ENERGY PROVISION AT THE BASE OF THE PYRAMID

Are there viable business models to serve South Africa’s low-income communities?
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LIST OF ABBREVIATIONS

AC: Alternating Current - means voltage or current that changes polarity or direction, respectively, over time.

BOP: Base of the Pyramid - the largest, but poorest socio-economic group which is comprised of more than 4 billion people living on less than $2.5 (R35) per day.

CapEx: Capital Expenditure

CSIR: Council for Scientific and Industrial Research

DC: Direct Current – means the voltage or current maintains constant polarity or direction, respectively, over time.

DoE: South African Department of Energy

FBE: Free Basic Electricity

GIZ: Deutsche Gesellschaft fuer Internationale Zusammenarbeit

GW: Giga Watts

Hybrid: A combination of Different Energy Sources, Renewable or Fossil

kWh: kilo Watt-hours

LED: Light Emitting Diode

Micro/Minigrid: A set of electricity generators and possibly energy storage systems interconnected to a distribution network that supplies electricity to a localised group of customers.

NERSA: National Energy Regulator South Africa

PV: Photovoltaic

RE: Renewable Energy

ROI: Return on Investment


SA: South Africa

SANEDI: South African National Development Institute

SSA: Sub-Saharan Africa

ABOUT THE AUTHORS

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About Impact Amplifier

Impact Amplifier believes that social entrepreneurs will unlock solutions to the seemingly intractable challenges, which have faced our continent for multiple generations. These entrepreneurs share the ability to see possibilities that others have never considered or simply bypassed. They reflect a deep sense of connection and commitment to shape the world into what is possible rather than what it is. To support these beliefs, Impact Amplifier provides investment readiness and acceleration services to businesses, which combine financial success with positive social and environmental change; assists impact investors to source compelling opportunities; and provides responsible sourcing, supplier development and sustainability advisory services to corporations and public institutions.
South Africa’s energy generation, electrical infrastructure and renewable energy provision is extraordinary within the African continent. It produces almost 50% of all the energy generated in Sub-Saharan Africa yet its only 5% of the continent’s population. 85% of its citizens have access to the grid as compared to the average 43% in the rest of Africa. In addition, South Africa has procured 6.3 GW of renewable energy with plans for 11.5 GW more, which will come on line over the next 13 years making it the largest generator of renewable energy on the continent.¹

Yet, within this backdrop, 60% of South African rural households have no access to electricity, large sections of low-income urban settlements throughout the country have no access, and over 40% of the households that are connected, are considered energy poor spending upwards of 20% of their monthly income on power.² ³ The predominant approach to providing new energy connections has been through the extension of the existing grid network. This network is powered principally by coal, which has the highest level of greenhouse gas emissions of any form of power generation. The existing network’s capacity has also been compromised because of aging infrastructure, coal supply, and management systems, which was exemplified by 100 days of load shedding in 2015.

In many countries throughout Africa both the public and private sectors have realised that building more centralised energy provision capacity and extending the grid system using non-renewable energy sources is both economically unfeasible and environmentally detrimental. What have emerged as alternatives, are a broad spectrum of decentralised renewable energy models to fill the void. These models are being led by both the private sector and civil society. South Africa paradoxically, has been slow to adapt these new models and has thus fallen behind many other African countries in delivering alternative mechanisms to address the energy poverty confronting its most vulnerable citizens.

This paper reviews the decentralised renewable energy models currently being used for low-income communities, if and how they have been tried in South Africa, where the models have been successfully applied, and the potential these models have for expansion within South Africa. As firm believers in the power of the private sector to create lasting, innovative solutions to the challenges confronting the poor, this paper is intended to support entrepreneurs, researchers, public benefit organisations, government and other institutions interested in exploring opportunities to create and expand economically sustainable energy models for the base of the pyramid within South Africa.
AFRICAN CONTEXT
The dominant approach to electricity access in Africa is through centralised power generation linked to an extensive grid network of end users. This approach however in isolation, is no longer appropriate, to provide the power required on the African continent both now and in the future.

Although rich in energy resources sufficient enough to meet its domestic needs, Africa is decidedly poor in energy supply. It is estimated that half of the global population that have no access to electricity are located in Africa, which amounts to more than 600 million people. Africa’s grid electrification rate stands at 43% of the population, with an urban electrification rate of 70% and a rural electrification rate of 28%. This level of grid connection is also misleading, because most of the population, which are connected are not provided on-going, consistent power supply at prices they can afford. The entire installed capacity in Sub-Saharan Africa is roughly 90 GW of power, which for context, is less than what is generated in South Korea.

There are significant variations between African countries, with regards to connectivity, energy sources, patterns of consumption, resource endowments and policy frameworks. In spite of these variations, the overall weakness and deficiencies of the power sector have created a recurring theme of constrained socio-economic growth and development.

According to the International Energy Agency, 645 million Africans could still lack access to electricity in 2030. While others have predicted that less than 45% of African countries will achieve universal access to electricity by 2050. The UN Secretary General’s Sustainable Energy for All has set a target of universal access to all by 2030 but this seems unlikely for Africa based on political will, availability of financing and the scale of electricity provision required.

While these pessimistic predictions are the norm, others categorically reject them such as the Africa Progress Panel. They believe that financing and political will are not fixed parameters and thus too difficult to predict into the distant future. Many countries, including Brazil, Indonesia, Thailand and Vietnam, have demonstrated that it is possible to accelerate progress towards universal energy access. In Africa, countries as varied as Ethiopia, Ghana, Kenya, Rwanda and South Africa are showing that rapid advances are achievable.

