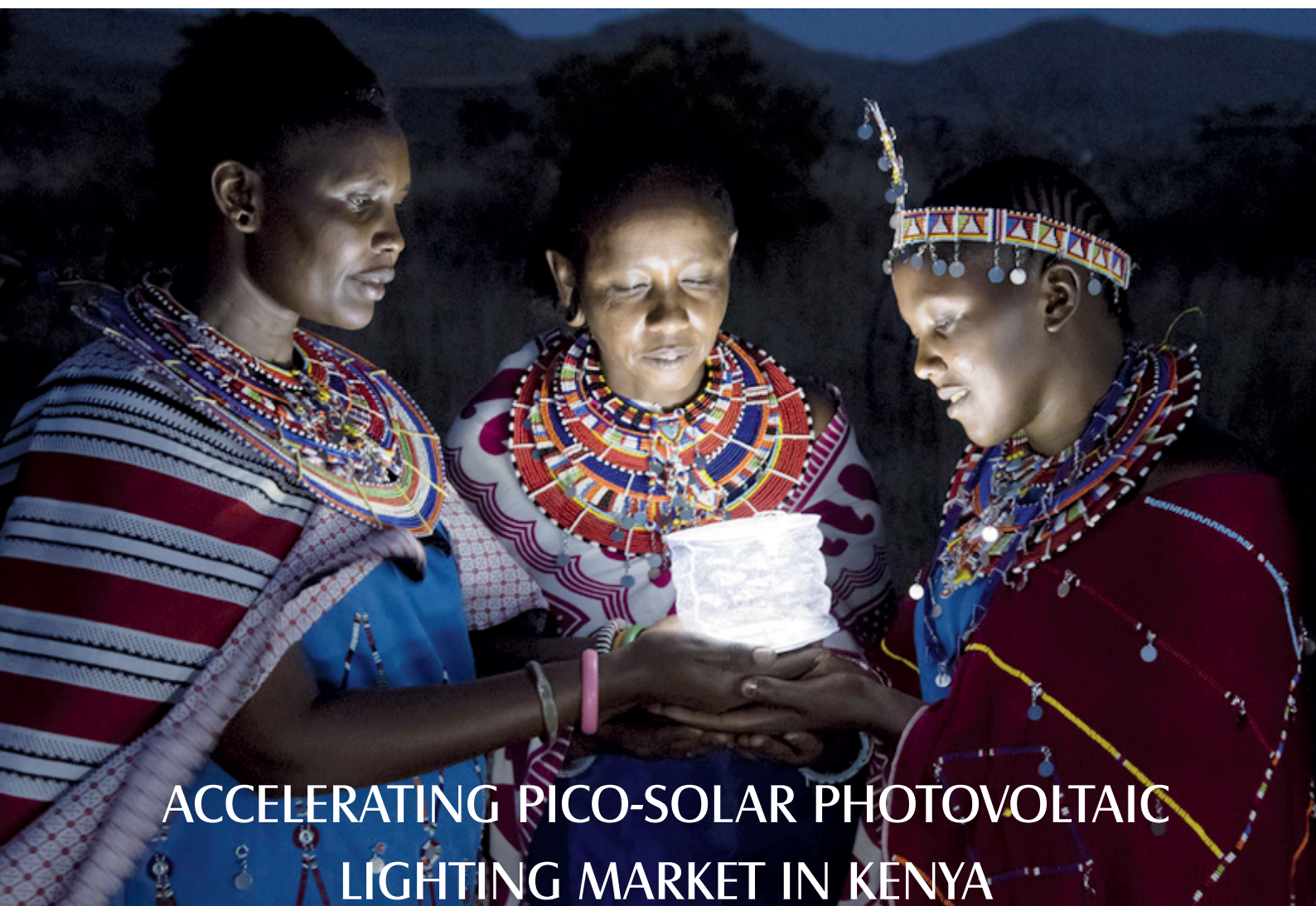




**KIRDI**

*Your Industrial Technology Partner...*



# ACCELERATING PICO-SOLAR PHOTOVOLTAIC LIGHTING MARKET IN KENYA

POLICY BRIEF

NOVEMBER 2017



## Key Messages

Pico-Solar referring to pico-solar photovoltaic lighting systems are the smallest, often portable photovoltaic (PV) systems that mostly combine a rechargeable battery and charge controller, with a very small Photo Voltaic (PV) panel.

Unlocking the potentials of pico-solar energy in Kenya will require the following:

- **Energy Policy** - Over the last decade the government has promoted renewable energy through a number of policy and regulatory frameworks. These include Energy Act 2006, Energy Policy (Sessional Paper No. 4 on Energy) 2004, The Energy (Solar Photovoltaic Systems) Regulations 2012, and Feed-in-Tariff 2008 which was revised in 2010 and 2012, and Energy (Local Content) Regulation 2014. Currently there is Draft Energy and Petroleum Bill 2015. All these instruments recognise the important role of renewable energy in meeting the energy demand. Though this is a step in the right direction, these instruments lack focus on the specific needs for scaling up adoption of pico solar. Due to its important contribution to clean energy access especially to the poor and rural communities, pico solar should be mainstreamed in the country's policies and planning systems, especially promoting pico-solar as part of the last mile connectivity policy.

- **Manufacturing, Standards and Labels** - Apart from Solinc Company which assembles solar panels in Kenya, almost all solar products in the market are imported. Promoting local manufacturing will not only bring prices down to affordable levels, especially to the poor, but will also have a bigger impact on the country's economic growth compared to importation. The government has targets to promote local manufacturing as part of the Vision 2030. This is evident in the Energy (Local Content) Regulation of 2014 which is meant to promote energy generation through locally available resources. The Regulation appreciates the need to promote local assembly. However the cost of importing components is a major hindrance. A study conducted by Lighting Africa in March 2016 indicates that the top two key challenges solar retailers are grappling with are low quality counterfeit products and faulty products that lower consumer trust of solar products.

