Renewable energy

Short reports 2021

Renewable energy short reports 2021

Introduction

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Battery Energy Storage Systems

Introduction

South Africa is facing many electricity-related challenges, including variable renewable energy generation on the power system, ongoing load-shedding and steep increases in electricity cost. Energy Storage Systems (ESS) have the potential to mitigate some of these issues. Examples of these ESS include pumped hydro storage, compressed air energy storage and battery energy storage. Battery energy storage systems (BESSs) are of interest due to their flexibility to be applied to many different applications and are location independent (as opposed to for example pumped hydro storage).

The main uses for BESSs are grouped into two categories. Firstly, in stationary applications such as backup power and peak shaving. Secondly, in mobile applications such as electric vehicles and cellphones. The type of BESS application needs to be aligned with the right BESS technology to maximise the value that can be gained.

Suitable applications

The uses of BESSs for stationary application are typically categorised according to where the BESS will be installed on the utility's transmission lines, on the utility or municipality's distribution network, or behind the meter at industrial, commercial or residential customers' sites, as shown in Figure 1. This location often defines the size of the BESS to be implemented.

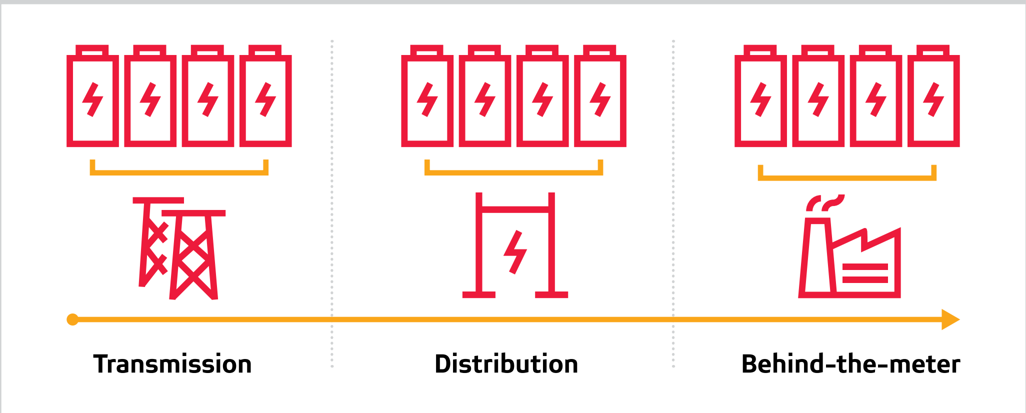

***Figure 1:** Grouping of BESS implementations for stationary applications.*

Applications or use cases of BESSs depend on where the systems will be installed, who owns the systems, and the regulatory and financial feasibility context within which the systems will be operating. A breakdown of typical applications can be seen in Figure 2.

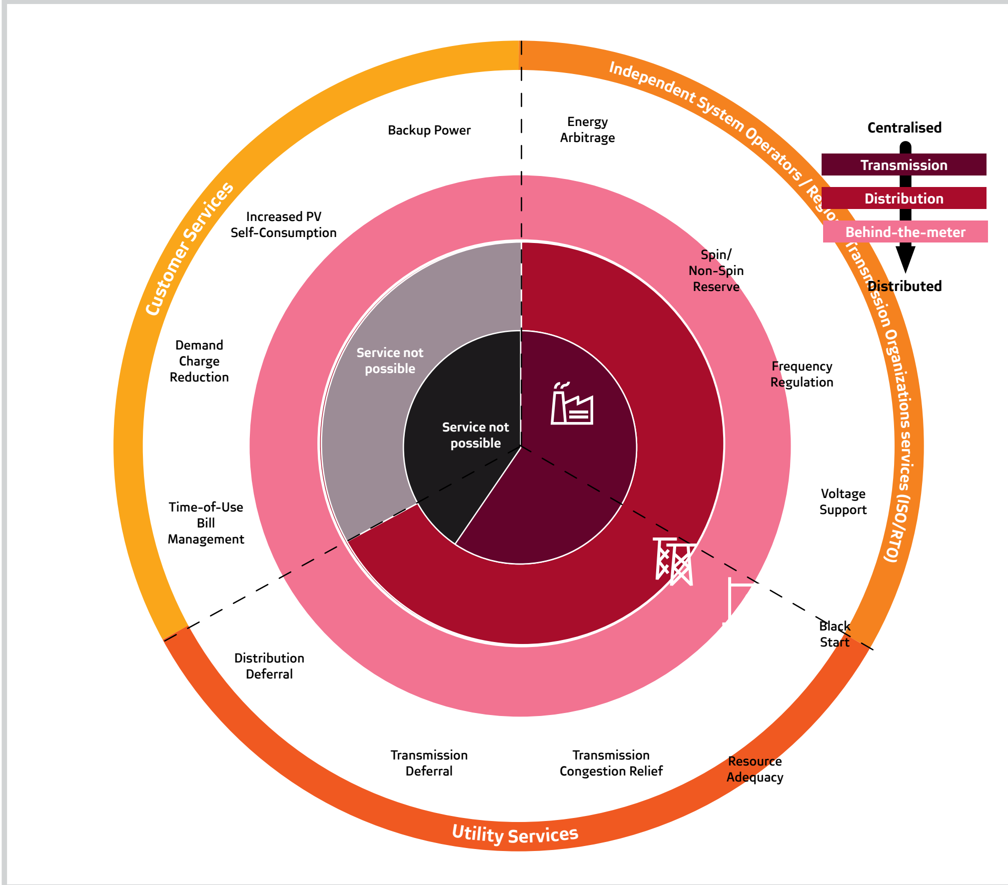

***Figure 2:** Applications of BESS spread across three different user groups. Source:[3]*

Some of the more typical applications for BESS are discussed below (peak-shaving, increased photovoltaic (PV) self-consumption, arbitrage and network upgrade deferral), to demonstrate how value can be extracted from BESS.

Peak shaving – The cost to the electricity grid increases as the demand for power increases. Often the country's demand is so high that "peaking generation" units such as gas turbines need to be used to meet it.

Due to the costs of running these peaking generation units, the electricity tariffs during these "peak" times are therefore also more expensive than during "off-peak" times. As shown in Figure 3, shaving this peak can be beneficial to both the utility, which saves on expensive fuel, and to the end customer, who saves on monthly electricity costs.

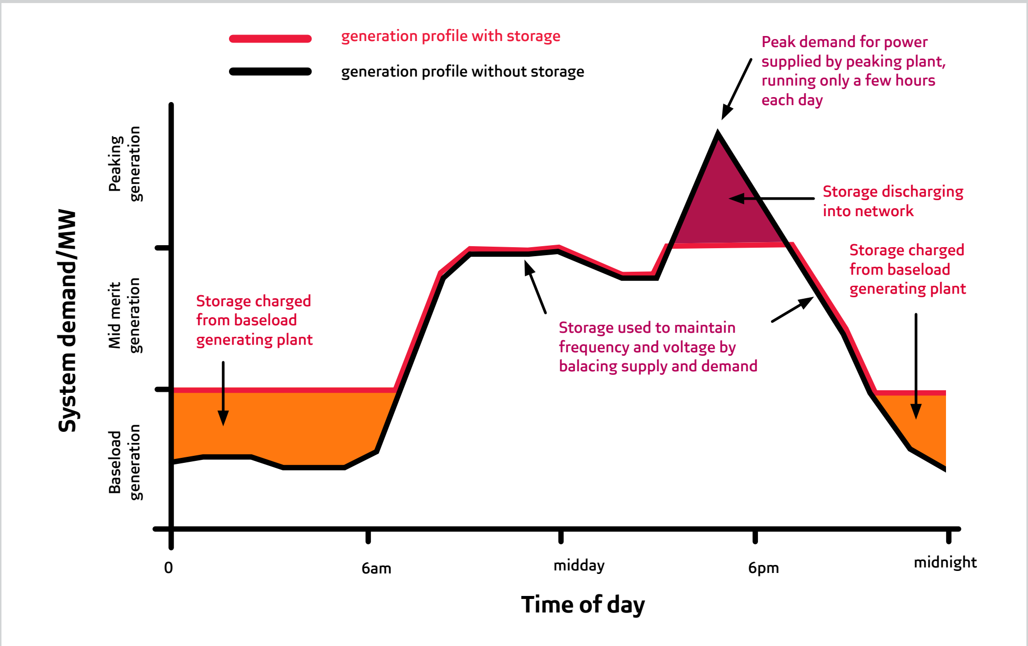

Figure 3: ***Peak shaving application for BESS. Source: EE Publishers***

Increased PV self-consumption – The challenge with renewable energy, including PV panels, is that resource availability (e.g. the sun) does not always coincide with demand. This is especially problematic for residential or commercial customers who are often not allowed to supply their excess PV energy back to the utility (generated when there is more solar resource than demand at their premises). BESSs allow these customers to save this excess PV energy for later use as illustrated in Figure 4, thereby increasing the customers' self-consumption of their PV energy.

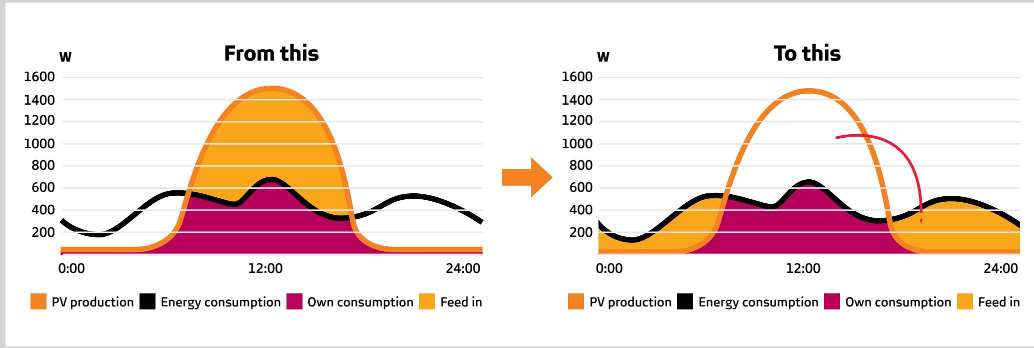

Figure 4: ***PV self-consumption. Source: www.redelectrical.co.uk***

Arbitrage – The value of energy, as with any commodity, is inherently linked to the demand. The higher the demand, the higher the price for energy would usually be. Capitalising on this pattern can be achieved by charging a BESS during low-demand periods at a low cost, with the energy stored then sold again at a competitive price during high-demand periods. A visual example of this can be seen in Figure 5 where the green zone indicates low energy prices and the red zone indicates high energy prices. The difference between the two is an indication of the value that can be obtained.

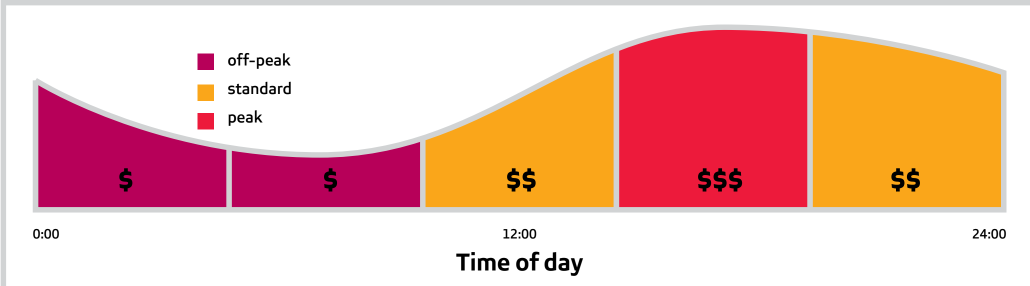

Figure 5: ***Arbitrage cycle for BESS, demonstrating a value extraction opportunity. Reconstructed from: energystorageconsultants.com***

Network upgrade deferral – A town or supply area may grow to such an extent that the peak demand exceeds the power capability of the current network infrastructure (wires, transformers, etc). Upgrading this infrastructure to meet the increasing demand during peak hours can be an expensive endeavour for a utility.

To mitigate this problem, a BESS can be installed to assist in providing additional power during these peak times as a supplemental source of energy to defer the cost of upgrading the network. A visual representation of this can be seen in Figure 6 where the red lines indicate a congested transmission network and the green indicates the supplemental power provided by the BESS to the town.