No matter what perspective you accept, it is clear that reaching the target of universal access by any date, will require a creative mix of innovative strategies, a unique blend of traditional and renewable energy sources, collaborative stakeholder networks, supportive legislative frameworks, and improved financing for the relatively high capital needs of the off grid energy industry. The bottom line is that “Africa cannot afford a low level of ambition when it comes to energy access.”
PROPORTION OF FOREST DEGRADATION DRIVERS

THE MISSING MILLIONS (POPULATION WITHOUT ACCESS TO ELECTRICITY, 2012)
Energy Provision at the Base of the Pyramid

SOUTH AFRICAN CONTEXT
SOUTH AFRICAN CONTEXT

In many ways South Africa stands in stark comparison to the rest of the continent. With only 5% of the population it accounts for around 30% of the continent’s power generation capacity.\(^4\)\(^6\) This contrast becomes even more extreme when made between Sub-Saharan Africa and South Africa were it then accounts for 50% of the overall capacity.\(^6\)

South Africa’s electrification is underpinned by its monopoly parastatal utility, Eskom, which is licensed to generate, transmit and distribute electricity in a centralised fashion. Although South Africa’s primary supply of power comes from coal powered energy generation, SA has developed a policy framework for renewable energy generation that acknowledges the value it can play in achieving and sustaining energy security in the long term. This policy has led to the creation of the South African Renewable Energy Independent Power Producer Procurement Programme (REIPPP). The REIPPP has gone through five open cycles where private producers are able to bid to sell renewable energy to Eskom. To date this programme has purchased 6.3 GW of power generated from 102 separate projects.\(^1\)

South Africa is well positioned, based on its existing infrastructure, commitment to renewable energy, and policy frameworks to be the first country in Sub-Saharan Africa to gain universal access. This position is underpinned by:

- The 44.2 GW of electricity currently produced – 92.6% is from coal, 5.7% from nuclear and the balance from renewables, and gas turbines.\(^3\)
- A target of 17.8 GW of its electricity to be supplied from Renewable Energy (RE) by 2030. This will reflect almost 20% of its projected demand in 2030.\(^3\)

Although South Africa has substantial generation capacity and relatively consistent supply, it is a country defined by vast extremes between the energy rich and poor. All of its historic success to date has not sufficiently addressed energy access or affordability for the poor who remain unconnected and underserved.

Unconnected

- It is estimated that 3.5 million (15%) households in South Africa are without grid connection.\(^4\)
- About 31% of the South African population lives in rural areas of the country. In these areas, more than 60% of households have no access to electricity.\(^11\)
- The backlog of connections is projected to grow by 100,000 households per year for the foreseeable future.\(^2\)
Underserved

- South African municipalities provide a 50kWh per household, per month, Free Basic Electricity subsidy to low income users. This generally only applies to those who are grid connected.\(^3,10\)
- 40-46% of households are considered ‘energy poor’, spending between 20-30% of their monthly income on their energy needs.\(^11,12\)
- Electricity prices have increased by 270% since the year 2000, respectively 11% p.a.\(^2,3\) compared to the average 3% Gross Domestic Product and 7% inflation rates per annum.\(^6\) Additionally, electricity prices are expected to increase over the next five years by minimally 10% per annum.
- Recently the electricity grid has become unstable with more than 100 days of nationwide load shedding experienced in 2015. Although this instability is expected to continue, open cycle gas turbines, better supply chain management and rapid installation of renewable energy plants have presently stabilised the grid.

While there is no doubt that grid electrification will remain the dominant means of energy provision in the country, this approach has and will remain inappropriate to address the needs of the poor.

40-46% of households are considered ‘energy poor’, spending between 20-30% of their monthly income on their energy needs.
Energy Provision at the Base of the Pyramid

THE OPPORTUNITY

Image: The Energy Blog
THE OPPORTUNITY

The decentralisation of energy provision poses an ideal opportunity to investigate flexible renewable energy models that can be adapted to local needs, as well as innovative solutions to reduce the burden shouldered by municipalities in the shift to decentralised electrical provision.

Providing these alternative solutions is an urgent imperative because limited access to affordable and adequate energy are key contributors to systemic poverty. The consequences of unaffordable and inadequate access include:\textsuperscript{11,12}

- A large share of income is spent on energy needs that compromises other basic human needs;
- Lack of access limits economic activity, means of communication and transportation;
- Limiting the ability of children to study at home after dark;
- Reliance on biomass or paraffin for heating and cooking, especially in rural communities, causes air pollution inside the dwellings, which creates substantial health and fire risks;
- Wood ‘fuel’ collection can pose a significant security risk for women and children; and
- Extensive use of wood and charcoal contribute to ecosystem destruction.

The social imperative for energy provision and the inadequacy of a centralised approach for all people in all places creates a vast opportunity for the private sector to develop and implement alternative solutions.

Some of these solutions include biogas, solar home systems, mini/micro-grids, energy kiosks, solar appliances and other models. Many of these models have gained traction in other parts of the world providing low-income communities with new access to power never previously realised. However, South Africa’s off grid energy ecosystem is very immature in comparison to many other African countries. This is likely a result of its energy success, the perceived size of the economic opportunity, and the lack of expertise in scaling these alternative renewable energy models.

