Technology Innovations: Solar - Off-grid

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Introduction

Photovoltaics (PV) solar technologies have been used for off-grid electrification for several decades. While the major share of the total global installed PV capacity (approx. 177 GW at the end of 2014) is grid-connected, off-grid PV systems have an important role to play in meeting energy access targets. Today approximately 70 countries world-wide have some off-grid solar capacity installed or programmes in place to support solar off-grid applications. PV is a highly suitable and economical technology for addressing energy access challenges in developing and emerging economies, as well as remote and rural areas.

Off-grid PV systems can provide electricity services for many different end-use applications, such as domestic and public lighting, telecommunication towers, and water pumping. Systems vary in size depending on their application and the electricity demand to cover. The smallest are solar pico-PV systems with a power range from 1 – 10 W, which can power small lights or low-power appliances, or mobile phone charging stations. Solar Home Systems (SHS), ranging from 10 – 500 W power, provide electricity to off-grid households for lighting, radios, television, refrigeration, and access to the Internet. This size system can also be used for non-domestic applications such as telecommunications, water pumping, navigational aids, and small community centres. These systems generally consist of a solar module and a battery, along with a charge control device, so that DC power is available during night-time hours and cloudy periods. For higher power demands, larger panels, additional battery capacity, and inverters to supply AC power may be needed. These systems range in size between 500 – 1000W.

Currently almost all batteries are deep discharge lead-acid type with a lifetime of 5 – 10 years. New battery technologies, such as Lithium-Ion, are offering significantly higher energy density and increased battery storage time.

Hybrid systems combine PV technology with other energy sources, such as a micro-hydro or diesel gensets, and include battery and inverter technologies to serve as micro-power generators supplying micro-grids or mini-grids. PV-hybrid systems can range in size from 3kW up to several MW. Micro and mini-grid PV-systems provide reliable and cost-effective power for rural electrification. The type of system installed must be adapted to the local power demand and environmental conditions. PV offers significant value economically as the costs of the PV modules continue to decrease and more efficient and better storage technologies are coming to market. Furthermore, PV off-grid systems offer an affordable way to provide electricity to many of the one billion people around the world who lack access to modern electricity services. The power provided is reliable and usually more economical than extending electricity distribution networks from existing power lines.

Trends, Policy, Financing and Cooperation

While globally, off-grid PV installations account for a small share of the total installed PV capacity, more and more countries are creating support schemes and setting targets, in particular electrification targets utilizing PV. Some countries are implementing technology specific programs such as for SHS. In Bangladesh over 3 million off-grid SHS with an average size of 60 W were in operation by the end of 2013. India aims to install 2 GW of off-grid systems and 20 million solar lights through its National Solar Mission. Solar powered micro-grids will be installed in 5000 Indian villages. Many East African countries are investing in micro-grid technologies using PV to provide electricity to isolated areas.

At the national level, initiatives are being implemented and supported through a range of financial incentives, such as loans, tax reductions and subsidies to encourage operators to use renewable energy technologies. Even with favourable geographic and social-economic conditions, and decreasing technology costs, the biggest challenge for solar technology implementation is financing. Distribution and maintenance are important costs that must also be considered, as well as costs for training a workforce to operate and maintain systems.

Several innovative financing models are emerging and gaining importance. The two most prominent models for solar systems are the “fee for service” in which the customer pays a regular fee for use of the solar system. The system is owned by an energy service company or ESCO which is responsible for the installation, maintenance and replacement of parts. The second financing model is a credit scheme such as micro-finance in which the customer takes out a small loan to cover the costs of the solar energy system technologies. Micro-finance has become one of the most popular models for increasing the use of PV off-grid systems. Well-known are the SHS and solar lantern micro-credit schemes in Bangladesh through Grameen Shakti, a renewable energy enterprise that provides credit through instalments making SHS affordable. Grameen Shakti has also set up solar micro-utilities for those who cannot afford individual SHS. “Pay as you go” (PAYG), another model, allows customers to pay a small up-front fee for a solar charger kit such as a light or mobile phone charging device and then pay for the energy they consume.

At the regional and international level there has been a trend towards public-private partnerships and private ventures to improve energy access using renewable energy technologies. Large banking institutions such as the World Bank, as well as regional and national development banks, are investing considerable funds in sustainable energy access. Other mechanisms such as the Green Climate Fund are available for renewable energy technology investments.

