



Executive
summary

Accelerating access to electricity in Africa with off-grid solar

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PRACTICAL ACTION
Technology challenging poverty



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Introduction

Today, more than one person in five lives without access to electricity; 48% are in Africa. Around 80% of those without access to modern energy live in rural areas. Given the high cost and slow pace of grid expansion to rural areas, decentralised options are often the cheapest and fastest way to extend energy access (IEA, 2014). Solar PV systems are the cheapest source of electricity for over one-third of Africa's population – a figure that is rapidly increasing with falling solar prices. There is now a wide variety of technical options that can provide off-grid solar electricity to individual households. These solutions to the challenge of energy access range from pico-solar lanterns (with a capacity of under 3 watts) to large solar home systems (above 2kW capacity), which power several lights and electrical appliances. New models of financing and distribution, as well as the development of pico-solar lanterns, have been instrumental in enabling low-income households to gain access to solar energy (Szabó et al. 2013). This report considers the full range of solar devices, using terms such as 'solar household solutions' or 'solar off-grid options', except where it specifically refers to solar lanterns or larger solar home systems (SHS).

This report was prepared for the Department for International Development in support of preparations for the Energy Africa access campaign, which aims to accelerate access to electricity in sub-Saharan Africa through solar household solutions. It presents evidence of the impact of solar household systems, reviews the market in the region and 13 selected countries (listed in Table 1 below), and identifies the key policy measures to enable accelerated access to electricity through solar household solutions.

The impact of solar household solutions

Impact on household finances

Poor households tend to spend a higher fraction of their income on energy, often for vastly inferior levels of energy services. Rural families across Africa spend ~10% of household income for 4 hours of light at night using kerosene, torches or candles. Families with a solar light save over \$60 a year, spending just 2% of their household income on lighting (SolarAid, 2012-15). Lighting Africa (2010) reported that replacing kerosene lamps with solar lights could offer returns on investment of 15-45 times the cost of the light. The Africa Progress Panel (2015) reported that halving the cost of inefficient lighting sources would save \$50 billion for people living below \$2.50 per day. It estimated that these monetary saving would be sufficient to reduce poverty by 16-26 million people.

Moreover, households with access to a solar product that charges a mobile phone can save money on charging fees. Off-grid households in Africa spend on average \$0.66

a week charging mobile phones, and travel 28 minutes one-way to the nearest charging station (SolarAid, 2012-15).

Impact on quality of lighting

Beyond financial savings, solar users benefit from extra lighting hours and better quality and more reliable lighting. A SolarAid (2012-15) survey found after purchasing a pico-solar light, households increased the amount of time that they light their home from 3.8 to 5 hours per night.

Impact on income generation

Improved quality and quantity of lighting can create opportunities for income-generating activities by increasing the time available for productive work. A number of studies found the availability of solar lighting after sunset increased the likelihood that enterprises will generate additional income by extending their working hours. Solar products that enable energy services beyond lighting create further income generating opportunities. Mobile phone charging businesses are particularly common. Solar-powered pumps also offer an increasingly attractive option for small-scale irrigation systems, but often with capital costs that are too high for low-income households.

Impact on health

By replacing kerosene lanterns, solar systems can help reduce household air pollution. The fine particulates emitted by kerosene-using devices exceed WHO guidelines. They impair lung function and increase infectious illness (including tuberculosis), asthma, and cancer risks. Poor lighting from kerosene lanterns is also associated with compromised visual health (UNICEF, 2015). Epidemiological evidence on the morbidity and mortality associated with kerosene lighting is currently inconclusive.

Solar household systems can also keep families and communities safer by replacing the use of flame-based lighting, thereby reducing burns, accidents and fires. Poisoning often occurs as kerosene is commonly sold in soda bottles and it can be mistaken for soda. UNICEF (2015) reported that the primary cause of child poisoning in developing countries is accidental kerosene ingestion, and burns are identified as one of the leading causes of child injury. One third of SolarAid (2014-15) customers interviewed in Uganda had experienced fires, burns and/or poisoning from kerosene.

Beyond improving health through safe household lighting, larger solar PV systems can improve the functioning of rural health facilities by enabling better lighting, ICT for administration, information, and aftercare services; laboratory equipment and refrigeration for the storage of vaccines, blood and other medical supplies. Over 30% of all health facilities in sub-Saharan African, serving approximately 255 million people, lack access to electricity (Practical Action, 2013).