This report explores what alternative models have been tried, what has worked in South Africa, what hasn’t and what is working in other parts of the world that South Africa can potentially mimic to realise this growing opportunity. It is our intention to document the state of where the country is as a means to support new entrants into the market with economically viable solutions.
ENERGY Provision at the Base of the Pyramid

STUDY STRUCTURE AND CONTENT

Image: http://sageography.myschoolstuff.co.za/wiki
STUDY STRUCTURE AND CONTENT

To determine what renewable energy business opportunities might be available within low-income communities, Impact Amplifier conducted a range of market-based research. The primary intention of this research was to determine whether there are financially viable, scalable business models that provide affordable renewable energy to both the unserved and the underserved. Thus, this review looked at provision models for rural and urban areas that are not connected to the Eskom grid, as well as households that are connected, but cannot afford the energy options available to them.

This review involved two core components:
- Reviewing existing BOP renewable energy models currently being used in South Africa; and
- Interrogating international best practice to both gain perspective on the South African businesses and determine if there are possible business diffusion opportunities where these models can be introduced to South Africa.

The primary intention of this research was to determine whether there are financially viable, scalable business models that provide affordable renewable energy to both the unserved and the underserved.
DEFINING THE SCOPE
DEFINING THE SCOPE

What is meant by financially viable, scalable business models that provide affordable renewable energy to both the unserved and the underserved in the context of this report is:

- **Financially Viable** – Initial assistance can be grant based to set up or purchase infrastructure, but at a minimum the operating costs and return on investment must be generated from on-going revenues at some clear scale of operation. Ideally however, the business will be able to scale without a grant-based investment.

- **Scalable** – The solution can be replicated or grow without increasing costs per unit to a larger number of recipients, regionally, nationally or internationally.

- **Renewable** – Any naturally occurring, theoretically inexhaustible source of energy – such as biomass, solar, wind, tidal, and hydroelectric power – that is not derived from fossil or nuclear fuels sources.

- **Un/under served** – Recipients who are not connected or cannot afford the energy they are connected to.
Energy Provision at the Base of the Pyramid

Energy Usage Table

Image: www.m-kopa.com
To better understand all the technologies and business models reviewed in this report it is important to understand how much energy provided from a renewable source, using direct current (DC), is required to power various common household devices. Please see the table below, which summarises the power required.

### Energy Usage Table

<table>
<thead>
<tr>
<th>Consumption Level</th>
<th>Appliance Providing Energy Service</th>
<th>Consumption W/Hour</th>
<th>Usage Hours/Day</th>
<th>Cumulative Appliance Need Wh/Day</th>
<th>Cumulative Energy Need *per Day Wh/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 3</td>
<td>Grain Mill</td>
<td>750</td>
<td>4</td>
<td>3,000</td>
<td>3,744</td>
</tr>
<tr>
<td></td>
<td>Water Pump</td>
<td>150</td>
<td>2</td>
<td>300</td>
<td>744</td>
</tr>
<tr>
<td>Tier 2</td>
<td>Fridge</td>
<td>150</td>
<td>2</td>
<td>300</td>
<td>444</td>
</tr>
<tr>
<td></td>
<td>TV/Tablet Computer</td>
<td>12</td>
<td>6</td>
<td>72</td>
<td>144</td>
</tr>
<tr>
<td>Tier 1</td>
<td>Lighting</td>
<td>10</td>
<td>6</td>
<td>60</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>Phone</td>
<td>5</td>
<td>2</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Tier 0</td>
<td>Desk Light</td>
<td>0.5</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

*The ‘cumulative energy/day’ column reflects the cumulative energy need if all appliances are used in a given day. For example, running a desk light, phone, lights and TV for the hours shown above requires a total of 144Wh and so on.*
BUSINESS MODEL AND TECHNOLOGY REVIEW

The following sections review various renewable energy technologies, BOP applications, current BOP models in South Africa, case studies of international best practice, and the key factors to making these business models successful.

- **Biogas** – is created by capturing methane released from decomposing organic matter within a sealed container. This gas is most commonly used for cooking.

- **Micro/Mini-grids** – consist of one or several energy generation sources (Solar, Hydro, Wind), storage, and a distribution network, which connects multiple users to electricity. The energy is stored and shared amongst a fixed number of households and or businesses.

- **Solar Home Systems** – are designed to meet the needs of a single household. These systems are made up of solar photovoltaic panels, a battery, charge controller and sometimes an inverter.

- **Solar/Energy Kiosks** – uses solar photovoltaic energy to provide charging facilities for customer devices (such as cellphones) and generates electricity to charge battery packs, which customers lease and take home for use.