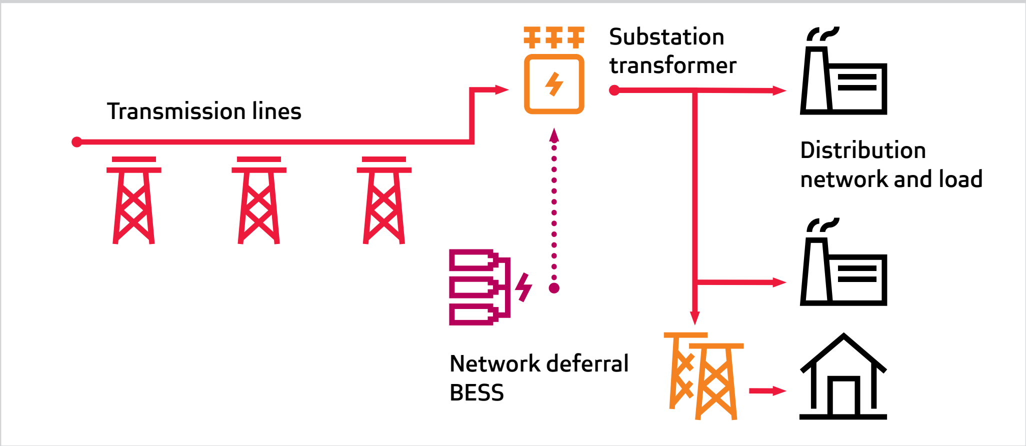

***Figure 6:* BESS assisting with a congested transmission network (red), thereby deferring network upgrades. Reconstructed from: USA Federal Energy Regulatory Commission**

Technology

There are many different BESS technologies available, such as lead-acid, lithium-ion (with many different sub-types), sodium-sulphur and vanadium-redox. These different BESS technologies each have their own key strengths, weaknesses and performance characteristics. Such characteristics include depth of discharge, power output, weight, energy density, response time, safety and thermal performance. For example, lead-acid batteries are very affordable as it is a very mature and well-known technology, at the expense of lifespan and weight, compared to, for example, lithium-ion which is lightweight due to its higher energy density, at the expense of cost.

Aligning specific BESS technologies with different applications can become very complex, and often intricate studies are required. The technology evaluation is usually done on a case-by-case basis to maximise the value that can be extracted from the BESS.
A typical setup for a stationary application of a BESS can be seen in Figure 7.

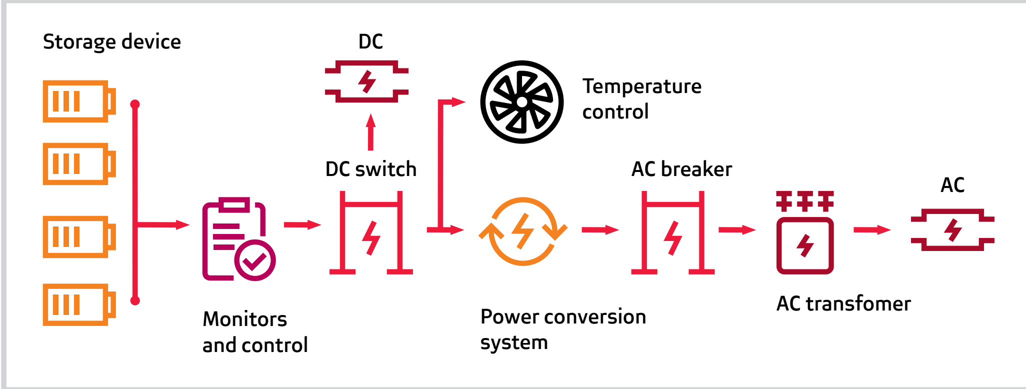

***Figure 7:* Typical BESS setup.**

Maturity

The different energy storage technologies vary in maturity and therefore market readiness.

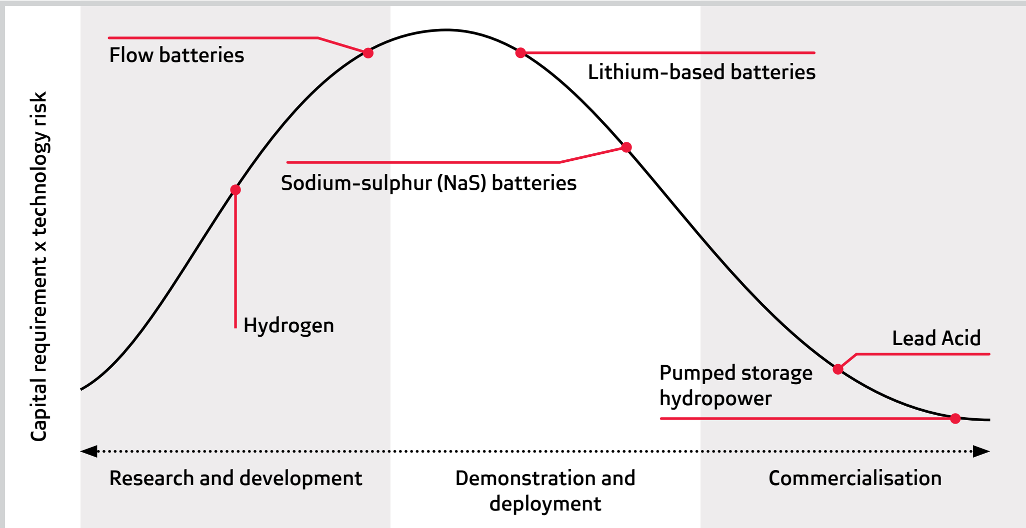

***Figure 8:* Maturity of energy storage technologies. Reconstructed from[2]**

Various battery technologies are still in development while lithium-ion and sodium-sulphur batteries have already moved into the demonstration and deployment phase. Lead-acid batteries, as a mature technology that has been commercialised successfully, remain a popular BESS option due to its affordability.

Financial considerations

The cost of BESSs varies between different technologies as can be seen in Figure 9, and should be carefully considered to optimise the financial viability of BESS projects.

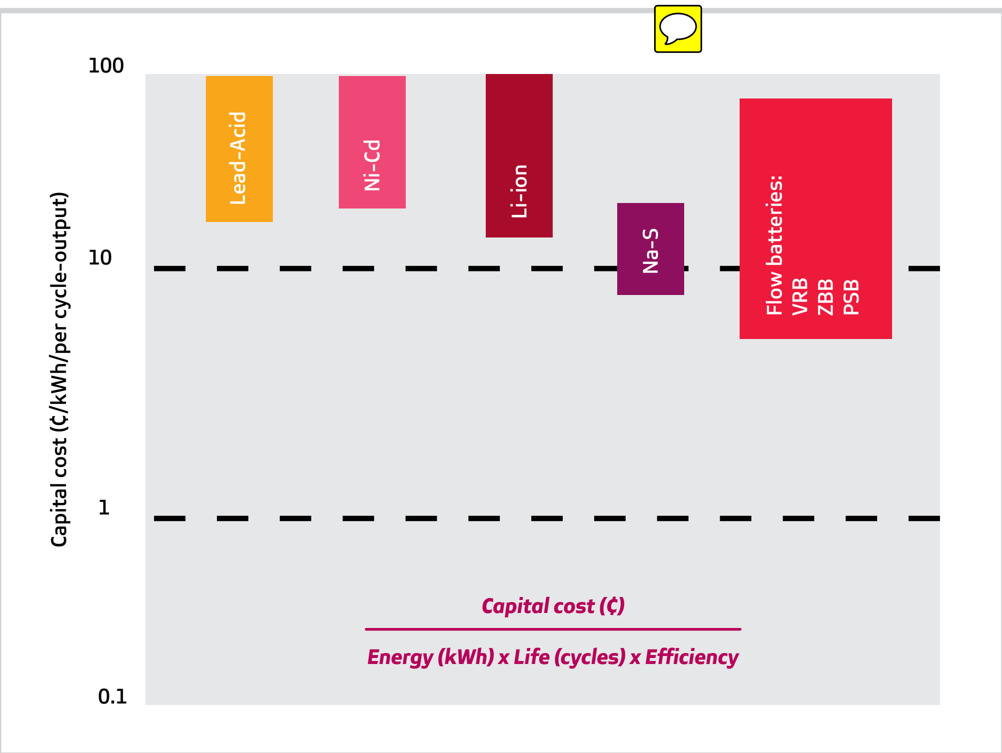

Figure 9: ***Comparing costs for energy storage systems in 2011. Reconstructed from[4]***

Given the fast changes currently occurring in the BESS industry, costings also need to be regularly updated. The fast-decreasing cost of lithium-ion illustrates this point, as shown in Figure 10.

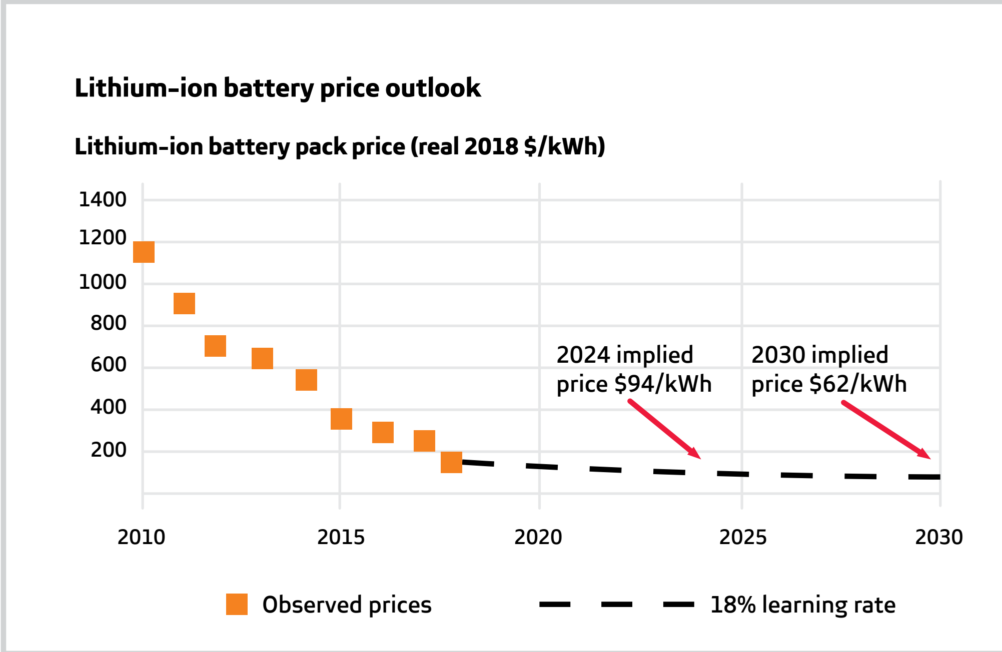

Figure 10: ***Lithium-ion cost trend in 2019. Source: [5]***

Regulations

Although international BESS standards are currently being updated, current BESS regulations in South Africa are mostly written for backup power (uninterrupted power supply) applications.

In the same way hurdles still exist to the free trading of energy stored in BESSs within the South African market. The proposed unbundling of Eskom into different entities, and the publication of the 2019 Integrated Resource Plan which requires potentially significant BESS capacity, might initiate a process to remove some of these hurdles.

The BESS industry holds large potential for growth and can bring benefits to various stakeholders through the many applications available. The future for BESS applications in South Africa is promising as technology prices continue to drop, and the regulatory context matures.

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Biofuels (for self-utilisation, such as fuel for vehicles or diesel generators)

Biofuels (for self-utilisation, such as fuel for vehicles or diesel generators)

Technology

Biofuels are fuels produced directly or indirectly from organic material (biomass). Biofuels may be derived from agricultural crops, including conventional food plants, or from specially grown crops. Biofuel may also be produced from forestry, agricultural or fishery waste products or municipal wastes, as well as from agro-industry, food industry and food service by-products and wastes. Biofuels can be categorised as first-generation or second-generation biofuels, depending on the material from which it is derived.

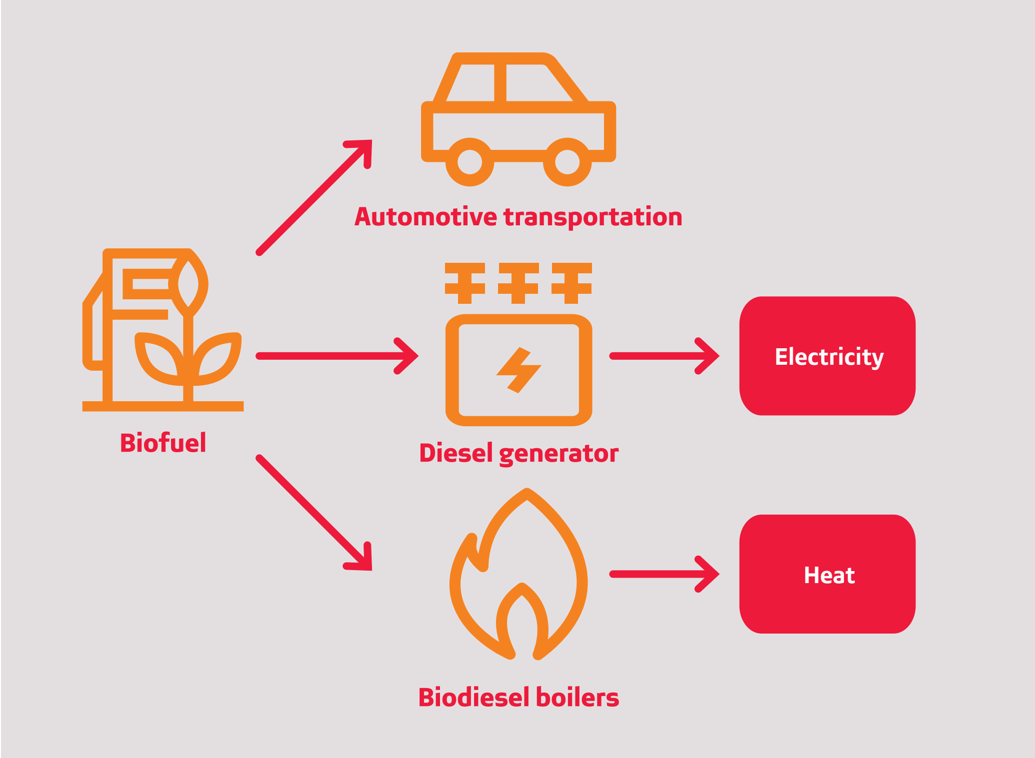
First-generation biofuels are mainly derived from feedstocks such as sugar, starch, fats and vegetable oil. First-generation biofuels are considered less sustainable than second-generation biofuels, due to the fact that if used in large quantities, it would have an impact on food supply. First-generation biofuels constitute the majority of biofuel currently used around the world.

