

Energy Access in South Africa

a toolkit for developing
successful green mini-grids

For more information please visit:
http://www.cityenergy.org.za/uploads/resource_426.pdf

The Carbon Trust, with support from the British High Commission's Prosperity Fund, has produced a toolkit which provides key information to mini-grid stakeholders, including municipalities, to develop operational mini-grid projects in South Africa. It includes information on the key success criteria for establishing successful mini-grids, sustainable business models, key project stages and outlines the things that you will need to think about along the way.

This mini-guide serves to provide a snapshot of some of the themes explored in the toolkit.

For the full toolkit please visit:
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What is a mini-grid?

- Mini-grids serve the same purpose as the main grid – to provide electricity to households and settlements. This electricity can be used for lighting, cooking, and other services such as water pumping or refrigeration.
- Rather than being part of the main grid, mini-grids are decentralised generation and distribution systems, built to reduce capacity constraints and supply end users in an unserved or underserved location. They can be autonomous or grid-tied systems.
- They typically deliver an intermediate level of service demand, serving communities in areas where grid extension is uneconomic and which require a consumption and service above that offered by Solar Home Systems (SHSs).
- Levels of electricity service correspond to 'Tiers' of the Global Tracking Framework. Mini-grids are able to deliver service corresponding to Tiers 2, 3 and 4, where SHS would be considered Tier 1, and main grid Tier 5 and above. Tiers 2-4 correspond to 50-2000kWh/household/year.
- Mini-grids can be considered 'green' when they use a renewable source of energy for power generation.
- Cost reductions and business model innovations are making green mini-grids cost-effective electricity solutions.



The case for mini-grids in South Africa is now compelling

The benefits of mini-grids to South Africa

- South Africa's national grid provides access to **85%** of South Africans but suffers from capacity and connection constraints, which are a barrier to the economy and the development of renewable energy.
- South Africa's New Household Electrification Strategy, initiated by the Department of Energy in 2011, states that although a 90% electrified target is possible, the rest will have to be off-grid.
- South Africa currently has an aging transmission grid infrastructure and there are challenges associated with grid congestion and increasing grid connection costs.
- **The Eastern Cape (64.5%)** and **Kwazulu Natal (67.0%)** have the lowest grid connection rates in South Africa, and the South African National Energy Development Institute (SANEDI) estimates that more than 3 million people in rural areas of South Africa are without access to electricity.
- South Africa is an energy intensive and growing economy which means that current energy challenges are likely to increase.
- Expectations of grid connection and quality of service are high within South Africa, including amongst those who are not yet connected to the grid.
- Currently, only **9% of South Africa's 45GW** of generating capacity is renewable (**86% coal**). South Africa has a target to increase renewable energy generation from **4GW to 13.225 GW by 2025**, and cap emissions at **600MT CO₂ by 2025** (current levels are **400MT CO₂**). There is therefore a big opportunity for green mini-grids to drive a more sustainable energy system.
- Green mini-grids provide South Africa with an opportunity to overcome current capacity constraints, reinforce the grid, and provide improved service delivery while increasing renewable energy generation.
- In South Africa, solar mini-grids could be ideal for electrifying communities due to the abundant solar resources that are available across the country.

Non-grid solutions are recognised as being necessary to effectively serve the c 3.4 million households without electricity in South Africa

South Africa Developments	Mini-grid Developments
Rising cost of grid electricity and municipality budgetary constraints	Falling costs of renewable technologies and energy storage
Need for quality, lifetime and level of service beyond SHSs	Increasing reliability and better quality of service
Grid congestion & connection backlog	Demand-side management technologies & strategies
Mobile money services available	Better remote payment and monitoring technologies
Growing awareness of renewable energy	Innovative business models