- **Solar Appliances** – These are devices, often lights, which have a small built in solar panel and battery. These appliances are typically portable and generate enough electricity to power themselves.
Biogas is produced by transforming organic waste into gas for cooking, heating or energy. Theoretically, biogas is suitable for small scale applications as well as large utility systems, using food waste, agricultural residues, and waste from abattoirs, animal farms and breweries. Biogas is beneficial to transform waste into energy and displace conventional energy supply.\textsuperscript{13}

On a household scale, a biogas digester requires 20-30kg of biomass and around 40L of water per day to provide cooking gas for 2-3 hours.\textsuperscript{14} Biogas is best contextualised in rural or farming areas within households, schools, communities and small/micro enterprises.\textsuperscript{15} Biogas is most viable in areas where there is adequate and consistent supply of organic material such as animal dung and kitchen waste, as well as plentiful accessible wastewater, free of kitchen detergents.\textsuperscript{16}

In South Africa, only 50 large scale (100kW or more) projects have been registered to date.\textsuperscript{17} Household level biogas has only been tried on a limited basis in South Africa, and no household based project has moved to commercial stages.\textsuperscript{3} The biogas currently being used is only a small fraction of the estimated potential biogas available. It is estimated that this untapped resources can produce 2.5GW per annum of electricity and provide gas for cooking for an additional 300,000 households.\textsuperscript{17}
Overall, there is no functioning, scalable business model in SA providing biogas to BOP communities.
SKG Sangha (SKGS) is a not for profit company, working in Africa, Asia and Latin America that designs and implements household level biogas digester projects, providing entire rural villages with digesters for cooking. To date, more than 100,000 household biogas digesters have been installed.¹⁹

A typical plant of 3m³ costs about $320 (R4,480), of which beneficiaries pay 20-40% by providing labour power and materials. The remainder is subsidised by government and donors and through the sale of carbon credits (~6tCO2 saved/plant/year). When ordered, a SKGS technician coordinates the work, sources local masons, supervises the construction and trains the owners. System failure is reported at less than 1%.

Each family operates their digester to ensure ownership. To be eligible for the program, families must own enough cattle to produce the dung required, use 50% of that for fertiliser for the fields, send their children to school and plant two trees.

This system saves women and children 2-3 hours of firewood collection per day, and eliminates smoke thereby reducing respiratory problems. Moreover, deforestation is reduced by 3.5 tonnes of firewood per year, per household. The economic benefits include reduced expenses on fuel; possibilities to sell the compost; and the opportunity to pursue other income generating activities in the time normally used to collect wood.²⁰

The overall experience with low-income household level biogas digesters has been very limited in SA and no commercially viable models exist. There appears to be interest however, from the national government in BOP biogas, and a roadmap is under development for creating possible models for implementation.

The success factors of international projects appear to be:

- Lowering the costs by:
  - Using dung owned by family cattle instead of buying it
  - Communities construct digesters
  - Economies of scale through massive projects
- Multiple revenue streams:
  - Sale of fertiliser for families
  - Sale of carbon credits for company who installs them
- Community involvement and ownership:
  - Local employment during construction and maintenance
  - Community ‘ownership’
- Bundling of social/environmental benefits makes it more attractive for government and investors:
  - Children must go to school
  - Planting of trees, reduced deforestation, increased recirculation of nutrients
  - Employment generation
MICRO/MINI GRIDS

CATEGORY OVERVIEW

Image: http://empoweredbylight.org/projects/project-zambia/sioma/
Micro/mini-grids are a set of electricity generators, and possibly energy storage systems, interconnected to a distribution network that supplies electricity to a localised group of customers. These grids often distribute electricity from a mix of sources, for example wind, solar and diesel, combined with an energy storage system. Benefits include the wide range of applications that can be powered by mini-grids, such as households, businesses as well as the variability of electricity generation.\textsuperscript{21}

Mini grids are most functional in dense areas a long distance from existing grid infrastructure or for those with unreliable energy provision. The drawbacks of mini-grids are the higher maintenance cost and relative high upfront investments.\textsuperscript{22}

Three mini grid pilot projects have been developed in South Africa. The first two, however were abandoned shortly after construction, as there was no model in place to collect fees from users nor operate and maintain the system. Since then, the DoE has issued feasibility studies for further pilot projects, but none have been realised to date.\textsuperscript{2} The third is a private sector initiative still in its pilot stage.

Internationally, mini grid systems have been successfully installed and are increasingly attractive based on rising grid connection costs, subsided PV and battery technology prices, and the need for DC electrification for productive use.\textsuperscript{2} There are essentially two types of mini-grids. The first are AC mini grid systems, which are able to connect to the main grid but, require an inverter to do so. AC is required for energy demanding appliances such as washing machines, electric stoves and heaters. DC mini grid systems are less complex and do not need an inverter and are therefore less costly, but electricity generated cannot be transmitted for long distances without major losses. These systems are most suitable for low energy demanding appliances such as lighting and charging.
MINI GRIDS - SA PROJECT EXAMPLE

The two failed mini-grids projects were located in Luncingweni and Hluleka, Eastern Cape. Each was a combination of wind and solar technology with a backup diesel generator. The primary intention of these were to determine the commercial viability of electricity generation for rural communities.

The projects were initiated and financed by the DoE, supervised by NERSA, implemented by ShellSolar SA, and coordinated by CSIR with an intended, but not realised community ownership structure. The estimated CapEx of $1.4 million (R20 million) was provided by the DoE and operational costs are estimated to have been $0.55 (R7.70) per kWh (2007), which was five times the price for grid electricity in 2015 and no revenue collection model existed. The system was designed to produce 86kW in Luncingweni and 15kW in Hluleka, providing electricity for 220 households in total.16, 21

Although the feasibility from a resource point of view was assessed, no studies were undertaken to investigate community desirability. This, combined with institutional uncertainty during all phases of construction and operations, led to mismanagement and no clear revenue collection model and maintenance. The plants got vandalised soon after completion and are now dysfunctional. “From a performance and energy access point of view, the two mini-grids were pretty close to being complete failures (South South North, 2014: 43)”.

