

Sustainable energy solutions for South African local government



A practical guide

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Overview

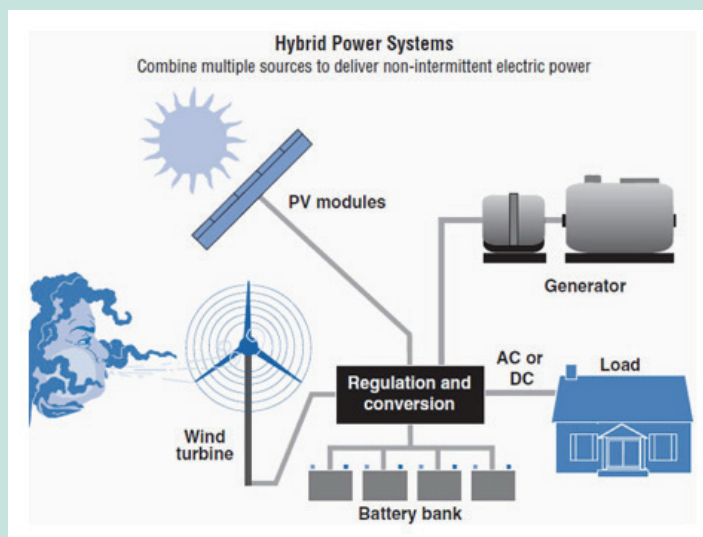
A hybrid system is an energy supply system that uses more than one source of energy. The term is used for vehicles and electricity supply systems. Examples of vehicles are hybrid cars that can operate alternatively on electricity or petrol, and hybrid busses that can operate on petrol or natural gas.

There will be a specific focus on decentralised hybrid systems to generate electricity. They include grid connected systems combining solar PV and wind turbines. Both sources generate electricity intermittently. Combining the technologies in a hybrid system expands the time during which electricity from renewable resources is available and minimises the need to draw electricity from the grid.

Many hybrid systems combine variable renewable resources such as solar PV with diesel or gas powered generators and/or batteries for storage to balance the variable supply. These systems can supply electricity at any time and are typical off-grid solutions. They are used for mini-grids or single properties in remote areas not connected to the electricity grid.

Figure 1 shows an off-grid hybrid system consisting of solar PV panels, a wind turbine, generator and battery bank (see case studies 1 and 2).

Figure 1: Off-grid hybrid systems supplied by solar PV, wind, batteries and back-up generator



Source: US Department of Energy <http://energy.gov>

Implementation

In South Africa hybrid systems have been piloted in a private public collaboration¹ in two mini grids in the Eastern Cape, one for the Hluleka Nature Reserve (see case study 1 below) and the other for neighbouring Lucingweni village consisting of 220 rural dwellings. The pilot projects were initiated by the Department of Minerals and Energy (DME) in 2003. They were implemented jointly by the National Energy Regulator of South Africa (NERSA), CSIR, Shell Africa and the Eastern Cape Provincial Government. The projects have been evaluated by the DME in 2008² and by the DEA and the South African National Energy Development Institute (SANEDI) in 2012³ with rather negative reviews (see case study 1) and no further mini-grid projects have been developed in South Africa. However valuable lessons have been learnt and the DEA / SANEDI evaluation concludes that:

1 www.energy.gov.za/files/esources/renewables/r_hybrid/html

2 DME (2008) Mini-grid hybrid viability and replicability potential.

3 SANEDI DEA (2012) Sustainability of decentralised renewable energy systems report.

Macro Developments

"... this service delivery alternative should continue to be considered [...]. This is in part due to the ability of mini-grids to supply energy for productive use, which is a necessary input for economic growth and job creation in rural areas. The mini- and micro-grid concept is making something of a comeback as solar PV prices continue to fall and grid extension process continue to mount. [...] Yet, in order to achieve positive outcomes, more attention needs to be invested in developing mini-grid technologies in terms of the design and business model, as well as ensuring community buy-in." (SANEDI, DEA 2012 p. 44)

Another example of hybrid energy solutions is mines that are complementing diesel generators with renewable energy such as solar PV. These have proven to be financially viable as case study 2 shows.

Hybrid systems are more likely to play a role in municipalities that incorporate remote areas not connected to the electricity grid. In these areas hybrid systems powering micro grids may be more viable than the extension of the national electricity grid. In these cases the local electricity supplier – Eskom or the municipality – can promote and facilitate the installation of hybrid systems to power micro-grids. Experiences of the pilot projects covered below should be carefully considered.

Grid connected hybrid systems require the approval by the electricity distributor (Eskom or the municipality). In addition, grid-connected systems need a NERSA generation license if they are larger than one MW. Off-grid systems do not require a generation license or approval by the electricity distributor. However all installers of hybrid systems must approach the municipality to establish the need for a development application and approval according to the town planning legislation and building regulations (see section: Municipal mandates, powers, functions and regulatory responsibilities).

