applied in both, a small community with a saturated market and a community with a larger market where electricity-reliant productive users are also present. In the case that productive users are already in the community, the Mini-grid operator shall not compete with them, since the productive users are covering the demand for manufactured raw materials in the local community. In both cases, since locally processed products from the rural mini-grid area are supplied to the city in a competitive manner, there is cashflow streaming into the community. Hence, income growth of the community is feasible, steady earnings for small farmer's or fishermen are secured, and since electricity is income-elastic in these rural regions, the

demand for electricity from the mini-grid also grows.

In this way, the Mini-grid company becomes a vertically integrated firm that offers electricity in a local market and supplies a complementary, locally manufactured good to an off-taker in an external market (outside the community). It generates positive revenues for the business, increases the income of small manufacturer’s families, who consume more electricity resulting from a virtuous cycle of the KMM.

3 The KeyMaker Model under Bi-Product Output theory

In this section, we analyse how a successful KeyMaker model offers positive returns and reduces the pay-back time of a mini-grid using bi-product output theory.

For a mini-grid company, who adopts the KeyMaker business model, the calculation of the total net income for a given output of electricity, and a given output of pre-processed good, is composed by the separate sum of total revenue from electricity plus the total revenue from the pre-processed good (since the two products are sold in different markets) minus the total costs of jointly producing electricity and KeyMaker good. This is reflected in the following formula:

$$I(e,q) = TR(e) + TR(q) - C(e,q) \quad (3)$$

with

$e \ = \ electricity\ (in\ kWh)$

$q \ = units\ of\ processed\ rural\ good$

$I(e,q) \ = \ Net\ Income\ of\ a\ KMM\ Bi\text{–}product\ company$

$TR(e) \ = \ Total\ revenue\ from\ electricity\ service\ from\ a\ mini\text{–}grid$

$TR(q) \ = \ Total\ revenue\ from\ the\ processed\ rural\ good$

$C(e,q) \ = \ Total\ costs\ of\ jointly\ producing\ electricity\ and\ KeyMaker\ good$

A quick look into this equation suggests that to increase income, one has to increase the total revenue of both business lines and minimize the total joint costs of joint production. This is accomplished through the following processes:

1. Increase total revenue of both business lines by

(A) Increasing production of KeyMaker good q with the use of electricity-reliant.

(B) Selling at a competitive price $p > p^*$ with p^* being the competitive market price

(C) Increasing demand for electricity

2. Minimize the cost of joint production by

(A) Achieving Economies of Scope

(B) Managing Electricity use efficiently

(C) Decreasing Transportation Costs

(D) Optionally: Achieving Economies of Scale and Scope

(A) First step: increase your total revenues: $TR(e) + TR(q)$

On the first business line, the Mini-grid is a natural monopoly that is usually regulated by the government; thus, it acts as a price-taker and cannot set a higher electricity price. Moreover, the quantity of electricity produced is restrained by a low-demand. Therefore, $TR(e)$ can only increase in the long-run through an increase of electricity demanded. Yet, one can increase the total revenue of the KeyMaker model: $TR(q)$. In the short-term, it is only on the production and price of the KeyMaker good, where the company has more degrees of freedom for an increase of revenues.

There are two ways to increase the total revenues of the KeyMaker good, which is computed as **the price of good p_q multiplied by the quantity of KeyMaker good q: $TR(q) = p_q \times q$.** One path is to increase price of good p_q and the other is through output expansion of the good q. For the latter to happen, it only makes sense to make use of the mini-grid's initial high investment on capital and labour, to produce electricity and pre-process the local raw materials to increase production capacities. Producing this second business line q comes almost for free since they are complements-in production goods. Complements-in-production occurs when the production of one good automatically triggers the production of the other. Moreover, an increase in the price of one complement-in-production causes an increase in the supply of the other. Without reliable electricity, the processing of a KeyMaker good would not work. Reciprocally, without the additional revenue stream from the KeyMaker model the Mini-grid business would have a hard time. Thus, combining both business strings under one company enlarges the production possibility curve for both products.

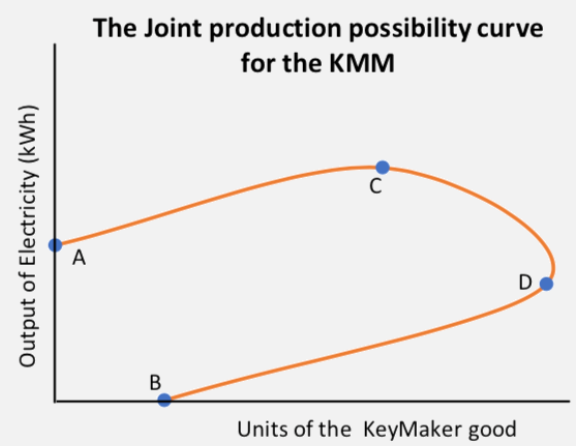


Figure 7: *Production Possibility Curve for KMM.*

Figure 7 provides a graphical representation of the joint production possibility curve (PPC), which represents the different possible amounts of electricity and KeyMaker good that a single-company may produce when all resources are fully efficiently employed. Point A and point B show the limited production possibility of two independent single-output enterprises without KMM (similar status as Figure 6a and Figure 6b), in contrast, points C and D exhibit the increase of productive capacity when the Mini-grid firm operates with the KMM. This means that the resources of the mini-grid are only fully efficiently utilized when producing both electricity and

a KeyMaker commodity. The shape of the curve is concave (when viewed from the origin), because, with marginal changes in the amount of labour and capital that are used for the production of electricity, one can significantly increase the units of produced KeyMaker good.[2]

An optimal combination of production could be point D, since the developer reaches a very high production of KeyMaker good together with a low output of electricity. However, the profitability of this point depends on the price $\boldsymbol{p_q}$ and the ability to gain buyers outside of the community.

To successfully gain market share and competitive advantage when selling the locally produced good in an external national market, the KeyMaker has to offer the good at least in the competitive market price $\boldsymbol{p_q^*}$**.** If there is a shortage of supply for the KeyMaker good, then there are no barriers of entry and the KeyMaker operator has an incentive to sell at a higher price: $\boldsymbol{p_q = p_q^* + \varepsilon, \text{where } \varepsilon > 0.}$

In the case that the external regional market is in equilibrium or if there is a surplus of supply, then the KeyMaker operator has the incentive to set a slightly lower price in the first months: $\boldsymbol{p_q = p_q^* - \varepsilon}$ (where $\boldsymbol{\varepsilon > 0}$) and increase the quality and marketing of the KeyMaker product to gain a large share of the market for the medium and long-run.

