Scaling up Successful Micro-Utilities for Rural Electrification

Private Sector Perspectives on Operational Approaches, Financing Instruments and Stakeholder Interaction

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PREFACE

"Scaling up Successful Micro-Utilities for Rural Electrification" is a contribution to the BMBF[1] funded research project "Climate Change, Financial Markets and Innovation (CFI)" of the Sustainable Business Institute (SBI). This study is based on the close cooperation between SBI, the INENSUS GmbH and the Energy Research Center Niedersachsen (efzn) of the Technical University of Clausthal.

Currently, more than 1.3 billion people (IEA 2011) do not have access to basic electricity services and 30 to 40% are potential customers for hybrid village grid solutions or micro-utilities. This huge market and poverty reduction potential is worth noting, and points to a well-coordinated effort required by public and private stakeholders on both the national and international levels.

Therefore, the SBI focused on the exploration of business models for off-grid electricity supply. In order to further explore the sector and its opportunities for private companies, SBI conducted a workshop with private sector decision makers and other experts in April 2012 in Frankfurt, Germany. Key topics of the workshop relate to the availability of suitable technologies and business models for off-grid power supply. Moreover, current market barriers were discussed and preliminary policy recommendations were drawn during the workshop.

This study builds on these findings and further refines our understanding regarding the successful scale up of the case of village grid systems for rural electrification. As (academic) literature regarding these issues is limited, the study is especially based on the experience of Nico Peterschmidt and his team and, in addition, other companies' experiences. Thereby, operational approaches, financing instruments and stakeholder interaction are investigated. We find that considerable barriers for technology diffusion exist. Major barriers that limit available and accessible funding are as follows:

- High transaction costs for relatively small-scale projects (long due-diligence process, long project development and implementation phases / costs);
- Lack of adequate investment conditions for private investors;
- Unwillingness of first market investors to consider micro-utility investments and of entrepreneurs to develop micro-utility projects due to unclear regulatory frameworks.

The identified lack of funding stems partly from the absence of general cost and risk assessment models for micro-utilities, resulting in a lack of methods and mechanisms for financial risk-taking. For this debate, the study is a starting point for further research that could build an adequate basis for private investors' decisions to invest in micro-utilities on a large scale. Further work should focus on:

1. Verifying the risk profile of micro-utilities and risk management models used in micro-utilities

[1] Federal Ministry for Education and Research, Germany

2. Finding ways to formalize lean management and scaling processes

3. Developing public and private strategies in greater detail to bring micro-utility approaches to scale.

In line with these points, we envision that one measure to tremendously facilitate market development is an assessment tool that facilitates the due diligence for private investors aiming to fund micro-utilities. This tool needs to be build on a sound foundation of identified and quantified risks, including potential private and public sector response strategies. Such a tool would not only allow financial institutions to get involved but could also be used by large utilities to increase their level of activity in this sector.

Within the broader debate on how to allow and support market development of these kinds of systems, the IRENA and its partners organized the “International Off-Grid Renewable Energy Conference” in November 2012 in Accra, Ghana (IRENA 2013). One of the lead authors - of this study, Nico Peterschmidt, - was invited to present its preliminary findings. We are honoured that IRENA decided to use these findings for the ongoing debate surrounding efficient and effective framework conditions for rural energy technology applications - even beyond the confines of the conference.

From a broader perspective, the way forward consists of linking national and international public and private authorities in order to further reduce transaction costs and jointly develop adequate framework conditions for different countries. This process could be facilitated by well targeted research that helps to reveal, structure and analyze existing country specific barriers and draft conclusions for public and private stakeholders. As a summary, scaling up village grid systems is a considerable but worthwhile challenge for all stakeholders involved, and this study aims to contribute to this joint ongoing endeavour.

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EXECUTIVE SUMMARY

In developing countries, electrification of small villages with low income populations situated far from existing electricity grids often seems an unattractive investment for larger entities. The private sector and public-private-partnership models have been identified as feasible solutions to address the electrification issue of these areas. The entities that provide electricity to these off-grid villages are called micro-utilities.

Pilot projects of micro-utilities have demonstrated that it is possible to supply rural villages with electricity from renewable or conventional power stations in micro-grids covering technical, operational and socio-economic aspects. However, when it comes to the scale-up and replication phase, the projects have to comply with national and international frameworks and standards. At this stage, most companies struggle due to the operational and risk management capacity required.

Risks of micro-utilities can be subdivided into risks that can be mitigated by internal methods and risks that can be overcome by using external support instruments. Internal methods are nowadays well understood but external support instruments pose a greater challenge. This study summarizes the lessons learned from existing successful micro-utility models across the developing world.

Within the past ten years, different instruments have been set up in many countries to support micro-utilities in their micro-grid electrification activities. These instruments include e.g. the legal frameworks regarding licensing and electricity tariffs, energy-focused equity investors, impact investors, loans provided by development banks, guarantees covering country risks, the Clean Development Mechanism, local and international subsidy schemes, support for local capacity building, tax reduction or exemption schemes, Micro Finance Institutions (MFIs) to support economic growth in the villages and anchor loads like telecom towers.

Based on these instruments some micro-utilities have been established using highly innovative management and technological approaches. Numerous start-ups in different developing countries are trying to follow up on these success stories. However, if one looks behind the curtain of success stories, most if not all of the highly celebrated successful micro-utilities are struggling with the same issues. These barriers can be mainly attributed to the fact that the instruments mentioned above are still not designed in a way where the micro-utilities are able to successfully enter into the scale-up phase.

Thus, even though these instruments are available, the market is still not materializing in the large scale. The reason is: Transaction costs to use the instruments are high, too high to be handled by Small and Medium Size Enterprises (SMEs) with small and medium sized projects. It can be assumed that the complexity of a project as well as its transaction costs increase exponentially with the number of instruments used in parallel for the same project.

The impact of complexity and high transaction costs can be reduced by economies of scale effects gained by larger project approaches. These larger electrification projects could be handled by large utilities as these entities have the required financial and management capacity. However, successful and sustainable private sector based micro-grid business models are usually developed and implemented by SMEs and not by large utilities due to reasons related to the company's structure, workflow management and Customer Relationship Management (CRM) in micro-utilities, which differs considerably from what can be handled by large utilities. To still be involved in this business, large utilities could get involved as investors for clusters of small local companies. However, so far, large utilities refrain from the high complexity vs. revenue ratio.

To summarize, there is not a lack of instruments in the sector but a lack of coordination amongst these instruments. Additionally, there is a lack of early stage patient capital to cover the high transaction costs that incur when preparing the approach for scale-up.

1. INTRODUCTION TO MICRO-UTILITY MODELS

1.1 Definition of the term "micro-utility"

Utilities in general can provide various services such as the provision of electricity, natural gas or drinking water, sewage treatment and other public services. However, in this study the word "utility" shall solely refer to bodies that supply electricity. The respective utility size applies for a company if either its "annual revenue from electricity sales" or its "No. of electricity customers" exceeds the value given in the following table:

Table 1: Definition of utility according to size for use in this study

Utility Size	Annual revenue from electricity sales	No. of electricity customers served
Large utility	> EUR 1 billion	> 1 million
Medium size utility	> EUR 100 million	> 100,000
Small utility	> EUR 10 million	> 50,000
Mini-utility	> EUR 1 million	> 5,000
Micro-utility	< EUR 1 million	< 5,000

A micro-utility is defined here as an organization owning and operating at least one power system connected to a small and local electricity distribution network supplying and selling electricity to more than one customer. Micro-utilities are of a small scale with typically <5,000 customers in several individual micro-grids. Their total revenue is usually below one million euros. Typically, micro-utilities supply electricity to rural areas which are not connected to the central main grid of the country or the region.

The large and medium utility sector and partly also the small utility sector is often covered by private corporations or the general government. In the small and mini-utility sector, cooperatives can be found frequently. The micro-utility sector is comparatively young and experiments have been conducted with cooperative, private sector-based, large utility-run, government-driven and hybrid models to find the right electrification model for this sector.

One of the challenges to meet when going towards electricity supply using such "smaller island grids" is the effect of reduced economies of scale. This means:

1. Decreased technical stability of the system due to higher concurrency of loads resulting from the lower number of loads available in a system and the higher load-step-effect of industrial loads in small grids

2. Prevention of conflicts arising due to decision making processes in village communities that are not transparent or predictable for micro-utilities

3. Revenue stabilization due to less diverse income sources of customers

4. Cost management especially regarding transaction costs

These aspects will be discussed within this report in different chapters in more detail.

1.2 Electricity production, distribution and metering technology used

In terms of power production technology, micro-utilities use either locally available renewable energy resources or conventional diesel or petrol gensets of different sizes to generate the electricity required. Renewable resources like biomass in digesters or gasification plants, micro hydro power in different kinds of hydro power plants, solar power in solar PV systems or wind energy in small to medium size wind turbines are widely used.

Micro hydro power plants are usually applied in standalone mode where the resource is available continuously, whereas solar and wind resources especially in small hybrid-systems with installed capacities of smaller than 100 kW require some kind of energy storage to match the timely distribution of resource availability with the electricity demand. In small systems of micro-utilities, typically batteries are applied. The vast majority of systems use lead-acid batteries of the vented, AGM or gel type. Only in extremely hot, extremely cold areas or in high security systems, NiCad batteries are applied. Lithium-based batteries and redox-flow batteries might enter the market in the future with decreasing costs for these technologies.

Small power production systems with up to 10 kW of power demand which will not be extended considerably in the future, systems with a high negative correlation between demand and renewable power supply as well as systems with small distances between feeders, are usually designed as “DC coupled systems”. DC coupling means that all renewable and fossil fuel electricity feeders as well as the inverter to supply the loads are coupled on the direct current (DC) battery bus bar.

Larger systems, systems in which the feeders are more than 50 m apart, systems with a high positive correlation of demand and renewable power supply, as well as systems which are supposed to grow considerably in the future are usually designed as “AC coupled systems”. AC coupling means that all feeders, the battery power and all consumers are coupled on the alternating current (AC) grid side. DC based devices like the battery or photovoltaic cells require an inverter to be connected to the AC coupled system.

In larger systems of typically more than 100 kW installed capacity with diesel or biomass gensets running especially during daylight hours, renewable energy is used as a fuel saver without additional storage capacity. However, most of the micro-utilities today are running their grids intermittently for 4 to 12 hours per day based on small to medium size diesel, petrol or biomass gensets.

For **electricity distribution** in most cases, low voltage overhead lines are used. The lines are made of copper or more often of aluminium to reduce the risk of copper theft. The poles are made of wood, concrete or less often of steel. Especially in desert areas grounding of the overhead lines can become problematic. In some rare cases underground cables are used for distribution. The decision of using underground cables or overhead lines is mainly influenced by costs resulting from the ground conditions which can be sand, rock, stones or soil as well as the number of off-takes. The dimensions of the lines must be appropriate to let the circuit breakers installed on the consumer side trip in case of a short circuit, taking into consideration the short circuit power available on the electricity production side. Furthermore, the decision for a single phase, a three phase or a mixed distribution grid depends on the short circuit power installed on the production side as well as the consumers connected. A three phase grid makes sense once there is enough sort circuit power installed on the electricity production side to start up a three phase 5 kW induction motor under load without a soft starter. Otherwise, usually single phase distribution systems are recommended. Only if larger customers are distributed over a larger area the application of medium voltage electricity distribution at a voltage level of usually up to 15 kV is applied.

There are different methods of **measuring and billing electricity** delivered to the customers. The decision for a metering and billing system is closely linked to the general management and tariff structure of the micro-utility. Most approaches have the main objective to keep connection costs per customer low while providing sufficient power to operate productive devices. Some approaches (e.g. The Power Source Group, Energy for Africa model) bundle all larger and productive appliances connected to the mini grid in a mini industrial zone which provides for strong power supply while connecting households and shops via connections which can just be used for lighting and communication appliances.

The most common and usually least cost method of measuring and limiting electricity is using load limiters that switch off the connection when the load exceeds a certain power limit but allow unlimited energy consumption within the power limit set. More sophisticated load limiters provide extra functions like limiting the number of hours of electricity usage. Load limiters are cheaper than full function meters as no calibrated active energy measurement is required. Some micro-utilities use conventional electro-mechanic Ferraris meters which measure energy but do not limit power usage. More sophisticated digital prepayment meters overcome this disadvantage of Ferraris meters. Balance can be uploaded to the prepayment meter by entering a pin code manually, inserting a chip-card or using mobile money service via cell phones. Some of these meters have additional functions like load limitation, mini-grid stabilization or electricity theft protection. There are no mass products for meters with extra functions on the market yet. A good survey of devices that are being used in demonstration projects or that are in an advanced development stage have been highlighted by Bhattacharyya (2013).