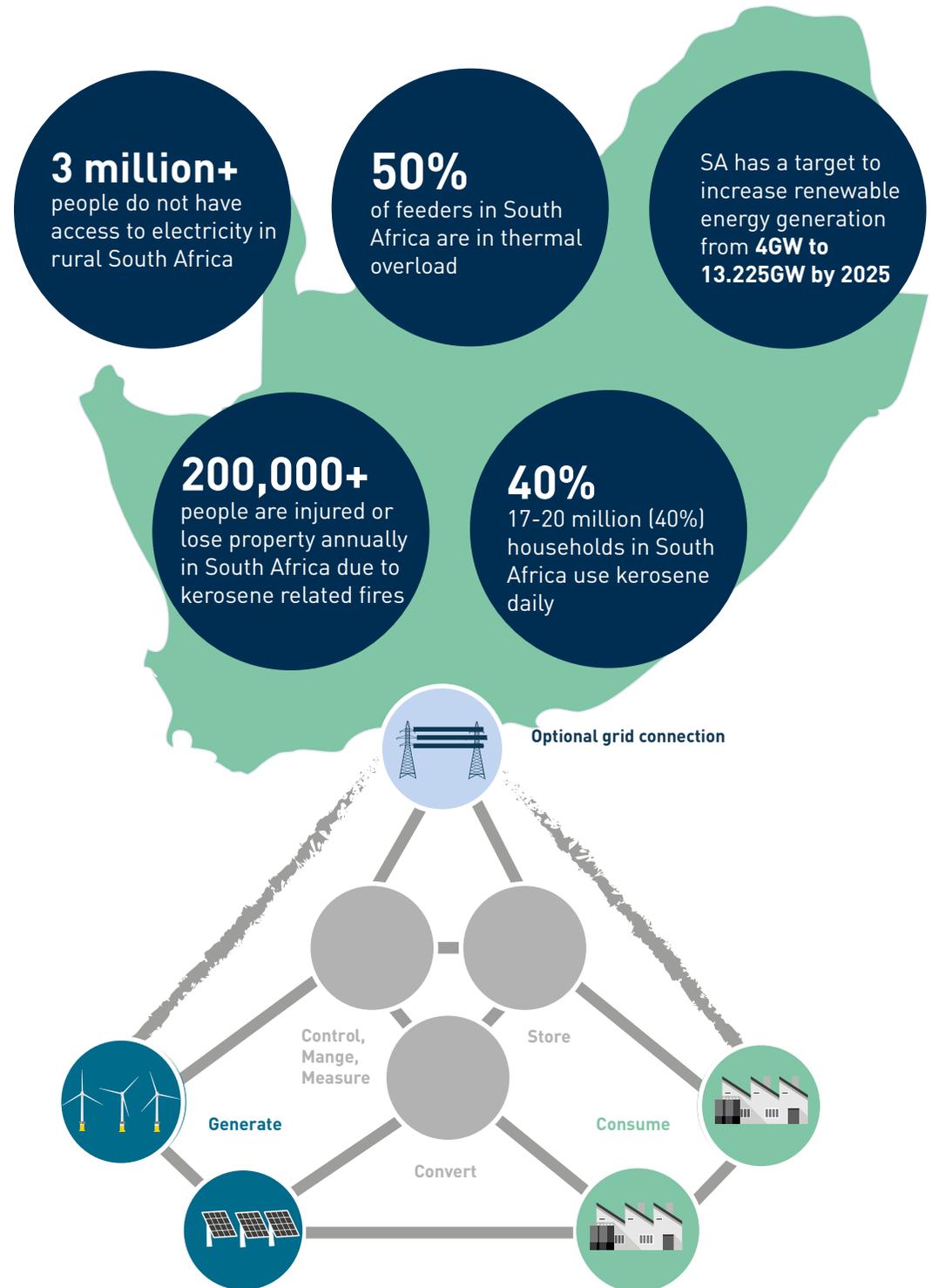

Mini-grids for South Africa

The benefits of mini-grids to communities

- Mini-grids benefit **socio-economic development**, particularly of lower income households, through job creation, improved education and **gender equality** (e.g. lighting enables increased literacy and gender equality by enabling women and children to study during the evenings).
- They provide **health benefits** – electric lighting replaces kerosene and paraffin which are used by **17-20 million** households in South Africa and which cause severe respiratory health conditions.
- They can be used to power water pumps.
- Mini-grids create **income generating opportunities** – the level of service from mini-grids can be sufficient to enable the powering of small companies and appliances such as refrigerators and battery charging stations, resulting in poverty alleviation. They provide higher energy consumption than solar home systems.
- A large enough mini-grid may provide further **health and educational benefits**, such as powering vaccine refrigeration or school computers, although the supply stability to achieve this can be a challenge.