In any case, in the medium and long-run the firm can increase the price of KeyMaker good $\boldsymbol{p_q > p_q^*}$ if the manufactured product has better quality when compared to its substitutes. Even though a precise measurement for the outstanding quality of a product is not possible, there are specific criteria that goods involving agricultural or farming harvests should fulfil.

In a cropping system, for instance, the parameters signalling quality of the raw materials are: soil fertility, nutrient levels, pest and disease control, weed control, control of soil erosion, access to water and water quality. For livestock, one should, in addition, control against the use of antibiotics and hormones (see Rigby et. al 2001), as well as the tenderness of the meat or thickness of the leather surface. Favourably, in most rural areas of, for example, Sub-Sahara Africa, the farmland is usually organically and traditionally managed.In this way, after setting up an operational value-chain, the KeyMaker model allows an enterprise to increase both the output of production of a processed commodity and its price. Thus, the total revenue from the KeyMaker good $\boldsymbol{TR(q)}$ increases.

KeyMaker Model vs. Arbitrage Business

Some people claim that the KeyMaker is an arbitrage dealer that makes a margin due to inefficiencies in the market. The KeyMaker however does much more than just trading. There is a structural change in the costs and ways of production, where relocation and decentralization of pre-manufacture to rural areas occurs. The KeyMaker processes rural goods to a certain stage, make them marketable and creates new trading linkage to metropolitan hubs. In the metropolitan areas, the KeyMaker good can be further manufactured. Arbitrage would be based on a short-term opportunity of price difference that the market will automatically close after a short period of time. In contrast, the KeyMaker model creates long term business opportunities as shown by the Tilapia and Pineapple example.

[2] However, as we see in **Figure 7**, these two outputs cannot remain complementary to each other at all levels of production. Over the segments AC and BD electricity and the KeyMaker commodity are complementary. Whereas over the segment CD they become competitive. After a point, an increase in the amount of locally processed product may need so much energy that it is not economical to produce both anymore.

As an important spill-over effect, when buying the raw materials or employing locals to pre-process raw materials, locals will increase their income and as a result of a positive income-elasticity, the local families will increase their energy consumption. Paying a fair price or wage to the locals working in the manufacturing of the KeyMaker good is the only way to also increase $\boldsymbol{TR}(\boldsymbol{e})$ in the medium-run.

(B) Second step: minimize total joint costs of production

For the KeyMaker business to have a wide margin, the developer has to follow a methodology to reduce his/her overall joint per unit costs of production $\boldsymbol{C}(\boldsymbol{e},\boldsymbol{q})$. The bottom line and essence of the KeyMaker model, from an economic point of view, is to reach economies of scope. For this reason, we address this section with more detail.

Economies of scope arise when the total production costs for one company to produce two products is lower than the costs incurred by single-product companies[3] (see Panzar et. al 1982). But how can a KeyMaker manager running a bi-product firm be able to achieve lower costs of production for both goods than two specialized firms?

Economies of scope *(4)*

$$\boldsymbol{C}(\boldsymbol{e},\boldsymbol{q}) \quad < \quad \boldsymbol{C}(\boldsymbol{e}) + \boldsymbol{C}(\boldsymbol{q})$$

When the total production costs for one company to produce two products: e and q.	is lower	than the cost incurred by two single-product companies.

with

$e =$ quantity of electricity

$q =$ quantity of KeyMaker good

$C(e) =$ Total costs of producing quantity e of electricity for a mini–grid without KMM

$C(q) =$ Total costs of producing q units of pre–manufactured good without a mini–grid nor KMM (e.g. costs from the urban competing firm)

$C(e,q) =$ Total costs of a mini–grid producing quantity of electricity e and units KeyMaker good q

In a bi-product company cost-saving is conceivable when there are shared fixed and variable costs across two different product/services lines, such that the total costs are less than if the operations were organized by two different firms. In the KeyMaker model context, economies of scope are achieved only when identifying significant presence of synergies between the production of a locally manufactured good and electricity.

[3] Panzar and Willing first introduced the concept of economies of scope in 1975. For more detailed discussion, see Baumol, Panzar and Willig (1982) and McFadden (1978).

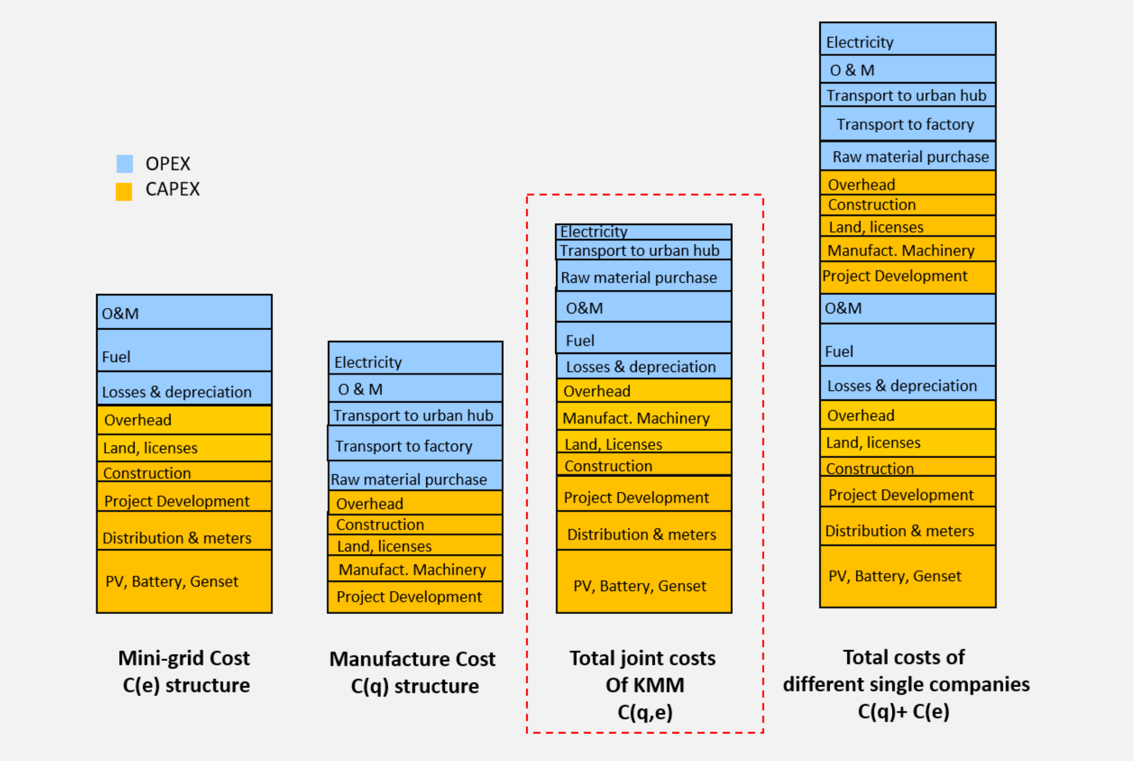


Figure 8: *A KeyMaker business which has reached economies of scope.*

(A) Identify cost synergies for CAPEX

Essentially any developer who sets out to invest in both a mini-grid project and a local pre-processing plant will share the common infrastructure (land, licenses) and skilled labour (overhead salary). Many activities in mini-grid operation and KeyMaker operation require similar expertise. Knowledge about logistics, management, controlling, accounting, handling of many small payments and processes is required in both businesses. Thus, running both businesses under one management, generates synergies and helps reducing travel, communication and staff cost on both ends. Moreover, procurement costs shall stay the same, since the Mini-grid operator will only create a virtuous cycle of increasing local electricity consumption if the income of small farmers increases (even though rates for raw material are cheaper than the centralized processor as he buys from intermediaries).