In rare cases highly sophisticated full function smart meters are used by micro-utilities which are connected through a wireless or Powerline Communication network to the internet via the mobile-telecommunication network. This approach provides the highest flexibility in business model design and billing but results in the highest customer connection costs (e.g. Millennium Villages and Shared Solar).

1.3 Micro-utility customers and their electricity demand

Reaching a certain number of kilowatt-hours (kWh) sold is critical to financially break even for a micro-utility. To reach this breakeven point the structure of customers, the customers' financial background as well as the customers' electricity usage behaviour is critical. As the micro-utility usually withdraws money from the village economic cycle there must be some income stream to the village economy.

Households supplied by micro-utilities typically have a comparatively low income and therefore are open towards demand and consumption management to achieve the highest benefit for money spent. This of course is only realized if incentives for consumption planning and efficient use of electricity are in place. For example the operator could design the tariff model in a way that users are incentivized to consume excess electricity from renewable sources.

Local metal, wood, tailoring, etc. **workshops** are the main drivers of the village economic and electrical load development. A strong income basis from workshops that also sell products or services to outside of the village provides options for income diversification and stabilizes the village economy. Cooperation with MFIs that provide micro loans for workshop investments can accelerate the economic development in a village as electrification alone does not always foster productive use and income generation. Literature indicates that additional methods like those mentioned above are recommended (Bhattacharyya 2013).

Shops and other micro businesses providing local services (e.g. cell phone shops, internet cafés, MFIs, restaurants, grocery shops, hardware stores and markets) are also important drivers of the village economy. These kinds of electricity users usually have much less electricity demand than workshops with their electrical machines.

All of the electricity consumers mentioned above increase their demand with time as their local economy and wealth grows. The effort to connect and train these customers in efficient, cost effective and safe electricity usage in a micro-grid is comparatively high and therefore, in many cases financial breakeven cannot be achieved right from the beginning.

Anchor loads like telecom towers or industry loads (e.g. ice production, cold storages, etc.) can be key to early breakeven of a micro-utility model. They usually have a reliable high and usually quite constant electricity demand which the system design and the financial model can be based on.

Micro-grids generally have limited power and energy capacity and the load factor, concurrency level and volatility of electric loads can be quite high (Harper *et al.* 2013). Therefore, a diversification of loads to reduce volatility in the micro-grid makes sense. This means a mixture of highly productive as well as controllable consumptive loads. The most favourable loads are usually base loads like telecom towers as these can be covered with limited power capacity reserve. Electricity users must be aware of the limitations of power and energy capacity in the micro-grid and must understand the control methods taken to keep the grid stable. This refers to demand side management using tariff systems to incentivize customers to use electricity in a certain manner as well as load management systems in terms of switching of loads controlled by the micro-grid system. This requirement for information increases the need for training of customers compared to national main-grid connections considerably and adds to the costs of micro-utilities that should also reflect in the tariffs charged. This is the main reason for electricity tariffs of micro-utilities being considerably higher than tariffs in the main-grid.

[1] The concurrency level is the portion of loads switched on (in Watts) at the same time divided by the total wattage of loads available to be connected to the grid. In large grids the concurrency level is rather low and constant whereas the concurrency level of small grids can be large and highly volatile. An individual customer can have a considerably higher effect on the concurrency level in small grids than in large once.

1.4 Market segmentation according to ownership and operational structure

The Alliance for Rural Electrification subdivides business models for micro-utilities according to ownership and operational structure into four different categories (Rolland & Glania 2011):

1. **COMMUNITY-BASED MODELS**

   In community-based models, the village community owns and operates the system. The village community furthermore provides maintenance services to the electricity supply system, collects tariffs and manages the micro-utility. Management is often realized through a village power committee which consists of village representatives elected by the village community or appointed by the village chief. Cooperative models are also covered by this group.

2. **PRIVATE SECTOR-BASED MODELS**

   In private sector-based models, small and medium sized companies or even individuals own and operate power production systems and micro-grids selling electricity to households or commercial customers. Larger, pure private sector business models are rare as socio-economic aspects of villages frequently lead to conflicts with the private micro-utility. More often, private sector models are interlinked with other models becoming more complex hybrid models.

3. **UTILITY-BASED MODELS**

   In utility based models large or medium size utilities own and operate the power supply system including the micro-grid and the power production part. Usually large and medium size utilities do not invest into micro-grids voluntarily but do so responding to e.g. a decree from the government. Often considerable cross-subsidies or subsidies from the government are required to run the micro-grids within the management structure of the large or medium size utility.

4. **HYBRID BUSINESS MODELS (OFTEN PUBLIC-PRIVATE PARTNERSHIPS)**

   Hybrid business models typically try to integrate success factors of the above mentioned models while eliminating risks. To do this the ownership and operation structure is subdivided into power production, power distribution and power sales and assigned to the different private and public partners. The ownership structure is often linked to the operational structure. This process is known as “legal unbundling” in the world of large utilities.

Besides the abovementioned models, there are 100 % development cooperation or government run models that shall not be covered by this study as this approach does not allow scaling up.

In the past, cooperative models have been a very successful driver of rural electrification in areas where large private and public utilities do not reach. Hundreds of millions of people were connected to national and island electricity grids using this approach. The major player for technical support in cooperatives is NRECA International Ltd. from the USA. The company originates from the cooperative sector in the USA where it takes its long term experience from. NRECA International published a comprehensive guideline for development of cooperatives and rural electrification (Yudkin 2009). This guideline contains a lot of information applicable in the micro-utility sector even if the legal structure of the micro-utility shall not be a cooperative.

Although cooperative approaches have been successful in certain areas, experiences from e.g. the Philippines show that beyond the sector which is covered by cooperatives, there are areas that are even further off the existing grids with lower income population. Electrification of these areas is considered uneconomical by existing cooperatives. Thus, new approaches have to be found to electrify these areas.

The Alliance for Rural Electrification identifies private sector models and hybrid models with Private-Public-Partnerships to be the most successful and most promising for electrification of especially small villages that are situated very far from each other with low income population, as these models can easily incorporate all measures to address the challenges occurring within micro-utilities. Thus, the present document focuses on private sector models and hybrid models including their challenges and success factors.

Within the segment of private sector models and hybrid models with partial private sector ownership, different approaches can be identified:

a. A widely spread private sector micro-utility approach is driven by some diesel or petrol genset operators who supply electricity to their own homes and businesses as well as to their direct neighbours with so-called spaghetti wiring. This approach is not scalable as these micro-utilities usually operate outside of the legal framework of their respective country and do not have the management capacity to handle the licensing and tariff negotiation processes with national authorities necessary once they reach a certain scale.

b. Large companies selling electricity as a by-product to nearby settlements of their own workers are a second private sector model which can frequently be found. Unfortunately, usually these companies are not motivated to scale their approach as selling electricity is not their core business and they do not expect high margins from this activity.

c. Thus, the most promising approach is SMEs making electricity supply their core business and trying to reach financial breakeven through quickly scaling up their business. The following chapters will focus on SMEs establishing micro-utilities.

2. RESEARCH METHOD AND CASE SELECTION

By looking at the phenomena of micro-utilities set up by specialized SMEs, the aim of the study is to find answers to the following questions:

1. How can micro-utilities be established and financed? What framework conditions are favourable for micro-utilities? (Chapter 3 and 4)

2. What are the risks that have to be managed during the implementation of the model and the operation of a micro-utility? (Chapter 3 and 4)

3. What are the barriers and gaps that micro-utilities are facing and how could they be overcome? (Chapters 4 and 5)

To answer these questions, literature and internet research was conducted. Besides researching in public registers and through internet search engines, several conference proceedings and publications of agencies like the World Bank (Bardouille 2012; Matsukawa *et al.* 2003), IEA (Niez 2010) and United Nations (Archambault 2012; Tenenbaum 2012) were analysed. It was found that in the field of rural electrification, comprehensive literature is available for solar home systems and national grid extension. Some of the general results of this literature can also be transferred to the subjects investigated on here. However, when it comes to mini- and micro-grids, literature gets less comprehensive and focuses on the description of barriers in highly subsidized mainly community and development cooperation driven systems. The conclusions of these publications can just partly be applied to private sector driven approaches as management and electricity customer relationships vary considerably between community / development cooperation driven and private sector driven models. A systematic scientific literature review regarding community and development cooperation driven approaches dated 2011 was described by Watson *et al.* (2012).

Unfortunately, private sector run micro-utility models are not covered by scientific literature yet. Only some grey literature such as Watson *et al.* (2012), Breyer (2013), Gradl and Knobloch (2010) and Bardouille (2012) can be found regarding this subject. This may be attributed to the fact that private sector engagement in terms of power supplying entities "micro-utilities" is still new to the sector. First micro-utility models have successfully been tested since 2008 only and are still in the development phase towards profitability. This lack of track record might also be the reason for the grey literature being rather descriptive than analytical. To summarize, available literature can only partly be used to derive conclusions and recommendations on micro-utility operation, framework and financing.

Therefore, this study builds especially on the authors own expertise. In addition to summarize and structure their own experiences, the authors also incorporated the insights of other companies and cases in the sector (see Appendix) and conducted 36 interviews and informal talks. The sample of experts included representatives from companies, (13) as well as public, private and social investors (7) and other organizations interacting with micro-utilities (15).

As key management staffs of such micro-utilities are typically reluctant of participating in surveys and scientific interviews, the talks were conducted in a rather unofficial manner during experience exchange sessions between micro-utilities and did not follow a fixed protocol. Whenever a statement was worthwhile quoting in this study the author got back to the respective person and placed a request for permission to publish the statement in this report.

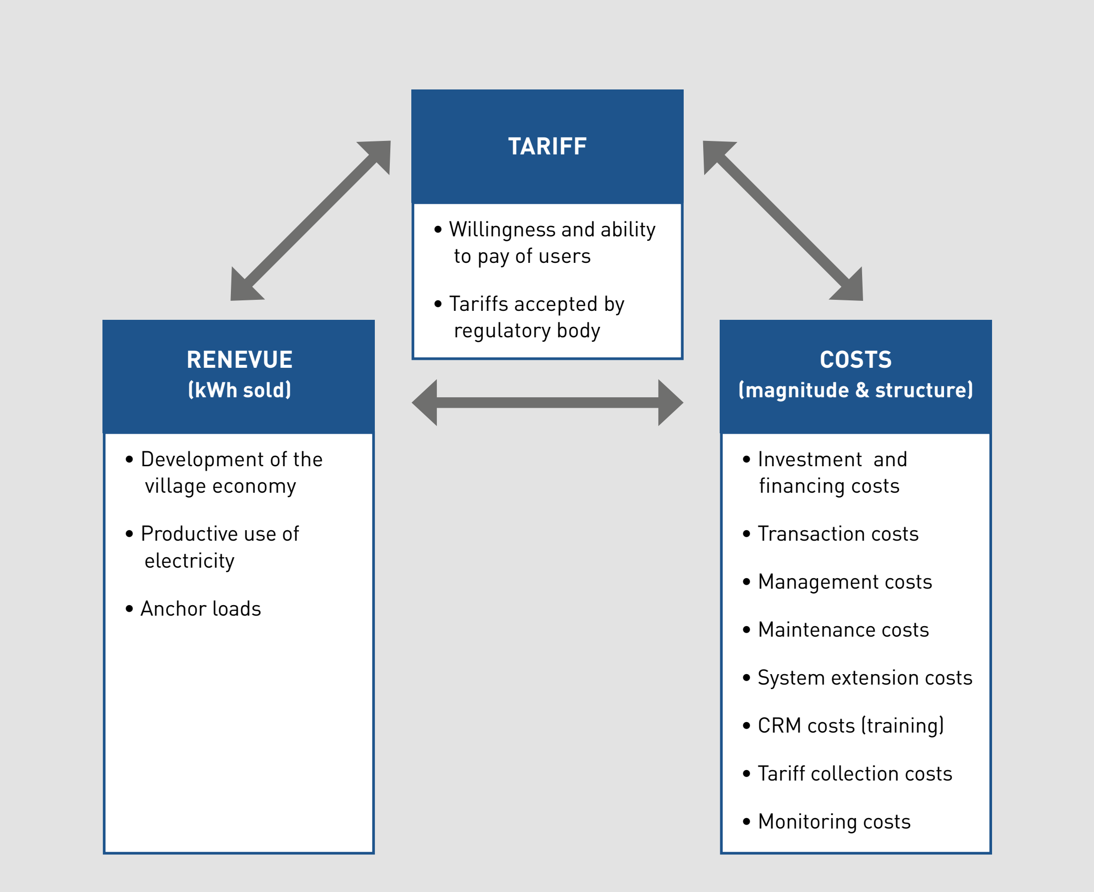
During the talks it became clear that most of the mini- and micro-utilities suffer from the same aspects retarding their development. These barriers for technology diffusion can be attributed to gaps in available financing instruments and / or missing or incomplete regulatory frameworks in their respective countries. The respective information is gathered, similarities are identified and recommendations are derived. This report summarizes the findings.

