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EUDP IEA Task 41
Deliverable 3.4 State of the industry report for isolated mini-grid power systems

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Summary:
This report presents a brief snapshot of the current global industry for the development and implementation of mini-grids. It draws upon two research projects in Kenya and South Africa, and current literature on this topic.

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Content

1. Introduction

This report has been produced with the intention of giving an overview of the status of the industry involved in making and/or developing/implementing mini-grids, and in particular, mini-girds running on 100% renewable energy. In this instance, we refer to a mini-grid as an infrastructure that is intended to supply electricity to a relatively small number of consumers using either exclusively renewable energy or a high percentage of electricity produced from renewable resources. A typical mini-grid constellation would be a combination of solar PV, possibly wind turbines, batteries and a distribution system to deliver the power to consumers. There is also the possibility that a diesel generator could be a component.

This report is based upon research carried out in two projects, where the author was deeply involved: “Kenya Mini-Wind” and “Modular Form of Rural Electrification”. In particular, the following two documents are used as reference material: “Rural electrification through private models: the case of solar-powered mini-grid development in Kenya” and “Modular Form of Electrification in Rural Communities in South Africa” (Final project report 30 November 2011). The report is supplemented and brought up-to-date with relevant literature and other reports as referenced.

1.1 EUDP IEA Task 41: Distributed Wind

This work constitutes part of a work package deliverable 3.4 of the EDUP IEA Task 41 Distributed Wind project. A summary of this project is given here:

The overall objective of this project is to identify and explore studies of particular Danish interest of Distributed Wind (DW) for cost effective technology development and integration into a continuously evolving energy system. This is done by collaborating and contributing to the IEA Wind TPC Task 41 international activities on DW turbine technology development and assessment in a series of dedicated work packages (WPs). IEA Wind TPC Task 41 is an international network centred on international collaboration and coordination in the field of DW. The purpose is to accelerate the development and deployment of DW technology as one of the leading generation source in global renewable markets, the facilitation of easier and faster DW integration into electrical grids, increasing thus the competitiveness of wind and accelerating the replacement of fossils fuels. The IEA collaboration is enforced partly by exchange of information, sharing of results, and conducting analyses and explorative studies in the form of reports and publications and partly by implementing a strong cross IEA Wind TPC Tasks collaboration effort.

2. State of the industry

2.1 Market for mini-grids

The market for mini-grids is generally agreed to be large with the major applications being in under-developed countries, where mini-grids are seen as a more cost effective and appropriate way to provide electrical power to communities. The alternative, expanding the national grid network is often seen as expensive, cumbersome and time-consuming. For example, according to William Brent, from Husk Power, up to 800 million people around the world are living in rural conditions without access to electricity. It is estimated that 60% of them could be effectively served by mini-grids.

Driven by falling costs of both PV and batteries, more mini-grids have been deployed in the last decade with at least 19000 now operating globally according to the World Bank. However, these serve just 2% of the World Bank's estimated potential population, which is calculated at 210 000 mini-grids world-wide. To reach this by 2030 (which would go some way to contributing to the UN sustainable development goal 7 – affordable, reliable and modern energy for everyone) would mean a doubling of the installed number of mini-grid every two years.

However, as William Brent points out, the industry is "nowhere near being on track to deliver that type of growth". The reasons for this are explored in the following sections.

2.2 Technology readiness

As experienced by the Kenya MiniWind project, there has been a significant development in the technology available and used when designing and implementing mini-grids for rural areas. Many developers are now only producing mini-grids that are supplied by renewable energy sources (mostly photovoltaic panels), thus allowing developers to brand their products as "green" and "sustainable".

Advances in manufacturing of PV panels has been the most significant technology leap and this has enabled the price of energy from sunlight to fall significantly. Battery technology has also advanced but in many cases this still remains to be the most stubborn technology to reduce costs, especially when whole lifetime costs (including replacement) are taken into account.

One technology area that has enabled more efficient use of the energy produced (and stored) by a mini-grid is that of the control system and intelligent loads. With this, then loads on the system can be better matched to the current energy production thus saving the amount that needs to be stored in the battery (with the inherent energy loss that this entails).

As with all renewable energy generation devices, initial capital costs are high for mini-grids and whilst there is always a need to design to a price, there is also a trade-off to be made when considering robustness and equipment costs. Research in the Kenya MiniWind project found that all too often, systems that had been installed only a few years ago suffered from both a lack of proper maintenance and a high number of faults/blackouts due to a lower quality level of equipment being specified. In practice, this was most evident not so much in the 'power station' (i.e. the location of the PV panels, batteries and control system) but more so out in the distribution of the network, with the design and installation of poles being crucial, together with the quality of the cabling, circuit protection devices and metering. This was often an area where costs were low, not because the technology was not available but because there was pressure to cut costs to a minimum.