How might mini-grids benefit municipalities?

- A mini-grid will ultimately be the primary provider of electricity locally, which will reduce the local demand for grid electricity and decrease budgetary pressure on municipalities to invest in new grid infrastructure.
- Mini-grids, through the provision of mid-tier electricity can enable the development of local industries, and create jobs.
- For remote communities, rural locations combined with low consumption makes grid extension too financially costly. For communities close to the congested main grid, the high cost of upgrading the main grid to accommodate their connection can also be uneconomic. Mini-grids provide the lowest cost option to increasing energy access in many areas.
- Mini-grids will also reduce the amount of grid infrastructure that the municipality must build to connect new customers.
- In some circumstances, the mini-grid may also be structured to ease congestion and provide additional connections in wealthier areas, e.g. for the development of new housing estates, which in turn can generate new income streams for the municipality.



What might a green mini-grid look like in South Africa?

- Grid-tied mini-grids, combined with isolated mini-grids for deep rural locations could offer the best route for 100% electrification in South Africa. The following key features are recommended for South African mini-grids.
- **Solar Powered:** South Africa enjoys high solar irradiation with limited seasonality which means that PV, potentially combined with solar thermal, should be the generation technology choice. Solar also benefits from low operational and management costs.
- **Grid-code compliant AC systems:** this means they can be part of the main grid as it grows, and avoids the need for DC appliances.
- **Grid-tied:** via a 60A farmer's connection where possible. This will enable constant service, regardless of possible system failures, and dramatically reduces cost as storage requirements are lowered.
- Utilise **before-the-meter energy storage** as a shared resource. Lithium-iron battery technology is currently best suited for this application and should be used ahead of Lead Acid due to lower lifetime costs.
- Use **energy storage and generation** to provide services back to the main grid (e.g. energy and frequency response).
- A **demand scheduling technology** should be used to manage the mini-grid and protect the integrity of storage technologies.
- **Accessible location:** good road access is recommended.

A toolkit for successful project development

With support from the British High Commission, the Carbon Trust has produced the South Africa Mini-Grid Toolkit for key stakeholders in South Africa. The toolkit acts as a reference document for the development of sustainable business models and operational off-grid projects in South Africa.

- It recommends pathways to develop a business case and revenue model for mini-grids.
- It provides guidance on business models, financing strategies and community engagement.
- It includes learnings and best practices from mini-grids in other countries.
- It provides further information on funding opportunities.

The toolkit also provides details of **additional sources of information**, including:

- Western Cape Government Environmental Affairs & Development Planning – provides a 'How to' guide that describes timeframes, steps and best practices.
- EU PDF Mini-Grid Toolkit financial model – provides default cost estimates.