Due to the process chosen to get most up to date information, the study compromises on accuracy and traceability. As the number of existing and operating micro-utilities is rather small and only these micro-utilities could be taken into consideration in this report, results and recommendations given could not be proven statistically. Thus, this report can mainly be seen as indicative without final proof. Thereby, this report identifies research potential for more exact surveys to be conducted as soon as more successful micro-utilities are in operation.

3. Operational management of micro-utilities

Based on scholars such as Rolland and Glania (2011), Yudkin (2009) and Bardouille (2012) as well as results of interviews and company case studies, the authors suggest the following framework and derive a set of recommendations and methods:

Figure 1: First sight factors of micro-utility profitability.



Managing these factors is not a simple task to perform as all of these factors are influenced by several institutional parameters and constraints which are of social, socio-economic, technological, economic and legal nature. Thus, micro-utilities frequently suffer from three problems: 1. unstable revenues, 2. costs that are difficult to predict, and 3. from conflicts between the village and the micro-utility influencing both, the income and cost side. Methods to manage the risks involved with the influencing parameters and constraints have been developed. These risk mitigation methods will be explained in the following chapters which are a summary of best practice reported by the different micro-utilities as well as retrieved from literature (Holland *et al.* 2001; Niez 2010)

3.1 Conflict prevention methods

Conflicts between customers and the micro-utility or between authorities and micro-utilities have been one of the main reasons for micro-utilities to fail. These conflicts are frequently related to the tariff-service-ratio (price-performance-ratio) in terms of the magnitude and affordability of tariffs as well as the service level and reliability of electricity provided and the lack of influence of customers regarding the decision making processes of micro-utilities. The smaller the number of customers in one system and the larger the utility that operates the system, the more often conflicts occur. The following issues should be addressed in order to allow for a sustainable market development / scale up.

Overcoming single operator and community system problems: There are a number of operational models for micro-grids being tested throughout the world. The extremes are the single operator model on the one hand and the community system model on the other hand. Both of them have their respective advantages and disadvantages:

- The **single operator** (monopolistic micro-grid operation approach) concentrates a lot of economic and political power in his hands as he decides about when to switch on and off electricity supply in the village. Once the villagers invested into productive appliances based on e.g. micro loans to be paid back through the usage of these appliances they are economically depending on the operator. If the single operator uses his power by switching off electricity the situation can easily escalate: Customers do not pay their bills anymore; the power stays switched off; customers try to steal electricity; customers express their resentments in the form of vandalism and often try to get rid of the single operator. Additionally the following might occur: As the operator is able to set monopolistic prices, he gains additional revenue which reduce the overall welfare of the local economy. Another problem may occur if the operator uses off-standard proprietary technology, so that investments of the local community especially production facilities in energy technology may become very specific. In this case the hold-up problem may arouse meaning the monopolistic energy supplier may alter contracts to his own benefits (Grossman & Hart 1986).

- In the **community system model** the political power is rather in the hands of the village. However, once the electricity demand grows and the power plant needs to be extended and therefore becomes technically more complex and maybe even hybrid, the village community usually cannot provide the technical know-how locally any more. These models when being applied in very small scale, often fail because of the absence of professional technical staff that can handle complex technology.

Developing an appropriate constellation of stakeholders: to establish a harmonious micro-utility model, all players involved should do what they can do best, and avoid tasks that they are not the most suited person or institution to do.

Villagers who are not able to handle the complex power system technology should not be in charge of its operation whereas operators from outside the village should not interfere with the social relations within the village. Therefore, the technology has to be simple to be handled by the villagers or there must be a professional operator for more complex technology. Potential conflicts must be handled through negotiations at eye level between the operator of the power supply system and the village community, which can be guaranteed through a thorough distribution of ownership of assets within the system. Long term concessions and fixed tariffs granted by the national electricity regulatory authority to the operator of the power supply system are usually counterproductive in this regard as negotiations at village level are undermined this way. To ensure fair, harmonious and peaceful negotiations, the politically enforceable power of the micro-utility in the village must be limited to the least extend possible. Business models using this constellation of stakeholders are suggested in Yadoo (2012), Peterschmidt (2011) and Iosfin (2007).

SUNLABOB overcomes both above mentioned problems by splitting the assets required into movable and fixed assets (e.g. Sunlabob model in Laos) in which the movable assets (power generation components) are owned by the micro-utility and the fixed assets including the grid, buildings and foundations are owned by the village power committee or any other locally organized public entity. This is how the micro-utility could be dismissed and replaced in case negotiations fail. Possibly another company may come into place. In this case the potentials for misusing economical power in terms of higher prices and the hold-up problem, as mentioned above in the monopolistic approach, are remarkably lower. Obviously, the contract structure has to be arranged accordingly. The same model can be used to make sure that negotiations between the village power committee and the micro-utility are held on eye level.

Energy for Africa uses a different approach founding a micro-utility together with the village. This is how, through the distribution of shares in the micro-utility company and e.g. veto-rights, negotiations on eye level can be guaranteed and an appropriate assignment of tasks can be initiated.[2]

Design a transparent tariff and billing model: Tariffs must be accepted by all parties before being put in place. Experience shows that tariffs accepted by the national regulatory authority might not be accepted by the villagers. Explaining the tariff calculations of the micro-utility to the village power committee and allowing them to contribute to the design and fixing of the connection fees, basic fees and per kWh prices can be a factor for successful long-term co-operation, mutual trust and, as a consequence, rapidly increasing electricity consumption as well as early breakeven. Especially critical situations can arise when tariffs have to be increased due to e.g. rising fuel prices.

The split of assets mentioned above resulting in the micro-utility being able to leave if necessary, provides the basis for on-eye-level negotiations. If the tariff has to be increased, the village has the option to accept the increase in tariff or to find an alternative operator who can provide a better price performance ratio. The original INENSUS MicroPowerEconomy model includes these principles. Unfortunately, due to some constraints of the public partner this concept could not be realized completely.[3]

[2] https://gc21.giz.de/ibt/GC21/area=gc21/main/en/usr/modules/gc21/ws-FLEXdialogue/info/ibt/downloads/BusinessCase_Novis.pdf

Assure grid stability: The technology for electricity generation and distribution must be designed to keep the grid stable at all times (avoiding overload cases, empty battery, etc.). The challenge is to keep operation of the system, Customer Relationship (CRM) and maintenance at the highest possible quality level while costs for these activities stay as low as possible. Private companies are best suited to meet this challenge using their own appropriate measures such as Quality Management Systems, training and lean enterprise / TPS approaches.

Creating a business relationship… There are examples in which development cooperation agencies or NGOs try to act as if they were private business representatives. However, due to the origin of these stakeholders, the atmosphere created in the villages is often much more a donorbeneficiary than a business relationship between these institutions and the communities. In this kind of atmosphere motivations are set wrongly, at-eye-level negotiation cannot be established and the interdependencies between the village and the power supplier could not be communicated clearly. Projects fail due to several small fraud cases, vandalism or misuse of the system. Thus, the micro-utility is obliged to make clear that the sole reason for it investing into village power supply is making profit. On the other hand the micro-utility shall clarify that a profitable business can only be based on a good customer relationship and that they will not and cannot interfere with any decision making processes in the village. The credibility of the micro-utility can just be supported if the CRM is actually performed by the micro-utility and is not outsourced to e.g. NGOs.

A special approach to establish a business relationship with the village was introduced by Husk Power Systems and others. The company does not only sell electricity to customers but also creates jobs by manufacturing incense sticks from the incineration waste of risk husk.[4] In fact, most micro-utilities train local personnel - at least one villager is trained to solve small problems with electricity and answer basic questions.

As a summary, most of the efforts mentioned above aim at strengthening the trust basis between the private operator and the electricity customer. Only with a strong trust basis it is possible to handle conflicts on a fair negotiation basis and demand growth can take place to an extent beneficial for the private operator. Therefore, a well-designed and well implemented Customer Relationship Management (CRM) is key to Bottom of the Pyramid (BoP) markets and Inclusive Business (Gradl & Knobloch 2010). CRM for micro-utilities means: local services (like helping customers with their appliances and electricity usage), good availability of supporting staff, reacting to electricity customers' questions and demands as well as proper training for villagers in using the electricity supply system is key for successful electricity sales. Customers who get access to electricity in their own home for the first time have a lot of questions which need to be answered by a well-trained person. Not answering these questions usually leads to experiments with electricity which carries the risk of electrocution and can easily cause blackouts of the complete micro-grid system due to limited short circuit power available in island power systems.

[3] http://www.inensus.com/en/micro_energy0.htm
[4] http://www.huskpowersystems.com/

3.2 Cost reduction methods

Cost reduction is an essential task to be solved by micro-utilities. The following methods have been developed to overcome the main challenges:

1. Incentives for electricity usage during times when abundant (renewable) energy is available can be realized using an adequate tariff scheme, as well as demand side- and load-management systems. This reduces fuel consumption and / or battery cycling and therefore reduces operational and replacement costs.

2. Collecting of money, operation and maintenance (O&M) and especially CRM comprising consultancy regarding electricity usage and tariff application on site are major general cost drvers. Fraud during money collection if done by rural citizens might cause financial losses for the system operator. Quality Management Systems and lean enterprise approaches integrated into the electricity metering and billing approach can help overcome these issues. As travel costs can be a considerable burden on micro-utilities measures to drive down these costs should be taken. One way of doing this is training of personnel who has low hourly rates and therefore can travel cheaply with local transport. Alternatively for recurring tasks local personnel staying in the village can be trained.

Especially in East Africa, Mobile Money is used to transfer money from one cell phone account to the next one. The Millennium Villages in e.g. Uganda make use of this widely available mobile money scheme in a Smart Metering technology from Shared Solar. By sending a text message the customers can recharge their electricity pre-paid meters.[5]

3. Independent research of the International Finance Corporation (IFC) underlines, that it is relatively easy to set up a working demonstration project with a large portion of subsidy (from private or public donors) which never has to earn back its investment (Bardouille 2012). Building up a scalable model which can be replicated in hundreds of villages and which has to be run profitably is a completely different deal. One of the key requirements for the implementation of a scalable model is a low cost but capable management team on the ground which is committed to the power supply business and covers all areas of expertise required like technological, business management and financial as well as sociological know-how. During the course of project preparation and realization options for short-cuts in terms of preliminary solutions (permissions, licenses, cooperation just for the demonstration project) might arise. These short-cuts are usually tempting and help accelerating the establishment of a pilot project on the one hand. On the other hand they often make it harder to scale up and bring the electrification approach to an economically viable stage in the long run. Potential short-cuts might arise on the financial side, on regulatory issues, on cooperation with partners or during implementation.

[5] http://sharedsolar.org/

4. For operation of systems, management staff is required. As the salary of the operational management staff is a major cost factor for micro-utilities it is important to realize the operational management cost-effectively but reliably. One way to do this is to find local people that have primary school education and train them until they can do the job reliably. Examples of how to do this are given in the book “Poor economics” (Banerjee & Duflo 2011).

5. Clustering of villages is a method of getting operational costs down. Travel costs can be decreased servicing several villages within one trip. Information usually spreads from one village to the next automatically. This is how costs for training of villagers can be reduced. The micro-utility should make sure that villages within one cluster do not compete with each other too much or are even in a fight with each other.