- **Consumer Awareness** - A study conducted by the Kenya Industrial Research and Development Institute (KIRDI) in 2016 shows that consumer awareness of pico solar has been growing in Kenya as evidenced by the increase in the percentage of households using products. However, the study also showed that in general, awareness is still low in many counties especially in the marginal areas. It was also noted that there are weak consumer protection policies resulting in an influx of counterfeit and faulty products reaching the market. Mobilising a critical mass of awareness, support and good will at all levels is necessary.

- **Fiscal, Marketing and Private Public Partnerships** - Kenya has the most developed solar home system market in the Eastern Africa region. The government has continued to provide fiscal policies targeting the large solar systems but limited focus on pico solar. In addition, access to capital at affordable terms and costs to consumers is a significant obstacle to up-scaling pico solar systems. There is a compelling and technically feasible business case to transform the pico solar market to make it more accessible, affordable and reliable.

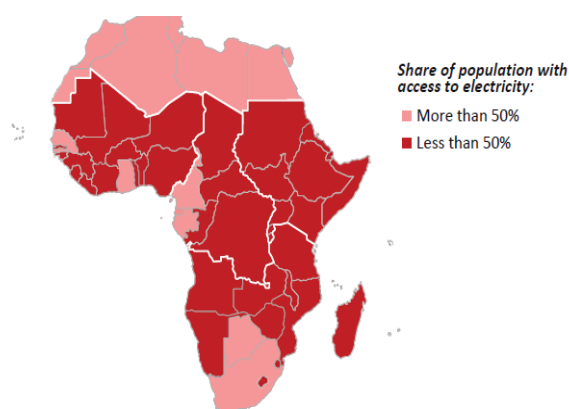
- **Waste, Environment and Climate Change** - Electronic and Electric Waste (E-waste) is emerging as a major challenge in solar market development. Whereas there are no global warming emissions associated with generating electricity from solar energy,

there are emissions associated with other stages of the solar life-cycle, including manufacturing, materials transportation, installation, maintenance, and decommissioning and dismantlement. While waste from used batteries and pico solar housings are immediate cause of worry, the problem will be magnified when the current solar panels reach their life span in the next 20 years which the average lifespan of a solar panel.

## Introduction

Access to modern energy services is a key enabler of socio-economic development. An estimated 1.5 billion people continue to live without access to electricity and 2.4 billion rely on traditional cooking fuels. More than 95 per cent of these people are either in Sub-Saharan Africa (SSA) or developing Asia and 84 per cent are in rural areas (International Energy Agency, 2015) (Fig. 1).

Sub-Saharan Africa is rich in energy resources but very poor in energy supply. The region has highest access deficit in electrification rate. Making reliable and affordable energy widely available is therefore critical to the development of the region that accounts for 13 per cent of the world's population but meets only 4 per cent of its energy demand (OECD/IEA 2014).



In Sub-Saharan Africa, 620 million people - two thirds of the population - live without electricity. only a handful of countries have electrification rates above 50%

Fig. 1 Share of population without access to electricity

Source: International Energy Agency, Africa Energy Outlook, 2014

Solar and other renewable energy technologies can significantly enhance energy access and contributes to economic and social development. This is especially true to the 1.5 billion people worldwide, many of whom live in isolated areas with no access to electricity or to clean water, primary health care, education and other basic services, all of which are largely dependent on access to electricity.

A 2014 socio-economic atlas of Kenya by Kenya National Bureau of Statistics (KNBS), shows that 6.1 million (or 69.5 per cent) of all households in Kenya use paraffin as their main source of lighting. Using paraffin for lighting is concentrated in rural areas and only 22.7 per cent of households use electricity for lighting. The use of electricity is unevenly distributed throughout the country, with only seven (7) out of 47 counties showing rates above the national average (KNBS, 2014). The use of Kerosene and biomass woodfuel for cooking is one of the main causes of indoor air pollution. According to World Health Organization (WHO), about 4.3 million people die worldwide annually due to cardiovascular and respiratory diseases linked to indoor air pollution especially in low and middle income countries (WHO 2014).

Kenya, like other Sub Saharan Africa countries, is endowed with vast renewable energy (RE) resources including geothermal, wind, solar, woody and non-woody biomass and hydropower for both on-grid and off-grid systems. Despite the potential of renewable energy,



Kenya's electricity generation is currently based on large-scale hydro power, fossil fuels, and geothermal, while other renewable energy sources play only a minor role (GoK 2015). Development of renewable energy sources is especially beneficial in rural areas where availability of affordable RE can contribute to agricultural productivity, health, education, communications, small business enterprise, and quality life. However, despite the advantages that increased use of such 'new' renewable resources could potentially bring to the country in terms of spurring rural development, the uptake of renewable energy continues to be low. Some of the barriers to renewable energy technology development are illustrated in Figure 2