Second-generation biofuels are produced through complex methods from feedstocks that are considered to be more sustainable, such as microorganisms. The sustainability of second- generation biofuel feedstock is defined by its availability, the impact of CO2 emissions, its impact on biodiversity and impact on land use. Currently, second-generation biofuels are under development and not widely used. These biofuels are not covered in this text due to their unconventional production and underutilisation in industry.

The two types of first-generation biofuels which are most commonly used in industry, are biodiesel and bioethanol. Biodiesel is produced from plant oils (oil-rich seeds such as soybeans, sunflower seeds and vegetable oils) and animal fats, which is used as alternative to diesel when blended to create a biodiesel blend. Conventional diesel engines can use biodiesel that has been blended with petroleum diesel at a certain volume ratio. The blend of a biodiesel is described as blend ratios, i.e. B20, B50 or B100. A B20 biodiesel blend means the blend contains 80% petroleum diesel and 20% biodiesel on a per-volume basis, or less (i.e. B50 = 50% biodiesel and 50% petroleum diesel; B100 = 100% biodiesel).

The use of biodiesel in diesel engines means that it can also be used in diesel generators for generating backup or off-grid electricity. Liquid biofuel boilers are also currently being used in residential, commercial and industrial heating applications. Unlike the use of biodiesel in vehicles, these boilers are designed to operate with biodiesel blends with higher blend ratios. Advanced biofuel boiler technologies can operate on biofuel blend ratios from B50 up to B100. These boilers typically have a system efficiency of 85% and can produce hot water of between 60 °C and 80 °C.

Bioethanol, which is also the most common type of biofuel used internationally, is an alcohol produced from organic materials, such as corn, potatoes, sorghum, sugar cane, starches from wheat and vegetable wastes. Bioethanol is primarily used by mixing it with petrol and using it in road transport vehicles.



The use of biodiesel and bioethanol fuels results in less CO2 emissions in vehicles, generators and boilers. Bioethanol typically has a lower energy density (MJ/kg) and produces less CO2 per kilogram burnt when compared to biodiesel.

Various methods can be used to produce biofuels, depending on the feedstock and desired product. A biological process called fermentation is used to produce ethanol. Thermochemical processes such as pyrolysis, gasification and synthesis are used to produce oils and biodiesel.

Biofuels (for self-utilisation, such as fuel for vehicles or diesel generators)

Resource

Biofuels are currently derived from seeds or starch-based feedstock. Large-scale dedicated biofuel production requires many hectares of land. Only 14% of the total land available in South Africa is arable. Used vegetable cooking oil contributes greatly to biodiesel production in South Africa. For ethanol production, large land is required for a sugar cane plantation. Sugar-cane farming is mostly done in KwaZulu-Natal and Mpumalanga.

Within the Draft Position Paper on the Biofuels Regulatory Framework (2014), licensed companies use feedstocks such as sorghum, sugar cane, sugar beets, canola, waste vegetable oil and other crops for the production of biofuels in South Africa. These companies are located in the Eastern Cape, Gauteng, KwaZulu-Natal and Free State provinces. South African government legislation does not favour small- to medium-scale biofuels producers. However, small-scale application is done using waste products such as used cooking oil, chicken tallow and beef tallow. Using waste as a resource limits its application to close proximity to waste sources.

Financial considerations

The production costs are dominated by feedstock (sorghum, sugar cane, etc.) costs, which vary over time. The cost of conventional diesel and petrol also varies with the price of crude oil. Since biofuels are used as a blend of biofuels and conventional fuels, its price per litre will vary depending on these mentioned cost changes.

Biofuel may not always be the financially feasible alternative for replacing conventional, low-cost fuel sources such as coal, diesel and paraffin, but it does offer an alternative solution for reducing CO2 emissions. To be financially feasible, the business model needs to combine environmental and social benefits, and also investigate possible higher value by-products.

With the implementation of suitable incentives and fuel levy rate reductions for the production of biofuels in South Africa, it can be expected that the competitiveness of biofuel will increase as the price of crude oil and other conventional fuel sources increases over the years. It is important to consider the cost of biofuel and relative to the fuel being replaced on a cost-of-energy (R/kWh) basis, and the expected price changes of these fuels over the years of its usage.

Operation and Maintenance

In order to manufacture biofuels, an initial capital cost is incurred to purchase the processing equipment. One should also consider the costs associated with the transport of waste as well, or the costs related to crop production. Biofuel is a specialised field – it is highly likely that a specialist will need to be consulted for troubleshooting and guidance throughout the production process. This is especially the case with thermochemical processes, which can also be energy- (electricity) intensive. Biodiesel is considered to have a high operating cost due to the high energy costs and regular maintenance of equipment. The product is considered to be a clean fuel source if processed correctly, which eliminates any need for modification to the vehicles or generators.

Business model needs to combine environmental and social benefits

Alternative solution for reducing CO2 emissions

Cost of conventional diesel and petrol (substitute)

Investigate possible higher value by-products

Biofuels (for self-utilisation, such as fuel for vehicles or diesel generators)

Suitable implementation

Biofuels can be used in various sectors and applications within the country, where petrol and diesel fuel are used. These sectors include transport, residential, commercial and industrial sectors. The implementation of biofuel production should be considered through investigating the market demand or need for liquid fuels or heat. This should be followed by an investigation into the available sources, preferably waste from existing activities in the region, followed by a detailed sustainability assessment that includes a life cycle assessment and environmental impact study.

Biofuels are suitable for and are commonly used in diesel generators, vehicles and farm equipment, such as tractors. The use of biodiesel in conjunction with biodiesel boiler technologies has a good potential for being implemented for low-temperature commercial and industrial heat applications.

Regulations

Currently, biodiesel production in South Africa is restricted by the South African National Standards (SANS) 1935 automotive diesel fuel standard, which is the voluntary standard for biodiesel producers. It stipulates that biodiesel should be a fatty-acid methyl ester (FAME) derived only from vegetable oil. This means that either oilseeds or their subsequent crude vegetable oil can be used for the production of biodiesel in South Africa. The regulatory framework that governs and relates to the production of biofuel in South Africa is listed below with a short description of the document:

- **Biofuels Industrial Strategy (2007):** This document identifies the potential role of biofuels in the country and also sets out targets for the penetration of biofuels on the national fuel supply, as put forward by government. The document also provides information on the incentive schemes to be put into place for achieving the strategy goals.

- **Mandatory Blending Framework of Biofuels (2013):** This document identifies the mandatory blending ratios of biofuels and biodiesels in South Africa. It also states that licensed petroleum manufacturers would have to purchase biofuels exclusively from licensed biofuel manufacturers in order to implement a blending concentration ration of 5% biodiesel blending with diesel and 2% to 10% concentration of bioethanol blending with petrol.

- **Draft Position Paper on Biofuels Regulatory Framework (2014):** This document published by the Department of Energy (DoE) provides more coherent legal framework for biofuel and biofuel production in the country by addressing concerns of financial viability. Furthermore, it provides the requirements for a biofuel producer to become licensed and the criteria which producing companies have to meet to qualify for the subsidy. In the document the DoE also developed a Biofuels Pricing Framework which serves as an incentive to potential biofuel producers and investors to enter the biofuel market.

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Biogas

Technology

Biogas is a mixture of methane, carbon dioxide and trace gases produced from organic matter such as agricultural wastes (agrowastes), manure, municipal waste, plant material, sewage, green waste or food waste. Biogas is considered a renewable energy source if managed sustainably. Methane is a greenhouse gas and can contribute significantly to climate change if not managed properly.

Biogas is typically produced through the breakdown of biodegradable waste through anaerobic digestion. Anaerobic digestion occurs when bacteria break organic matter (biomass) into organic acids, which are further decomposed into biogas in the absence of oxygen. Digestion can either be in wet or dry systems. In wet systems, the feedstock is converted to a slurry mixture with 80%-95% water content. The feedstock requires treatment prior to the decomposition process in the digester. In dry systems, or more precisely solid state fermentation, the moisture content is much lower (less than 75%).

Typically small/medium commercial scale biogas plants are rated at a capacity of 25 kW to 250 kW, and plants of more than 250 kW is considered to be large-scale biogas plants or digesters. The heat produced from burning biogas depends on the ratio of methane to carbon dioxide. A large methane to carbon dioxide ratio means that more heat can be produced. One of the byproducts of biogas production through anaerobic digestion is organic fertiliser.

The biogas produced through anaerobic digestion in small-scale biogas plants can be used for electricity production or heating, or both, which is referred to as a combined heating and power (CHP) plant. The picture above shows the basic layout of a typical biogas CHP plant.

The feedstock (manure, energy crops, agrowastes, etc.) used to produce biogas is stored in the slurry tank. The feedstock is transferred into the digester in which biogas is produced through the process of anaerobic digestion. The additional storage tank is used for the effluent produced by the anaerobic digestion process. This effluent matter can be used as biofertiliser. In typical small-scale biogas energy systems, the gas from the digester or storage tank is transferred to a CHP gas engine which is used to drive a generator to produce electricity. The waste heat from the gas engine can be used for a number of applications, such as heating the digester to optimum temperature, space heating, heating water or for process heat applications. The biofertiliser produced during the digestion process can be used for farming purposes or sold to relevant markets.

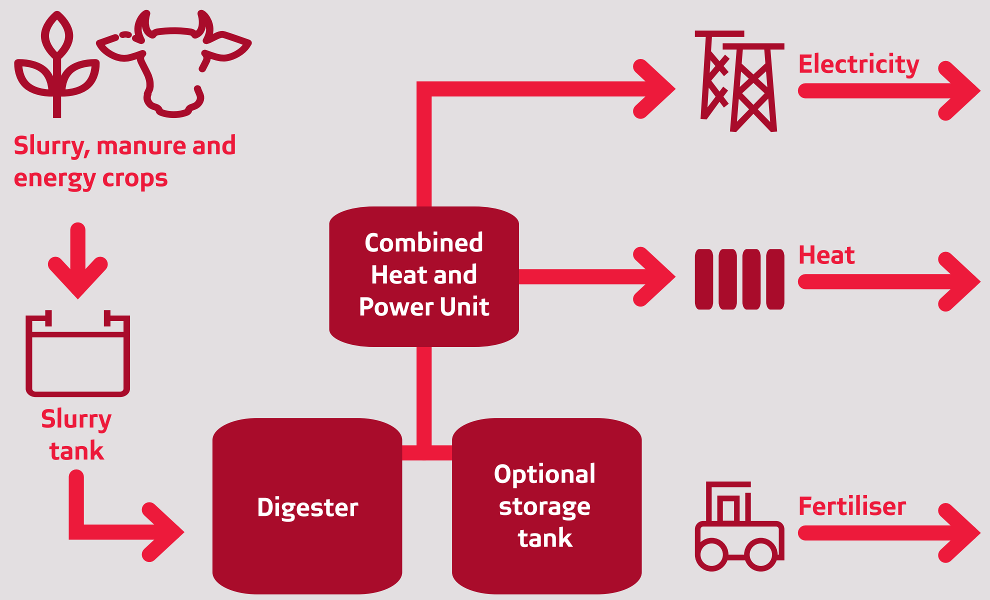

Figure 2: *Figure 1: Basic layout of an anaerobic digester CHP plant (http://www.rawad.co.uk/farmers/technology/)*

The anaerobic digester is the most critical part of a biogas energy plant. Advanced instrumentation is required for the monitoring and control of the complex microbial decomposition of the organic matter process by ensuring that the necessary organic matter is fed into the digester at specific times and the necessary temperature and pH balances are maintained. This not only allows the digestion to occur more efficiently and produce more biogas, but also ensures a high quality effluent discharge for fertiliser, a consistent supply of high quality biogas production and an extended plant lifespan.