6. Franchising models can decrease the project preparation costs for the franchisee considerably. Each franchisee can therefore breakeven with fewer villages connected. The management structure of the franchising system can be lean and therefore cost effective as in depth knowledge about technology and operation is available with the franchisor. Lower cost employees can run the systems on the ground.

3.3 Revenue stabilization methods

Stabilization of revenue streams of micro-utilities comprises two dimensions, namely the revenue generated through electricity sales to customers and the risk or opportunity of quick changes in customers electricity demand.

The reliability of the revenue stream of micro-utilities depends on:

- The income of villagers from salaries and therefore on the national and regional economic development
- The income of villagers from harvests and therefore on environmental constraints
- Electricity theft and fraud and thus on the local social integrity as well as the relationship between the micro-utility and its customers (see chapter 3.1)
- The consumer structure, the structure and diversification of income generating activities in a village and last but not least
- The electricity metering and tariff collecting techniques.

INENSUS uses the following methods to stabilize the income stream of electricity customers by micro-utility management approaches in their systems:

1. **Cooperation with a Microfinance Institution** fostering productive use of electricity in the village or own activities to foster productive use.

2. Giving customers the option to use a **larger power bandwidth** in order to operate motors iversifying income sources. However, the system stability should have highest priority.

3. Customers shall be motivated to **plan** their **electricity consumption ahead for some months.** But the **tariff and billing model must be flexible** enough not to force customers into bankruptcy through electricity purchase contracts in case of lower income.

4. **Appropriate metering concepts** make a difference in developing potential for the villagers and therefore the development potential of the revenue stream of the system operator. For example customers face lacking flexibility in electricity consumption with load limiters on the one hand. On the other hand related flat-rate tariffs do not incentivize efficient use of electricity and frequently lead to system overload in terms of energy. The conventional electromechanic meters (Ferraris meters) lead to system overload if many consumers switch on their appliances at the same time causing a power demand higher than the power available. INENSUS applies a metering technology which overcomes the above problems and keeps the grid stable.

Changes in electricity demand can result from economic growth or decline of different business sectors. In many existing models growth and decline of load, both lead to higher tariffs. This is a deadend of a micro-utility that needs to be avoided. As micro-grids are small and the diversification of productive electricity use is limited, the micro-utility is required to react to changes with system and business model adjustments without increasing the tariff in steps that are too large for villagers to sustain. The two following methods can be applied:

Firstly, micro-utilities can only operate profitably if local economy of scale effects can be gained. This means that the increase of demand for electricity has to be fostered by either anchor loads (telecom or industrial appliances) or by supporting local micro enterprises. Especially the latter will also increase productive use of electricity and economic growth of the village economy. If an anchor load can be supplied that is a reliable electricity customer independent of the village economy the probability of steps in demand that cover a large percentage of the revenue is decreased. Furthermore, anchor loads like telecom base stations or other industrial loads combined with village power supply can provide the required local economies of scale to make an electrification project economically viable.

The mobile telecom industry association GSMA and the Rockefeller Foundation are taking the approach of using telecom base stations as anchor loads for micro-grids forward actively and provide support to micro-utilities and the telecom industry. Respective publications are Jhirad and Sharan (2011) and Taverner *et al.* (2010). The solar industry is slowly entering into this sector.

In India, Uganda and other countries, this approach is currently being tested by different companies.

Secondly, opening growth potential of the power system economically and technically provides for scalability. Subsidies to finance assets of the system can buy down the tariffs, however, when the system needs to be extended according to a growing demand either new subsidy is required or the tariffs need to be increased. Subsidies for extension measures are usually not available from donors. At a stage when an extension of a system will be necessary, the electricity customers already invested into productive appliances for their respective business. A considerable increase of the electricity tariff might destroy their business model and destroys their ability to pay back loans, etc. To avoid this effect all power producing assets can be financed by the private sector partner without using subsidies (refer to separation of fixed and movable assets as mentioned in chapter 3.1). This is how, when it is necessary to extend the power plant to cover increasing demand, additional power producing components can be paid for by private finance which is usually available more easily than subsidy. The power and energy output usually increase with the total installed cost of the power plant almost linearly. The installed cost vs. output ratio is proportional to the electricity cost price. With this method, tariffs can stay constant if the power plant capacity is financed from equity and loans instead of subsidies.

The micro-utilities Sunlabob and INENSUS West Africa are using the split of asset model incl. the scalability potential without increasing tariffs as mentioned above. Some other micro-utilities are currently investigating on options to use this model in their respective political and legal framework.

3.4 Inter-linkages between operational methods in micro-utilities

All successful micro-utilities use some or all of the methods mentioned above and some micro-utilities might have additional methods that are not mentioned here.

As the methods and success factors are interlinked it is important to set up a system of methods used. The failure of one of these methods usually leads to a collapse of the complete system. Thus, the system of methods used is the core of the micro-utility business model and essential for its success.

Many projects organized top-down on the scratchboard by large utility companies and / or development cooperation showed that it is not easy to integrate all these methods into a harmonious model which generates profit. Thus, in the past, many of these well-intended approaches failed for different reasons.

Furthermore, the methods chosen have to be adjusted to local socio-economic and social conditions as well as to the political framework. For example in well-established villages in Chile it might make sense to use costly and highly sophisticated smart meters to open up services for productive use appliances, whereas Indian rural customers rather expect low connection fees and accept related limitations in service from the meters or load limiters applied. The knowledge level about risks and opportunities of electricity might be different in villages that are close to large cities than in villages that are far off. Therefore, different services of the micro-utility might be required in the different villages.

4. Financing instruments for micro-utilities

Access to finance has been a challenge for most micro-utilities. Nowadays, numerous financing instruments like equity, loans and grants from public and private as well as national and international investors are available. The financing requirements of micro-utilities are explained in this chapter and available instruments are introduced.

Generally, it can be assumed that the complexity of a project as well as its transaction costs increase exponentially with the number of instruments used in parallel for the same project. This is due to each of the instruments not only requiring reporting data but the instruments interacting with each other, and coordination of a higher number of instruments means coordinating a higher number of interconnections and interdependencies between them. The fact that some instruments require similar reporting data reduces the complexity slightly but does not outweigh the additional coordination requirements according to the interaction of the instruments. The smaller the micro-utility, the higher the percentage of transaction costs within the electricity tariff. According to authors' estimations, transaction costs can add up to 50% of the electricity tariff in extreme cases.

4.1 Financing requirements along the project development timeline

A sustainable and scalable micro-utility concept requires the entrepreneur to balance interests from different stakeholders. Performing this task for a specific legal and socio-economic framework takes time and effort resulting in considerably high transaction costs at early development stage. Figure 2 displays the development timeline of an average private sector micro-utility from the initiation stage till breakeven. Major development steps are indicated. Financing needs of micro-utilities are contrasted with available financing instruments from public and private investors.

During the development phase of a model adjusted to local conditions, salaries have to be paid, information has to be gathered and socio-economic relations in village communities have to be understood. In some cases renewable energy monitoring campaigns have to be conducted. All of this can be realized with limited budget for salaries, travel, communication and measuring equipment. Depending on the effort put into the model and its degree of innovation EUR 20,000 to EUR 100,000 might be required of which in some cases up to 50% can be funded by subsidies for business development or scientific research.

Selecting the village for a pilot site and acquiring (often preliminary) permissions from authorities is the next cost driver, especially if detailed socio-economic studies of the village selected have to be performed. Costs for founding a legal entity to become the micro-utility add to the other cost factors. It can be assumed that the entrepreneur has to spend EUR 30,000 to EUR 150,000. There might be some programs (inlcuding Public-Private Partnerships (PPPs)) supporting this phase from the public side with up to 80% of subsidies.

Once these steps have been taken, the pilot system can be set up. Depending on the kind and magnitude of the system to be installed and implemented, EUR 100,000 to EUR 500,000 are required. The costs of the pilot are usually higher than the costs of a replication project. Some rare impact investors might be willing to enter at this early stage. However, usually, investors want to see a proof of concept and therefore want to see the pilot system working for some time successfully before they start the due diligence process. Electricity tariffs charged in the pilot project are usually calculated based on the cost structure of the later replication project. Thus, during the pilot project phase, micro-utilities usually do not have a positive cash-flow.

After successfully operating the pilot system for a few months, an equity or debt investor can be contacted and a due diligence process can be initiated. Besides financial aspects this due diligence process comprises sociological, socio-economic, environmental, technical and legal aspects. This adds from EUR 30,000 to EUR 150,000. Some investors can provide grants covering parts of their own costs.

> The due diligence for INENSUS's project in Senegal took 1.5 years and required considerable financial resources from the entrepreneur. These resources are not only salaries, communication and travel costs of the entrepreneur but also financial resources to cover fees imposed by the investor (e.g. travel costs of the investor) and costs for studies performed by the investor or by external consultants appointed by the investor (sociological, technical, environmental, etc.). Parts of these costs were covered by a grant, other parts needed to be covered by INENSUS.

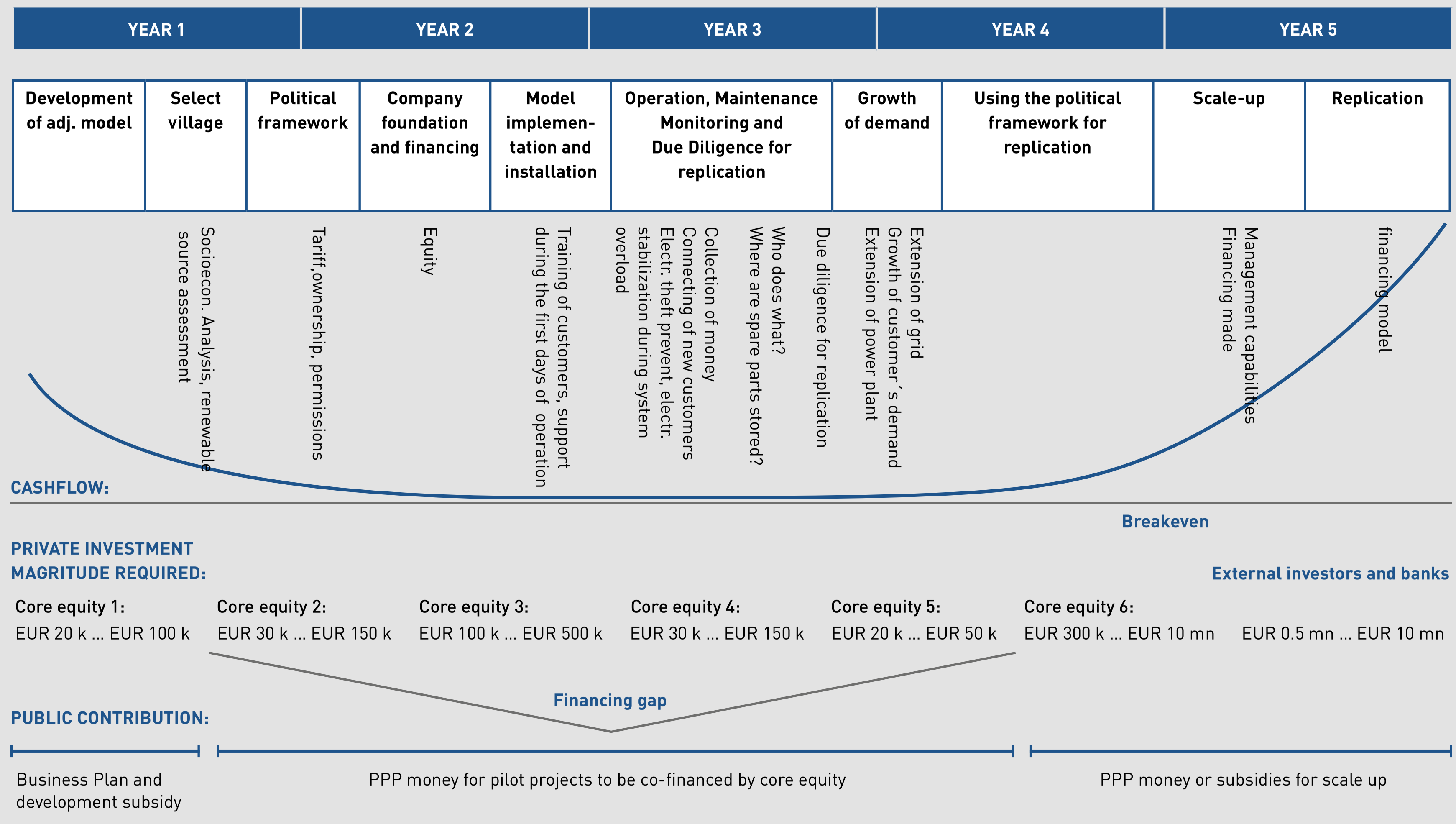
The effort of the entrepreneur required to pass the due diligence process does not change much with the magnitude of finance required. Thus, to reduce the related fixed costs, it is recommendable to aim for higher volumes and larger projects instead of smaller ones. Most of the investors have a clear idea of what magnitude of finance they are prepared to go into and what profit they are targeting. This information is often kept secret. Considerable misunderstanding can be avoided if the entrepreneur and the investor can speak openly about the aims and expectations of the investor right from the beginning.