(B) Manage electricity use efficiently

Not only are the average costs reduced by sharing the costs of infrastructure and know-how, but also the variable costs of producing electricity. Firstly, the costs of processing a KMM good (which is electricity-reliant) are higher in the local community than in a metropolitan area, since the cost of electricity is higher when supplied by a mini-grid as opposed to power from the main-grid. Nonetheless, the extra costs can be avoided if the time of manufacture for the KeyMaker good is adjusted to be powered by peak solar generation (deferrable loads / load management). Yet, as seen in Figure 9 and Figure 5, the outputs of electricity and KeyMaker good should remain complementary at an efficient level of production. If the locally processed product is too energy-intensive, it may not be economical to produce in a deep rural area.

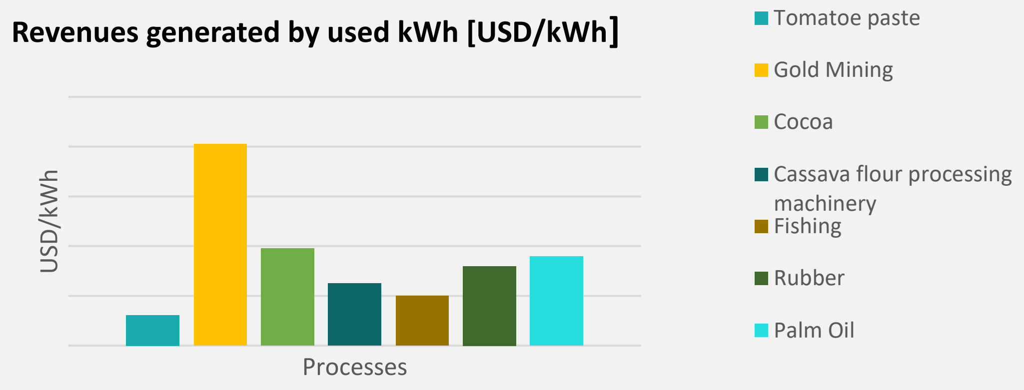


***Figure 9:** Revenue generated per Electricity Use in KeyMaker good processing.*

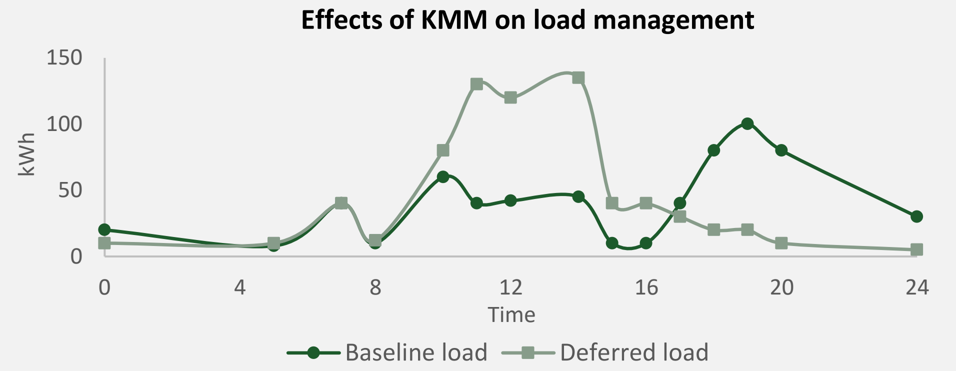


***Figure 10:** Load Management.*

A good indicator to know if the processed product is economically viable is to compute the revenue per unit of kWh for different plausible KeyMaker goods. Figure 9 presents the revenues generated by the used electricity of seven toy examples of a hypothetical portfolio of mini-grids. In this hypothetical example, the processing of tomato paste is as energy-intensive as gold mining (measured in kWh per processed output); nevertheless, the revenues generated per kWh of electricity consumed are much higher for gold mining. Thus, one should not only look at how energy-intensive the processing of a KeyMaker good is but how it can positively affect the cash-flow of the project by increased revenues per kWh.

Moreover, to reduce the costs of a profitable energy-intensive processing good or to nullify the variable costs of low to medium energy-reliant goods, it is crucial to defer the electricity load. Deferrable loads can be classified as an electrical demand that can be met anytime within a definite time interval. To profit from the vertical structure of a bi-product company, the operator can put excess renewable energy into filling stocks or tanks in devices used for manufacturing of KeyMaker goods or schedule certain manufacturing at peak solar power generation time (see Figure 10). There are two types of electricity-reliant machines for processing: with flexible loads, such as water pumping, and large intermittent daytime load (like grain mills or mining crushers). Unused capacity is quite expensive, as well as the fuel needed to run the diesel back-up generator ($0.4 per kWh-$0.70 per kWh). Thus, to attain significant economies of scope in the use of electricity, the manufacturing of KeyMaker good should be powered by renewable energies. In

this way, the extra variable costs for manufacturing are modest and amounts of relatively expensive electricity is reduced (see **Figure 9**).

(C) Decrease Transport costs

Another crucial parameter to diminish the joint variable costs per unit in comparison to the costs incurred by a single-manufacturing firm are transport costs. These costs involve transporting raw materials to a small factory and from the small factory to the whole-sale market. Therefore, transport costs diminish if and only if the measurement of the volume or of the weight of physical production in manufacturing is significantly less than the physical volume or weight of the input raw materials. Accordingly, *bulk-reducing* type of products are good candidates for KeyMaker goods. A **bulk-reducing product** is such that the input raw materials weigh more or occupy more volume of space compared to the final processed product. For this reason, bulk-reducing industries diminish costs when their manufacturer is located near its source of inputs. Some examples of this type of goods include tomato paste, which typically reduces ten times the volume of its input tomatoes. Similarly, cassava flour, cocoa pulver and finished copper bars, which weigh less than the copper ore used to make the product are of a bulk-reducing type.