Biogas plants can provide a relatively reliable source of energy throughout the year, depending on the variability and availability of feedstock used for anaerobic digestion. Biogas can be generated on both small and large scale. In most small-scale applications where the sewage waste and other organic wastes from households and communities are used as feedstocks, the biogas generated is only used for heating purposes.

Resource

Energy from biogas is considered to be a renewable energy source, since waste and residues from forestry and agriculture activities are used, and this is consistently available. Currently, organic waste used in small-scale biogas energy plants are primarily sourced from the livestock sectors (manure), meat processing sectors (abattoirs) and the agro-industrial sector in South Africa. Biogas can also be sourced from landfills in the form of landfill gas, which is usually done at a very large scale. Treated municipal sewage waste can also be used for biogas production as the main feedstock, or it can be mixed with other organic waste. South Africa has a relatively large farming and waste industry which may provide stock for the local small-scale biogas industry or small-scale biogas plants.

A report published by the Deutsche Gesellschaft Fur Internationale Zusammenarbeit (GIZ) and prepared by the Agricultural Research Council, entitled Estimating the Biogas Potential for Electricity Generation from the Agrowaste Industry: A Resource Assessment for South Africa, identified the potential of electricity production of biogas from wastes produced by agroprocessing, meat processing and livestock sectors per province in South Africa. The overall findings of this study are shown on the right.

The study done by the GIZ shows that there is good potential for the use of biogas from these sectors, especially the livestock farming and agroprocessing sectors, in provinces such as Gauteng, KwaZulu-Natal, Western Cape and Eastern Cape.

The resource availability of biogas feedstock is highly dependent on the specific feedstock used for anaerobic digestion. The primary feedstock(s) used for anaerobic digestion is available throughout the year, although it could be region-specific. Certain feedstock(s) required for anaerobic digestion may only be accessible in regions of the country where these industrial activities are localised, for example agro-industrial and meat processing wastes, and would be a challenging and costly undertaking in regions of the country where these resources are not available.

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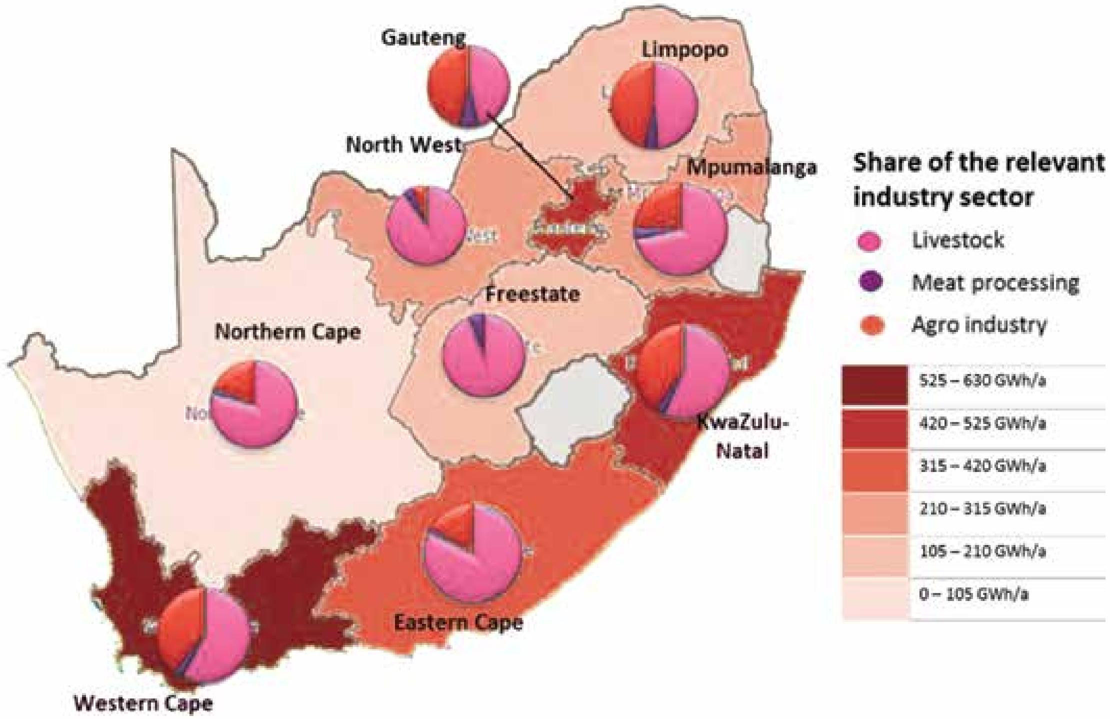


Figure 1: *http://www.biogasassociation.co.za*

Financial considerations

Operation cost driven by the costs and availability of feedstock

The successful operation is labour intensive and requires skill and a clear understanding of the processes to maintain a working plant

Often, biogas is used for heating purposes only (negating the need for purification)

High capital costs (cost depends on capacity of the plant and quality of biogas produced)

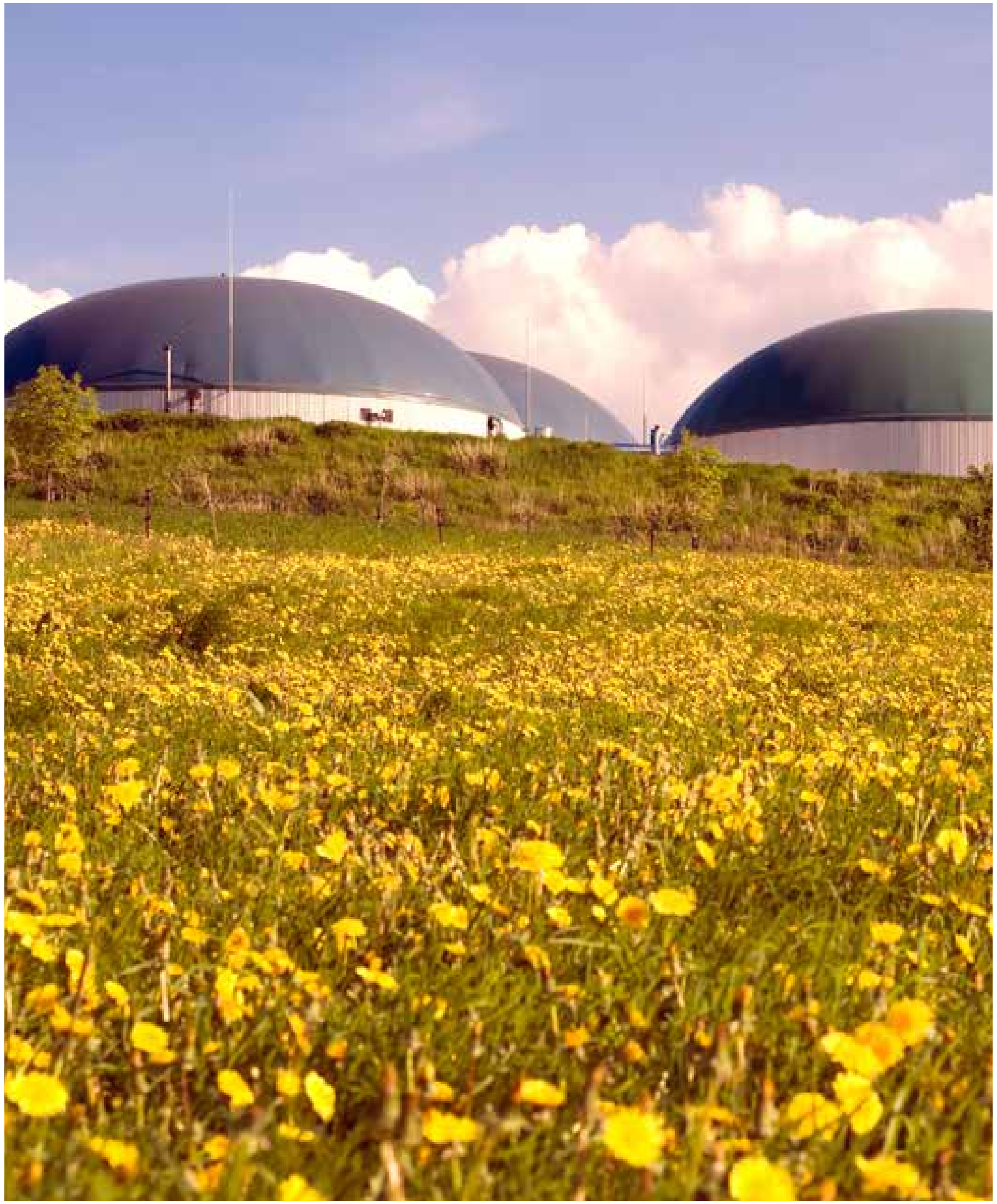
The cost of biogas plants or digesters depends on the capacity of the plant and the quality of biogas produced. For high quality biogas, also known as biomethane production, the biogas needs to be purified and is normally used for electricity generation. However, this raises the capital and operational costs of the biogas plant. In most cases, the biogas is used for heating purposes only, negating the need for purification. Such plants have relatively low capital costs. These costs are dependent on the material used for the gas storage and process plant, which can either be plastic bags, clay, cement or steel structures.

In most cases, biogas plants are not financially feasible when only considering energy production. A business case can however be made for many systems when byproducts and waste processing are involved.

Currently there is a lack of financial and regulatory incentives such as grants, subsidies and tax cuts related to biogas production in South Africa. Another challenge experienced by the implementation of biogas digester plants, especially for large-scale installation, is the high capital costs. The cost of energy (R/kWh) from small-scale bioenergy plants can be variable and is largely dependent on the operation cost driven by the costs and availability of feedstock year on year. These costs could vary significantly for each project based on locality and feedstock. The way in which the plant is intended to be operated over its lifespan would also influence the overall cost of energy and the financial feasibility thereof.

Operation and maintenance:

It should be noted that small-scale biogas plants can be simply built and require little maintenance when used for heat. However, since the process of anaerobic digestion uses live bacteria, it is highly sensitive to various environmental factors and slow to respond. A small error in the feed volume, pH level, temperature or type of feed can result in the complete failure of the system. The successful operation of the plant is labour intensive and in many cases it requires skill and a clear understanding of the processes to maintain a working plant.



Suitable implementation

There is currently quite a number of large-scale digesters in South Africa and more are being developed. These are typically being implemented at landfill and industrial and municipal wastewater treatment sites. Small-scale digesters are being implemented and targeted at smaller commercial facilities within the meat processing sector (abattoirs), agroprocessing sector (fruit processing, sugar milling industry, dairy industry, breweries, wineries, etc.) and livestock sector (cattle, dairy, pig and poultry farming, etc.), where very good potential has been identified.

Biogas produced by low-cost residential digesters is commonly used in South Africa for heating purposes only, especially for cooking. The potential exists for using biogas for generating electricity and heat in rural areas of South Africa to supply residences, schools, villages, etc.

In South Africa, there are several companies providing biogas plant solutions for energy production. Biogas for energy production is a suitable alternative to provide heat and electricity for companies and agricultural activities in localised areas. The implementation of biogas plants within the agro processing, meat processing and livestock farming sectors could prove to be a sensible renewable energy solution when using waste as feedstock. Agricultural and farming activities with large yields of organics could use biogas energy as an alternative energy source.

Biogas production through anaerobic digestion presents a market opportunity for livestock farmers. Biogas can be used for heating purposes on farms (such as dairy farms) and can reduce their dependence and associated costs of waste processing services. The remaining residue which is rich in nitrates (i.e. nutrients required by plants) can be sold as high quality fertilisers to surrounding crop farmers.

Regulations

The licencing requirements for biogas projects are not clearly stipulated in current legislation, but the following laws and regulatory frameworks have an impact on the development of biogas plants in South Africa. The regulatory frameworks are listed along with the relevance to the biogas sector.

- **National Environmental Management Act (Act No. 107 of 1998):** This Act identifies a number of environmental issues and related matters which need to be considered. Furthermore, the Act provides principles for decision-makers and sets procedures for government officials involved in environmental management. It also explains environmental matters of sectors such as waste management, air pollution, etc.

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  An environmental impact assessment (EIA) would have to be undertaken in terms of this Act, depending on the design and scale of a biogas project. Other relevant authorisations may also be required, such as a waste management licence, water use licence, atmospheric emission licence and land use planning authorisation.

- **Electricity Act (Act No. 41 of 1987):** The Act provides information on electricity generation and electricity supply in South Africa. Furthermore, it confirms the role of the Electricity Board (Energy Regulator).

- **Electricity Regulation Act (Act No. 4 of 2006):** Biogas developers need to familiarise themselves with this Act to better understand technical requirements of biogas installations specifically for electricity production. Although generating licences are not required for renewable energy projects that do not feed/sell electricity to the national grid and are smaller than 1 MW, biogas projects is an exception. The Gas Act (Act No. 28 of 2001) stipulates that all biogas plants should be registered with NERSA.