Impact on education

There is clear evidence that better access to lighting provides children with opportunities to increase the quality and time of their study/homework. SolarAid (2012-15) found that school children in Kenya, Malawi, Tanzania and Zambia rated limited lighting as their main barrier to learning and do homework. After obtaining a solar light, children increased their study time on average from 1.7 to 3.2 hours each night. Other studies found similar improvements, but to differing degrees. Larger solar PV systems can also provide rural schools with electricity. Practical Action (2013) estimated that 65% of primary schools in sub-Saharan Africa, representing 90 million pupils, lack electricity.

Impact on the environment

Worldwide, kerosene lamps emit an estimated 270,000 tonnes of black carbon per year, causing a climate warming equivalent of close to 240 million tonnes of CO₂, a magnitude similar to the annual emissions of Vietnam (Lam *et al.*, 2012; WRI, 2015). Alstone *et al.* (2015) estimated doing

that, when black carbon is accounted, the climate forcing from households using kerosene lighting is nearly 10 times as high as that of the typical grid-connected households in Kenya. Harrison & Lam (2015) found that switching from kerosene to solar can reduce annual household emissions by as much as 555kg CO₂e.

An outcome of the growth in sales of solar household systems will be the associated increase in electronic waste. Recycling and electronic waste facilities are uncommon in Africa and there is a low level of awareness of the risks, of battery disposal for example. Some organisations have started recycling trials.

Impact on quality of life

SHSs can have significant positive impacts on quality of life. In Bangladesh, 82% of SHS users agreed that their system had increased their social status, stating that neighbours and relatives from other villages visited their houses more often to enjoy the clean lighting. Their SHS increased the amount of time that they engaged in social activities (Urmee & Harries, 2011). In Africa, 85% of pico-solar users said their solar light affected the activities they were able to do at night (SolarAid, 2012-15).

Impact on communications and access to information

Solar household systems that offer more than just lighting can significantly improve communications and access to information. In Uganda, 80% of phone owners charged their phones using solar systems, suggesting that access to SHS enables telecommunication in non-electrified areas (Harsdorff *et al.*, 2009). Access to reliable and affordable charging for mobile phones can also facilitate access to financial services such as mobile money; allowing

rural and/or unbanked populations to be served. In Bangladesh, 95% of SHS users reported improved access to information through mobile phone, TV or radio. Many agreed that by watching TV or listening to the radio they had greater access to information and were more informed about general news, health-related issues, weather and natural disasters (Urmee & Harries, 2011).

Impact on livelihoods: through solar supply chain

The development of the solar market creates jobs and income-generation opportunities throughout the supply chain. In Bangladesh, the Africa Progress Panel (2015) found 114,000 jobs in solar panel assembly were created in the last 10 years. Up to 15,000 new jobs have been created in sub-Saharan Africa through the distribution of off-grid lighting (UNEP, 2014).

The market for solar household solutions

The market for quality-certified solar products has grown rapidly over the past five years, reaching almost 3.5 million units in 2014. This market grew by 165% between 2011 and 2012, and by 204% between 2012 and 2013. The rate of increase fell to 27% between 2013 and 2014, and it may have declined in the first half of 2015.

Good market information about non-certified products is unavailable, but Lighting Africa estimated that they had a 57% share of the total market in 2012 (Lighting Africa, 2012). If non-certified products are taken into account, the growth in the overall market may be continuing.

Three countries – Kenya, Tanzania and Ethiopia – accounted for 78% of the sales in 2014, reaching a market penetration of 15-20% of off-grid households. These countries have a comparatively supportive policy environment for solar household solutions. For the region as a whole, market penetration is estimated to be around 3%.

The development of pay-as-you-go business models, which aim for high customer density, and the growth trend of existing companies, suggest that markets are likely to expand outward from their existing location.

The great majority of quality-certified products sold (over 90%) are below 10W in capacity. Although there is some evidence that consumers will move up the 'energy ladder' and upgrade to products with added capacity or functionality, most sales are expected to continue to be entry-level products.

Technology advances have led to improvements in product performance and reductions in price. PV modules have decreased in price by 85% over the last decade, and products quality-tested by Lighting Africa declined in price by 70% between 2011 and 2014 (Lighting Global, 2015). Though there are likely to be further reductions in the cost of LEDs and lithium batteries, efficiency savings from appliance use are expected to be the main driver of future cost reductions.

Business models

There are five general business models (Lighting Africa, 2012): partnerships between companies and institutions; distributor-dealer channels; proprietary distribution; franchise models; and, rental or leasing systems. Business models and their financing are evolving in response to rapidly changing market conditions.