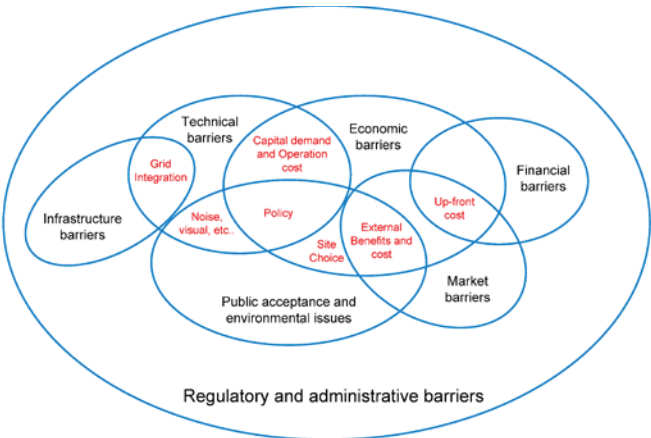


Fig. 2 Renewable technology barriers

Source: Overview of Current Micro grid Policies, Incentives and Barriers in the European Union, United States and China, Amjad A., et al.,2017

Among all the renewables being promoted to enhance energy access, solar energy has the fastest market-growth. For example, between 2000 to 2010 solar photovoltaic (PV) was the fastest growing renewable power technology worldwide (OECD/IEA 2011). Rural electrification using solar PV has been emerging as a viable option for the developing countries. The PV systems not only provide reliable, clean, and environment-friendly energy but also create employment opportunities in the vicinity of its operation (UNEP 2014).

Kenya has abundant solar energy resources. Its daily average solar insolation is estimated to be about 4-6 kilowatt hours per square meter, which is considered one of the best for solar electric energy production in sub-Saharan Africa<sup>1</sup>. Depending on the conversion efficiency of solar modules, 10-14 per cent of this energy can be converted to electric power<sup>2</sup>. Off-grid and mini-grid solutions to energy access are therefore an important supplement to the electricity network expansion in the general sustainable energy electrification strategy of developing countries. Furthermore, solar market development has also been aided by the global fall in the solar PV prices over the last decade (Fig. 3).

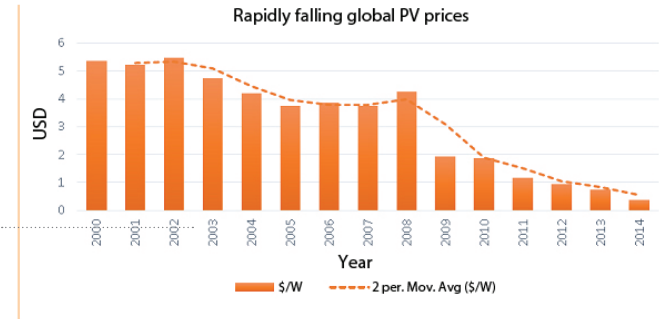


Fig 3: The global PV module prices learning curve, 2000 - 2014

Source: The Energy Collective,2014

“Solar power is the last energy resource that isn’t owned yet - nobody taxes the sun yet.”

Bonnie Raitt, 1978

The Kenyan solar market is one of the most advanced in Eastern Africa, and indeed in Africa. Traced back through the 1980s, it is one of the classic examples of a market driven largely by the private sector. It is estimated that the overall solar market has increased by more than 100 per cent in Kenya with an estimated 300,000 solar home systems (SHS) installed and generating about 8-10MWp (Hankins et al. 2009). Lighting Africa sales results collated from manufacturers of quality tested products indicates that over 2.2 million units of solar lighting products have been sold in Kenya since 2009. This program expects to grow to over 2.7 million by June, 2016 (Fig. 4).

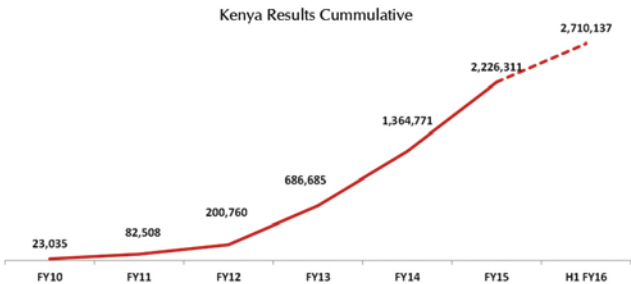


Fig. 4 Lighting Africa projected cumulative sales in Kenya

Source: Solar Home Systems projected cumulative sales in Kenya, IFC Lighting Africa, 2016

While market led models have played a big role in solar development in Kenya, there is no doubt that a large segment of the population, especially the poor, have been left out of this race or at best forced to rely on poor and counterfeit products because they cannot afford the high cost of buying quality solar products. Reasons for this range from infrastructure, to socio-economic factors where most people are not able to afford the cost of technology.

One of the strengths of solar PV is the opportunity it provides to target different income levels by varying generation capacity. Systems vary in scale, and cost, from small portable solar lights (pico- solar) to large home systems able to power several high-powered appliances. While much focus has been placed on the larger systems, pico-solar has received little attention.

International Energy Agency (IEA) defines “Pico Solar PV Systems” as small PV systems with their PV panel capacity usually a few Watt peak, but can be as small as 0.3 Wp or up to 10 Wp (Fig. 5) which has been made practical thanks to dramatically increased energy efficiency of appliances and, in particular, the spreading of LED lights.

Pico Solar PV systems have experienced significant development during the last few years, combining; for example, the use of very efficient LED lights with sophisticated charge controllers and efficient batteries. Having a small PV panel of only a few watts, essential services, like lighting, phone charging and powering a radio can be provided. Lately, scalable/modular pico-solar systems are in the market. Households can therefore buy a small kit and later add an extra kit.

The modular products allow extra lights and services to be connected

1. [http://www.erc.go.ke/index.php?option=com\\_fs&view=faq&catid=2&Itemid=649](http://www.erc.go.ke/index.php?option=com_fs&view=faq&catid=2&Itemid=649)  
2. [https://energypedia.info/wiki/Kenya\\_Energy\\_Situation](https://energypedia.info/wiki/Kenya_Energy_Situation)

and even a small TV to be considered purchasing capacity improves. With a large segment of the Kenyan households using kerosene as their main source of lighting, pico-solar home systems (PSHS) can play a big role in providing energy access especially to the bottom of the pyramid population in Kenya and substitute the use of kerosene for lighting, in addition to other crucial services.