- **Gas Act (Act No. 28 of 2001):** According to these regulations, all owners of biogas projects are required to register with the National Energy Regulator of South Africa (NERSA). It provides regulations and requirements for the storage licensing, production activity registrations and trade licencing of biogas.

- **Public Finance Act (Act No. 1 of 1999):** Most of the developmental institutions which are the biggest funders of biogas development in the country, are governed by the Public Finance Management Act. Potential biogas developers will have to familiarise themselves with the provision of this Act, to assist them in their investment decisions.

The use of biofertiliser through the anaerobic digestion process is governed by national regulations. The Department of Agriculture, Forestry and Fisheries published a document which outlines the guidelines for the registration of Group 3 fertilisers, which includes biofertilisers, in order to permit its production and use. This document was issued by the registrar of the Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act (Act No. 36 of 1947) and was effective since 1 March 2016.

Renewable energy Short reports 2021

Biomass

Technology

Since early history, human beings have been producing energy from biomass for their principle source of heat. Modern technologies are much more efficient and cleaner than traditional open fires that use processed biomass, such as logs, wood chips, wood pellets, charcoal and wood briquettes are used.

Biomass is a fuel derived from organic matter and can be used directly to produce heat or be further processed to produce biofuel (e.g. biodiesel and bioethanol) or biogas (methane). When biomass is burnt, the chemical energy in the material is released as heat. This heat can be used for industrial processes or to generate steam to drive steam turbines for generating electricity.

Biomass used as fuel can be classified into two categories, namely woody biomass and non-woody biomass. Woody biomass includes forest residues, untreated wood waste (e.g. sawmills by-products), crop residues (e.g. straw) and short-rotation woody crops (e.g. willow or invasive plant species). Non-woody biomass includes animal waste, agricultural activity waste, industrial and municipal waste, processing waste and high-energy crops (e.g. rapeseed, sugar cane and maize).

In most cases where short-rotation woody crops and high-energy crops are grown specifically for the purpose of energy production, they are referred to as energy crops. The non-woody biomass such as agricultural, animal, industrial and municipal waste requires further processing to develop other fuel products, such as biodiesel and biogas, and are unlikely to be used in a standard biomass boiler.

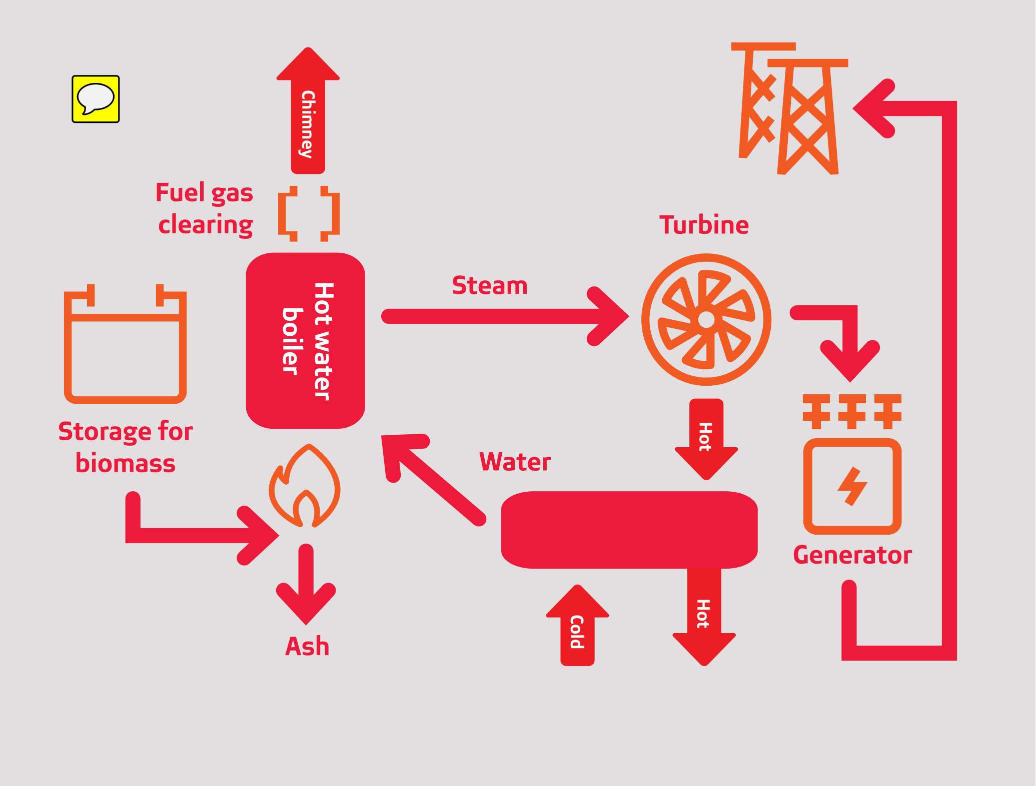
In small-scale biomass-fired power plants, biomass feedstock (i.e. wood, wood waste or sugar cane waste) is burnt frequently in the form of chips, pellets or briquettes to produce heat. With sufficient heat, steam can be generated and be used directly for heat supply, or for electricity generation in a steam turbine, or both, known as a combined heat and power (CHP) plant. The heat generated by small-scale biomass boilers can also be used for space heating in buildings or for supplying heat to industrial processes.

Unlike other renewable energy sources, biomass energy systems emit carbon dioxide (CO2). However, if managed correctly, this CO2 is taken from the atmosphere by replacing the plants and trees, to allow for a sustainable cycle. This CO2 cycle means that biomass can be considered to be a renewable energy source when managed sustainably. The CO2 emissions released when burning biomass is significantly less than the emissions from conventional fuel sources, such as coal and oil.

Biomass

The majority of today's small-scale biomass plants use woody biomass feedstock from forest residues and wood processing waste. Biomass has a high moisture content and low density, and requires further processing for efficient burning. Pellets or briquettes are manufactured by compressing the byproducts from the forestry industry and are burnt as fuel in boilers. Currently, short-rotation energy crops are not commonly used in small-scale biomass power plants, although it shows good potential as a sustainable feedstock for producing energy on a larger scale. A good potential has been identified in the use of high-energy crops, such as sugar cane bagasse, exploitable alien invasive plants and pulp and paper industry wastes for the use as feedstock for energy production in small-scale biomass plants.

Figure 1 below shows the basic components of a conventional biomass CHP plant for producing electricity and heat. With modern technology, most of the plant processes can be automated.



The bunker stores biomass, which is fed into the boiler and burnt. Water is heated in the boiler at a high temperature and pressure to generate steam. The steam is used to drive a turbine or screw- type engine, which is connected to a generator to produce electricity. The figure shows that steam passed through the turbine can additionally be used in district heating networks, for space heating in buildings or industrial process heat. The steam generated by the boiler could solely be used for providing industrial process heat that doesn't require the use of a turbine.

Resource

South Africa has limited potential for bioenergy when taking rainfall constraints, food security and variability of supply into account. There are however, some niche applications for energy crops, but the most attractive source of biomass is organic waste and alien species.

Energy from biomass is considered to be a renewable energy source, since the fuel that consists of waste and residues from forestry and agriculture activities, as well as wood processing, is consistently available. In order to ensure the energy security from the biomass fuel and for it to be considered a renewable energy source, these wastes and residues have to be managed and used in a sustainable manner and not exploited in large quantities. This is more critical when considering the use of energy crops as feedstock for bioenergy plants. With the use of energy crops, it is critical that these plantations are established, managed and harvested in a sustainable manner.

Figure 2 below shows the Bioenergy Atlas of South Africa, developed South African Earth Observation Network (SAEON), which especially shows the model results of the resource availability of all woody biomass from chipping and pelleting in South Africa.

The online database also provides resource maps of other mentioned small-scale biomass energy plant feedstock, namely invasive alien plants and sugar cane. It can be seen from the resource map that the availability of pelleted and chipped woody biomass exists around the southern and eastern coastal regions as well as the north-eastern inland regions of the country.

It is important to consider the supply availability and cost of the biomass feedstock from source(s) over the operational lifespan of a bioenergy plant. South Africa has large farming and forestry sectors which produce tons of organic waste per year. However, availability of this waste may be subjected to variability of farming/forestry industries.

Although invasive species are considered a good source of biomass, it is by nature a limited resource that will no longer be available once it is eradicated.

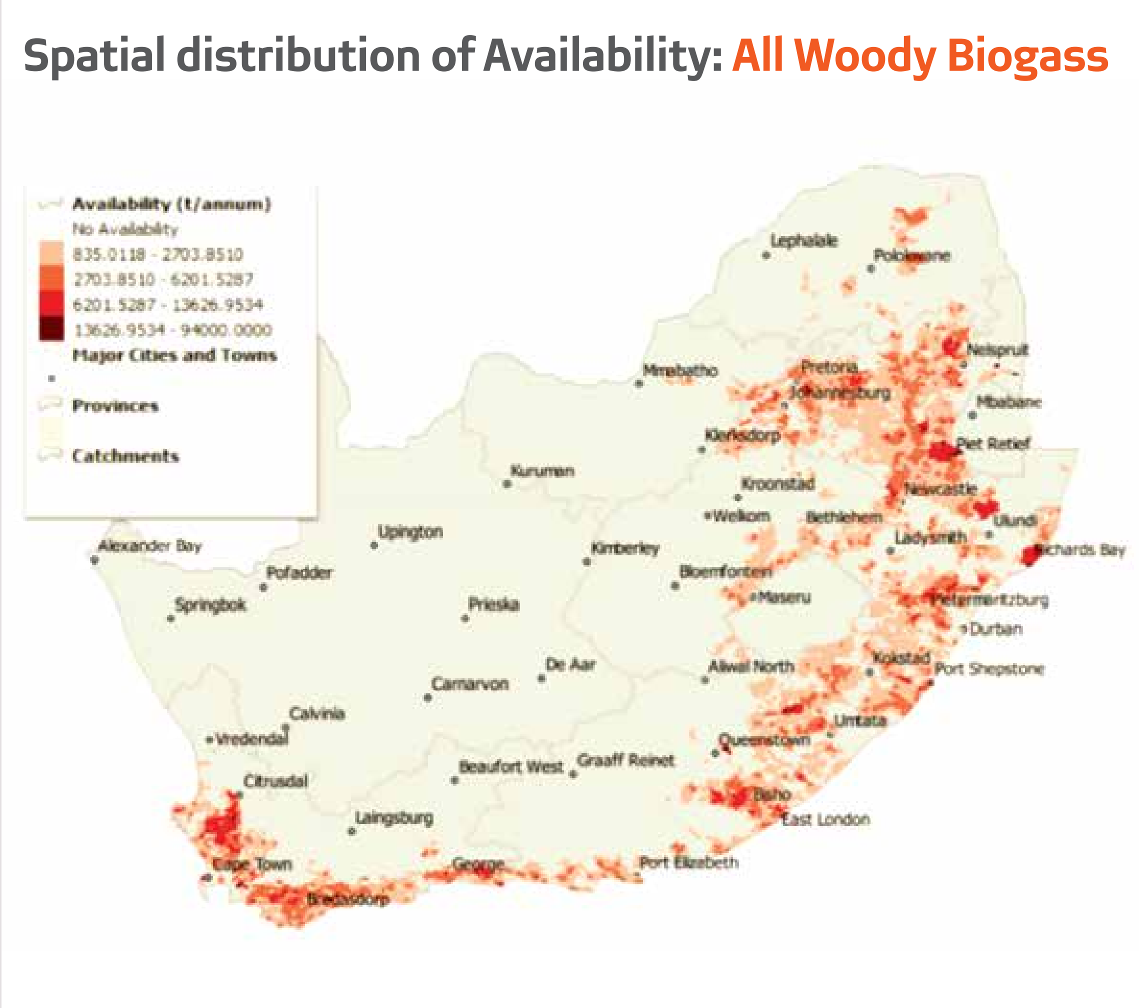


Figure 2: The resource availability of all woody biomass from chipping and pelleting in South Africa (http://bea.dirisa.org/themes-1/models-and-forecasts)

Financial considerations

Quality, variability and cost of pelleted and chipped biomass feedstock

Land availability and usage, depending on the area required and scale of the plant

Require a considerable amount of maintenance

Higher tariffs

The quality, variability and cost of pelleted and chipped biomass feedstock can significantly contribute to the total operating costs of a small-scale biomass energy plant. A crucial consideration is based on the value of the type of biomass used and the financial viability of it being used for energy production as opposed to other uses in a different market. The cost of energy (electricity or heat) produced from bioenergy plants will to a large extent represent the financial feasibility of biomass projects.

The cost of energy (R/kWh) from small-scale bioenergy plants is highly variable and dependent on a number of factors, namely capital cost, maintenance costs, the cost and variations of chipped or pelleted biomass feedstock over a year of operation, the quality of feedstock and the manner in which the plant is operated each year. The cost of energy should be compared to current energy costs for an individual or company when using biomass to replace existing electricity or heat sources, while taking expected rises in electricity and fuel costs into consideration.