As a result, the entrepreneur has to invest from EUR 200,000 up to EUR 1 mn in order to get to a stage where a micro-utility can be supported by an external investor. At that stage the micro-utility is typically already three to four years old. Usually, there is still one year to go until breakeven is reached. Some innovative investors like the company "Persistent Energy Partners" identified this financing gap and are entering into early stage financing of micro-utilities.[6]

Existing micro-utilities have walked through this financing gap either by winning business plan awards providing prize money (Husk Power Systems, CarbonX[7], etc.) or by putting in equity and equity in kind (The Power Source Group, INENSUS, etc.). Often, when investing into the company, the investor requires the entrepreneur to add additional equity in order not to exceed a certain percentage of the total investment or company shares.

[6] http://persistentenergypartners.com/
[7] http://www.carbonxenergy.com/

Figure 2: Financing requirements along the micro-utility development timeline



4.2 Private investment

Core equity

As can be derived from chapter 4.1, the most critical part is to find an entrepreneur who is also prepared to invest into the micro-utility business. The financial involvement of the entrepreneur is usually a key prerequisite of equity-investors and banks. Often the input from the entrepreneur can at least partly be provided as equity in kind meaning that during project preparation and project implementation the operator brings in unpaid services and / or goods which are accounted for as equity. The entrepreneur should also have the key management role in project preparation, realization and operation as investors want to see his / her management ability and only invest if the management ability could be proven. The due diligence process therefore can also be seen as a test of management qualification.

As indicated before, the preparation and implementation time of a micro-utility can take up to four years. On the one hand, there are not many private financing instruments available to support the related investment of the entrepreneur within this development period. On the other hand, international public donors supporting this phase with a subsidy of up to 50% require companies to invest their own core equity as counter finance. Loans or equity from impact investors are usually not eligible as co-investment at this stage.

SMEs are often not aware of the expenditures waiting for them on their development timeline and underestimate the effort to be taken until they can reach the scale-up phase. Thus, they frequently spend large amounts of their core equity for business development activities in an insecure political framework and run out of money before they reach the stage of being interesting for investors. At this stage, some entrepreneurs transform their business into an NGO as acquiring capital in terms of grants at an early stage is easier for NGOs than for private companies. Others move on with a low budget strategy spending money and taking the next step whenever core equity is available. Both strategies decrease options for replication and scale-up considerably.

A successful micro-utility entrepreneur has to bring along a lot of supporting characteristics: Under the presently given framework conditions, intrinsic motivation, philanthropic thinking, availability of core capital and the willingness to invest core capital into a micro-utility business have to match the entrepreneur's technical and business management education as well as his high-level network of connections. At the same time the entrepreneur must still be prepared and able to act on the villagers' level. These personalities are difficult to find.

Analysis of the management team structure of successful micro-utilities shows that in the vast majority of them the driving force is an entrepreneur who studied and worked in the USA or Europe or was even born there. Local entrepreneurs that want to found a micro-utility as a social business, usually either lack core capital, education or the network of international contacts.

Abdou Rahime Diallo, African Diaspora Policy Centre:

"The African Diaspora has got a role to play in electrifying African off-grid villages. Equity, technical and financial knowledge as well as motivation to support development in their home villages are available. What is missing in most countries is an intriguing and easy concept of how to reduce complexity in establishing a micro-utility."

The African Diaspora Policy Centre (ADPC) enables African Diaspora in Europe to connect more closely with the continent as a collective force. The thematic areas are Peace building, Better Governance, Migration & Development and Brain Gain.

A good pool of high level candidates is the diaspora community living in industrialized countries maintaining strong connections to their home countries. The diaspora community is contacted frequently when entrepreneurs are sought. Diaspora networks are a good source for entrepreneurship and core capital. Examples from The Power Source Group and INENSUS show that it is possible to also attract strong local investors and companies to invest into a micro-utility outside of diaspora networks. Both companies found local joint venture partners or local investors.

Equity and debt investors for micro-utilities

In the energy sector low risk investments with long payback-periods are common. This also holds true for micro-utilities, especially if wind and solar energy are involved. In large utilities of industrialized countries, payback-periods are typically in the range of 15 to 30 years. Due to higher risk profiles of micro-utilities, investors expect considerably shorter payback periods compared to large utility investments. With the long company preparation phase of 3 to 5 years and an additional 7 to 10 years amortization period after scale-up investment, an investor who enters into the company right after foundation, has to wait for 10 to 15 years until the first return on investment can be expected. Especially SMEs are not used to such long amortization times. Additionally, the return is relatively small and typically is in the range of 5 to 15% IRR, much smaller than the 20 to 30% a typical investor of a developing country would expect. Therefore, even social or impact investors usually expect considerably higher returns. Of course, the relatively short payback period and relatively high expected returns reflect in high electricity tariffs.

Equity and debt investors have different magnitudes of investments they are prepared to go into. Furthermore, they usually want to limit their risk by staying below certain percentages of total investment required. The following table summarizes these conditions. The table gives just indications. In different projects the different financing partners might decide differently than shown in the table below:

Table 2: Investors and their typical investment targets within micro-utility projects derived from the authors' experience.

	Amounts available	Percentage of total investment	Expected interest rates
Expected input from core equity investor	Usually USD 50 k - USD 0.5 mn	Usually: >50% Minimum: >25%	15 to 20%
Impact investor / social investor	Usually between USD 0.5 mn - USD 4 mn	25 ... 30% of shares	15 to 20%
Mezzanine Finance from international development banks	Minimum: USD 5 mn – USD 10 mn	Usually: >30% of total investment Sometimes: up to 50%	3 to 18% (depending on performance of company)
Loans from international development banks	Minimum: USD 5 mn – USD 10 mn	Usually: >30% of total investment Sometimes: up to 50%	6 to 12% (interest fixed throughout payback period)

Usually a combination of several social investors[8] and banks is possible. To reach the minimum amounts, clustering of villages and projects is necessary. Most impact investors enter into an investment only as co-investors. This means that there needs to be at least one of the big players involved first. The International Finance Cooperation of the World Bank Group (IFC) is the investor mentioned most often as the big player co-investors trust in.

The micro-utility sector is still young and banks as well as equity investors do not have much experience and expertise with this sector. Thus, investors try to adopt methodologies for due diligence processes known from either large power plant projects or from financing MFIs or apply a mixture of both. Probably with increasing experience in this sector investors can gain considerable streamlining potential in the due diligence process.

Karin Bouwmeester, FMO – Netherlands Development Finance Company:

"Small micro-utility projects with difficult to assess risk structures are still comparatively new to Development Banks. FMO is one of the first development banks entering this sector."

FMO is the Dutch development bank. The bank supports sustainable private sector growth in developing and emerging markets by investing in ambitious companies. FMO believes that a strong private sector leads to economic and social development, empowering people to employ their skills and improve their quality of life. FMO focuses on three sectors that have high development impact: financial institutions, energy, and agribusiness, food & water. With an investment portfolio of EUR 5.9 bn, FMO is one of the largest European bilateral private sector development banks.

[8] A social investor is an investor accepting a lower profit from his investment if the social benefits for a community to be defined resulting from the investment are high enough.

Today, little experience is available with micro-utility investments and thus, the risk of such an investment cannot be assessed completely. Therefore, first-market investors ask for high risk premiums which often result in expected interest rates of 20 to 30% IRR. These profits often cannot be provided by Micro-utilities while keeping the end customer electricity tariff at a reasonable level below the willingness and ability to pay. Social or impact investors fill this gap offering equity with an expected IRR of usually around 15%. The data base of Aspen Network of Development Entrepreneurs[9] provides an overview of investors active in specific regions of the world. The website of this network comprises an interactive map showing e.g. investors active in a specific country having a specific thematic focus. Another list of potential investors can be found on the website of INAISE[10].

Local banks usually have little experience with the micro-utility sector and therefore ask for high collateral before entering into a financing contract with a micro-utility. Loans are usually smaller compared to international development banks but efforts for the due diligence process might also be less especially if 100% collateral is available. Sometimes, local banks are prepared to provide loans in local currency. This decreases the inflation risk of the micro-utility as well as the risk of sudden and considerable devaluation of a currency. Interest rates of local banks are sometimes above the expected IRR of social equity investors.

International development banks are sometimes prepared to enter into micro-utility investments asking for less collateral than local banks. Due diligence processes can be long and expensive. Therefore, for the entrepreneur as well as the bank, investments of less than EUR 5 mn are not feasible. Recently the German development bank DEG together with the German Ministry of Economic Cooperation and Development set up a program to subsidize the bank's costs in a due diligence process. DEG is now prepared to invest into projects requiring investments of some million EUR and above. Such programs usually do not reduce the effort and cost of the entrepreneur. Therefore, the entrepreneur has to decide if such a due diligence process makes sense. Development banks usually invest in EUR or USD. Thus, the entrepreneur bares the risk of inflation with countries that have not linked their currency to any of the currencies mentioned above.

Program of Activities (PoA) is the **Clean Development Mechanism (CDM)** approach of the UNFCCC[11] which allows several small projects to be combined as one project. More small projects can be added to the same general application in a later stage. Usually, a minimum of 20.000 tons of CO2 emission reductions per year have to be combined to make the costly application process (> EUR 100,000) viable. The same applies to Verified Emission Certificates which can be sold on the voluntary market as on one hand the application costs are less but on the other, the revenue from these certificates is also less. For example, 20,000 tons of emission reduction per year translates into roughly 500 Senegalese villages with 1000 inhabitants each to be electrified within a three year period of time. Although projects below 20,000 tons of CO2 reduction per year benefit from a simplified application procedure the expenses are usually too high to be recovered. Rural electrification projects are usually eligible for Gold Standard certificates which target higher prices on the carbon credit market. However, the application requires even more effort and adds some more costs[12].

[9] http://ande.force.com/
[10] http://www.inaise.org/
[11] http://unfccc.int/2860.php/
[12] http://www.cdmgoldstandard.org/

As the application process for the CDM requires a lot of effort and experience, usually it is reasonable to involve a professional service provider or a professional CDM project development company. However, with these small projects (below 500 villages of 1000 inhabitants each) the CDM management costs eat up most of the revenue from carbon certificate sales. Thus, there is not much revenue left for the entrepreneur. Scaling up the projects or combining village power supply with supply of commercial loads (e.g. telecom base stations) might be a solution to make financing by revenues from the carbon credit market economically viable.

Large utilities are familiar with long term investments with limited IRR expectations. Capital to go into micro-grids is often available especially with large utilities from industrialized countries. However, at the moment most large utilities are considering the risk of investment in the micro-grid / off grid sector to be too high. As processes in the micro-utility sector vary considerably from established structures in large utilities, the only straight forward option for large utilities to enter the micro-utility sector is an investment into micro-utilities.

As one prominent example, the large utility EDF is already active in the sector of rural electrification and mini-grids in developing countries. However, the approaches taken are still closely linked to classic utility procedures. If large utilities want to be successful in the standalone micro-grid sector they have to be willing to learn from best practice examples which show considerably different management structures compared to classic large utility approaches.

Stefan Koch, Manager Corporate Sustainability, E.ON AG

"Business options in the micro-utility and inclusive business sector are being analyzed by large utilities like E.ON. But to make inclusive business a potential long term business opportunity for large utilities, the revenue vs. risk profiles have to be clarified and improved. Besides it becomes more and more essential to develop appropriate and new business models. These must be tailored to the concrete demand at the Base of the pyramid on the one hand. On the other hand successful approaches must be aligned with corporate strategies in order to really scale sustainable solutions over time."