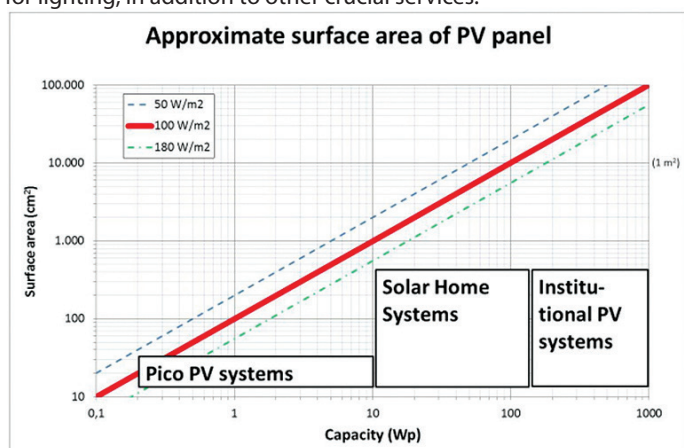


Fig 5: Defining the range of pico-solar systems

Source: Pico Solar PV Systems for Remote Homes, IEA, (2012)

According to Lighting Africa estimates, pico-solar market in Kenya is worth about USD 50 million. Some of the modular pico-solar products are shown in Figure 6.



Fig. 6 Some pico-solar products in the Kenya market

## Manufacturing, Standards and Labels

The impact of manufacturing on economic development has been widely studied. Very few countries have been able to grow and accumulate wealth without investing in their manufacturing industries, and a strong and thriving manufacturing sector usually precipitates industrialisation. The manufacturing sector is widely considered to be the ideal industry to drive Africa's development (AFDB, 2014; The Economist, 2014; The Economist, 2016). According to the above reports, there is a direct correlation between export levels and the economic success of a country. By increasingly adding value to products before they are sold, revenues are boosted, thereby raising average earnings per input. Furthermore, the manufacturing sector is also more sustainable and less vulnerable to external shocks than commodities.

Kenya has set itself an ambitious plan to make manufacturing sector contribute up to 20 per cent of the GDP in five years by 2020. This implies that manufacturing must become part of the future direction of pico-solar development in the country. Currently, only one company called Solinc East Africa based in Naivasha is known to locally assemble solar panels while Sunlight products are being designed in Kenya but manufactured in China.

The advantage of local manufacturing can support a country's balance of trade, import substitution, job creation and affordability of the products. Furthermore, distributed solar products and associated services can also support local manufacturing in rural areas which are not connected to the national grid. The importance of local manufacturing is also linked to ease of quality control monitoring. In contrast, it has been difficult to monitor quality of imported products, hence a flood of counterfeit products in the market. A market survey by Strathmore University showed that more than 25 per cent of solar kits fail within first six months. This is an evidence of imported low quality products getting into the local market. Lighting Africa's March 2016 Kenya retail report indicates that the top two key challenges solar retailers are grappling with are low quality/counterfeit products and faulty products that lower consumer trust of solar products.

Key issues to be address regarding local manufacturing should focus around the following questions:

- (i) what are the challenges of local manufacturing?;
- (ii) support structures necessary for local manufacturing to support design, testing of equipment, product certification, reference laboratories;
- (iii) what policy and regulatory framework is required?;

### Box 1: Pico-Solar Opportunities and Challenges in Kenya

Kenya Industrial Research and Development institute (KIRDI) with assistance from the Low Emission and Climate Resilient Project undertook a study on pico-solar market in Kenya. The main objective was to undertake a baseline study addressing technical and socio-economic aspects of pico solar PV systems in Kenya.

As part of a larger project on climate change interventions, it was expected to provide information to be used for production of a prototype for a Kenya manufactured solar lantern. This would later be distributed to Kenyan households to reduce use of kerosene and so reduce greenhouse gas emissions.

The study covered six countries namely Bungoma, Embu, Kirinyaga, Kitui, Migori and Samburu and interviewed 460 people of which 61 per cent were female and 39 per cent were male. The study identified the following key areas that require urgent action: Manufacturing, Standards and Labels; Fiscal policies, Marketing and Private Public partnerships; Pico solar energy Policy; Consumer policy, Awareness and; Waste, Environment and Climate Change. These issues were then subjected to a further discussion at a three -day key stakeholders' workshop held in Nakuru from 28th to 30th June 2016. In the following sections, key recommendations from the workshop are presented.

iv) are there production requirement in terms of capital, finance, human capacity, marketing system, and, land)?