(D) Achieve economies of scope and scale

As in the mini-grid business, also in the KeyMaker Model, economies of scale play a significant role. Only the integration of a large number of small sites can bring the overall business to fruition. When achieving economies of scale, together with economies of scope, the short-run average cost of electricity production decreases. The higher profits from the KMM can help to cross-subsidisy a lower tariff.

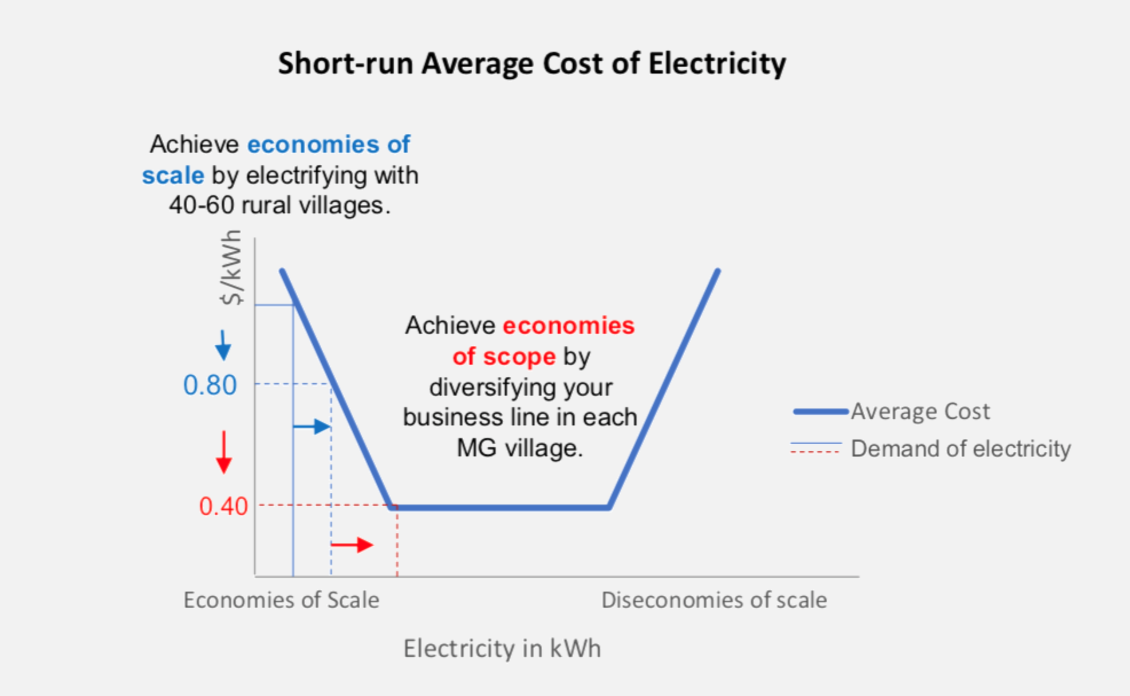


Figure 11: *Achieving Economies of scope and Economies of scale.*

In **Figure 11**, we depict a prototype short-run average curve of a Mini-grid developer, who installs 40-60 mini-grids in various sites can reduce average costs to 0.8 dollars per kWh. However, by achieving economies of scale together with economies of scope in every village one can reduce average costs of production to 0.5 or 0.4 dollars per kWh. In this way, as the average costs

of generating electricity for all the rural villages decreases, for the same regulated price the KeyMaker can get a higher average margin.

The most significant advantage of investing in a firm which has the potential to exhibit both economies of scope and economies of scale is a reduced cost per unit of production for both goods. Reaching economies of scope together with economies of scale is a necessary and sufficient condition for a natural monopoly (see Baumol 1977). A significantly lower cost per unit allows the KeyMaker business to earn greater profit even when maintaining the initial price-point. On the other hand, competitors with higher costs will tend to get out of the market (see **Figure 13**). However, as the operator applying a KMM first has to outperform the competition with better starting conditions, the combined economies of scale and scope may first help him to compete before the natural monopoly comes into play.[4]

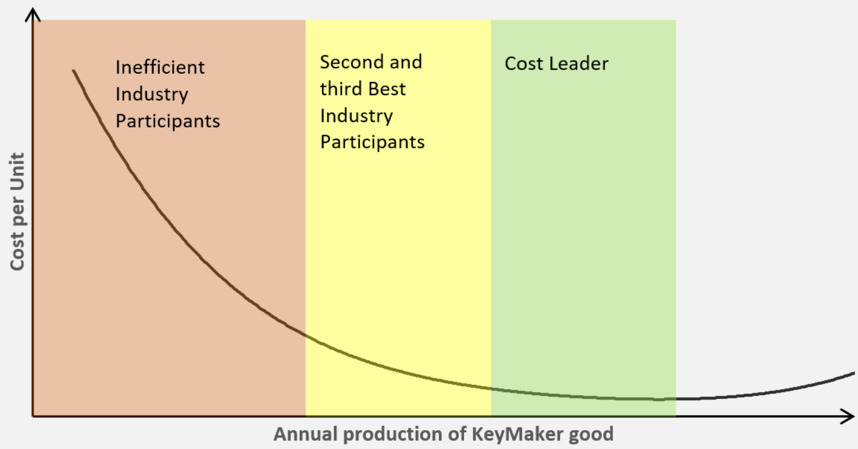


Figure 12: *Long-run average cost-curve for the KMM good.*

3.1 Why is the KMM economically viable?

In this section, we establish that the KMM is economically viable by demonstrating that profits increase and that payback time is reduced.

1. Profits Increase

A Mini-grid company offering only electricity, as stated above, is economically viable, although not scalable, which means:

$$I(e) = TR(e) - C(e) > 0 \quad (5)$$

with

$I(e) = Net\ Income\ of\ a\ mini\text{–}grid\ company\ offering\ only\ electricity$

$TR(e) = Total\ revenue\ from\ electricity\ service\ from\ a\ mini\text{–}grid$

$C(e) = Total\ costs\ of\ producing\ electricity$

[4] See Appendix.