The main current trend is the emergence of the pay-as-you-go (PAYG) model, under which ownership of the solar product is transferred to the consumer after a limited payment period. The PAYG market is very dynamic, with new approaches appearing quickly, companies changing their approach, and others disappearing from the market. A recent survey found that 60% of PAYG companies use mobile payments to collect revenue (Lighting Global, 2015).

Investment

Investment for the (quality-certified) off-grid lighting sector increased from \$ 9 million to \$ 22 million between 2010 and 2013, and to about \$ 100 million in 2014 (Kearney, 2015). Most of the investment in 2014 went to PAYG businesses. It is likely that total investment in 2015 will be lower than in 2014.

In general, solar companies say they are able to raise about 20% of the capital they need annually, which totals around \$ 300 million. Only the largest companies are able to raise significant amounts of investment.

About 80% of the investment in 2010 was equity funding, but this proportion has reduced as debt finance and mixed investments have grown.

Estimating market growth

The key variables affecting growth in the market can be categorised as demand, supply, policy and finance factors. The study identified several variables in each category with a view to collecting data on them and estimating market growth for selected countries. However, the data available are of insufficient quality for this purpose. Some variables were expected to affect more than one factor, and the factors themselves may not be independent of each other, which would present a challenge for assessing their influence on market growth.

A simple model was therefore developed for the study, to understand what it would take to achieve universal access to electricity under three scenarios: Business as Usual, Sustainable Energy for All, and Power for All. These scenarios assume universal access is achieved by 2080, 2030 and 2025, respectively. The model under these scenarios was applied to market in sub-Saharan Africa as a whole and to the market in 13 selected countries: Ethiopia, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda, Sierra Leone, Somalia, Tanzania, Uganda Zambia and Zimbabwe.

The model is based on the premise that the most important factor determining market growth rates is the amount of investment the sector is able to raise annually. This amount is affected by the four factors (demand, supply, policy and finance), which are scored (out of ten) in each scenario according to their positive impact on investment raised. Factor scores were assumed to be constant under the Business as Usual scenario, to improve

Table 1: Year that universal access is achieved under each scenario

	Business as Usual	SE4All	Power4All
Sub-Saharan Africa	> 2030	2030	2025
Ethiopia	2019	2019	2018
Ghana	> 2030	> 2030	> 2030
Kenya	2019	2019	2018
Malawi	2028	2026	2023
Mozambique	> 2030	> 2030	2027
Nigeria	> 2030	> 2030	> 2030
Rwanda	2024	2023	2022
Sierra Leone	> 2030	> 2030	> 2030
Somalia	> 2030	> 2030	> 2030
Tanzania	2022	2022	2021
Uganda	> 2030	> 2030	2026
Zambia	> 2030	> 2030	2026
Zimbabwe	> 2030	> 2030	> 2030

slowly under the Sustainable Energy for All scenario, and to improve more quickly under the Power for All scenario.

The model focuses on three quality-certified product categories, estimating the annual sales for each that would be possible with the investment raised. This then determines the number of people who gain access to electricity each year.

The main findings of the model are summarised in the table below which shows the year that universal access is achieved in the market for solar household systems under each scenario. Under the business as usual conditions, universal access is achieved by 2030 in only four countries, those where the market is already relatively well-developed. Under the initial assumptions used for the Power for All scenario, five of the thirteen countries do not achieve universal access by 2030. Six countries achieve universal access by the Power for All target of 2025.

Policies to accelerate access to electricity through solar household systems

A rapid expansion of the market for solar household systems will require appropriate policy and regulatory frameworks in sub-Saharan African countries.

Consultation with stakeholders in the market and with policy makers, combined with analysis from other studies,

identified nine key measures to create a supportive policy environment for solar household solutions. These are:

- The removal of **policy uncertainty**, by including off-grid electrification through market mechanisms in national electrification strategy, policy, regulation and plans.
- Help to mobilise **access to finance** for actors across the value chain, in cooperation with financial institutions and other funding organisations.
- Measures to **facilitate the import** of household solar related equipment, for example by removing fiscal and import barriers.
- The provision of a **level playing field** for the household solar sector, including reviewing subsidies for liquid fuels.
- The **protection of consumers' rights** by ensuring solar system providers are accountable through legal provisions.
- The adoption of international **quality standards** and raising consumer awareness about them, to prevent market spoilage from sub-standard products.
- Promotion of **consumer awareness** about access to electricity through clean, high-quality solar products.
- Ease access to end-user and **consumer finance**, particularly through mobile payment mechanisms and micro-finance.
- Build a **qualified workforce** for the sector and increase domestic value creation by developing relevant training capacity.

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