SAMSET brief on Solar Photovoltaics (PV)

This briefing note has been designed for use by city officials and planners working in sub-Saharan Africa. It is a practical guide, which identifies easy to achieve energy interventions that will save money (for cities, businesses and households), promote local economic development, and enhance the sustainable profile of a city. This note is specifically aimed as a support tool to achieve the implementation of key interventions within municipalities across sub-Saharan Africa.

African municipalities need to be prepared to deal with an explosion in demand for services from burgeoning populations caused by two factors – high population growth in Africa as a whole, and rapid urbanisation. An interesting feature of population growth in sub-Saharan Africa is that it is expected to take place mostly in small and medium sized cities, rather than capitals (UN-Habitat, 2010). These changes are taking place at a time when many countries are devolving administrative powers to local governments, yet municipal authorities lack the skills and expertise to address challenges, to manage resources, and to implement and enforce policies.

Energy is only one of many services that municipalities need to address in the face of increasing urbanisation, but it is crucial to any form of urban development – planned or otherwise. People need energy as part of their every-day lives. The supply of energy is closely linked to economic development, health and individual wellbeing, as well as to local and global environmental sustainability.

Recognising the emerging role of municipalities, with limited capacity, in addressing energy provision in urban centres, the "Supporting African Municipalities in Sustainable Energy Transitions" (SAMSET) project seeks to build capacity and develop a practical and effective knowledge exchange framework for supporting actors involved with municipal energy planning. This note is an output of the SAMSET project.

The purpose of the note is to give planners an idea of the range of energy interventions that it is possible for them to implement at the municipality level. It provides enough information to give a basic understanding of different energy technologies – enough to start making enquiries and engage in discussion. More detailed technical expertise will, however, be needed in order to design a bankable project.

Full guide can be found at africancityenergy.org/uploads/resource_101.pdf

More info can be found at africancityenergy.org/

More project info can be found at samsetproject.net

Overview

Photovoltaics (PVs) involve the direct conversion of light into electricity. A photoelectric material can absorb photons of light and release electrons. It is the capture of these free electrons that results in an electric current that can be used as electricity.

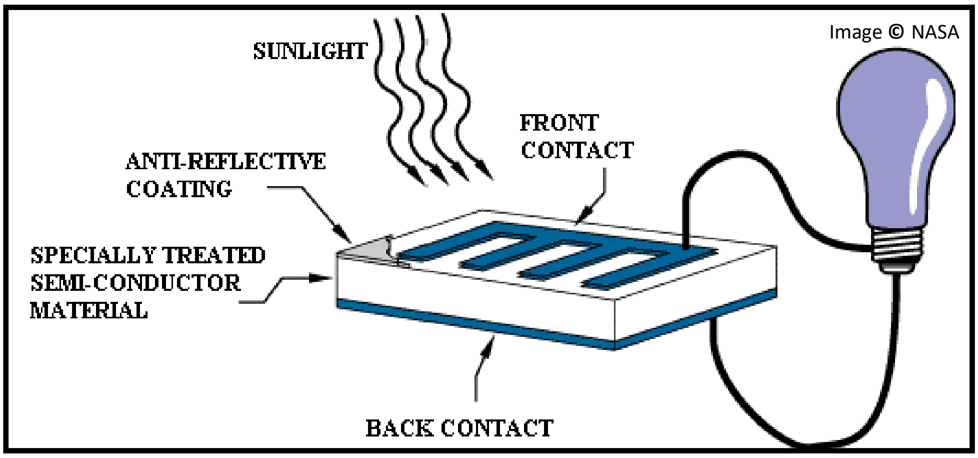
A basic PV cell has a very thin semiconductor material that forms an electric field; positive on one side and negative on the other. When light energy comes into contact with the cell, electrons are released from atoms in the semiconductor material. Electrical conductors attached to the positive and negative sides of the semiconductor material form an electrical circuit and capture the released electrons. This forms an electric current (electricity) which can be used to power a load.

PV modules are a number of PV cells that are electrically connected to each other and mounted, while an array is formed when multiple modules are wired together. In general, a larger area will produce more electricity. They are designed to supply electricity at a specific voltage; however, the current produced is directly dependent on the amount of light that reaches the module. The most common PV cells are made from crystalline silicon. This material has been used for more than 50 years and the manufacturing processes are very well known.