Thus, the net income is positive but not necessarily with a high-margin. Moreover, a single-company supplying the metropolitan market of processed good $\boldsymbol{q}$ is at least financially sustainable, which means that:

$$I(q) \;=\; TR(q) - C(q) \;> 0 \qquad (6)$$

with

$I(q) \;=\;$ *Net Income of a manufacturing company producing quantity q of the good*

$TR(q) \;=\;$ *Total Revenue of processed good*

$C(q) \;=\;$ *Total Costs of processed good*

Joining inequality **(5)** with inequality **(6)** we have that the sum of the total revenue of both single-companies is greater than the costs incurred by two single-output firms, that is:

$$TR(e) + TR(q) \;>\; C(e) + C(q) \qquad (7)$$

This means that a Mini-grid company under the KeyMaker business model, who has achieved economies of scope, i.e., the costs joint production are lower than the costs of separate production $\mathbf{C}(\mathbf{e},\mathbf{q}) < \mathbf{C}(\mathbf{q}) + \mathbf{C}(\mathbf{e})$. Thus, by transitivity of inequality (7) with the equation of economies of scope we have

$$TR(e) + TR(q) \;>\; C(e,q) \qquad (8)$$

Which indicates that the income of the KeyMaker Mini-grid business is higher than the income of two single independent companies. But how much more income? This depends on the following equation:

$$D_{KM} = \frac{C(e) + C(q) - C(e,q)}{C(e,q)} \qquad (9)$$

The degree of success $\boldsymbol{D_{KM}}$, measures the percentage cost saving that occurs when the goods $\boldsymbol{e}$ and $\boldsymbol{q}$ are produced together. Firstly, if $\boldsymbol{D_{KM}} > \mathbf{0}$ (is greater than zero) it means that economies of scope exist. Secondly, this parameter measures the percentage of higher-income that the bi-product business of Mini-grid and KeyMaker together reach, as opposed to the sum of two independent Mini-grid and Manufacturing companies that would act on the local and external market (at equal prices). As a rule of thumb, if $\boldsymbol{D_{KM}} > \mathbf{0.20}$ then the KMM has the potential of a successful business model. Of course, the larger the value for $\boldsymbol{D_{KM}}$**,** the more attractive margin that the KeyMaker company obtains.

2. Pay-back time is reduced

To further assess the profitability of the capital investment in a Mini-grid under the KeyMaker model it is important to evaluate the pay-back time. Mini-grid companies make long-term investments which require a large amount of capital invested in the initial years, mostly in fixed assets such as property, PV, battery and Genset equipment. The additional capital invested needed to start running the KMM is marginal in comparison (see **Figure 13** where the investments for KMM are minimal in the first year). Due to the considerable increase of cash inflows coming from the second business line of a mini-grid, the break-even point can decrease from an average of 10 to an average of 8 years (on a conservative scenario). A decrease of two years for amortization time is quite significant when considering the low extra cash outflows required for a functioning KeyMaker business stream.

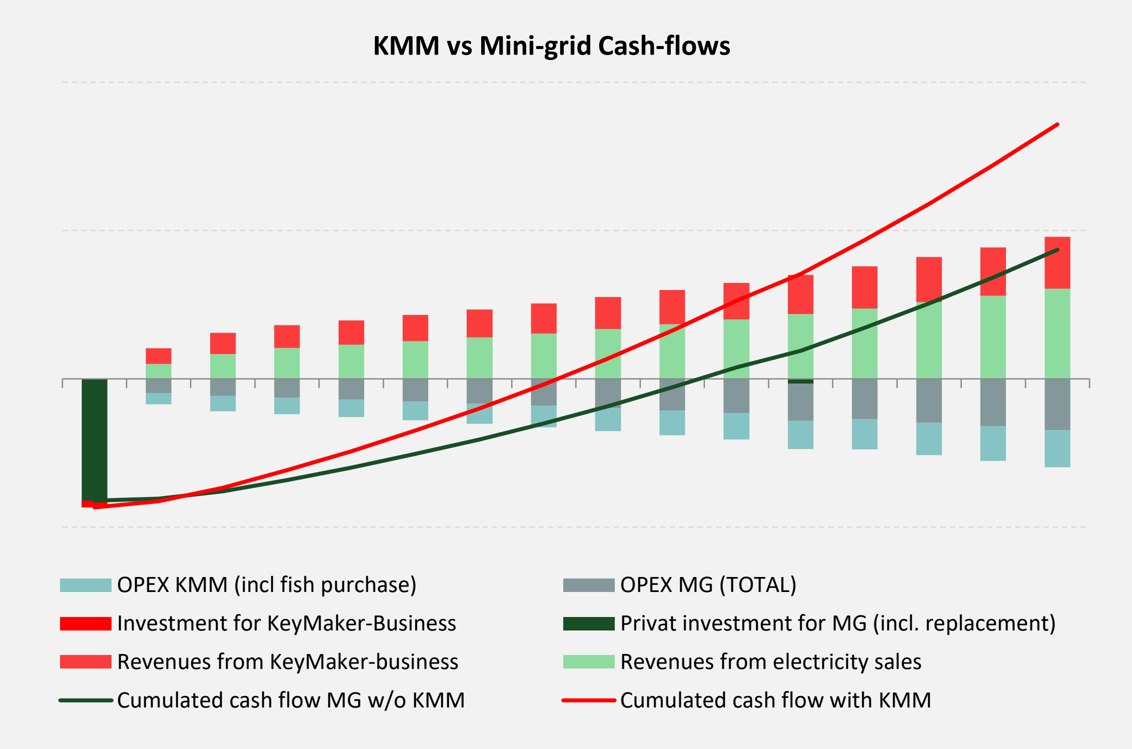


Figure 13: *Cash-flow of mini-grid project with KMM.*

4 KeyMaker Models in practice

In the following, KeyMaker model ideas are presented as examples to visualize what potentially successful KeyMaker Models are made of.

4.1 Case study: Tilapia trade in Tanzania

Local fishermen have so far not been able to organize the cool-chain and logistics to supply Tilapia to the large cities where the demand centers are. This is where the mini-grid operator JUMEME with its management capacities comes into the picture. JUMEME purchases Tilapia from local fishermen paying fair prices making this business attractive to more and more fishermen, cleans the fish, deep-freezes the Tilapia using its locally generated electricity, packs it in cooler boxes, delivers it via ferries to the mainland and onwards via lorries to wholesalers in Dar Es Salaam where the Tilapia is sold with a margin. In Q2 2019, JUMEME delivers around 800 kg of Tilapia per week to Dar Es Salaam. JUMEME's aim is to deliver 1 ton of Tilapia per day.

JUMEME KMM in a nutshell

JUMEME is a rural PV Mini-grid power supplier in islands of Lake Victoria. In Tanzania, Tilapia demand is higher than supply. Currently, 80% of Tilapia fish is imported from China.

JUMEME, as an early adapter of the KeyMaker Model approach, has proven how freshwater Tilapia fish can be processed and stored locally. The company collaborates with Tanzanian local communities to collect Tilapia on islands in Lake Victoria; it freezes fish on-site just a few hours after the catch with Mini-grid electricity reducing postharvest losses; it springs two stages of trading intermediaries and delivers at wholesale price highest quality frozen Tilapia to the capital: Dar Es Salaam. JUMEME was able to set-up a reliable and cost-efficient transport chain from its Mini-grid site in Lake Victoria to an off-taker in Dar Es Salaam where significantly higher prices are reached than in the next City (Mwanza). The optimized supply chain with frozen fish reduces overall transport cost as middleman are left by site. Through the on-site freezing water losses are reduced and therefor weight loss is diminished. This results in higher revenues as less of the initially paid fish weight is lost.