Financial Aspects

Off-grid hybrid systems are relatively expensive. As their components vary according to local resources and demand it is not possible to provide cost estimate. The financial viability of hybrid systems is expected to improve with the reduced capital costs of the renewable components such as PV panels.

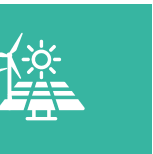
These systems are being considered for rural electrification but the costs of power are often prohibitively high for poor users. However, they have proven to be financially viable in remote locations such as small islands or mines where they replace or complement expensive diesel generated electricity.

Barriers and Opportunities

The main barrier for hybrid systems supplying rural communities is cost.

Another barrier is the technical complexity of the systems due to their many components that need to work together seamlessly. Local trained personal to operate and maintain the hybrid system is necessary to manage a hybrid system successfully and over a long time.

A further barrier is the imitations of the system that cannot provide the same level of service as the power grid, e.g. the capacity of a hybrid system is limited and overloading will result in its collapse. Very clear communication to manage the expectations of the user community is needed to overcome this problem.





Case Study 1: Hluleka Nature Reserve*

The Hluleka Nature Reserve is located 20km south of Port St. Johns at the Wild Coast. Before installing the hybrid system the nature reserve had strongly reduced its electricity consumption by replacing electric stoves with gas stoves and electric geysers with solar water heaters. Energy saving light bulbs were also installed.

The hybrid system consisted of two 2.5kW wind turbines mounted on 6.5m high poles, 56 PV panels of 100W each (5.6kWp), inverters, a battery bank to provide 5 days reserve electricity, and a diesel generator as back-up. The system was designed to carry the household load of chalets as well as the load of the water pumping and purification system.

The DME evaluation states that the design and construction of the system was sound but proved to be too small for the load. The evaluation criticises the high cost of electricity estimated at R5.35/kWh (compared to around R0.30/kWh for grid electricity in 2007). They also critique the lack of monitoring that should have been central to a pilot project and made the project difficult to evaluate. At the time of the DME evaluation one wind turbine was not functioning and some solar panels had been stolen as shown in the photograph below. The reason for theft was that the system was installed far away from the reserve where it was not properly secured. The electricity supply relied strongly on the diesel generator

The main concern raised in the DME evaluation was the lack of a maintenance budget and trained staff to operate and maintain the system. The components of the system were imported and when an inverter broke down a technician had to be flown in from Germany. The limited sense of ownership and lack of management were the principle causes of the poor performance.

Recommendations focus on involvement of the beneficiaries of the electricity and management. This should start with an accurate assessment of electricity demand. It is recommended to then use a modelling tool for sizing the system. A financing and revenue model must be developed that covers costs of operations and maintenance. The recommendations also state that a mini-grid in a rural area generally involves the following role-players whose responsibilities must be clearly defined. These are:

- ◆ Regulatory authority (licensor)
- ◆ Project developer
- ◆ Engineering consultant
- ◆ Contractor
- ◆ System operator
- ◆ Maintenance contractor
- ◆ Training provider
- ◆ Users

The evaluation by DEA and SANEDI found that the hybrid system was relying wholly on the diesel generator at the time of their evaluation in 2012.

* This case study draws extensively from Ortiz, B. et al. (2009). Potential for Hybrid PV Systems for Rural South Africa, in: Proceedings of Solar World Congress 2009: Renewable Energy Shaping Our Future. Unless referenced otherwise, information is sourced from this document.

Figure 2: Renewable energy components of hybrid system at Hluleka Nature Reserve



Source: Ortiz et al. (2009) Potential for Hybrid PV Systems for Rural South Africa, in: Proceedings of Solar World Congress 2009: Renewable Energy Shaping Our Future.

Figure 3: Vandalised PV panels at Hluleka Nature Reserve



Source: DME 2008 p.18





Case study 2: Thabazimbi Chrome Mine in Limpopo*

The Thabazimbi Mine uses a hybrid system supplied by solar PV and diesel generators. The Thabazimbi area is remote with only limited grid connection and high transportation costs for diesel. The area has high solar irradiation making it ideally suited for the use of PV. Since 2012, a solar PV system with a capacity of 1MW complements the diesel generated electricity. The PV system generates up to 1.8GWh per year and minimises the fuel consumption during the day. It saves the mine up to 450 000l of diesel and reduces CO₂ emissions by up to 1200t per year.

Considering the estimated installation costs of R20m and the estimated annual savings for diesel of R4m, this hybrid system is financially viable.



Figure 4: PV installation at Thabazimbi Mine



Source: Paul Robert Stanka <http://en.sma-sunny.com/en/first-pv-diesel-hybrid-system-in-the-megawatts-goes-into-operation/>

* www.SMA.de/en/products/references.htm