If not externally sourced, the provision and use of energy crops also possess the cost consideration of land availability and usage, depending on the area required and scale of the plant. This would have a significant impact on the overall costs, the feasibility thereof, as well as the cost of energy generated from the small-scale bioenergy plant.

Small-scale bioenergy plants have the potential to not only offset the electricity consumed from the national utility provider, Eskom, and the use of conventional fuel for heat production, but also to grow the local clean energy industry, generate revenue from biomass-related enterprises and further establish the technology and market within the country.

Operation and maintenance

It should be noted that small-scale bioenergy plants require a considerable amount of maintenance when compared to other renewable energy technologies (e.g. PV and wind) and considerable operating capacity, as expected with the operation of any other boiler technologies. Bioenergy plants require frequent monitoring and cleaning (ash), which will further be influenced by the type and quality of the feedstock. The operational costs and cost of energy of small-scale bioenergy plants are largely influenced by the costs of sourcing the biomass. In the case of invasive species, the cost is attributed to the removal of the plants, transport to a facility, processing of the material (pelletising, drying, etc.) and the labour involved throughout the process.

Suitable implementation

Most biomass can be used for higher value applications, such as biomaterial, biochemicals and biofuels. Using biomass for energy is considered a low-value use. As such, biowastes, such as invasive plants, agricultural residues and green waste refuse are more suitable for use as a heat source or for electricity generation.

The key consideration for a biomass energy plant is the availability of a consistent supply. Sensible locations for the adoption of small-scale biomass energy plants are within regions or in close proximity to waste biomass material in large quantities, as well as areas where other potential feedstock such as sugar bagasse and exploitable alien invasive plants exist. These areas will exhibit lower costs of biomass feedstock as transportation costs would be minimised, which in turn decreases the operational costs of small-scale biomass energy plants.

Industries such as the sugar cane, pulp and paper, sawmill and wood processing industries and various agricultural/farming activities have for a long time been considered as sectors in South Africa with good potential for using biomass waste and residues for the generation of heat and electricity through small-scale bioenergy plants. In some cases, the operation of these plants are aligned with other initiatives, such as the Department of Environmental Affairs' Working for Water (WfW) programme, which aims to eradicate alien species.

Biomass-to-electricity plants are rarely implemented in grid-connected areas due to the relatively low cost of electricity. Most feasible biomass plants are used for generating heat only. Small-scale biomass energy plants for heat and electricity production is a sensible solution in rural areas where energy access is problematic, and low-income informal settlements within the country where the majority of people rely on burning wood for cooking and space heating.

Regulations

As put forward by the Department of Environmental Affairs, there is currently no specific comprehensive legislative framework that governs the waste-to-energy sector and specifically the use of biomass for energy production. However, there are individual pieces of legislation that deal with certain aspects of waste-to-energy. This legislative framework is identified and listed below:

- South African National Environmental Management Act (Act No. 107 of 1998): This Act identifies a number of environmental issues and related matters that need to be considered. Furthermore, the Act provides principles for decision-makers and sets procedures for government officials involved in environmental management, and also explains environmental matters of sectors such as waste management, air pollution, etc. Other relevant authorisations, such as an atmospheric emission licence, may also be required.
- **Electricity Act (Act No. 41 of 1987):** The Act provides information on electricity generation and electricity supply in South Africa. Furthermore, it confirms the role of the Electricity Board (Energy Regulator).
- **Electricity Regulation Act (Act No. 4 of 2006):** This Act exempts the requirement for a generation licence when installing a renewable energy system, such as a biomass power plant, which has a capacity of less than 1 MW, and permission has been received from the relevant network owner (municipality or Eskom).

Renewable energy Short reports 2021

Electric Vehicles

Introduction

Transportation has been a key driver of economic and social activity, and one of the largest and fastest-growing energy sectors. This sector contributes around 10% of South Africa's greenhouse gas emissions [1], with around 90% of these emissions caused by petrol and diesel internal combustion engine (ICE) vehicles. The uptake of electric vehicles (EVs) is envisaged to be an important part of low-carbon technology pathways for transportation in South Africa.

The South African policy landscape supports the uptake of EVs in the transportation sector. The Department of Transport has introduced the Green Transport Strategy 2018-2050, aimed at promoting cleaner mobility in general and EVs specifically in South Africa [2]. In December 2018, the Department of Trade and Industry has also released the Automotive Masterplan for 2035, which highlights the importance of industry and government investing in the required infrastructure to keep abreast of the global move towards EVs [3].

SA's adoption of EVs is gaining traction. From a fleet of around 1 200 plug-in EVs currently (mid 2019), it is projected that there could be as many as 145 000 EVs on local roads in the next six years, according to the Director of uYilo e-mobility, Hiten Parmar.

In the South African submission to the Paris Agreement on climate change [4], the government indicated that it would support 2.9 million EVs to be used on SA roads by 2050 and ZAR 6.5 trillion to be invested in the EV industry over the next four decades.

Technology

There are various propulsion technologies available in the automotive market. These technologies include, but are not limited to:

- ICE – Internal combustion engine, typically running on petrol or diesel. This makes up most of the vehicles in the South African market.
- BEV – Battery electric vehicle. Vehicles are powered purely by a high-density battery energy storage system. BEV is often denoted just as EV.
- HEV – Hybrid electric vehicle. A combination of ICE and BEV, with the BEV charged by the ICE and regenerative braking only.
- PHEV – Plug-in hybrid electric vehicle. An HEV that is also chargeable at home/work/ charging station directly from the electricity grid.
- FCEV – Fuel cell electric vehicle. Uses hydrogen technology instead of batteries as the energy storage technology.
- EREV – Extended range electric vehicle. It is a type of PHEV configured to use the ICE only as a backup engine.

A practical example of the current maturity of EV technology would be to compare current ICE and EV models with similar specifications. Given South Africa's present low EV uptake levels (which might distort aspects such as purchase price), the table below compares two EV and ICE models recently launched in the USA. USA purchase prices are used (excluding government purchase price incentives), while South African fuel and electricity costs are assumed.

As can be seen below, the EV's maximum driving range remains the specification that compares least favourably with the ICE equivalent:

Specification	ICE	EV
Purchase price in the USA	$32 500	$35 000
0-100 km/h	8.1 sec	5.6 sec
Max range	796km	352km
Top speed	250 km/h	208 km/h
Power	140 kW	285 kW
Torque	250 Nm	441 Nm
Warranty	4 years/80 000km	4 years/80 000km
Fuel consumption	17.5 km/l	5.16 km/kWh
Fuel cost per unit fuel in SA	R15.83/l	R1.54/kWh
Fuel cost per km in SA	R0.91/km	R0.30/km

Financial considerations

Major funding towards commercialisation has led to a rapid decrease in the price of EVs, and significant global uptake.

EVs promise to be more affordable than ICE in the long run when considering the purchase price as well as running costs. Figure 2 plots these costs over a four-year period during which the EV and the ICE are assumed to have both driven 100 000km.

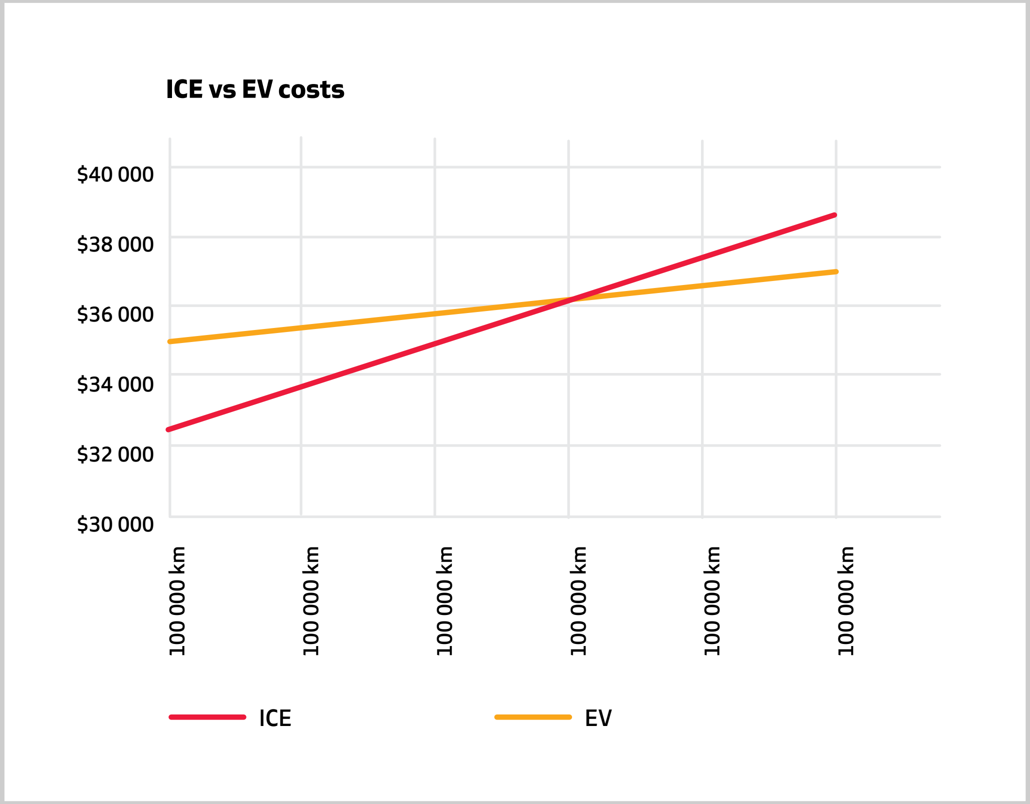


***Figure 2:* EV and ICE costs (purchase price and running costs) compared over 100 000km of ownership.**

The total cost of ownership of the EV becomes less than that of the ICE after around 60 000km. Although it can be argued whether the models chosen in this example are indeed equivalent, the aim is rather to demonstrate the impact of a higher purchase price combined with lower operating costs.

The potential lower ownership costs of EV compared to ICE vehicles are confirmed by a Canadian-based study done in 2018 [5]. This study indicated that over a 10-year period the average EV is 3.5 times more affordable in terms of fuel and service costs than an equivalent ICE counterpart.

Towards increased uptake of EVs

A 2016 US and German customer survey identified purchase price, driving range and charging infrastructure availability as the main barriers to increased uptake of EVs, as shown in Figure 3. Misconceptions about EV maintenance costs, reliability and driving performance also act as barriers to EV uptake.

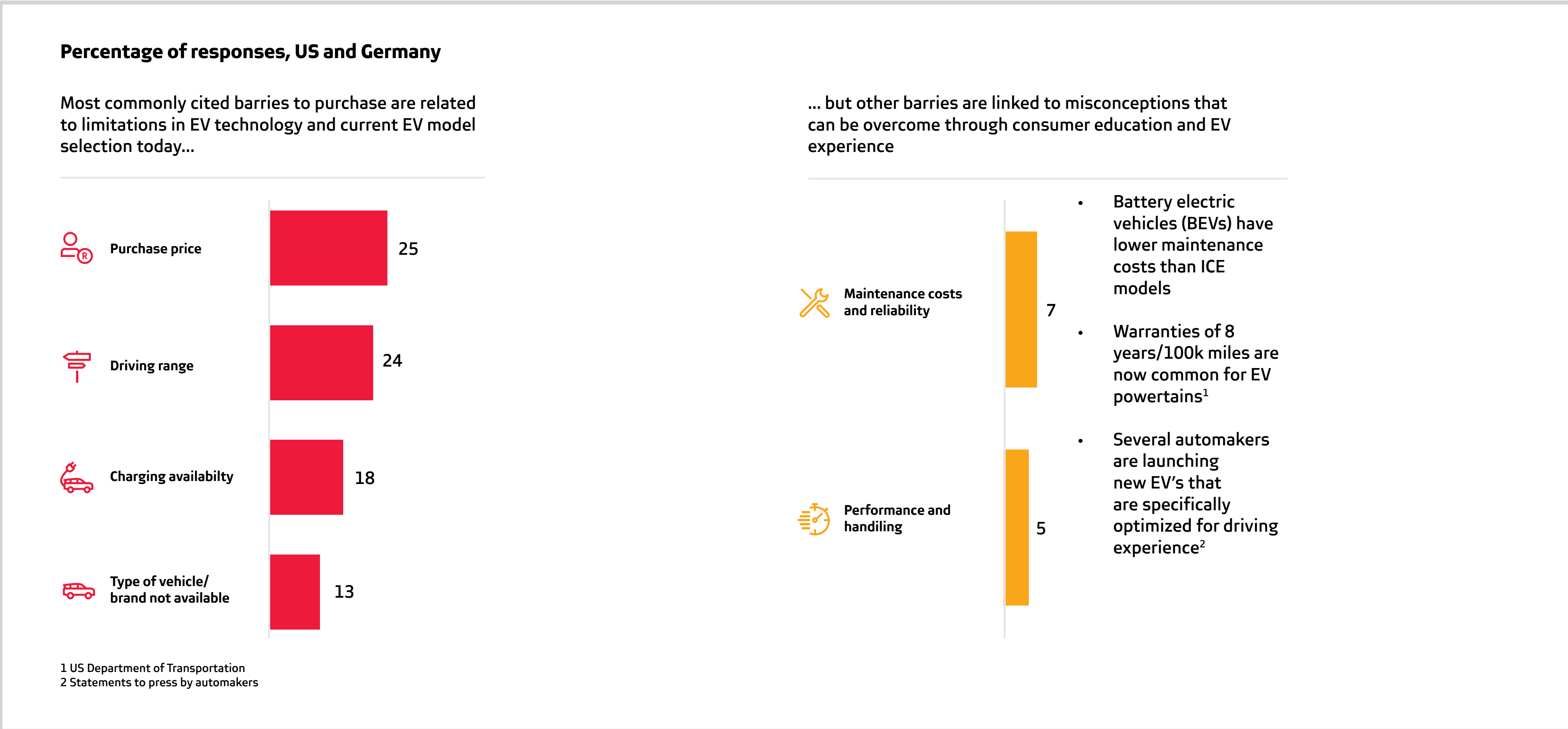


***Figure 3:* Misconceptions about EVs. Source: McKinsey & Company**

In the years since 2016 the purchase price and range barriers have steadily been reduced, as illustrated in the earlier comparison between recent ICE and EV models. In South Africa the national network of charging stations is also continuously expanding, with 134 charging stations installed nationwide by November 2019 as shown in Figure 4.