With its mini-grid on ground the overhead staff of JUMEME is able to perform this activity with minimal additional costs for human resources. Moreover, there are no additional costs for rent, since the refrigerators are placed on JUMEME's site.

JUMEME is seeing increasing volumes and margins in this business. As a next step, the collection model is being extended from one site to up to 10 sites. Later, an expansion to Lake Tanganyika may be taken into consideration.

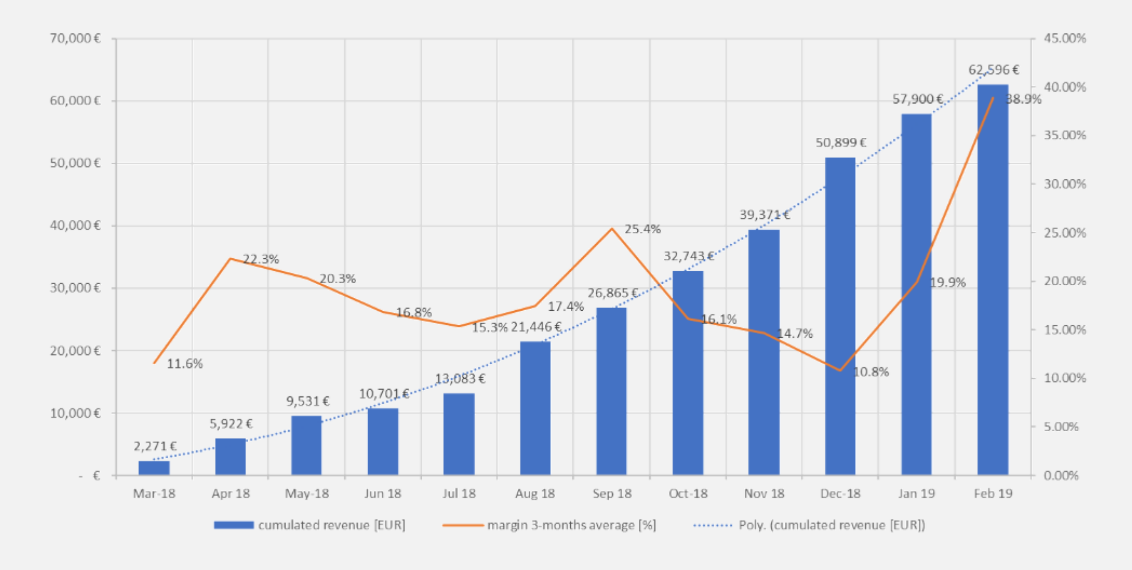


Figure 14: *Margin of KMM.*

While JUMEME is striving to enhance Tilapia collection, it keeps the ecologic sustainability of Lake Victoria in mind. As a large scale-up of this business may lead to over-fishing, JUMEME is developing a cage farming approach in Lake Victoria as the next stage of KeyMaker Model implementation. Farming Tilapia close to the islands is commercially attractive as many of the ingredients for Tilapia fish feed are grown on the islands and thus, the delivery cost can be saved. Fish feed makes up for roughly 75% of the total cost of Tilapia farming and thus flushes money into the pockets of local smallholder farmers growing fish feed ingredients, accelerating local development. Large fishes come from the fishermen; small fishes come from the fish cages with fish fed by locally produced feed. In the cage farming approach, electricity will not only be required for freezing the fish for storage and delivery purposes but also for processing of fish feed. Mills and pallet-extruders with significant electricity consumption are required.

Cage farming is a new approach to Tanzania. Kenya and Uganda have already set up successful cage farms while Tanzania is just now opening this opportunity. Contacts with international fish farming experts from Germany and Uganda have already been established, and the strategy for implementation of JUMEME's fish farming activities has been refined. JUMEME will be one of the first companies trying cage farming in Tanzania close to islands in Lake Victoria. JUMEME and INENSUS have been experimenting with fish feed recipes. A first trial cage has been set up in May 2019 with a first harvest expected in six months from now. Electric machines for floating fish feed production using mini-grid electricity have been procured, and fish feed production mainly based on local resources along the lines of the KeyMaker Model is being started.

4.2 Case study: Pineapple processing in Zambia

Credit: Zambezi Pineapples

The mini-grid company Zengamina operates a 700 kW hydropower station at the Zambezi river in the furthest north-west of Zambia. The mini hydro project supplies over 600 households with electricity and has transformed the standard of service and staffing of district social facilities (hospital and schools). Yet, these services used only a maximum of 350 kWh, that is, half of the power capacity of the mini hydropower station was underutilized. The low utilization of the plant, in turn caused challenges to the financial viability of the mini-grid. At the same time, most of the pineapples in Zambia are produced in this district, but struggled to reach a market with bad roads. This is why, Zengamina's CEO Daniel decided to establish a pineapple drying factory using excess electricity from the small hydropower station to process, add value and create local jobs. With the support of Musika (NGO), the company Zambezi Pineapples was born. It sources highest quality pineapples available locally from smallholder farmers and processes them into dried fruit and juice using renewable, mini-grid electricity. Decades before, a government-operated factory had processed pineapples but had to give up operations, lack of energy being one of the challenges. Though Zengamina and Zambezi Pineapples are not one company, they share the advantages from economies of scope by a joint coordination. For example, the drying machines are timed to run overnight after the general community's evening peak, to better spread the demand of electricity. Local pineapple farmers benefit from a reliable local buyer and the rural community from reliable electricity. Latest information about the financial well-being of the companies could not be obtained.

Credit: Zambezi Pineapples

4.3 KeyMaker opportunities that have not been tested yet

Besides the two examples mentioned above, there is a wide range of potential for further KeyMaker opportunities. Some candidates are further explained in the list below, in order to give a general idea of how KeyMaker Business could be implemented.

- ✓ Wherever locally produced **sweet water fish** does not find its way to the market, it can be deep-frozen at the mini-grid site right after catching, shipped as frozen fish to a wholesale off-taker in a city and sold for a margin. Freezing provides the decisive advantage over the competition as this reduces water losses during the delivery chain while keeping the fish as fresh as it gets, advantages that cannot be generated by delivering fish on ice.

- ✓ Mini-grid companies have run trials with **tomatoes** in cold storages, as they had good soils and water for irrigation at their mini-grid sites, but shipping costs to the markets were too high to compete with vendors growing tomatoes closer to the off-taker. If these companies had let the tomatoes ripen in the sun and produced tomato paste at their mini-grid side, they would have reduced transport cost drastically while delivering

the sweetest tomato paste possible, increasing the sales price. This may have helped them outperforming their competition.