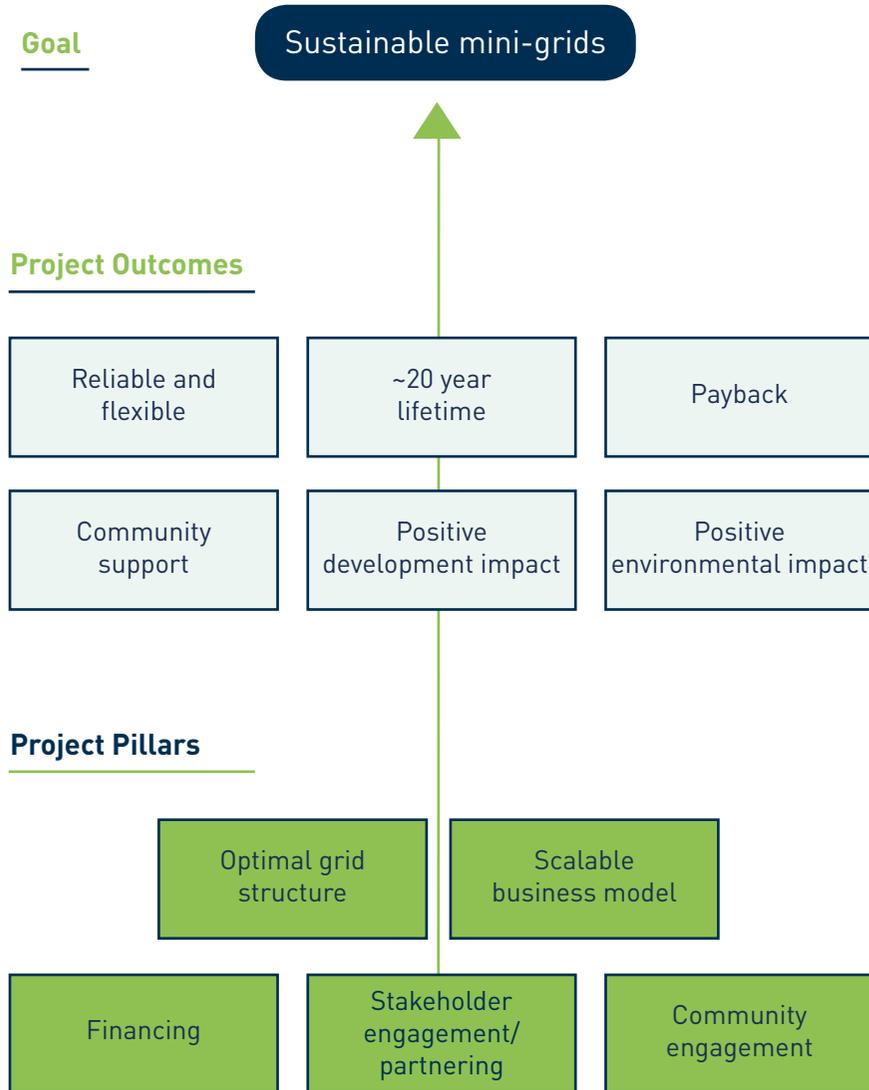
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A pathway to successful mini-grids in SA

Key success criteria for establishing mini-grids

The toolkit proposes the following pathway for developing successful green mini-grids in SA. We explore the **five key pillars** in detail:



Project Pillar	Success Criteria
Optimal mini-grid infrastructure	Design simple, integrated, replicable, modular grid
	Target highest possible quality of service
	Plan for demand management & scheduling tools
Scalable business model	Leverage existing infrastructure for balancing
	Develop a public-private partnership initially
	Develop payment model adapted to customers' ability to pay and consumption growth
	Define clear ownership and responsibilities model with project developer(s)
	Target accessible off-grid population zones
	Identify local champions and baseload customers
Financing	Maximise data collection and utilisation
	Identify sources of capital and operating subsidies early on in the process
Stakeholder engagement & partnering	Adapt source of finance to stage of project development
	Identify local innovative providers of finance
	Exchange information with peer projects
Community engagement	Identify and engage with key market entry enablers
	Ensure buy-in through direct and early engagement
	Develop local employment and ownership
	Deliver training and manage expectations
	Align with community structures, other initiatives and local and national economic development goals

Some example considerations from the toolkit

Permits and other regulatory requirements will be required.

- Obtaining licenses - a distribution license will be required for a mini-grid operator.
- Ensuring compliance - with grid codes and technical standards.
- Securing planning permission – this is subject to the relevant authority.
- Environmental Impact Assessment - check with the local provincial department of the Department of Environmental Affairs whether your project requires an EIA (most likely not required).
- Procurement standards – the Municipal Supply Chain Management Regulations set a minimum procurement standard which all municipalities have to adhere to.

Health and safety procedures will need to be established.

Funding – financial sustainability of mini-grids is one of the main challenges for developers and additional funding support is often needed.

- There are a number of sources of finance that can be applied for.
- Successful applications for funding require the preparation of documentation and financial and business models.
- Financial stability can be achieved by designing and scaling the system to achieve a suitable payback period within the regulatory restrictions.

Geospatial datasets can be used to compare electrification models.

Training is recommended for users of mini-grids.

Local manufacturing can lower costs of mini-grid development.

Pilot Projects are recommended to unlock mini-grids as a mainstream energy technology in South Africa.

- There is a need to demonstrate key technical, business case and contractual aspects of mini-grid models for S.A.
- Successful pilots can unlock public financing that is currently available for other modes of electrification.
- Pilot projects will not require a license.
- It should be possible to access international donor funding for the development of a pilot mini-grid project.