However, significant barriers in the South African context for the mass uptake of EV remain:

- Standard import tax of 25% applies to all EVs while ICE vehicles imported from Europe are taxed at 18%.
- Electric vehicles are further subjected to 17% ad valorem (luxury tax) duty because the battery price typically pushes the overall cost of the vehicle into a luxury thresh old.
- Residential electricity consumption peaks at around 18:00 in the afternoon: Additional load from mass after-work charging of EVs around this time can overload the residential electricity grid.
- The current EVs available in the market do not cater to the emerging middle class and middle-income group. These are individuals who purchase vehicles that cost between R150 000 and R350 000 and constitute a large portion of the South African market [9].

Regulations, laws and policy can greatly influence the EV market and encourage the future uptake of EVs.

This is for example evident in Norway, where a favourable policy context resulted in the country having the largest per capita uptake of EVs in the world (by mid-2019,12.1% of passenger vehicles on Norway's roads were BEVs or PHEVs [6], [7]). Examples of the incentives in Norway include:

- No import tax on EV.
- No VAT on EV purchases.
- Free parking in public spaces for EVs.
- Dedicated lanes that are shared by only EVs and buses.

In South Africa, the following are needed:

- Aligning South African import duties for EVs with pro-EV government policies. The current misalignment is highlighted in The Department of Transport's Green Transport Strategy 2018-2050, where it is recommended that specifically the ad valorem (luxury tax) duty is reconsidered for EVs.
- Enhancing public charging infrastructure and fast-charging stations to address range anxiety.
- Reinforcing local grid infrastructure, and/or implementing charging schemes to enable residential charging without overloading the local grid.
- Standardisation and interoperability of charging infrastructure.

Internationally, EVs have matured to the point where they are offering a credible alternative to traditional ICE vehicles. EVs can play an important role in reducing our society's CO2 emissions and ultimately mitigating climate change.

***Figure 4:* EV charging stations in South Africa as at November 2019. Brown points indicate high-power charging stations. Source: plugshare.com**

Renewable energy Short reports 2021

Hydropower (small-scale rural/agricultural application)

Technology

Hydropower schemes are largely used in South Africa for electricity production on both small and large scale. The technology is well understood and has been used for decades by the national utility provider, Eskom, for large-scale electricity production and energy storage. Hydropower refers to the generation of electrical power through the extraction of energy from a moving stream of water. Hydropower schemes are considered renewable and sustainable, as they do not consume any resources for energy production; they rely on a natural water cycle.

Power generation in hydropower schemes depend on two characteristics of the system, namely the head, which is the elevated height difference between the reservoir and the turbine, and the flow rate of the water into the turbine. Both play an important role in how much energy the turbine can extract from the water.

Hydropower schemes can be implemented as impound or run-off-river systems. The impound hydropower schemes entail the damming of rivers or streams and redirecting them downhill towards a turbine and generator system, which is used to generate electrical power. The run-off-river hydropower scheme creates a channel to divert part of the river through the turbine. The run-off-river system is generally used for smaller systems and is considered to be more environmentally friendly because, unlike the impound method, the flow of the river is not interrupted by a dam, which also prevents flooding of the valley. The types of turbines used depend on the size and depth of the dam. The type of turbine used in a small-scale hydropower scheme will also depend on the maximum flow and head of the specific site where it will be implemented.

Figure 1 shows a generic layout of a small-scale hydropower scheme. The system is composed of an intake weir at the water source, a channel for diverting water towards the system and a fore-bay tank/reservoir/dam in which water is collected and temporarily stored before directed into the downhill penstock towards the powerhouse containing the turbine and generator.

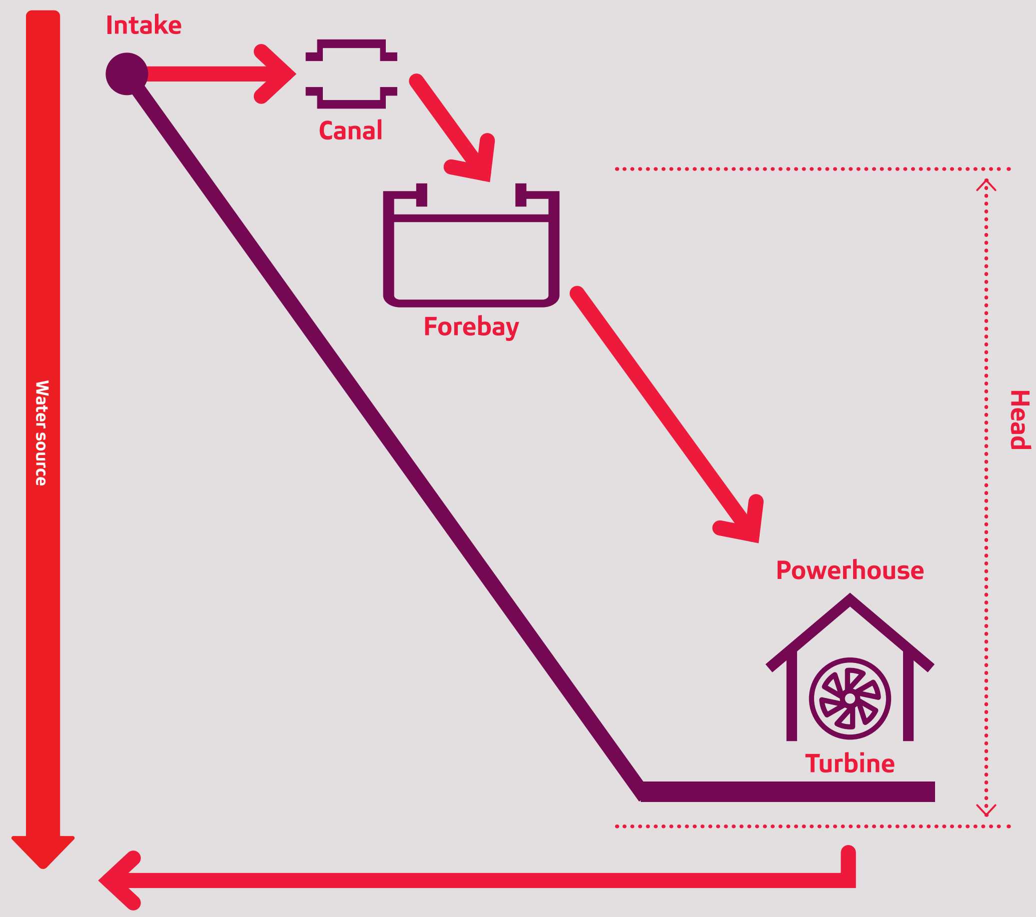


***Figure 1:** Illustration of a typical small-scale hydropower scheme (https://www.nrel.gov/docs/)*

The water situated in the fore-bay tank or reservoir possesses potential energy. As the water is diverted down the penstock towards the turbine, this potential energy is converted into kinetic energy, which is then converted to mechanical energy via the turbine. The turbine then rotates the generator shaft to generate electrical power for consumption.

Hydropower (small-scale rural/agricultural application)

An advantage of hydropower schemes, when compared to other renewable energy technologies such as solar PV and wind, is that they can provide a continuous supply of electricity, which is available on demand, although subject to continuous availability of the water resource throughout the year. Other than being a renewable and sustainable energy source, hydropower schemes have long lifespans, require minimal operational costs (can be as little as 1% of capital cost per annum), have high efficiencies (75% – 85%) and can serve more than one purpose. Hydropower schemes can serve as flood control, supply water for irrigation and/or consumption and can be used for recreational purposes.

Hydropower plants can be characterised as small or largescale, depending on the amount of output power the system can deliver. Hydropower schemes with an installed capacity of less than 10 MW are considered small-scale. These small-scale hydropower schemes can be further allocated into four categories, depending on the output capacity of the system, namely small, mini, micro and pico hydro systems. Table 1 below categorises small-scale systems via capacity.

Classification	Installed maximum capacity
Small hydro	1 MW - 10 MW
Mini hydro	100 kW - 1 MW
Micro hydro	10 kW – 100 kW
Pico hydro	< 10 kW

Off-grid micro and pico hydro systems are typically implemented in developing countries where electrification is required in isolated communities, whereas mini hydro systems tend to be grid-connected. Several types of hydro turbines are used in small-scale hydropower schemes. The type of turbine used in small-scale hydropower schemes depend on features such as the head of the water and its volume of flow as well as other factors like the availability of local maintenance and system components. The Pelton wheel is an example of a widely used turbine in small-scale hydropower schemes due to its lower cost and technical design.

***Image 1:** An example of a pico hydro system, using a Pelton wheel turbine, in the Western Cape (the tanks are used as artificial reservoirs)*

Hydropower systems can also be used for energy storage applications. This is done by running and pumping water between two reservoirs, where one reservoir is located at a lower elevation than the other. The water is pumped from the lower to the higher reservoir for storage during periods when the electricity demand from the grid is low. When the demand for electricity is high, the water is allowed to flow back from the higher to the lower reservoir and drive the hydropower system to generate electricity. This is referred to as pumped storage and allows for a reduction in the peak demand of electricity from the grid. This generates financial savings by reducing the peak demand from the grid and offset the use of electricity consumption during periods with high tariffs. It does, however, incur large losses of energy in the process.

Resource

In small-scale applications, reliable river streams are required for continuous and effective electricity generation. South Africa is known to suffer from water scarcity, having few permanent (i.e. perennial) river sources. The energy available from a flowing stream is quantified by flow velocity and elevation drop, i.e. flow rate and head respectively.

The implementation of small-scale hydropower schemes is likely to have the highest potential in the mountainous regions of the country, with high annual precipitation levels, and where localised free-flowing rivers and dams are located at higher elevations but are still accessible.

Flat-land regions of the country, which experience very dry climates throughout the year, such as the Northern Cape, would likely have a very limited availability of hydro energy resources (dams and rivers) for feasibly harnessing its energy through the use of small-scale hydro technologies. Past investigations into the potential of small-scale hydropower schemes in South Africa have identified the most sensible sites with available hydro resources within the southern and eastern regions of the country. A map which identifies suitable locations for micro hydropower generation, has been developed by the Department of Minerals and Energy Affairs, Eskom Corporate Technology and the CSIR.

To prove the technical viability and financial feasibility of small-scale hydropower schemes, it is essential to measure the flow of the source, typically over a whole year or longer, and its potential annual electricity production, and to identify seasonal variations.