E.ON is one of the world's largest investor-owned power and gas companies with a strong international focus - committed to providing cleaner & better energy. The corporation co-financed the study Energize the BoP – Energy Business Model Generator for Low-Income Markets and is engaged in the World Business Council for Sustainable Development Focus Areas "Access to energy".

To overcome the above mentioned challenge and make use of the potential that lies in large utility involvement, cooperation between a large utility and micro-utilities could be a solution. Several concepts could be realized, e.g.:

1. The large utility invests into a franchising model on the franchisor side while the franchisee can borrow parts of the capital required from the franchisor. Security for the money borrowed can be the power producing movable equipment applied. The borrowing process can be quite easy as the conditions and preparation of the business plan are supported by the franchisor.

2. A large utility invests into a micro-utility structure which has several branches to supply villages in different regions of the country. Local entrepreneurship has to be fostered through the design of the employment contracts along with the local personnel.

4.3 Public financing instruments

Different international and national subsidy and PPP programs are available for different countries that can be tapped by private companies.

For example, programs for pilot system installation and programs for the replication stage can be applied for. Usually these programs require core equity from the partner-company as counter finance. Equity from equity investors outside of the company as well as debt financing is not accepted as counter finance. Furthermore, the companies applying for these programs usually have to prove a minimum revenue and balance sheet size.

Development banks like KfW / DEG, FMO, IFC and others are prepared to provide debt finance of usually above EUR 5 mn to micro-utilities. In some cases development banks subsidize their own transaction costs to be able to provide debt finance of as low as EUR 1 mn. The micro-utility has to assess if passing through a complex due diligence process makes sense for small amounts of debt finance required. In some countries like Tanzania local banks are encouraged through guarantees of rural electrification agencies to provide loans to micro-utilities. The guarantees provided shall reduce the interest rate of the loan.

Direct Subsidies

Direct subsidies are available through national rural electrification agencies or directly from international donors. The national rural electrification agencies can be approached through an application procedure defined locally. The international donor programs usually need to be accessed through a tendering procedure. Calls for proposals are published by e.g. the European Commission or the Dutch government frequently.

Besides grants for the up scaling phase, small grants can be provided through PPP programs. In some cases the grant comes together with support from for networking and project management from the implementing development cooperation institution.

Foreign Investment Guarantees

Guarantees are helpful to lower the interest rate of a loan to an acceptable level or generally reduce the risk of banks to a level where they would be prepared to enter into a loan contract at all. As SMEs often cannot provide guarantees themselves they depend on support from outside. The following examples give a first impression of what guarantees can be available:

Guarantee of the German Federal Government is offered to German companies through the consultancy company Price Waterhouse Coopers (PWC). This instrument covers environmental risks and political risks of direct investments of German companies into foreign countries. It is often used in parallel to a loan contract with DEG. Costs of the guarantee are 0.5% per year of the total value of the German direct investment. Some upfront costs apply for larger projects.[13]

[13] http://www.agaportal.de/en/dia/index.html/

Governed by the African Development Bank (AfDB) and supported by the Danish and Spanish government, the **African Guarantee Fund** for Small and Medium Sized Enterprises provides guarantees for SME investments through local banks. The fund was inaugurated on 1 June 2012 and will be in operation soon.[14]

MIGA (Multilateral Investment Guarantee Agency) is a member of the World Bank Group. The organization provides investment guarantees covering currency inconvertibility and transfer restriction; expropriation; war, terrorism, and civil disturbance; breach of contract; non-honoring of sovereign financial obligations.[15]

National guarantee funds like the following example from Uganda: Partial Risk Guarantee (PRG) - This is a cost overrun insurance facility of the **UECCC** (Uganda Energy Credit Capitalisation Company), available during the construction phase of the investment project. This facility enables projects to initially access guaranteed cover for cost overruns of up-to 15% of the total project cost. Additional overruns beyond the 15% but in any case not exceeding 50% of the project cost may be financed on a 50:50 basis between UECCC and the developer.

Foreign exchange risk mitigation

In developing countries, loans and mezzanine finance are often provided and need to be paid back in EUR or USD instead of using the local currency. This comes with a considerable risk of rising exchange rates for the micro-utility. While tariffs in many countries can be indexed to diesel fuel prices (e.g. the Philippines), a direct indexation of the tariff to inflation is not permissible. Furthermore, classic instruments handling inflation risk in investment portfolios are not applicable for SMEs as these companies do not have the capacity to run large investment portfolios in parallel to their investment in the local micro-grid sector. It can be stated that there is a lack of instruments in inflation risk mitigation to be handled easily by SMEs.

4.4 Remaining investment gaps

Core equity

One of the reasons why micro-utilities are not founded in larger quantity is that this business is financially not as attractive as it could be for the entrepreneur. On one hand, large companies which have core capital available are not motivated to enter into the micro-utility sector. High barriers and difficult to calculate risks add to the low profitability. On the other, smaller companies have the intrinsic and philanthropic motivations to found micro-utilities but often lack core capital. Joint Ventures could be a solution to this problem. However, when involving a large company in this business, it is important to ensure that the management and cost structures stay lean, as introduced in chapter 3.

[14] http://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/african-guarantee-fund-for-small-and-medium-sized-enterprises/
[15] http://www.miga.org/index.cfm/

Paolo Mele, Renewable World:

"Small companies often have the most innovative ideas and highest ambition to electrify rural villages as these entrepreneurs often come from villages and know what they are talking about. Unfortunately, core equity to build a business upon these ideas is rare. Finding investors that are prepared to enter in such an early stage is extremely difficult."

Working through local partners in East Africa, South Asia and Central America, Renewable World supports the provision of renewable energy services for poor communities in order to improve livelihoods, health and education. Renewable World is supporting micro-utilities that are in an early development stage e.g. by acquiring finance.

Thus, entrepreneurs who have the adequate professional background, such as diesel genset operators who are active in many developing countries, and who could provide core equity for this business, are often not interested in the micro-utility business. As indicated earlier, in order to change this, the following challenges need to be met:

1. The development and pilot phase has to be shortened and more cost effective. The strongest lever to do so is the proper preparation of the political and legal framework, the facilitation of license acquisition and the facilitation of due diligence processes.

2. Frameworks for scaling of the model to more villages in the same country have to be more predictable and reliable on the licensing, tariff and especially the public contribution side.

3. One approach to make investments into micro-utilities more attractive for entrepreneurs is closing the early stage long term investment gap which will be dealt with in the next chapter.

The project development funding gap

As shown in chapter 4.1, micro-utilities have to finance the 3 to 4 years of the pilot- and due diligence-phases themselves and spend between EUR 200,000 and EUR 1 mn within that period of time. SMEs from developing countries and especially start-ups usually cannot afford this investment. Investors supporting this early stage are also rare.

Barbara Boerner, Canopus Foundation:

"Micro-utility start-ups usually have just a little anchor equity available that is used up in or before the pilot phase and therefore require additional funding at an early stage. Unfortunately, early stage impact investors are rare and often cannot be reached by micro-utility start-ups."

Canopus Foundation is a venture philanthropy foundation supporting social-entrepreneurs that electrify low income households with renewable energy. The foundation has a wide network among impact investors and micro-utilities.

There are different options of how to overcome this financing gap. A combination of the following options could solve the problem:

1. Grants covering a higher percentage of the total pilot project development cost which lower the financial burden on entrepreneurs. These grants do not interfere with the scale up and system extension potential as long as no movable assets are financed by these grants.

2. Investors are prepared to step into the business already at the pilot project development stage.

3. The political framework including licenses, tariffs, etc., possible adjusted business models and access to finance for the scale-up phase (equity, loans and grants) including the due diligence process are prepared by the public partner of the PPP. This reduces the preparation and investment costs for the entrepreneur, shortens the preparation timeline and thus improves the profitability of the project for the entrepreneur and the investor.

Foreign exchange risk mitigation gap

International development banks supply loans and mezzanine capital to micro-utilities in developing countries usually in EUR or USD and require the loan or mezzanine facility to be paid back in the same currency. As tenures of loans provided to micro-utilities are comparatively long (typically 10 to 15 years), there is a considerable risk of inflation and foreign exchange rate fluctuations. In countries where the currency coupled to EUR or USD there is the risk of sudden devaluation of the currency. SMEs often do not have the means to mitigate this risk using portfolio balancing methods. Thus, this service could be provided by the bank, a donor or the government of the development country. Matsukawa *et al.* (2003) introduces methods applicable to the infrastructure investment sector. These are:

1. Local currency financing

2. Currency hedges

3. Mechanisms that allocate exchange rate risks to governments

4. Tariff indexes

5. Liquidity facilities

6. Suspension of investment programs

In most countries there are instruments available to overcome the foreign exchange risk mitigation gap. However, in many cases these instruments are difficult to use by SMEs.

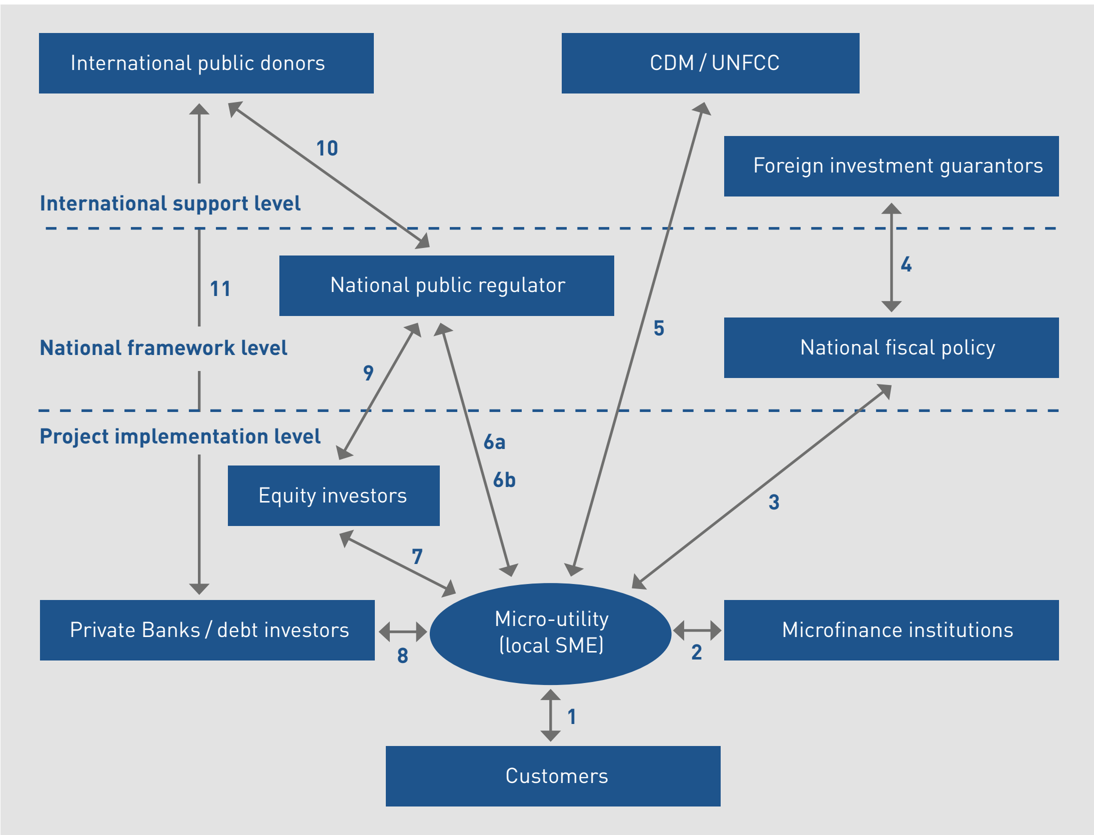
5. MANAGING STAKEHOLDER INTERACTION FOR SCALING UP

In the pilot phase of a micro-utility, usually exemptions from licenses apply, or the absence of a license is silently accepted by the authorities. The network of stakeholders involved at this stage is small as no external financing and financial risk mitigation is required. Once the micro-utility model is being prepared for scale-up to breakeven, additional stakeholders and formal processes come into the picture. This makes the scale-up process complex, time consuming and expensive for the entrepreneur especially in countries where the framework and support instruments of the different stakeholders are not adjusted to each other. The interrelations between different support instruments will be introduced below.