Technology

Thin film technology: Silicon is readily available, but it must be refined to an extremely high purity to manufacture crystalline silicon cells, making it quite expensive. Thin film technologies are being developed to make it possible to create a PV material by sequentially depositing thin layers of different materials into a very thin structure. They require little semiconductor material and are easy to manufacture, potentially resulting in a significantly lower cost of PV systems. There are still issues regarding life-span and functioning in hot environments, and they currently cost just as much as, or more than, crystalline silicon cells. However, as the technology progresses, thin film panels could make PV systems much more financially viable for everyone.

Polymers: Due to the growth of the industry, newer technologies are being developed. These include polymer cells which have recently emerged as a low cost alternative to silicon cells. Inorganic components within these cells are now replaced with polymers, making them more flexible. This means they can be rolled out onto surfaces such as roofs. Recently scientists have set a world record for polymer cells with 11% efficiency, paving the way for further investment in the technology.



Case Studies: Cadbury Cocoa Partnership, Ghana

The Cadbury Cocoa Partnership, a social intervention initiative of the Cadbury confectionary company, has invested $1.3 million in the installation and distribution of solar power to 10,000 households in 160 farming communities in Ghana.

The distribution is part of the company's effort to support a sustainable cocoa supply chain. In addition, the partnership will supply and install solar panels in 22 basic schools in rural communities for the improvement of academic performance, support two clinics to enable them store medication and medical instruments to ensure improved health delivery, and also power three food-processing units to enable women in the identified communities add value to their farm produce.

Perovskites: Perovskites are another highly efficient low cost solar technology. Over the last seven years, scientists have managed to increase the efficiency rate that these cells can convert solar energy into electricity, from 4% to 20%. In contrast, it took more than 60 years for researchers to develop current silicon cells. At present, silicon cells can convert no more than 25% of the sun's energy into electricity whilst perovskites can operate at a high level of efficiency even with numerous defects.

There are now several PV manufacturing facilities located in sub-Saharan African countries – South Africa, Mozambique, Nigeria and Kenya, and as demand grows, the number of factories is likely to increase. This can give rise to some anomalies in policy towards renewable energy technologies as governments seek to protect domestic producers e.g. import duties.

The Case

Globally, there are around 1.4 billion people who experience sunlight for the majority of the year but do not have access to grid electricity. Harnessing solar power has the potential to not only reduce poverty but also makes an invaluable contribution to economic development. Solar photovoltaic (PV) energy offers people without access to the grid the opportunity to light their homes and businesses in areas where electricity can either extremely expensive and unreliable.

Approximately 70% of Africa's population, remain unconnected to the grid relying upon expensive and inefficient sources of energy such as candles and kerosene for power. Current projections indicate that by 2030 more than 700 million Africans could be living without electricity.

When considering the installation of PV, cases in both electrified and unelectrified areas need to be considered. This is because generation costs in remote areas are different to those in electrified areas, and these need to be considered when making decisions around PV installation.

According to UN-Habitat, Africa is urbanizing at a rate of 4% per year meaning that over the next 15 years, cities in Africa will experience higher growth rates than other regions of the world. An increase in migration from rural to urban areas can exacerbate poverty and inequality and as a result there is a stark difference between the opportunities available to those with and without access to electricity.

Electrified areas: The installation of PV systems in households that are already electrified will have the following advantages:

Reduce impending pressure on local utility.

Less money spent on electricity: systems can be sized to provide all electricity needs, but the installation of a small system will also provide some electricity savings to a household.

Less non-renewable resources being used and less CO2 being produced: Solar energy is a free source of energy that will not run out and produces no pollution during operation.

If an electricity surplus is generated through PV systems, this can be fed back into the grid. The equivalent amount of electricity can be used later from the grid at no cost, further lowering electricity costs.

Despite this, the financial case for PV is currently not very strong, due to the high capital cost of the technology.

Unelectrified areas: The case for unelectrified areas needs to take into account the cost of obtaining and distributing liquid fuels (diesel for generators, LPG for gas solutions), or of extending the electricity grid to encompass these areas. The maintenance of the equipment (usually generators) also needs to be taken into account.

Image © Cadbury

Often these areas are very remote and the expense of extending the grid does not justify the small income such an installation will generate. Therefore off-grid solutions need to be found.

Generators generally require high level maintenance, and have the additional problem of requiring a steady supply of diesel to operate. Skilled technicians are not readily available in these areas, and fuel supply is not consistent. Generators are noisy and contribute to air pollution. In contrast, PV installations are generally very reliable and low maintenance, and are not dependent on a fuel supply chain. This makes the technology very attractive in remote, unelectrified areas particularly as generation is clean and noise free.