Some of these issues are discussed further in the following section.

i. **Ownership of technology** is still dominated by the developed countries. Hence issues regarding intellectual property rights slow down local manufacturing. A good example is where Sunlight products and Mibawa pico-solar are designed in Kenya but manufactured in China because the molds are patented in China. This limits Kenya from manufacturing the products in locally.

ii. **The unit cost of electricity** is too expensive. This is reflected in high cost of production. A part from the high cost, unreliable electricity supply characterized by regular power outages is causing enormous losses to manufacturers. This situation is replicated almost in all sub-Sahara African countries (Fig. 7). As geothermal gradually replaces thermal generation in Kenya, it is expected that this problem will be solved in not so far future and the cost will eventually come down.

iii. **Cost of Finance** - Most mainstream financial institutions are reluctant to fund renewable energy projects. In cases where this funding is made available, the cost of borrowing is too high and unaffordable to local manufacturers. The prevailing high dollar rates complicate the situation further for manufacturers who rely on imported inputs for manufacturing. Tapping into the green energy and climate funds could be an option to accessing low interest loans as long as the loans are not passed through intermediary banks that end up placing more barriers between the funds and intended beneficiaries.

iv. **Policy and Regulatory Framework** - The current policies are either weak or poorly implemented and have therefore failed to unlock the potential of the local manufacturing capacity in Kenya. These include policies that protect the local manufacturing industry from unfair competition from imported goods especially influx of counterfeit products. A report by KIRDI (year) shows that 74 per cent of the solar products in the market are of good quality while 26 per cent are poor quality. A similar study conducted by Lighting Africa focusing on the Kenya retail market found 65 per cent were of good quality and 35 per cent counterfeit or unverified quality. This is a high percentage considering that pico-solar is a new product that is yet to gain ground in the local market. Policies should address the right incentives to attract investors in manufacturing. In addressing quality of product in the market, the Kenya Standard KS 2542:2014 is an important instrument though its enforcement is limited. The Lighting Africa programme has been playing an important role in filling the gap through establishment of screening and voluntary accreditation scheme.

v. **Manufacturing de-materialization** - Using less and less material for a more output of robust products. This should be anchored on:

a. Design for ease of disassembly so that it becomes easier to promote recovery, reuse, refurbishment, and recycling

b. Public disclosure on pico-solar products about what is recyclable, reusable and/or toxic

vi. **Standardization of parts** for the pico systems to enable replacement of the parts should be a considered. For example batteries and the light source (LED) should be made replaceable.

vii. **Low capacity both human capital and infrastructure** is a major bottleneck in local manufacturing. Capacity building at all levels is a key area that requires action for local manufacturing to thrive.

viii. **Low level of funding of science technology and innovation** has further limited innovation and commercialization of research and development outputs. Innovation is a key ingredient in local manufacturing, which should be strengthened.

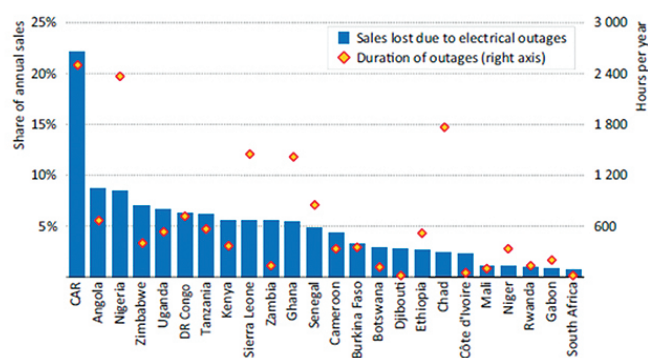


Fig 7: Impact of electricity outage on business in Africa (world bank 2014)

Source: World Bank (2015b); IEA analysis, 2014 Africa Energy Outlook.

ix. **High cost of land** especially in large cities is a major constraint to local manufacturing. The government should develop industrial parks where small manufacturers can establish business at a subsidized rental cost.

## Fiscal, Marketing and Private Public Partnerships

As a result of the global trend towards solar energy and driven by the lowering prices, the structure of the industry, the nature and role of producers and distributors are undergoing change at multiple levels. Existing business models are at the centre of policy discussion across many countries and new players are entering the market. Attracting investments in off grid is increasingly becoming a priority, as are the strategies and enabling technologies to flexibly manage supply and demand.

Though limited attention has been given to pico-solar system, the reality is that the market is rapidly growing especially among the poor living in rural areas. The market is using a variety of models to reach

### Box 2: Social Impact of Solar

Reliable solar power raises the living standards of rural families who do not have access to the electrical grid. Using Mobisol solar energy 150,000 children can now do their homework at night without inhaling the noxious fumes of kerosene lamps. In addition, many Mobisol customers use their solar system commercially: Approximately 15,000 small businesses generate an additional household income of over 5 million Euros per year with their Mobisol system. Mobisol also creates new green jobs and training opportunities in the typically precarious labour markets of East Africa. The "Mobisol Akademie" provides a comprehensive education for the company's employees and so far, over 800 jobs have been created. Press Release: Mobisol provides reliable solar power for a quarter million beneficiaries in Africa, June 22, 2016



the end customers. Rapid developments and innovation using mobile phone platform based models (e.g. Pay-As-You-Go (PAYG)) are rapidly revolutionizing the market while providing new avenues to innovate in designing new products which means there ever growing market demand.

There is a compelling and technically feasible business case to transform the pico solar market to make it more accessible, affordable and reliable; but as with energy systems, investing in market infrastructure is capital intensive. In addition, accelerating the deployment of pico solar market requires an enabling environment that takes into consideration the dynamic changes in the market and the context-specific conditions that influence investment decisions.

The government of Kenya has supported development of renewable energy in the country through a number of policy and regulatory frameworks. Though these policies are not specifically targeted to pico-solar, there are aspects that can be used to promote the development of pico-solar market. The following examples are illustrative.