5.1 Existing conflicts of interest

A number of regulations and support instruments have been set up to guide micro-utilities in acting according to the respective national policy as well as to performing well and growing quickly. Without obeying these regulations and making use of the support instruments, a micro-utility cannot grow beyond a certain scale. Unfortunately, in many countries the regulations and support instruments are not adjusted to each other. Figure 3 identifies conflicts occurring between regulations, support instruments, the Micro-utility and customers. Balancing interests at the level addressed requires highly experienced and educated management staff with a wide and high level network of contacts to influential people.

Figure 3: Conflicts between stakeholders due to support instruments and frameworks not adjusted to each other



1. Customer vs. micro-utility: In order to set up a fruitful long term business relationship, it is important to design the micro-utility in a way that balances power among the local community and the private operator (see chapter 3).

2. MFIs vs. micro-utilities: Microfinance was very famous with donors within the last decade. Thus, MFIs received a lot of attention from donors and therefore often expect the provision of safety funds by the project partner as well as immediate benefits from cooperation with a micro-utility and are not willing to invest into this new business.

3. National fiscal policy vs. micro-utility: Micro-utilities usually do not have a full overview of which taxes will apply. As micro-utilities are special businesses, even after consulting a professional tax advisor, getting a clear picture of all applicable taxes is difficult.

4. National fiscal policy vs. foreign investment guarantor: Foreign exchange risk, see chapter 4.3.

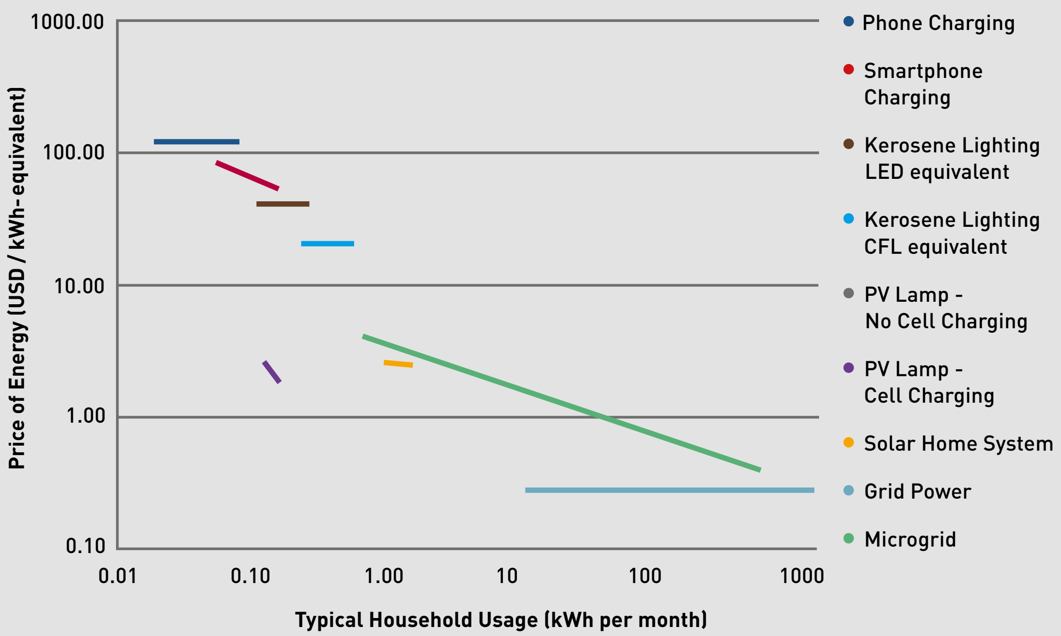
5. CDM / UNFCCC vs. micro-utility: The CDM is a strong instrument supporting the application of large scale renewables and large quantities of small scale renewables in developing countries. Unfortunately, the CDM is not applicable for micro-utilities as they do not reach the scale required to let the revenue from emission reduction certificate sales compensate the effort and cost of applying and maintaining the monitoring processes. Subsidies may not be used to finance the CDM development costs.

6a. National authorities / ministries vs. micro-utilities: As mentioned before, acquisition of permissions and licenses can cause considerable transaction costs. Unfortunately, these transaction costs are not reflected in the tariff calculations of the regulatory authority and must be covered by the entrepreneur accordingly.

6b. National authorities / public regulator: Regarding the electricity tariff for consumers it is not clear if all consumers should pay the same price or if micro-utility consumers pay a higher price per kWh. This subject poses a very difficult issue for politicians to decide on. On one hand, it is obviously desirable to have everybody in the country pay the same tariff from electricity in order to give on the first sight equal chances to all citizens (e.g. Philippines). As a result, more than 50% of the income of micro-utilities is publicly paid subsidy. On the other hand, opening up the tariff structure can accelerate rural electrification processes considerably (e.g. Tanzania). There is a twofold advantage for those who choose immediate electrification with higher tariffs rather than waiting to be connected to the main grid in the future: Firstly, new rural business centers can be established where micro-grids exist, and secondly, micro-grids replace even more expensive lighting provided by kerosene lamps or candles.

7. and 8. Banks vs. micro-utility and equity investors vs. micro-utility: Micro-utilities usually have limited financial capacity due to limited core capital. Thus, the magnitude of projects that can be handled by micro-utilities is limited as well. This, on one hand, results in a demand for loans that is usually at the lower end of what international development banks are prepared to deal with. On the other, the effort for due diligence procedures is almost independent of the loan amount. Accordingly, high effort of highly educated management staff for limited electricity production capacity that could be purchased and installed using the loan, results in higher tariffs. Unfortunately, this effort is often not reflected in the tariff calculations of the regulatory authority and therefore decreases the IRR of the entrepreneur.

Figure 4: Price of energy vs. typical household usage for different power supply devices and connections in Haiti (Archambault 2012)



Barbara Boerner, Canopus Foundation:

"Due diligence processes for investments into the off-grid electricity sector take several months and sometimes up to two years. Surviving this period of time while supporting the process is often a challenge for small and medium size enterprises."

Canopus Foundation is a venture philanthropy foundation supporting social-entrepreneurs that electrify low income households with renewable energy. The foundation has got a wide network among impact investors and micro-utilities.

9. National authorities / ministries vs. equity investors: Equity is the most expensive version of financing. Thus, the investor expects the project to be implemented as soon as the money arrives in the bank account of the micro-utility. As mentioned above, national authorities usually just start preparing the legal framework for licenses and permissions when the money arrives in the bank account of the micro-utility and need an often unpredictable duration until the framework is in place completely.

10. International public partners / donors vs. national public regulator: On the one hand public institutions have tight schedules for spending the money as budgets are only available for a certain fiscal year. If the money cannot be spent in time, the budget will be gone. On the other hand, money can only be spent if some conditions are fulfilled. This puts micro-utilities under pressure to prepare the project and fulfil the conditions in time. Frequently the conditions of the Public Partners / Donors are related to the acquisition of licenses from national authorities.

Especially in countries where privately operated micro-utilities are new, the legal framework for issuing these licenses is often not in place. In that case, ministries have to advise or the parliament has to be involved. This process can take a long time, longer than the Public Partner / Donor is prepared to wait. Some might say that the micro-utility should start working on acquiring the licenses before applying for donor funding. However, most authorities in developing countries usually start working on the respective issues only when there is a concrete and urgent inquiry. From the authorities' view, this is the case when the money to realize the project has arrived in the bank account of the investor. Some micro-utilities fail due to this difference in planning horizon.

John Herrman, The Power Source Group:

"Long decision making processes of authorities and ministries can be a major challenge for micro-utilities as these companies usually do not have the financial means to bridge the time gap easily. Time in which a micro-utility cannot generate adequate revenue means losses due to high fixed costs that cannot be avoided."

The Power Source Group is a micro-utility operating in the Philippines. The company was the first private sector company to make use of the comparatively advanced regulatory framework for private power providers in the Philippines (Congress of the Philippines (2008)). Although the political and regulatory framework was already in place there were some questions that were not answered and the respective authorities had to take a decision on. Thus, it took The Power Source Group years until the tariff and the operational subsidy, adding to the applicable end customer tariff to make operation profitable for the company, was approved.

11. International public donors vs. private banks: Similarly, the due diligence process of banks and equity investors can take from some months up to two years. The actual duration depends on a number of factors relying on the availability of company's data, licensing procedures, etc. The duration of the due diligence process already covers large parts of the total validity period of the donor money. In some cases this conflict might lead to failure of a project.

5.2 Establishing a suitable framework for private investment

For the scale up of micro-utilities beyond the pilot phase a complete and applicable political and support framework with instruments adjusted to each other has to be available. The framework has to be prepared and adapted for each country individually according to the socio-economic, environmental, institutional and political constraints of the respective country. In addition, established frameworks are in some cases continuously adapted. Therefore, application processes for licenses and tariff approvals are always new for the related authorities and may take longer, in some cases years.

Due to the lack of communication between the political and the private sector, often frameworks are established that do not meet the requirements of the local private sector micro-utilities. In addition, young micro-utilities that start-up often do not know exactly what framework they need to meet challenges that might occur during the up scaling phase, or to what extent the lack of coordination of existing framework instruments might turn into obstacles they did not notice earlier.

Thus, the pioneering entrepreneur running a scale-up process with his micro-utility pays a considerable portion of transaction costs, influencing the political and support framework which competitors who are early adopters or late followers will be able to benefit from. Today, only intrinsic motivation (e.g. supporting the weak) makes first movers act, who then choose to become NGOs instead of private companies, limiting their scaling potential. Furthermore, many large players (large utilities or large PV companies) are waiting and watching small companies, and letting them pay the transaction costs required.

Case INENSUS West Africa:

In Senegal, the rural electrification authority ASER is in charge of implementing the micro-grid electrification strategy of the national energy ministry. When INENSUS West Africa applied for an electricity production and distribution license for becoming a micro-utility in a pilot project in 2009, no official application and evaluation procedure was available. Thus, INENSUS just received a support-letter from ASER, which was not legally binding and encouraged INENSUS West Africa to set up the project. With the support of GIZ, INENSUS was able to start implementing two pilot projects.

When INENSUS was ready to scale-up the pilot project to another 30 villages with 30,000 rural citizens in 2010, the related investment could not be performed without legally binding licenses. Thus, INENSUS discussed with ASER, the regulatory authority and other public stakeholders at the national and international levels, about how to finalize required decrees and define licensing procedures for micro-utilities. ASER was supposed to be the communication hub in this process, but unfortunately, between early 2009 and late 2012, the Director of ASER was replaced several times. As of September 2012, the legal framework for micro-utility licenses is close to being fully available. INENSUS will most likely never recover the costs involved in this lobbying process.

Usually, industry forms interest groups and NGOs to influence the political framework of a specific country. In the micro-utility sector there are just a few players in every country. Thus, forming an NGO would be a costly proposition that SMEs usually cannot afford. Therefore, the framework has to be developed and established either in a bottom-up or top-down fashion.

Starting coordination of the sector at the international level, e.g. through the IRENA with its vast network, and the World Bank and the United Nations each with their respective levers, implementation on the national level could be facilitated. At the national level, Rural Electrification Authorities that have been established in many developing countries can be of major support. They are in the right position to implement well-adjusted framework conditions and support mechanisms.

Example Tanzania:

There are a few countries which are already advanced in solving some of the problems mentioned above.

The government of Tanzania with the support of the World Bank is setting up a framework which strives to coordinate the regulatory framework with support instruments and structures the micro-utility market with an aim to attract private investors and system operators (Tenenbaum 2012). Major achievements include the applicability of cost reflective tariffs, the provision of capital from local banks, the almost completed structure of the regulatory framework, the availability of grants adjusted to the national framework (USD 500 per new connection) and the setup of a CDM program of activities.

For example the company Windpower Serengeti is making use of this framework, becoming a micro-utility in the Serengeti area with a wind solar hybrid power plant supplying approx. 4000 inhabitants.

In contrast to the top-down approach, the bottom-up approach starts with those successful micro-utilities which have already paved their way through the national political framework and managed to coordinate some support instruments to establish a profitable and sustainable business. These utilities might set up cooperation with partners from national authorities as well as with financial partners and run a franchise system, giving franchisees a head-start in terms of model development and financing as well as reducing transaction costs using the knowledge and network of the franchisor considerably.

Example Husk Power Systems:

The Indian company Husk Power Systems was the first to establish a franchising system for micro-utilities. The franchisor sells the systems and the maintenance services, trains the operators and guides the partner in civil work and acquisition of finance (subsidies and carbon credits). Additionally, the franchisor provides a sales channel for the by-product char.