At the international level, the UN Sustainable Energy for All (SE4All) initiative and the International Renewable Energy Agency (IRENA) are helping countries establish political and regulatory frameworks for advancing clean energy access, including micro-grids using PV.

Regional Focus

Since the advent of democracy in South Africa, off-grid PV technology has received increased national government attention as an energy supply option. Before then, the technology was applied mainly in commercial farms, usually in combination with diesel. As statistics from the South African Department of Energy (DoE) attest that between 2009 and 2014 43,517 off-grid installations were made, out of a total of 1.1 million new connections.[1] Over the 2013-14 reporting period alone, 14,092 off-grid installations were installed, out of a total of 292,714 new connections.[2] The target is to reach 300,000 off-grid installations by 2025, as part of the government’s drive towards universal access to energy, the main motivation being the

[1] (South African) Department of Energy, Annual Report 2013/14.
[2] Ibid

need to avoid the high costs of extending grid electricity to rural areas, as well as informal settlements in urban or peri-urban areas.

Some of the progress in this regard has been achieved through the introduction of public-private partnerships (PPP), which granted ‘concessions’ to private companies to provide energy services in agreed areas, each over a period of 25 years. Some of the challenges experienced have included delays in procurement, project implementation or verification processes, as well as the risk that funds allocated over a rolling annual basis could be forfeited if not disbursed according to plan. However, corrective measures have typically been successfully executed to allow further progress in the roll-out of projects.

Key Factors Shaping Off-Grid Solar PV

As technology prices continue to decline, as supportive policies are established and financing becomes more accessible, PV technologies for off-grid use will continue to grow and diversify. Some of the important factors impacting the continued development of off-grid solar technologies are:

- Improving energy storage technologies and overall PV system efficiency.
- Innovative payment and new banking models, such as pre-payments and mobile phone banking.
- Reduced total cost of energy (life cycle cost) including operation and maintenance training for users.
- Social and economic factors that influence the operation of solar PV systems in communities using electricity for the first time.
- Monitoring of solar PV systems field performance to support the development and planning of future projects.
- Increased implementation of certification and standardization of technologies, system design, installations and maintenance, as well as personal responsible for the system.

The further progress of off-grid electrification in South Africa will take the following into account.

- **Inadequate centralised power generation capacity as a boost to off-grid PV**: As the mismatch between centralised power generation capacity and national demand continues (and even increases), there will be increased interest in distributed generation options. Off-grid PV will also benefit from the increase in grid-based embedded PV connections, primarily in the form of lower costs.
- **Technology innovation will be a key driver in the further development of the off-grid PV sector**: Interest in DC micro-grids, development of low-voltage DC appliances and reduction of battery storage costs are some of the salient drivers that will spur the further deployment of off-grid PV technology. This may even result in such deployment being extended to urban (and peri-urban) areas, as communities seek ways to minimise the impact of inadequate centralised generation capacity and rapidly increasing prices.

Challenge Questions

1. How can financial institutions and policy makers provide better access to financing, especially for the “base of the pyramid”?
2. How can communities, planners, etc., define realistic, affordable and reliable, long term electrification pathways using solar PV systems for users without previous experience with electricity?
3. How will access to the Free basic alternative energy (FBAE) grants in South Africa change (these are not quite working and local authorities struggle to roll this out)?

4. What policy mechanisms should be considered to encourage the dissemination of end-use technologies that complement off-grid PV supplies and improve efficiency (e.g. efficient lighting, low voltage DC appliances, etc)

5. How should developers address communities' fear that once off grid PV is installed, this means that the grid will not ever reach this area (and off grid PV is seen as inferior)? How can the perception that off-grid solar power is inferior to grid power be overcome?

6. How will planners and developers manage the scaling up of energy services to meet increased demands, for example increasing PV systems from 1 to 5 KW?

7. How should life-cycle challenges and the environmental impact of technologies be addressed (i.e. recycling, increased battery lifetime)?

8. What should be done to ensure that systems are installed and maintained properly and operators are trained appropriately so systems operate as planned?

9. Should there be more stringent standards for the technologies installed and should all countries meet quality standards and certification for technologies, installation and operation?

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