The Energy Act 2006, Energy Policy 2004 and the Draft Energy and Petroleum Bill 2015 recognize the potential of the country solar energy and recommend an accelerated and focused approach for exploiting solar energy

- Energy (Local Content) Regulation 2014 on localizing production using indigenous natural resources and human capital.
- Sessional Paper No.4 of 2004 highlights in subsections:
  - a. 6.4.1 (iii) promote the development of local capacity for manufacture, installation, maintenance and operation of solar energy technologies
  - b. 6.6.3.2 (ii) continue current fiscal policy of allowing procurement of plant, equipment and related accessories and major spare parts for power generation free of duty and taxes during project implementation
- The tax, fiscal and other incentives enumerated in sessional Paper No. 4 are amplified in the draft Energy and Petroleum Bill 2015.
- In recognition of the renewable energy resource endowment in the country the draft energy bill recommends the establishment of a Renewable Energy Resource Advisory Committee
- To attract private sector capital in solar energy resource electricity generation, the Ministry of Energy issued the Feed-in-Tariff for Solar Energy Resource generated electricity. While these are steps in the right direction, it is important to note that these policies are envisaging larger solar systems and not pico systems.

On the question of quality verses price: Customers prefer quality

products, as long as the price is not prohibitive. Both the policy and the market must ensure that all users get acceptable quality products for their basic needs. Market segmentation model as used in the smartphone market is a good example of a successful model. There are smartphones designed for different categories of consumers' top end to lower end but all access the basic services of a smartphone.

Clear and long term fiscal policies are required to jump-start the market. Incentives such as tax breaks, duty exemption or facilities providing low interest finance are necessary to develop the market. Carbon-based financing mechanisms such as the current climate technology centre network (CTCN), Clean Development Mechanism (CDM) and other voluntary schemes can play important role in mobilizing resources for pico-solar market. The problem in Kenya and indeed many African countries has been capacity to develop bankable projects that can compete internationally for the carbon-based financing. Capacity building in this field would help to create a critical mass of project developers to take advantage of carbon financing funds.

Innovation at all levels including higher institutions of learning, small and medium enterprises (SMEs) as well as grassroots innovators must be supported to play their role. There is a noted disconnect between research and innovation as they relate to the government (policy) and private sector. The Triple helix structure has worked well in many countries such as Brazil (sugar/bioethanol industry) and Japan. In helix structure there is a clear linkage between research and innovation with the government and private sector. In Kenya, the Kenya Climate Innovation Centre provides an example of such collaboration.

## Energy Policy

An appropriate policy can play a central role in driving deployment of pico- solar energy. They require long-term stability, timely and adequate adaptation. Policies that changes after a short period are most likely to compromise investors' confidence. A good example is taxation of solar products that keep changing every financial year.

The appropriate policy and regulatory environment will help reduce solar energy investment barriers and increase investors' confidence in the sector. A good example is the Energy (Local Content) Regulation 2014 which if well applied can promote local assembly of quality pico-solar products substantially. The real or perceived risk, the relatively short track record of many solar energy technologies, the relatively small size of many solar energy projects and the limited experience of project developers all act as barriers to investment. Further analysis is necessary to understand the most effective use of financing instruments required to scale-up investment, including those that de-risk investments and improve access to affordable capital for projects.

Increased transparency of investment statistics and trends is necessary to enable policy makers to identify available options, examine the strengths and weaknesses of different approaches and implement the most appropriate mechanisms.

### Box 3: Kenya Climate Innovation Center (KCIC)

The Kenya Climate Innovation Center (KCIC) is hosted by Strathmore University and established through a partnership of Strathmore University, Global Village Partnership (GVEP) International, the PwC and Kenya Industrial and Development Research Institute (KIRDI). KCIC provides holistic, country-driven support to accelerate the development, deployment and transfer of locally relevant climate and clean energy technologies. The KCIC provides incubation, capacity building services and financing to Kenyan entrepreneurs and new ventures that are developing innovative solutions in energy, water and agribusiness to address climate change challenges. The Kenya CIC is an initiative supported by the World Bank's infoDev and is the first in a global network of CICs being launched by infoDev's Climate Technology Program (CTP).

Some key issues that were identified in building supportive policy environment include: building comprehensive, up-to-dated and freely accessible database of pico-solar statistics through the continued collection of pico-solar country statistics. This could include strengthening collaboration with other data-collecting organisations, consolidating and standardising data currently collected by different agencies, and presenting this data in more accessible and user-friendly forms. Ministry of Energy and Petroleum (MoEP) is the chief custodian. On the other hand all players must do their responsibility in collecting and availing this information. Since the current Energy Bill and draft Energy Policy have covered renewable energy as a priority; what is now required is well-developed pico-solar energy strategies with clear targets and timelines to guide market development and monitoring of progress. The strategy should also include how to manage e-waste. The e-waste management strategy should ideally be pegged on the waste management hierarchy that puts preference to waste avoidance, reduction, reuse, recycling, recovery, treatment and then final disposal.

## Consumer Awareness

Consumer awareness is simply the understanding by an individual of their rights as a consumer concerning available products and services being marketed and sold. The concept involves four categories including safety, choice, information, and the right to be heard.

In recent times consumers choose their favourable and familiar brands due to the rise in their consciousness. Consequently for businesses in order to compete with others they must create love for their brands in the minds of consumers. All these involve levels of consumer awareness. It is therefore in the interest of the market to have informed consumers. Informed consumers will also play an important role in keeping accountability in the market. There is also need to develop consumer protection policies to safe guard against counterfeit to hold manufacturers responsible for quality and after sales services. One big complain that was recorded during this study is where product are sold with warranty periods of 2 or 3 years but when the product breaks down before the expiry of the warranty period the suppliers refuse to take them back or repair. With clear and properly enforced regulations such should never happen.

In addition, local entrepreneurs play a major role in deployment of decentralised solutions in rural and remote settings, but the institutional and human capacity is often lacking to fully benefit from the varied opportunities solar energy presents is often lacking.

An important aspect of the transformation of the solar market will be the provision of, and access to, timely, accurate and information

of the services/products. This should include clear guidelines on how to channel complains from the customers. Kenya Renewable Energy Association (KEREa) has established SMS based platform where customers can channel their complaints but this need to be replicated and connected to policy enforcement agent who can hold the suppliers to account.