Using this franchise system, Husk Power Systems installed 84 gasification power plants within four years.

6. SUMMARY OF IDENTIFIED BARRIERS FOR SCALING UP

Successful micro-utilities have been established mostly using highly innovative management and technological approaches. Numerous start-ups in different developing countries are trying to follow up on these success stories. However, a closer look at the success stories reveals, that most, if not all, highly celebrated successful micro-utilities are struggling with the same issues. In the micro-utility case, five potential barriers emerged from the data. In the following, each barrier and its potential link to other barriers is discussed in detail.

First, entrepreneurs face the challenge of developing a model which balances risk, returns and responsibilities between the local community, the private operator and investors. The micro-utility may be owned and operated by the community, the private sector (utility or SME) or a combination of both. Past experiences show that communities receiving adequate training are capable of running a micro-utility but face difficulties once the system needs to be extended. Pure private sector models can handle operations as well as necessary system extensions. However, due to a monopoly-structure, conflicts of interests arise regarding electricity price. Therefore, most successful models are developing hybrid approaches that aim to balance the power between electricity consumers and providers while also allowing for investments in system extensions. It should be noted that capability building of communities, i.e. the energy consumers, regarding familiarisation with energy production facilities represents a relevant share of the costly pilot phase. However, defining ownership of the electricity system, setting the electricity price and allocating public support represent difficulties that need to be addressed. In addition, many models require some sort of adaptation to country-specific conditions, for example with regard to the decision-making structures of local communities, national regulations or specific risk-return characteristics.

Second, high transaction costs due to lack of regulatory frameworks hinder the scale-up of micro-utilities. During the pilot phase of a micro-utility, authorities usually accept the absence of licenses. The network of stakeholders involved at this stage is small and beyond grants, no external financing and financial risk mitigation is available. Third party financing is rare at this early stage. Thus, micro-utilities have to put in considerable amounts of high-risk equity or apply for business plan competitions with award money to be able to provide their core capital. Small companies or companies without an international network of supporters usually do not reach the stage of gathering enough finance to finalize their demonstration project successfully. Once the micro-utility model has proven viable and is in principle ready for scale-up, additional stakeholders and formal processes arise, e.g. the rules for taxation and the regulation of the electricity tariff. Most countries currently lack a suitable formal process for micro-utilities, which makes the scale-up process complex, time-consuming and expensive for the entrepreneur. In some cases, even well-intended legal frameworks for micro-utilities do not meet requirements of the private sector's specific business model. To sum up, in most cases, the acquisition of permissions and licenses causes considerable transaction costs for the private sector. These transaction costs are in general not reflected in the tariff calculations of the regulatory authority and must be covered by the entrepreneur accordingly. In similar cases other industries form interest groups (industry associations) to increase their influence on the political framework of a specific country. Due to the limited number of private companies operating in the micro-utility sector in each country or region, the formation of an industry association would be a costly proposition. Therefore, international institutions such as the UN, IRENA and others are vital supporters of the sector.

Third, there is lack of funding to scale-up successful pilot projects. Currently, the development and pilot phase is too long and not yet cost effective. To prove a micro-utility model works requires funding for 3 to 4 years of the pilot- and due diligence-phases (EUR 200,000 and EUR 1 mn respectively). Subsequent scaling up of such a proven model requires additional funding from public and private investors. As the effort for due diligence procedures is almost independent from the loan amount, transaction costs for investors are comparably high. Beyond potential investors such as large utilities, pension funds, and private banks, even development banks face issues of comparably small investment amounts, perceived high risks and challenging evaluation of village-level projects. For international long-term finance of micro-utilities (typically 10 to 15 years), considerable risks of inflation and foreign exchange rate fluctuations exist. Entrepreneurs often do not have the means to mitigate these risks e.g. by using portfolio balancing methods. In the short term, PPP funds that reduce or transfer at least parts of the risks involved in the investment process and easier access to finance can facilitate the scale-up phase. In the long term, a proper preparation of the political and legal framework, the facilitation of license acquisition and of due diligence processes seem to be more effective.

Fourth, a lack of coordination in public support instruments results in increased transaction costs. More specifically, it may be assumed that the complexity of a project as well as its transaction costs increase exponentially with the number of instruments or funding sources used in parallel. This is partly because each instrument requires reporting data, but a larger issue concerns the interaction of different instruments, resulting in multiple interconnections and interdependencies among them. The smaller the micro-utility is, the higher is the percentage of transaction costs within the electricity tariff (in some cases up to 50%). The challenge for public policy and public investors here is to set up a framework of instruments, adjustable to national characteristics, without limiting the options of micro-utilities to develop and implement their own innovative and creative business models.

Finally, the alignment of administrative procedures of public stakeholders such as national authorities and international donors and the private sector is often very difficult. In case national regulations and support instruments have been set up to guide micro-utilities in acting according to the respective national policy as well as to scale-up their operations, other challenges arise. As regulations and support instruments are often not adjusted to each other, conflicts of interest between public and private stakeholders occur. These conflicts have to be addressed while assuring a balance of interests between any other stakeholders involved. A concrete example is the challenge to align the national licensing process and the availability of international donor money. Donor money is only available for a certain time period and under certain conditions, which includes, for example, the legal approval of micro-utilities by national authorities. If the framework conditions are not yet defined or implemented, the approval process that is, in most cases, only initiated once funding is available can take longer than the time period for which the donor money is available. A similar challenge exists with equity investors, who request a high return once the transaction to the micro-utility is completed. Similarly, national authorities often only start the approval process once funding is available which often takes an unpredictable amount of time.

7. CONCLUSION AND RECOMMENDATIONS

Compared to large, medium, small and mini-utilities, micro-utilities have some specific requirements especially related to low cost competent local management structures. The reason for this requirement is the high portion of transaction costs compared to the total costs involved at a small number of kWh sold. Thus, the licensing and tariff negotiation procedures designed for large to small utilities with considerable higher economy of scale effects are a challenge for micro-utilities.

Support and financing instruments established for micro-utilities have their own constraints. Matching these constraints with each other and with the legal framework can result in transaction costs that make the usage of support instruments uneconomical for micro-utilities. There are two approaches to overcome the transaction cost challenge:

1. Financing instruments could be set up supporting the company foundation and scale-up preparation phase where most of the transaction costs occur. The financing instruments should be a mixture of grants and early stage long term investments, preferably equity. Long term loans should be available in local currency for reasonable interest to reduce the foreign exchange risk of the micro-utility.

2. Transaction costs can be reduced by coordinating constraints of support instruments, financing instruments and the legal framework of the respective country. Country specific private sector electrification programs involving a number of financing and support instruments adjusted to each other might be established.

A mixture of both approaches might solve the problem. The IRENA, UN Foundation and other organizations could play a central role in the coordination process.

The private sector could contribute to this coordination process by setting up franchise systems in which the franchisor walks through all coordination processes required. The franchise can use this readily prepared framework to reduce the transaction costs for his / her specific projects.

In the long run these actions might even attract large utilities' interest for the micro-utility business. Large utilities would be the perfect investors for micro-utilities as they are very familiar with long term investments in infrastructure and therefore have appropriate risk management approaches and the required experience. However, when involving large utilities, it is important to keep the management structure of micro-utilities lean.

Especially due to high transaction costs, the micro-utility business seems unattractive for entrepreneurs and first market investors. If the transaction costs can be reduced by coordination approaches, the micro-utility market potential might be unlocked and more entrepreneurs would set up their companies, leading to profitable and sustainable development of the sector.

For the first time, the study summarizes experience of the authors and of other experts implementing micro-energy systems. Due to the early phase of the whole market and the limited literature, the findings and recommendations have an explorative character. As a next step, academia has a relevant role to play in firstly, identifying and analyzing the conditions for implementing micro-utilities in specific countries and, secondly, deriving recommendations for public and private decision makers in these countries. By unlocking the tremendous market potential, the proposed research approach can result in a significant acceleration of market transparency, knowledge transfer and capacity building, and thereby increase further implementation of respective regulation, public and private funding sources and support entrepreneurial success. Realization of the market potential for micro-energy systems can lead to relevant public benefits regarding health, environment and economic growth.

APPENDIX

Company	Development stage of project in 2012	Technical and operational description	Country	Framework Conditions	Business case
Access	Finalizing model and preparation for seven village mini-grids	Solar water pumping and SHS, no proof for „village grid“ found, rather single SHS for individual houses	Mali	ERIL framework condition similar to conditions in Senegal: AMADER supplies concession + licenses. Regulatory Authority approves tariffs. If available grants of 70 to 80% of capital investment are supplied originating usually from the World Bank, KfW, etc.	Adjusted to conditions in Mali
Carbon X	First village electrified, plans for extension	Solar PV in first village, bio gasification in follow up projects	Tanzania	Project funded through grant and core equity, projects <1MW exempt from tariff approval in Tanzania. Options for project development grant (up to USD 100,000 per project for prefeasibility, environmental study, business plan development), peformance grants (USD 500 per household connected),CDM-PoA access and loan finance access provided by Rural Electrification Agency untapped by CarbonX	Single Operator Model
Energy for Africa	Pilot system installed	Rice husk gasifier with battery storage and prepaid smart meters	Senegal	Project under ERIL (‚électrification rurale d‘initiative locale) framework: License for production and distribution of electricity as well as concession for village from ASER (Agence Sénégalaise d‘électrification rurale) + Tariff approval by CRSE (Commission de Régulation du Secteur de l‘Electricité). Grants that are part of the ERIL structure are not used in the project. Project implemented by Novis.	Village holds shares of the micro-utility just as the professional company
Husk Power Systems	80 plants supplying electricity to 300 villages established, franchise	Rice husk gasifier	India, franchisees in other Asian countries and Africa	Subsidy on capital costs for system implementation from Indian Ministry of New and Renewable Energy, no direct regulation of prices or site selection.	Franchising approach adjusted to Indian conditions, starting cooperation with franchisees in African countries
INENSUS West Africa (since early 2013 called ENERSA)	Pilot village connected, scale-up for 30 more villages initiated	Village grids	Senegal	Project under ERIL (‚électrification rurale d‘initiative locale) framework: License for production and distribution of electricity as well as concession for village from ASER (Agence Sénégalaise d‘électrification rurale) + Tariff approval by CRSE (Commission de Régulation du Secteur de l‘Electricité)	PPP model adjusted to Senegalese framework, risk management model of Micro-PowerEconomy, solar and small wind technology

Company	Development stage of project in 2012	Technical and operational description	Country	Framework Conditions	Business case
Sunlabob	Pilot system installed	Solar products, SHS, village grids	Laos, Asia, Africa	n/a	PPP model adjusted to wind, solar and hydro hybrid systems as well as to the conditions in Laos and other Asian countries
The Power Source Group	Large pilot village connected, preparations for other communities of the same size and smaller projects	Micro-grid installations (customized mix of biogasification, photovoltaic, wind, exhaust heat recovery cogeneration and conventional diesel)	Philippines	Based on the electric Power Industry Reform Act of 2001 (EPIRA) Qualified Third Parties (QTPs) which are private sector companies or NGOs, are entitled to electrify „missionary areas“ declared by the Department of Electricity, govt. of the Philippines (DOE). These areas are usually far off the main grid and have a limited number of customers. The electricity tariff is regulated and will be fixed close to the main-grid tariff. To operate the system profitably, the Universal Charge designated for Missionary Electrification (UCME) covers the gap between the per kWh tariff paid by the electricity users and the Full Cost Recovery Rate as a grant paid to the QTP. Within the missionary areas the QTP usually has to sign a contract with the Electric Cooperative in charge of that area and can secure kind of a concession this way.	Model adjusted to the framework in the Philippines, fostering productive use through the Community Energizer Platform TM concept
Wireless Energy	Several village power systems under construction	Small wind turbines and SHS, micro-grids	Chile	Publicly funded electrification models in cooperation with national utility. No private sector investment framework known.	New demand side management approaches, adjusted to conditions in Chile
Windpower Serengeti	Early stage project development	Solar PV and wind turbines with diesel genset	Tanzania	Small projects below 100 kW are not subject to regulation in Tanzania.	n/a

“Climate Change, Financial Markets and Innovation“ (CFI) PROJECT OVERVIEW

As part of the research project “CFI – Climate Change, Financial Markets and Innovation“, funded by the Federal Ministry for Education and Research (BMBF), Germany, the SBI carried out a series of studies about renewable energies in emerging and developing countries including

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