2.3 Context, modular design and appropriateness

Relevant and suitable technology is available for mini-grids but one area where the industry is struggling is in trying to 'mass produce' systems in order to reduce costs. The difficulty is in having to design a bespoke system for any one particular area. This is costly in terms of design costs but also in terms of manufacturing/assembly that has to be able to cope with varying designs. There are also significant costs associated with surveying particular sites individually, so as to try and ascertain the relevant information so that an appropriate design can be made. It was often seen, for example, that mini-grids were sized for modest growth only for demand to outstrip supply and the mini-grid to then be regarded as insufficient and a poor solution.

Another aspect that the industry is still getting to grips with is the concept of providing energy for commercial use and the growth of local business and enterprises. Most common is the provision of cooling (for example refrigerators for shops selling food produce, and freezers/ice makers for meat and fish storage) and these loads are relatively easy to cope with technically, even if the rate of growth is more of a challenge to predict. At the other end of the scale is the use of, say, welding equipment – something that typically requires a three phase supply and has characteristic rapid rises in current draw. Many systems seen in southern Africa were not designed for this manner of use but customers continued to try to connect welding devices, often tripping other customers out and shortening the lifetime of some mini-grid components because of the heavy current draw.

A possible solution to these manner of challenges is that of modular design. The Modular Form for Rural Electrification project in South Africa showed that by making mini-grid systems open to extension and connection between modules, then mini-grid systems could be adapted without large re-design costs, as the needs of the community grew and would even allow private households to become energy generators (with, for example, a small roof-top PV panel) and to plug into the grid and receive payment for energy generated.

2.4 Industry challenges

Without question the biggest challenges for the mini-grid industry are the regulatory framework and access to sufficient and appropriate financing.

2.4.1 Regulatory frameworks

The regulations for mini-grids pose challenges from two particular aspects. Firstly, many countries do not yet have a fully-developed framework of regulations, standards and certification for mini-grids. This means that authorities often try to rely on regulations that were designed for other purposes or – if in doubt – then overly cautious safety standards are applied, making both processes for approval and designs cumbersome and more expensive than needs be.

Secondly, for companies trying to work in more than one country (which is the case for most mini-grid developers as individual countries do not currently provide a sufficient market on their own) then the variation in regulations has proved to be a hindrance in being able to have the common designs and production facilities that would enable costs to be lowered.

Regulatory challenges also come in the shape of inappropriate requirements. An often-quoted concern is that of power quality. If a mini-grid is to produce a power quality similar to that of a national grid, then this places an unnecessarily high specification on the mini-grid equipment and control system, resulting in the cost of a kWh of electricity being very high. Rural communities can most often be perfectly fine with a less-than-grid-quality power but if the regulations do not allow for this then the mini-grid industry is at a significant disadvantage.

2.4.2 Financing

Financing for implementing mini-grids has been – and still is – one of the biggest barriers for the concept and plagues the status of the industry. As always with financing, it revolves around the balance of risk and return. Here there is a two-fold connection with regulation. On the one hand, why should investors run the risk of backing private entrepreneurs with multiple sites for mini-grids when more certain returns are assured by investing in more centralised power generation facilities? On the other hand, the planning and regulatory risk of a facility is often not proportional with size of the facility, so why invest in mini-girds with all the regulatory problems for each site, when it may well take the same time and effort to obtain permission for one large facility?

The tariffs that are allowed to be charged to the electricity produced have also been a subject of contention and one that investors have been wary of. If a mini-grid developer/owner has to, by law, charge the market price for the electricity produced then this makes it very difficult to attract financing. To encourage investment in mini-grids, some countries allow a higher tariff to be charged, so that operators can be more realistic in tariff setting and thus offer investors a more secure return on their investment.

The uncertainty that surrounds mini-grid development and operation has thus resulted in an sector where a type of donor-funding (e.g. foreign aid or World Bank funding) has almost been a pre-requisite before any private investors are willing to enter into providing the large amounts of funding that are required if the global goals for access to electricity are to be achieved. This has resulted in a rather turbulent sector where development companies come and go, often relying on very entrepreneurial and philanthropic types of organisation which can be very innovative and flexible but lack the depth and stability of the companies that develop more centralised renewable energy projects.

3. Conclusions

The status of the mini-grid industry is one of being “in waiting”. It is waiting for reliable funding opportunities on which to build a more stable pipeline of concepts, developments and projects. In many countries, it is a matter of political will to focus on this manner of provision of electricity for their citizens, and to implement more streamlined policies that will allow international private investors to provide the type of financing necessary to make mini-grids a reliable proposition.

4. References

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DTU Wind Energy is a department of the Technical University of Denmark with a unique integration of research, education, innovation and public/private sector consulting in the field of wind energy. Our activities develop new opportunities and technology for the global and Danish exploitation of wind energy. Research focuses on key technical-scientific fields, which are central for the development, innovation and use of wind energy and provides the basis for advanced education at the education.

We have more than 240 staff members of which approximately 60 are PhD students. Research is conducted within nine research programmes organized into three main topics: Wind energy systems, Wind turbine technology and Basics for wind energy.

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