Overall, the technological challenges are manageable, however better program design is necessary combined with community buy in, ownership and revenue collection models to develop a successful business model.

The third pilot is called Zonke Energy, which initiated a DC micro grid in Jabula, an informal settlement in Cape Town, which in its 30 years of existence, has never had access to grid electricity.23 Zonke installed a single mini grid system connecting 10 households, which provides lighting, cell phone charging, radio and optional appliances (television, and DVD players) at a cost of $0.07 (R1) per hour.23 The other primary available energy source in the community are petrol generators. Power from this source cost $1.43 (R20) per hour. The households pay a fixed weekly or monthly price to get access to the system. Zonke is in the process of raising capital to expand to an additional 90 households to demonstrate that the commercial model is viable at a large scale.

Overall, the technological challenges are manageable, however better program design is necessary combined with community buy in, ownership and revenue collection models to develop a successful business model.
Powerhive East Africa, a subsidiary of Powerhive Inc., is the first private utility in Kenya to receive a concession from the Kenya Energy Regulation Commission to produce, transmit and sell electricity. The company operates its pilot project in Kisii, Kenya, where around 90% of the population live without electricity.\textsuperscript{24, 25} The pilot project consists of a solar photovoltaic micro grid system, which has been operating since 2012. The four pilots are located in four villages in Kisii and have a total generation capacity of 80kW, which supply more than 1,500 individuals.\textsuperscript{24, 25} The project combines First Solar’s PV technology, and Powerhive’s control systems.

Smart meters and cloud based micro grid management software are used in conjunction with a flexible, prepaid billing system. Notifications are sent to users’ mobile phones when their credit balances are low, at which point customers can buy credit and activate power supply immediately.\textsuperscript{25} Connection fees are $24 (R336) and prepaid electricity tariffs are structured so that the user’s cost of electricity is less than what would be paid for traditional, non-renewable energy sources (such as kerosene and diesel).\textsuperscript{25}

Close attention was paid to sourcing local materials, using local capacity as well as understanding consumer behaviour and need.\textsuperscript{26} This was to ensure a sense of ownership within the community, and enabled appropriate technologies to be set up such as the flexible payment model, which reduces commitment, increasing the number of sign ups, even among sceptics.\textsuperscript{26} Training is also provided to local operators and technicians so that they are able to make optimal use of the Powerhive software.

This Kisii pilot project demonstrated that the technical risks of micro-grids systems are limited, revenue streams are predictable and that there is substantial growth potential.\textsuperscript{26} Future plans for the business include extending the solar mini-grids to 100 villages in West Kenya, with 1MW installed capacity and capable of serving 90,000 people.\textsuperscript{27}

\textbf{MINI GRID - SUCCESS FACTORS}

The following are the key differences between the South African models and those that have been effective internationally, thus defining some of the key factors for success:

- The technical setup of all international cases was much simpler than the designs of the SA pilot projects. The technical knowledge of the operators and clear systems and procedures are also critical.
- Many international cases generate electricity for multiple uses; for households, water pumps and productive activities to balance the load profile and reduce the need for batteries.
- In contrast to the SA experience, most are privately initiated and run, albeit with considerable public support and financing.
- Community desirability studies and a large degree of community engagement are essential to ensure acceptance, which were not the case in the SA pilots.\textsuperscript{28, 29}
- Clear and simple revenue collection systems that allow for energy access to be turned off remotely if payment terms are not adhered to.
- Operations, maintenance and management are key to success, thus ownership, rights and responsibilities have to be defined and sufficient cash flow has to be put aside.\textsuperscript{29}
SOLAR HOME SYSTEMS

CATEGORY OVERVIEW
Solar home systems (SHS) are standalone photovoltaic systems for off grid households. A SHS typically includes one or more PV modules, a charge controller and at least one battery. SHS usually operate at a rated voltage of 12V direct current and provide power for low power appliances such as lights, radios and small TV’s for about three to five hours a day. Larger appliances can be powered through an inverter, changing to alternating current and 240V.

Although largely inaccessible to poor households, SHS have been the predominant form of alternative energy systems in the SA context. The upward trend in PV installations has demonstrated the potential role this technology can play in the SA electricity generation mix in the BOP market.

The benefits of SHS are the modularity, rapid deployment, ease of application, the low maintenance and fast decreasing cost for the panels. Often the CapEx is subsidised by state agencies in combination with international donor money, whereas the maintenance, operations and profit are covered through the yields from selling electricity and appliances. Additionally, SHS are heralded as more scalable than micro-grids since only a single household needs to be convinced to commit to the service as opposed to having to convince a significant portion of the community to buy in to micro-grids.

In SA, SHS have been rolled out via concession programs to consortia as well as on a household-by-household basis. In the concession model, companies are acting on an explicit government mandate as a sole provider of SHS in the area. The focus of these programs has been on social objectives – safety, education, and economic activity – rather than on financially viable business models. Independent SHS providers are rare in SA (iShack being an exception) and business models have not gained traction in comparison to successful international companies such as those which exist in Kenya and Tanzania.
The socio-economic impact has been positive, especially with regards to education, quality of life and income.

The remaining companies face challenges regarding maintenance, revenue and FBE collections and have required several capital investments by the DoE and parent companies to continue operations. Lack of coordination between institutional stakeholders, foreign ownership, ad-hoc tenders and implementation represent further challenges.