- ✓ So far, cattle are being transported to the slaughterhouse alive. During the transport process, the cattle are consuming those hormones that are required to make the **beef/meat** tender after slaughtering. If the cattle were slaughtered at a mini-grid site with cold storage facility, hormones would still be available after slaughtering to make the beef tender. Hanging the beef for some weeks before delivery adds to the quality. Compared to life cattle transport, transporting carcasses is perhaps way cheaper as the amount of meat shipped in one lorry is multiple compared to the live cattle transport scenario. If done properly, higher quality beef can be produced at a lower cost using the KeyMaker Model.
- ✓ **Freez-dried/lyophilized fruit** is a trend in industrialized countries. The processed fruit can be stored for long, keeps most of its vitamins while making a crunchy snack. Some upper or middle-class in developing countries may soon become interested in this new food. By freeze-drying fruit, it becomes extremely lightweight and relatively stable (can be shipped in plastic bags). Thus, shipping costs may be decreased by local freeze-drying of berries, mangoes, etc. Similar to the tomatoes, the quality of the fruit increases if the fruit can ripe at the bush or tree instead of on the way to the factory.
- ✓ Some communities may have experience with poisonous snakes. Some medicine is based on **snake poison**. The amount to be transported is very small. The effort to produce snake poison is high. Experience in keeping snakes together with low labour cost in rural areas compared to cities may play an important role in making snake poison production financially viable under a KeyMaker Model. Electricity will be required to preserve the product and to keep the snakes.
- ✓ In many countries in Africa, large portions of the mining products come from artisanal mineral mines producing gold, diamonds, cobalt, etc. Often, the **minerals** produced by these mines are channelled to smugglers, by-passing the national taxation system while leaving the local workers with little revenue. This regularly forces the local workers to risk their health and environment using chemicals, mining techniques, and explosives when trying to make a living out of their daily work without the required background knowledge. Governments are interested in formalizing the artisanal mining sector. The KeyMaker Model may be an instrument to handle the sector if mini-grid companies and the government cooperate closely. The mini-grid company may fill the knowledge gap on all ends, become a reliable and law-abiding off-taker and trader of the minerals produced, facilitate local processing and increase living standards for the self-employed workers by reliable electricity supply.

5 Policy aspects - The KeyMaker Model as a tool for rural development

From a government's perspective, the KeyMaker Model may be considered a tool to accelerate rural development comprising electricity supply infrastructure, rural job creation and especially the inclusion of rural communities into national trade with its related cashflows. All of this may come at a minimum public financial contribution as the private sector may take over the majority of the investment cost once the framework has been set correctly. By doing so, the government may accelerate the supply of electricity to large parts of the 1.3 billion individuals not having access to electricity yet. At the same time, they create job opportunities for rural dwellers and foster rural development.

KeyMaker Model communities may transform from net recipients of government funds to significant taxpayers and net contributors to the national budget. If the KeyMaker Model lives up to its promises and is scaled up across the country, it may reduce the country's dependence on imports or even leading to export opportunities, which would stabilize the national currency. If the domestic industry picks up the KeyMaker Model with related mini-grid investments, Direct Foreign Investments into the strategically important electricity sector can be limited and profits can be kept inside the country. National pension funds may play an important role as investors into readily working mini-grid / KeyMaker schemes. Keeping the KeyMaker profits inside the country may also make sense, as the technical innovation related to mini-grids, processing and trade is transferred rather quickly and does not require capital from abroad.

Besides all these opportunities, the KeyMaker Model holds some risk of KeyMakers exploiting communities as the Mini-Grid-KMM may combine in the long-run monopsony power over labor and raw materials for KMM. This is where the government may come in with light-handed enabling regulation protecting both, the community's and the KeyMaker's interest. Local government acting as mediators and regional courts may play an important role. The regulators can set minimum wage for rural local labour and a minimum price at which raw materials can be sold to the Mini-grid-KMM. These prices should be aligned with the social opportunity cost.

Even though the remoteness of deep rural areas favours the application of renewable energy sources for mini-grid electricity supply, the government may actively foster the application of a minimum percentage of renewables in the energy mix through regulation. This may reduce the dependency of the KeyMaker Model on the price variation of potentially imported diesel fuel and related impact on the price level of the KeyMaker good.

Moreover, there are a variety of methods for raw material production in tropical areas. The techniques of productions are not fixed. For agriculture and livestock, local specialized institutions should regulate a sustainable use of chemicals and capital equipment, which the Mini-grid-KMM might be incentivized to use, to increase output of production.

When starting the KeyMaker Model, productivity may be rather low, and thus, the nascent market may need some protection. As soon as the spirit of transformation has been picked up by the deep rural communities, individual business people in the villages may innovate and increase efficiency. At this stage, the protection and support may be reduced. The protection and support should address the level of the KeyMaker and may feature the establishment of import duties on those products with the highest potential of becoming rich KeyMaker goods. Additionally,

KeyMaker companies may be incentivized to start this business with certain tax holiday schemes for instance, the first three years after the company foundation.

Furthermore, fostering KeyMaker Model could also have a positive impact on secondary or tertiary targets of governments. For example, the smuggling of gold from artisanal gold mines could be significantly reduced when KeyMaker model is successfully applied in mining sites and gold (or other precious raw materials) can find their way to the official markets.

These recommendations shall not be a call for more protection of the national market. International KeyMaker project developers may come in with their expertise implementing KeyMaker Models that, once up and running, can be taken over by national industry.

As great the impact potential of KeyMaker Models, and the related change to the positive that KeyMaker Models may trigger in rural communities, the dangerous the negative effects that may kick in, in case of a KeyMaker business failing. From one day to the other, large parts of the community may be unemployed. In the meantime, people may have given up their traditional risk mitigation measures of generating income from various sources. The government may want to develop safety nets for such cases. In industrialized countries, unemployment insurances are provided to rescue the population in these cases.

Policymakers may use the KeyMaker Model as a strategic tool to foster rural industrialization in certain economic sectors. The strategy may comprise concerted actions of various ministries. For example, a government experiences that the demand for fruit juice in urban areas is increasing drastically and that close to 100% of the fruit juice is imported although there is a lot of fruit in deep rural areas perishing due to a lack of local demand. The government may then set up a KeyMaker program that involves the ministry of finance and the ministry of energy. The ministry of finance increases imports duties on fruit juice. As a result, juice prices for urban customers will increase for a short period until the KeyMaker Model has got to speed. The expected additional income from duties will be provided as a budget to the ministry of energy to support the establishment of a private sector-led KeyMaker business around fruit juice. The ministry of energy identifies clusters of communities with excellent excess fruit and establishes electricity distribution networks in those communities. It furthermore, prepares a tender procedure for private sector KeyMakers to establish the solar generation stations for the mini-grids and the processing plants and operate both, the fruit juice business and the electricity business. The government may support the start-up phase of the KeyMaker with tax holidays or additional grants. To make the whole project work, probably a wholesale off-taker, refining and finalizing the processing of rural fruit juice, preferably in an urban area needs to be included in the program. In the end, there may be a significant macro-economic benefit to the national economy based on fewer imports stabilizing the national currency, more taxes from those fruit juice producing rural areas that are finally connected to the national economic cycle, having electrified additional deep rural communities for good.