PV is specifically useful for remote schools and clinics which depend upon a reliable electricity supply to function properly. They are also suitable for home lighting and media appliance use in remote areas.

A third of all health centres and primary schools in sub-Saharan Africa lack any access to electricity. This means that 90 million students and 255 million patients are left being educated and receiving healthcare from places that have no power. Nearly 60% of refrigerators used in health clinics in Africa have unreliable electricity, compromising the safe storage of vaccines and medicines and hospitals are sometimes forced to operate with no lighting or power for equipment, putting people's lives at serious risk. Children without domestic lighting struggle to do their homework in the evening, which negatively impacts their education and hampers their ability to fulfil their potential. Students are increasingly segregated, and drop-out and fail rates are high.

PV home systems for domestic use in rural areas are usually only large enough for lighting and media services, with the additional electricity still required for cooking and refrigeration requiring larger PV systems. Even small PV systems require large subsidies to make them affordable to rural communities and economically reasonable to the supply companies. However when faced with expensive (extending the grid) and unreliable (diesel generation) alternatives, the subsidisation of PV in these areas is an increasingly viable option.

Batteries: As many communities in sub-Saharan Africa do not have reliable access to grid power, off-grid solar systems are increasingly used. However, in order to store the power collected to use at times when the sun is not out e.g. at night, batteries are required. In many cases these can be expensive, bulky and inefficient at storing energy. Despite this, the solar battery market is expanding, particularly with the growth of electric cars such as those produced by Tesla who's Roadster was the first car to use Lithium-Ion battery cells. These batteries have significantly reduced in price over time and are increasingly used within the solar power industry as they have a higher energy density than conventional lead acid batteries. Lithium-ion batteries also have a longer life, up to 6 times longer than lead acids and with much less energy loss between charges.

With the rapid growth of mobile phone use across sub-Saharan Africa, the need for charging on the go is no longer considered a 'first-world problem'. As a result, portable solar chargers are increasing in popularity particularly for those who travel often. The development of the 'Solar Backpack', a backpack with a solar panel fitted on the back has provided opportunities for school children to maximise their potential. The solar panel is connected to a battery which, when exposed to sunlight for 3-4 hours can power an LED lamp for up to 8 hours. This allows children in places with no electricity the chance to study at night and not get exposed to the toxic fumes of kerosene.

Potential for Rollout

Off-grid systems were previously much more expensive per MWh than grid power however, it is expected that in the long term electricity prices will continue to increase and the cost of PV production will decrease as the technology becomes more viable. Between 2008 and 2012 solar costs dropped nearly 80% due to significant technological breakthroughs and increasing market competition.

On-grid power can also be extremely unreliable; nearly 66% of the population in sub-Saharan Africa live in areas where connection is either too expensive or difficult for other reasons. This is one of the primary reasons many are predicting a solar energy boom in coming years as solar technology is increasingly seen as a low-risk investment.

The PV market has surged in Africa and is projected to become one of the fastest-growing markets in the world. Africans spend around $10.5 billion a year on kerosene to provide lighting for their off-grid businesses and homes. Many of those in rural areas get electrical power from diesel generators at prices of roughly $1 per kilowatt-hour (kWh). Solar lighting products generally offer more cost-effective and cleaner alternatives, providing electricity at less than 20 cents per kWh.

Ghana has a population of over 26 million and just 65% have access to electricity. Wide disparities exist between rural and urban settings with less than 50% of rural dwellers having access to the grid. However, the country receives between 1,800 and 3,000 hours of sunshine per annum making it a friendly environment for solar energy to flourish. Subsidies are also available to improve the affordability of solar power, helping to pay for part of the total cost of PV systems or offering special bank loans to offset payment commitments.

Despite the growth of solar power however, around 92% of solar-electrified households in Ghana use solar lighting in tandem with traditional kerosene lanterns to address all their lighting requirements meaning solar systems are currently not adequate to be used on their own.

In contrast, Kenya is one of the few countries in Africa that has been relatively successful in the solar PV business. By focusing on small home and commercial systems and excluding larger commercial or grid-connected systems, an annual PV market of 1.5 MW has developed. Recent estimates indicate that there are between 200,000 and 350,000 solar PV home systems in use in the country. Kenya is therefore a trendsetter in attracting and utilizing private capital to enhance development of solar energy, setting an example which can be replicated by the other countries such as Ghana and Uganda.