Overall, despite the positive associated socio-economic outcomes, the SHS concession failed to deliver its goals and failed to develop a sustainable operating business model.
SHS INDEPENDENT COMPANY - PROJECT EXAMPLE
The most developed model of an ‘independent’ SHS company in SA is the iShack project. Developed and owned by the Sustainability Institute, the iShack has the goal of upgrading existing informal urban and peri-urban communities by installing systems with a 75W-100W panel, 100Amp battery to power lights, cell phones and a TV.

To date, more than 1,000 units have been installed, with the CapEx provided by the Bill and Melinda Gates Foundation and the SA Green Fund. The iShack works on a pay-for-service model dedicated to cover operational costs, without ownership. Participants pay a once off fee to start and then go onto a pay-as-you-go system for usage. A full month of power on the largest system is $10.70 (R150). The iShack secured the payment for the FBE from Stellenbosch municipality, which is paid directly to them. The business has made considerable advances on its pricing model, installation and service delivery, however faced technological challenges regarding the activation of the modules and battery life span. As technology is maturing rapidly this is considered to be a manageable problem. Acceptance by communities, initially very low, has grown substantially, but a structured engagement process is required to secure community buy in.

Overall, the iShack model has worked operationally, but needs to further prove its financial sustainability and address the remaining challenges to enhance the scalability of its business model.

SOLAR HOME SYSTEM - INTERNATIONAL CASE
One of the most successful decentralised energy companies serving the BOP in Africa has been M-Kopa. As of July 2016, this company has supplied 400,000 homes with low cost solar energy. M-Kopa operates in Kenya, Tanzania and Uganda and over the last three years has added new clients at a speed of 500 per day. About 40% of the CapEx, stated as approximately $200 (R2,800) per system, is subsidised by donor organisations including the Shell Foundation and the Gates Foundation.

To join the program, clients pay a $30 (R420) deposit plus $0.5 (R7) for 24h energy services. Small, incremental payments can be made via the mobile money system M-Pesa. After one year, clients own their system and can upgrade to a bigger panel or use it as collateral for consumer loans.

The M-Kopa starter system provides an 8W panel, a battery, LED bulbs, a torch and phone chargers. The system and payments are activated and monitored via a global system for mobile communication chip, generating vast amounts of data. The systems are distributed and installed through large agent networks.
The following are the key differences between the South African models and those that have been effective internationally, thus defining some of the key factors for success:

- Ensuring there are no conflicts with electrification policies and plans – for example in one of the concession areas, the grid arrived shortly after SHS installations took place.
- SA customers expect that the grid will arrive and fear that introducing SHS into their communities means it will not; this is not the case for other countries like Tanzania and Kenya.
- Independent of South African customers’ grid expectations, SHS models have thrived where communities are interested in new technologies while simultaneously hungry for energy solutions.
- The ‘small panel’ model pursued by M-Kopa (lights and a phone) does not seem to work in SA as people desire power for a TV and fridge, and thus bigger panels – this leads to higher CapEx/unit requirements in SA.
- Little/no sense of ownership or pay-to-own models are present in SA. Many customers only are interested in the solution if they ultimately own it.
- A clear and simple revenue collection model is vital. Revenue collection is more complex due to the lack of mobile payment systems in SA. M-Pesa for example has failed twice in SA.
- The CapEx is high and the revenue is low, so the business model must be designed for longer term profits with financial partners that share the same requirements.
- The technology solutions implemented in SA to-date were not mature enough, leading to high maintenance and operating costs. Being technology agnostic is critical to ensure the best solution for diverse markets.
- Both business model and technical knowledge by the operators is critical to building long term sustainability.
- Establishing a comprehensive distribution channel to get SHS into the market, via agents or by some other means is vital for success.

A clear and simple revenue collection model is vital. Revenue collection is more complex due to the lack of mobile payment systems in SA. M-Pesa for example has failed twice in SA.
SOLAR/ENERGY KIOSK

CATEGORY OVERVIEW
A solar kiosk is a self-functioning system that not only produces its own energy, but also stores additional energy in battery banks or mobile batteries to charge other products.36

The kiosk financial model involves either powering customer products – like phones and tablets – or charging batteries, which are then taken home for usage. Kiosks can be both mobile and stationary depending on the kiosk operator’s capacity and the customer’s demand. It generally consists of photovoltaic panels that power the kiosk, and may include additional batteries for storage. In some instances, the PV panels are complemented with diesel generators for backup.

Solar kiosks target a very specific market: off grid or energy insecure households/businesses that cannot afford solar home systems, yet are still willing to pay for electricity. The various models are:37

**Business to Business:** Develop charging station (hardware) and then sell/rent/lease it to a local customer such as a NGO, bank, or community operator. The developer generates revenues through the sale/lease of the station and/or the supply of appliances.

**Business in a Box:** Kiosks are run as a small business or part of a franchise – selling mobile, tablet, lantern or battery charging. Often the solar kiosk is the only illuminated building, and thus it serves as a community hub. The solar kiosk can take advantage of selling services such as drinks, streaming television and providing other internet services.