## Waste, Environment and Climate Change

Using solar power equipment reduces the negative environmental impacts associated with combustion of fossil fuel. Unlike fossil fuel power generating facilities, solar facilities have very low emissions of gaseous pollutants such as sulphur dioxide, nitrogen oxides, carbon monoxide, volatile organic compounds, and the greenhouse gas carbon dioxide during operations. In addition to these benefits, construction and operation of solar facilities creates both direct and indirect employment and additional income.

The primary environmental concern arising from solar technologies is the disposal of batteries, and certain heavy metals in the electronic components and mother board. Batteries are required to store electricity produced by solar panels so the power can be used at night and on cloudy days. They are an essential component of any passive solar installation. Some of these batteries contain lead acid, which makes them difficult to recycle and a threat to the environment if they are disposed of wrongly. The primary concern is that developing countries may not have the means for proper disposal of or recycling lead acid batteries. Used lead acid batteries (ULABs) from photovoltaic solar system are hazardous waste. However, Chloride Exide Company registered in Kenya recycles ULABs and has collection centers in most of the counties. It also has a payback scheme of 5% on a new battery and sends regular SMS to the end users for maximum collection of ULABs. In addition, they manufacture lead acid batteries with warranty of 2 years on new batteries.

While there are no global warming emissions associated with generating electricity from solar energy, there are emissions associated with other stages of the solar equipment life-cycle, including manufacturing, materials transportation, installation, maintenance, and decommissioning and dismantlement. Most estimates of life-cycle emissions for photovoltaic systems are between 0.07 and 0.18 pounds (32g and 82g) of carbon dioxide equivalent per kilowatt-hour<sup>33</sup>.

In recent years the electronics industry has gained notoriety for creating an endless stream of disposable products that make their way at life's end to developing countries, where poor people without safety gear cut and burn out valuable materials, spilling contaminants



Fig 8: A collection e - waste from solar Products

3. [http://www.ucsusa.org/clean\\_energy/our-energy-choices/renewable-energy/environmental-impacts-solar-power.html#.V3AE3bh97IU](http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/environmental-impacts-solar-power.html#.V3AE3bh97IU)

into their water bodies, air, and lungs.

Solar modules contain some potentially dangerous materials found in other electronic equipment and devices including silicon tetrachloride, cadmium, selenium, and sulphur hexafluoride (a potent greenhouse gas). Kenya Standard KS 2542 as well as the Lighting Africa Kenya have attempted to draw a line on the max concentrations of these chemicals allowable. However, as mentioned earlier, enforcement has not been strong enough. As solar products gain entry into mainstream markets, insiders and watchdog groups are beginning to talk about Extended Producer Responsibility (EPR) and recycling in an attempt to address the pitfalls of poor management of electronic waste and retain the industry's green credibility.

Solar modules have an expected lifespan of at least 20 years so most have not yet reached the end of their useful lives. However, before a significant number of dead panels pile up, a program on managing waste should be developed and implemented. Key issues to be addressed include: Status of solar waste in the country; Legal and regulation framework on management of e-waste, standards and quality assurance; Waste management options and; e-waste management progress tracking, monitoring and evaluation.

The problem of e-waste can only be addressed through a multi-stakeholder approach where each stakeholder plays their role. Regulators; for example, National Environment Management Authority (NEMA) has responsibility such as licensing of transporters. They also maintain tracking documents to ensure that the mode of transport and disposal methods used comply with the stipulated recommendations.

Kenya Revenue Authority (KRA) is responsible in keeping track of imports and ensuring they reach the right destination. The private and non-governmental organizations must also play their roles. Safaricom has started doing this for e-waste from mobile phone. To manage e-waste over a long period of time, there is a need to compile, manage and maintain the variety of records.

Currently the recycling of solar panels faces a big challenge. There are no recycling plants yet. Also, there are inadequate volumes of

e-waste to support a recycling industry. Recycling of solar panels is particularly important because the materials used to make the panels are rare or precious metals like silver, tellurium, or indium. Due to lack of recycling facilities, the panels and content recoverable metals may be going to waste and this can contribute to resource scarcity in future.

There is need to consider extended producer and consumer responsibility that will aid the take-back-schemes for pico-solar products that are no longer in use. This should be considered hand in hand with design for ease of disassembly so that it becomes easier to promote recovery, reuse, and recycling. Some notable efforts on e-waste recycling in the absence of E-Waste regulations include those by Safaricom, WEEE Centre, Communication Authority of Kenya and East Africa Compliant. This is illustrated in Box 4.

## Recurred Structures

Some legal and regulatory frameworks on management of E-waste already exist. These frameworks are inadequate and poorly enforced. Therefore, there is need for enforcement of the frameworks, as well as revising them to match with the current trends. E-waste management board should be established to implement guidelines on E-waste management.

Some of the existing legal and regulatory framework include; EMCA, 1999/EMCA (Amendment), 2015 on management of environment; Environmental Management and Coordination (Waste Management) Regulations of 2006, E-Waste Management Guidelines, The National Solid Waste Management, and; Draft Environmental Management and Coordination (E-waste) Regulations of 2016.

There is need to have a structure to guide end users, manufactures, importers and the dealers to keep inventory and monitoring of E-waste. This will help to:

- (i) encourage segregating at source;
- (ii) create collection mechanisms such as take back schemes and collection centers;

### Box 4: Safaricom – WEEE Centre Case Study

Safaricom in partnership with Waste Electrical and Electronic Equipment Centre (WEEE Centre), has one of the largest E-waste programme in Kenya. The WEEE Centre provides e-waste collection, dismantling and automated processing services in Nairobi and several other major cities in Kenya. WEEE Centre primarily sources e-waste from the private & public sector and through collection campaigns aimed at individual households.