Solar Sister, East Africa

Solar Sister recruits and trains women in East Africa by providing them access to these jobs and empowering them through economic opportunities. It provides an opportunity for women without gainful employment to start their own social enterprises using a network of contacts to sell solar lamps in rural communities. Each Solar Sister Entrepreneur buys her lights and cook stoves from Solar Sister then sells and delivers them, woman-to-woman, throughout her local community.

Image © Solar Sister

The Solar Sister model has expanded to Kenya, Uganda, Sudan, and South Sudan to help reach even the remotest parts of the continent. The model generally seeks to help alleviate energy poverty by encouraging consumers to switch from the expensive and hazardous use of kerosene and candles for lighting to solar lighting and other products such as solar lamps.

Barriers to Implementation

- High initial investment/start-up costs.
- Long payback periods.
- Lack of favourable finance packages for consumers and solar energy entrepreneurs.
- Lack of well trained personnel at all levels.
- Lack of certification of installers and service provider.

Implementation

Ghana's Renewable Energy Act (2011) has a number of incentives to increase the use of renewable energy such as solar PV:

Feed-in-tariff scheme offer guaranteed prices for electricity generated from renewable energy sources.

Licensing regime for commercial renewable energy service providers.

Purchase obligation under which power distribution utilities and bulk electricity consumers would be obliged to purchase a certain percentage of their energy required from electricity generated from renewable energy sources.

Off-grid electrification – promote mini-grid and stand-alone renewable energy systems for remote off-grid locations.

Renewable Energy Business Fund to promote public private partnerships.

Ghana REFIT: Ghana has enacted a FiT scheme providing high prices for generators, however it presents a weaker ground for the expansion of renewable energy. Financing costs are very high and there are large macro-economic risks from strong currency devaluation and double-digit inflation rates. Because FiTs are denominated in the local currency, foreign investors are not protected against further devaluation. The wide gap between the prices paid for generation covered by the FiTs and prices paid by final consumers anticipates the possibility of social opposition and a potential withdrawal from the scheme. In fact, there are already movements away from FiTs and towards an auctioning scheme as seen in Ghana's recent launch of a competitive bid for 20 MWp of solar PV capacity.

Uganda REFIT: As of Phase 3 (2016), Uganda's REFIT does not include solar PV and instead prioritises hydro power, bagasse and wind. It is noted however that these may change/be updated during each REFIT review. In 2014, the Electricity Regulatory Authority (ERA) states that solar photo-voltaic (PV) electricity was not generated in sufficient quantities for inter-connection to the national grid. However a Feed-in-Tariff (FiT) of US$ 11 cents per kWh for grid connected solar PV energy was approved.

Support for Implementation organisations: Municipalities can identify rural communities in need of electricity. They can then facilitate the establishment of PV implementing organisations that will:

Provide an attractive payment solution to the end user.

Establish an installation and maintenance programme.

An implementing organisation would buy and install the PV system(s) and retain ownership. The electricity generated from the system would then be sold to the consumer by:

Metering electricity used and charging a fixed rate.

Signing a lease or hire/purchase agreement over a fixed period of time for the PV equipment.

Charging a fixed monthly tariff.

The electricity user would bear no capital costs and would not have to worry about maintenance to the system, which is an important factor to homeowners. Municipalities can assist this process by:

Sourcing funding to subsidise the systems.

Being a 'Community Liaison' and assisting in awareness raising.

Case Study: Ghana's Largest PV Installation

A Chinese firm, Beijing Xiaocheng Company, has developed a 20 MW solar project to help Ghana overcome its power crisis. The plant is the largest PV installation in Ghana and is a signal of intent for a country that is making great efforts to increase its reliance on clean energy.

The 20 MW project was developed by a subsidiary of Beijing Fuxing Xiao-Cheng Electronic (FXXCE), who contributed the US$30 million in funding itself. The plant is the first large-scale solar farm in Ghana, constructed on a 100 acre piece of land about 70 km from the capital and is now successfully connected to the grid.

Before the BXC plant, the largest PV plant in the country was just 2 MW, so this marks a significant stride for increasing capacity. The Ghanaian government has already shown a desire to build its renewable energy industry, culminating in a commitment of US$230 million last year to be earmarked for to the Scaling-up Renewable Energy Program (SREP) Investment Plan for Ghana. Part of this plan is to supply 30,000 Ghanaian homes with their own PV systems.

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