Solar/Energy Kiosks are best contextualised in rural areas where there are congregations of people, such as in or near a school. This model doesn’t work if the area is too isolated, and thrives amidst congregations with numerous energy needs. The kiosk approach is relatively unsuccessful in urban settings. Customers are not willing to visit a central charging point to charge devices, such as solar lanterns and batteries, if there is a closer or easier means of charging devices.
The most advanced pilot of a solar kiosk model in South Africa is the SolarTurtle by Ugesi Gold. The first SolarTurtle was deployed in mid-2015 to a rural Eastern Cape community, with the second launched in February 2016, the PowerTurtle. The goal for both is to demonstrate the business model in practice and identify areas for improvement. One of the unique characteristics of the Solar and PowerTurtle is the ability to fold and lock the panels up at night, which greatly reduces the risk of vandalism and theft.

The SolarTurtle has a 4kW system, which can provide basic electricity to 300-400 households. Franchisees can derive income by offering two services. The first is by providing electricity: the kiosk sells and recharges battery packs (which can be taken home to power 12V DC appliances); provides charging on site; and sells solar appliances and electrical equipment. The small battery pack can power a LED light for 6 hours and costs the customer $10.70 (R150), and $0.70 (R10) to recharge. The large battery pack can power a small TV for 20 hours’ costs $32 (R450) and $4.30 (R60) to recharge. The second revenue stream is through the sale of prepaid airtime, ice and fridge space, internet facilities, as well as agricultural and water purification support. The capital investment to install the SolarTurtle is $25,000 (R350,000), and a further $3,571 (R50,000) is required for initial stock. The expected annual profit is $12,143 (R170,000).

Ugesi Gold and partners developed an additional model called the PowerTurtle, which was designed as a mini grid solution for unconnected hospitals and schools. Considerable interest has been shown by public institutions, in South Africa and in the rest of the continent. The CapEx for the first pilot amounted to $39,285 (R550,000), which was provided by government agencies. The CapEx for the second pilot is expected to drop significantly to $25,000 (R350,000).

The current challenges include lack of mobile payment solutions, high transaction costs, and complex logistics due to low inventory/batch sizes. In addition, the model has yet to develop a ridged franchisee and revenue management system.

Overall, the financial sustainability is still to be proven.
**SOLAR/ENERGY KIOSK - INTERNATIONAL CASE**

An internationally successful case is the Solarkiosk E-Hubb, developed by the German company GRAFT and deployed in Ethiopia, Kenya, Ghana and Tanzania. Solarkiosk operates more than 60 kiosks in rural areas under the retail hub model, selling solar home systems, electrical appliances, airtime and fast moving consumer goods; as well as providing cooling services and water purification. Solarkiosk also aims to act as a local social hub and source for education, entertainment, light and products.29

The kiosks are operated via franchises and allow modular extension of the PV system. This also extends to local business model adaptation, such as outdoor cinema or supplying electricity to local communities via the mini grid model. Solarkiosk equally pursues financial and social objectives and is funded by investors (CapEx/operational costs are unclear) and is in a replication/growth stage.41, 42

**SOLAR/ENERGY KIOSK - SUCCESS FACTORS**

Due to the early stage of solar kiosk models in SA, comparisons between ‘why has it worked internationally and not locally’ cannot be drawn.

Even internationally, experiences regarding the long term financial sustainability and scalability remain scarce (only two companies operate more than 30 kiosks). Globally, most businesses are either in a prototyping stage or early growth stage. Moreover, donors and governments fund most identified cases, and only a minority are funded by investors or banks.42

The key success factors of international projects appear to be:38, 42

- Use of a micro franchise model with independent entrepreneurs operating the kiosks;
- Adapt the model to the local context and, where appropriate, adding other services beyond energy to include products and services like - phone charging, mobile money transfers, and basic household staples;
- Develop partnerships with local institutions, for example local banks for cash management, mobile financial services for revenue collection, schools, or mobile clinics;
- Sophisticated logistics to reduce transaction costs and manage revenue collection;
- Remote data and transaction monitoring, focus on the deployment of the hardware and management of kiosk entrepreneurs, rather than the actual management of the kiosks/goods/assortment; and
- The ability of the community to adapt to new technologies.
SOLAR APPLIANCES

CATEGORY OVERVIEW

Image: http://www.recode.net/
SOLAR APPLIANCES – CATEGORY OVERVIEW

Appliances are self-sufficient portable devices that can be recharged. Self-sufficient appliances are either powered by a small built in solar cell, or linked to a solar charged battery. Batteries are usually exchanged and recharged at a solar kiosk or by a SHS.

Solar appliances address the lack of access, the instability of access and affordability of energy. Although the initial costs are often higher than their equivalent (traditional) solution, the running costs are substantially lower. The benefits include increased safety, cleaner lighting inside the dwelling, and the possibility to study or perform other economically productive activities in the absence of daylight.

The product is either purchased directly by the customer, subsidised by donors or government agencies, crowd funded, or cross subsidised by non-BOP buyers. Solar appliances are generally distributed via solar kiosks, development institutions, franchises, or traditional retail channels.
SOLAR APPLIANCES - SA EXAMPLES

There are a wide range of companies producing and reselling appliances, batteries and energy efficient products, which find application in BOP communities within South Africa. Most of these appliances are solar powered, however windup based solutions have been piloted as well. Examples of companies operating in South Africa include Sungrid Group with their brand Waka Waka, Khaya Power, and Restio with their brands EnerGCare and Nuru light. Most of these companies are not in SA only, but operate in other African countries.