Kenya generates an average of 3,000 tons of e-waste each year from computers, monitors, printers, mobile phones, fridges, batteries and other devices. Lack of e-waste awareness, along with poor separation and disposal systems, has led to e-waste being mixed with ordinary waste in dumpsites. The WEEE Centre is addressing these problems by managing e-waste and creating awareness.

At its initial campaign Safaricom collected over 10 tonnes of waste including obsolete laptops and mobile phones through an initiative that saw waste recycling containers placed in Safaricom outlets. The firm also expanded the initiative through launch of a caravan that went around the Nairobi city's environ collecting electronic waste with a target to collect 50 tonnes in five weeks of the caravan tour. In 2015 the firm reported that more than 170 tonnes of e-waste was collected during the year and cumulative collection of over 220 tonnes of e-waste since inception of the programme.

The dramatic increase in waste collected was a result of the successful awareness campaign and collection roadshows held in 2015. In total 32 towns and residential estates in over 24 counties were visited during the campaign and citizens were taught about the importance of proper disposal and recycling of e-Waste. The campaign also targeted institutions, such as universities and government offices, where large amounts of e-waste accumulate. Waste Electronic and Electrical Equipment (WEEE) Centre, processes what it can here in Kenya and the rest of the waste is sent to partners in Europe.



(iii) provide temporary storage and returns mechanism to the dealers or collection centers;

(iv) conduct massive creation of awareness to the end users on E-waste management;

(v) provide incentives to encourage the dealers, manufacturers and end users to develop E-waste buy back schemes. In addition there is need to have a policy that harmonizes collected data so that the date of manufacture and the lifespan of the products can be known.

## Recommendations

Building on experience on pico-solar to date, there is need to focus on awareness creation and capacity building of stakeholders including policy makers, entrepreneurs, financiers and consumers including on required institutional and infrastructure to support pico-solar market. The awareness program will be based on an inter-agency coordination to avoid duplication of roles and conflicts. The coordination infrastructure could use an online platform, periodic stakeholder review and stakeholder analysis and consultations.

A comprehensive, up-to-date, and freely accessible database of renewable energy statistics through the continued collection of renewable energy country statistics should be developed, by strengthening collaboration with other data-collecting organisations, consolidating and standardising data currently collected by different agencies, and by presenting this data in more accessible and user-friendly forms.

There is need to promote local manufacturing of quality pico-solar products to protect consumers from poor quality products mainly originating out of the country. This should be supported by strong innovation networks and forward looking in-depth technology analysis that will result in design, prototyping and reverse engineering to adapt current technologies to end-user needs and enhanced possibility of recycling.

There is need for the Government to set aside a specific percentage of finances for funding off-grid solutions as a priority in line with the last mile connectivity e.g. solutions for subsidies; need for revolving funds to buy off-grid solutions to support distributors and low end users. Focus should also be placed on promoting accessibility to pico-solar products especially in the marginalized areas through innovative financial mechanisms. This should include a deliberate attempt to attract private sector financing and also to provide a framework for research to contribute to pico solar development.

E-waste from solar energy components is a potential problem that must be addressed by all stakeholders by developing appropriate policies and standards. For example, digital innovations like GPS, GSM, and SMS should be incorporated in the pico-solar home systems to aid in traceability, adherence warranty provisions, E-waste management and emission estimation.

The draft Energy Policy 2015 and Bill as well as the Energy (Local Content) Regulation and Kenya Standard KS IEC/TS 62257-9-5 are important policies that should be used to promote development of pico-solar. Considering the important role of pico-solar systems in enabling access to clean energy; especially to the poor communities in rural areas. What is required is a pico-solar energy strategy with clear targets to guide and drive the development of this market in Kenya. The policies also need to be accompanied with attractive fiscal incentives to attract investment in the sector. The current fiscal incentives are biased towards large solar systems.

## References

EMCA 1999/EMCA (Amendment) 2015.

Government of Kenya (GoK), 2015. Sustainable energy for all action agenda (draft).

Hankins M., A. Saini, and P. Kirai. 2009. Target market analysis. Kenya's solar energy market. Available at

<https://www.giz.de/fachexpertise/downloads/gtz2009-en-targetmarketanalysis-solar-kenya.pdf>, last accessed on June 15, 2015.

KNBS, 2014. Highlights of the Socio-Economic Atlas of Kenya

KS IEC/TS 62257-9-5.

OECD/IEA. 2014. Africa energy outlook. A focus on energy prospects in sub-Saharan Africa. World Energy Outlook Special Report. Paris: IEA. Available at <http://www.iea.org/publications/freepublications/publication/weo2014>

[africaenergyoutlook.pdf](http://www.iea.org/publications/freepublications/publication/weo2014), last accessed on June 21, 2016.

OECD/IEA. 2011. Clean energy progress report. Paris: IEA. Available at [https://www.iea.org/publications/freepublications/publication/CEM\\_Progress\\_Report.pdf](https://www.iea.org/publications/freepublications/publication/CEM_Progress_Report.pdf), last accessed on June 21, 2016.

UNEP. 2014. Green growth report. Nairobi: UNEP

## Acknowledgements

This policy brief was developed through the support of the Low Emission and Climate Resilient Development (LECRD) Project coordinated by the Ministry of Environment and Natural Resources. The project is funded by United States Agency for International Development (USAID) through United Nations Development Program (UNDP).