6 References

Banerjee, D. (2011)
Poor economics, a radical rethinking of the way to fight global poverty. Public Affairs.

Baumol, W. (1977)
On the proper cost test for natural monopoly in a multiproduct industry. American Economic Review. Vol. 67 pp. 809-822.

Baumol, W., Panzar J.C and Willig R. (1982)
Contestable Markets and the Theory of Industry Structure. New York: Hartcourt Brace Jovanovich.

Enerdata
Available online: *https://yearbook.enerdata.net* (accessed on May 2019).

Glemarec, Y. (2011)
Catalysing Climate Finance: A Guidebook on Policy and Financing Options to Support Green, Low-emission and Climate-resilient Development. New York, NY: United Nations Development Programme.

Greer, M. (2011)
Electricity Cost Modeling Calculations. Elsevier, USA.

Innovation Energie Développement (iED) (2013)
Low Carbon Mini Grids: Identifying the Gaps Building the Evidence Base. France.

Karnani, A. (2007)
Fortune at the bottom of the pyramid: A mirage. California Management Review.

Mas-Collel, A. & Whinston, M. & Green, J. (2006)
Microeconomic theory (Indian ed.). New Delhi; New York: Oxford University Press.

McFadden, D. and Fuss, M. (1978)
Production Economics: A Dual Approach to Theory and Applications. North Holland.

Oakley, D. Harris, P. & Hazard, C. (2007)
Modern energy - Impact on micro-enterprise: A report produced for the department for international development. AEA Energy & Environment in collaboration with Integrated Energy Solutions.

Peters J. and Vance C. (2011)
Grid Extension in Rural Benin: Micro-Manufacturers and the Electrification Trap. World Development Vol. 39 No. 5 pp.773-783.

Pindyck, R. and Rubinfeld, D. (2001)
Econometric Models and Economic Forecasts. Boston: Irwin/McGraw-Hill.

Prahalad, C.K. & Hart, S.L. (1998)
The fortune at the bottom of the pyramid. Strategy Business, 26, 54-67.

Rigby, D. & Caceres, D. (2001)
Organic farming and the sustainability of agricultural systems. Agricultural Systems 68(1): 21-40.

Rolland S. & Glania, C. (2011)
Hybrid Mini-grids for Rural Electrification: Lessons Learned. Brussels, Belgium: Alliance for Rural Electrification. p. 72-73.

Seelos, C. & Mair, J. (2005)
Social entrepreneurship: Creating new business models to serve the poor. Business Horizons. Vol. 48: 241-246.

Tenenbaum, B. & Greacen, C. & Siyambalapitiya, T. & Knuckles, J. (2014)
From the bottom up: how small power producers and mini-grids can deliver electrification and renewable energy in Africa (English). Directions in development; energy and mining. Washington DC; World Bank Group.

Waissbein O, Glemarec Y, Bayraktar H, Schmidt TS. (2013)
Derisking renewable energy investments. New York, USA: United Nations Development Programme (UNDP).

7 Appendix

A KeyMaker consultant can further analyze the geometry of the joint total cost function from a KeyMaker business. If the KMM has achieved both economies of scale and economies of scope, then the cost function $\boldsymbol{C}(\boldsymbol{e},\boldsymbol{q})$ is a concave surface in a three-dimensional space. This case is portrayed **Figure 15b**. In both graphs, we have three coordinate axes: the x-axis shows the amount of electricity produced by the mini-grid, the y-axis shows the amount of supplied KeyMaker good and the vertical axis shows the surface of combined costs for different combinations of these two outputs. As one increases the production of both products along the brown ray, in **Figure 15b**, the rate of change in the total cost production decreases or stays the same. In contrast, a bi-product firm that has a convex surface, does not enjoy neither economies of scope nor economies of scale (see **Figure 15a**). That is, as production of both goods increase, the total costs increase steeply.

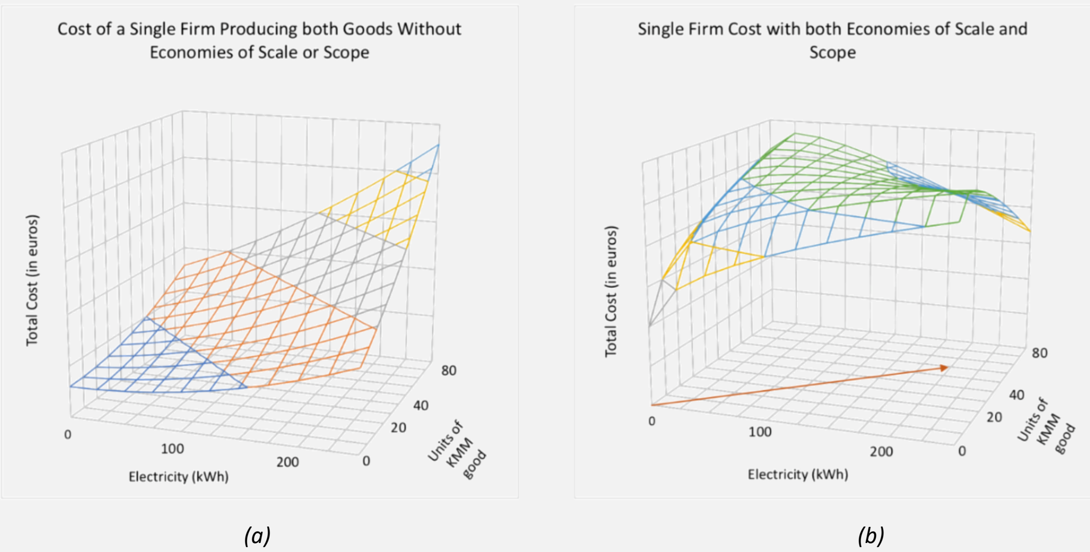


Figure 15: *Total cost curve for unsuccessful KMM (a) and total cost curve for successful KMM (b).*

In both **Figure 15a** and **Figure 15b** each color band corresponds to an interval in the vertical axis. So if the colors are changing a lot (in relation to changes in horizontal axes), it means the total costs are rising steeply compared to where the colors are not changing for a bigger change in the horizontal axes. Moreover, the vertical shift is explained by total fixed costs. Such a total cost function can be approximated from the sum of the fixed and variable costs of producing electricity and complementary good minus the positive externalities across activities in the production processes.