The actors in the South African market can be differentiated according to their distribution and payment models:

Aid agencies: Nokero, EnerGCare
Franchises: Khaya Power
Agents/Reseller: Waka Waka, EZY Light, EnerGCare

Pay to own: EZY light, Barefoot, EcoBoxx
Installments: Barefoot Power
Subsidised: EnerGCare
Cross subsidised by non-BOP customers: WakaWaka

For nearly all of the mentioned companies, solar appliances for BOP customers represent a business unit in the company. The service mix beyond selling appliances includes advisory (Restio), sale to non-BOP customers (SungridGroup), and traditional electrical equipment (EZYLight).

The development and production of these appliances is normally done without external funding, and working business models do exist, however their profitability and sustainability require further investigation.
d.light designs, develops and sells affordable solar powered lanterns to households and schools with no electricity access, aiming for ‘extreme affordability’.

The company operates in over 44 countries in Africa, Asia and South America, and have sold over 1 million lanterns. It has been largely financed by traditional venture capital and social impact investors, such as Grey Ghost, Nexus India Capital and the Acumen Fund.43

d.light sells its products through distribution partnerships with existing organisations such as M-Kopa, micro franchise networks, gasoline or LPG distributors and NGOs.

The entry level product, the A1 light, retails for $9.99 (R140), which the company sells as “the world’s most affordable quality solar lantern, ever (d.light, 2017)”. This low price can be achieved through a no-frills design, production in Asian markets, and the Give Light Programme, which connects individual donors with NGOs distributing the product.

According to d.light, once the product is paid off, customers see a 30%-50% income increase based on lower kerosene/paraffin expenses and higher productivity.43

"d.light designs, develops and sells affordable solar powered lanterns to households and schools with no electricity access, aiming for ‘extreme affordability’."
SOLAR APPLIANCES - SUCCESS FACTORS

Not enough is understood about the SA models to compare them to international successes. However, more generally, there appear to be two decisive success factors that stand out in the appliances segment, the distribution channels and affordability/financial sustainability.

- Distribution:
  - Due to the often low population densities in rural unconnected areas, establishing and maintaining efficient distribution channels is crucial to ensure financial sustainability.
  - Partnerships with local retailers and agents are indispensable; the most successful appliance manufacturers have also established strong connections to SHS companies.

- Affordability/Financial Sustainability:
  - Pricing needs to be considered carefully due to the relative high cost of the product in relation to the income of the customers and low level of financial savings. To ensure customer interest, the product price should not be higher than the on-going energy cost in the form of paraffin/kerosene/wood/batteries or other.
  - Financing appliances is key in some instances to ensure affordability but collection of unpaid debt comes with its own perils. Connecting with other financial products and institutions is a good way to share the risk and bind the customer to a broader relationship beyond the product.
  - In contrast to self-sufficient products, rechargeable lanterns and batteries require charging stations, which are often operated through micro franchises. This creates an on-going revenue stream and incentives for maintenance, as well as a reduction in the upfront costs.
  - Self-sufficient products may have a bigger impact in remote areas as they do not require any charging infrastructure.

Beyond these two core elements another success factor is the quality of the technology. Too often low quality products are distributed and then fail, causing frustration among users who blame renewable energy solutions, as opposed to poor quality products provided by ‘benevolent’ aid organisations.
Energy Provision at the Base of the Pyramid

International Models

Other International Models
OTHER INTERNATIONAL MODELS

Internationally, there are an abundance of other solutions to the energy needs of the poor beyond what has been covered in this report, using different sources, and designed for various uses and distribution models. A few outstanding examples include:\(^{44, 45}\)

- Pedal Powered Water Pumps (IDEI & Proximity Designs): by developing low cost pedal powered water pumps and irrigation systems ($15-35)/(R210-R490), companies like Proximity Design reduce the arduous and time consuming task of water collection and have been proven to create 33% more yields at zero variable cost. The savings on fuel and time can be used for other activities and modular upgrades with solar panels.

- Solar thermal applications to process food are rare, but interesting business models such as Fruits of Nile (FoN) have emerged. FoN connects local fruit and nut producers with international markets by providing the farmers with solar thermal dryers on an interest-free loan, training and quality control. This increases product shelf life and lowers transportation cost, allowing local small-scale producers to tap into international markets and earn 200% more than their average income.

- Micro scale hydro (IBEKA) and wind (blueEnergy) technologies have matured, resulting in a lower CapEx making them plausible for new business models. These technologies are also applicable in rural contexts, addressing a material need for affordable off grid solutions. IBEKA builds community owned micro hydro stations in Indonesia and have installed more than 57 grids to date, benefitting more than 50,000 people. The CapEx is usually grant funded, and households pay $1-$2 (R14-28) per month to cover operations and maintenance.\(^{44, 46}\)
PARTING THOUGHT

As previously stated, more than any other Sub-African country, South Africa is both the closest and has the greatest potential to provide universal access to affordable energy. However, to realise this ambition will require: a new mix of centralised and decentralised solutions; new, flexible financial markets to fund these decentralised solutions; greater local government control in policy, planning and the funding process; and, supportive legislation, which removes encumbrances and encourages private sector entrants. Most importantly, the goal of universal access will remain a distant ambition without bold entrepreneurs with the courage to enter new markets with new products and services, and with the determination to keeping trying until commercially viable, scalable models emerge.

This report intends to provide both a snapshot of what is currently happening, but also motivation to enter where others have yet to venture.
RELEVANT LITERATURE

44. Ashden. Ashden champions and supports sustainable energy leaders to accelerate the transition to a low-carbon world. Available at: http://www.ashden.org/.