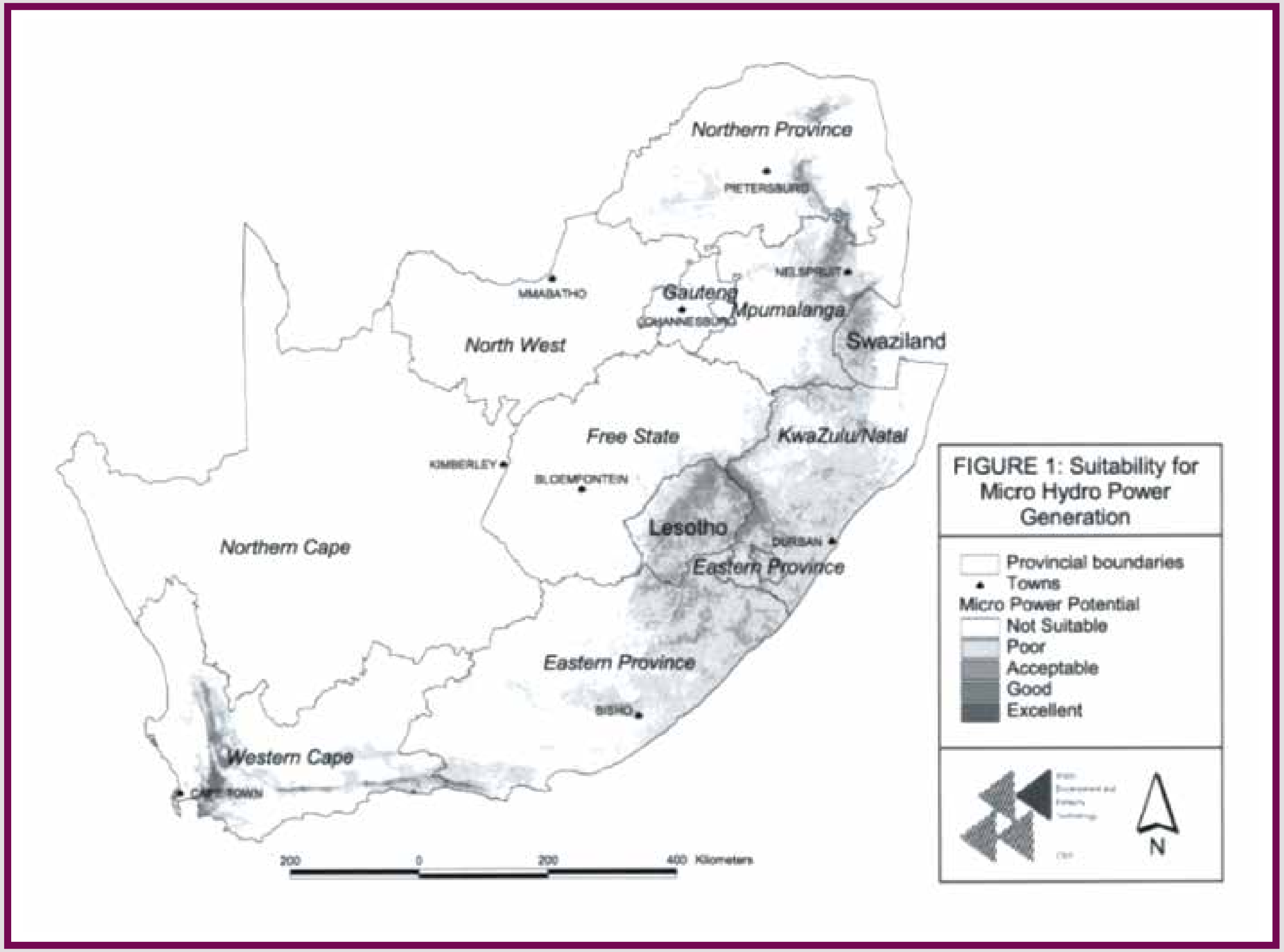


Figure 2: *http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.569.5199&rep=rep1&type=pdf*

Financial considerations

Cost dependent on size of plant and layout of infrastructure

Long useful life potentially greater than 25 years

Low need and cost of maintenance

Possible need for environmental impact assessments

Hydropower schemes are known to have high initial capital costs. The civil works typically account for the largest percentage of the total cost. The capital costs would be dependent on the size of the plant and the layout of infrastructure – costs can be reduced if the river is used directly and minimal damming of water is required. In certain cases, such as with off-grid, rural applications where the power plant could be located a great distance from the electrification sites, the cost of transmission and distribution of the generated electricity could also significantly increase the capital costs. These costs should be accurately explored for determining the financial feasibility of small-scale hydropower schemes. The cost of energy (ZAR/kWh) from small-scale hydropower schemes vary from plant to plant and is dependent on the size, capital cost, operation and location of the specific plant. Therefore, the cost of energy can significantly vary, depending on how the plant operates and performs throughout each year of its lifespan, as well as the availability of the hydropower source. Depending on the scale and application of the specific hydropower scheme, additional costs could be incurred by conducting the necessary social and environmental impact studies.

Other financial considerations include fees associated with the use of dams, costs incurred for obtaining a water-use licence from the Department of Water Affairs (DWA) and costs incurred for obtaining an electricity generation licence from the National Energy Regulator of South Africa (NERSA). The requirement of the electricity generation licence would however depend on the size and specific application of the small-scale hydropower scheme, for example it would be required for off-grid, rural area electrification where electricity will be generated, distributed and sold.

Operation and maintenance:

An advantage of hydropower technologies when compared to other renewable energy technologies, is its extended operational lifespan and robustness. Most hydro- turbine hardware manufacturers quote a design life of 25 years, although existing projects have proven the technologies to operate effectively for more than 50 years with suitable maintenance. Hydro turbines require minimal maintenance without major overhauls over its lifespan, allowing for minimal costs relating to the operation and maintenance of systems. The civil works of small-scale hydropower schemes, such as dams or reservoirs, are susceptible to ongoing maintenance over the systems lifespan.

Suitable implementation

In South Africa, most large-scale hydropower schemes are under the control of the state-owned enterprise, Eskom. Many hydropower schemes are mainly used for pump storage in which hydroelectricity is generated during peak-demand hours and pumped back upstream when the demand is low.

Small-scale hydropower schemes are well suited for rural electrification, especially in mountainous areas such as the Eastern Cape, KwaZulu-Natal and parts of the Western Cape. There is also good potential for localised farming industries of South Africa. Farms typically have privately owned, on-site dams, or are located in close proximity to rivers and river networks, which could serve as a source of hydro-energy. Ideally, small-scale hydropower should be located by rivers with consistent water flows, usually associated with regular rainfall. The Western Cape has small-scale hydropower plants, however, the seasonality of the rainfall results in extended periods of reduced or no water flow. To reduce environmental impacts, run-off-river systems are more suitable for the use of existing infrastructure.

Small-scale hydropower still faces some barriers in South Africa, including long waits for approval from stakeholders such as the Department of Water Affairs, which slow down the implementation process. Unclear government regulations on small-scale hydro and inaccessibility to some sites also slow down the implementation process. The lack of locally developed components and maintenance services, presents a challenge for small-scale hydropower in South Africa and Africa as a whole.

Regulations

The national regulations are not comprehensive enough to provide clear guidance on small-scale hydropower systems, especially relating to feeding electricity into the electricity grid. As such, most municipalities in major towns and cities of South Africa have their own bylaws concerning the renewable energy tariffs, which include aspects such as net metering and embedded generation. Embedded generation refers to the connection of produced electricity onto the national grid, which could be the case for small-scale hydropower systems.

The following listed laws and regulatory frameworks have an impact on the development of small-scale hydropower plants in South Africa. These regulatory frameworks are listed along with the relevance to the small-scale hydropower sector.

- **National Environmental Management Act (Act No. 107 of 1998):** It promotes the application of environmental assessment and management tools to ensure integrated environmental activities. It provides the general objective for integrated environmental management, which is achieved through the completion of an environmental impact assessment (EIA). An EIA aims to identify, predict, evaluate and mitigate any environmental impacts of a proposed development, which may require environmental authorisation by relevant authorities. The requirement of an EIA or basic assessment for environmental authorisation for a proposed small-scale hydropower scheme should be confirmed with the relevant authorities on a case-by-case basis.

- **Electricity Act (Act No. 41 of 1987):** The Act provides information on electricity generation and electricity supply in South Africa. Furthermore, it confirms the role of the Electricity Board (Energy Regulator).

- **Electricity Regulation Act (Act No. 4 of 2006):** It describes the role and responsibility of the National Energy Regulator of South Africa (NERSA) with regard to the processing and issuing of electricity generation, transmission and distribution licences. It clearly describes activities which require licencing and provides conditions under which exemptions of licencing can be granted. For example, it exempts the requirement for a generation licence when installing a renewable energy system if the installed capacity is less than 1 MW and permission has been received from the relevant network owner (municipality or Eskom).

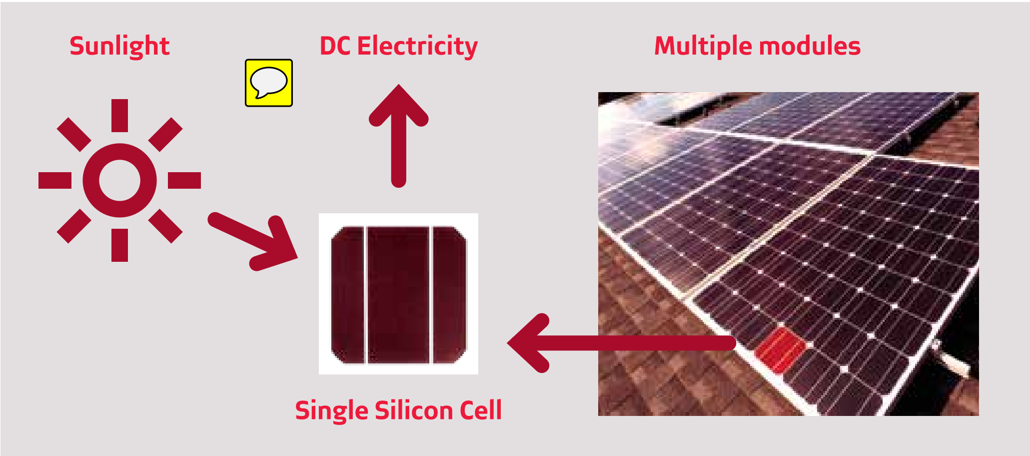
- **National Water Act (Act No. 36 of 1998):** This document manages the way in which water resources are managed and used in South Africa. It is aimed at protecting, conserving and managing water as a whole. The document places water usage in three different categories of authorisations, including no requirement for registration, registration without licencing and the requirement for registration and licencing. Typically small-scale hydropower schemes fall under the category which requires no registration, however, authorisation is still required from relevant authorities as a flowing course of water and its characteristics are commonly affected by the implementation of small-scale hydropower schemes. Depending on the scale, design and location of the proposed hydropower scheme, further authorisation through registration and licencing may be required.

Renewable energy Short reports 2021

Solar Photovoltaics (PV)

Technology

PV stands for photovoltaic, which is derived from the ancient Greek word phôs, meaning light, and the word volt, an electrical term named after the Italian physicist Alessandro Volta. In essence, PV modules (commonly referred to as "panels") are composed of interconnected silicon cells that convert solar radiation into electricity. The cells absorb photons (light) to create a flow of electrons. This flow of electrons is what we commonly refer to as direct current (DC) electricity.



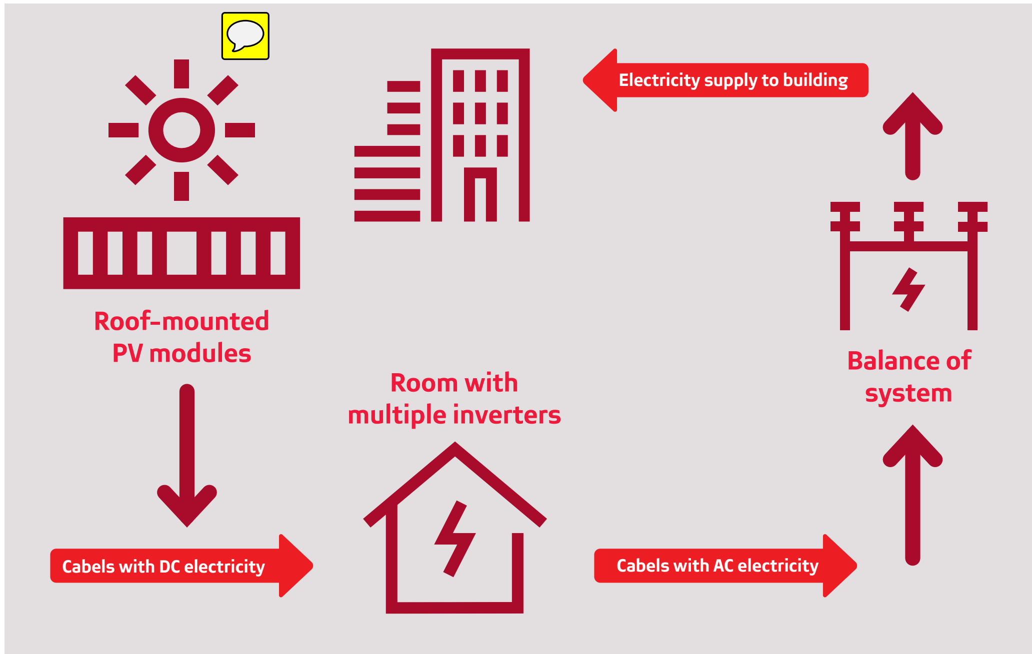
The more light the PV module is exposed to, the more current it generates. Maximising exposure will also maximise the amount of electricity it generates. The placement and mounting of PV modules are thus an important aspect of a PV system's design. It is important to note that in the South African context, the technology is sensitive to temperature. The efficiency of PV cells decreases in hot temperatures, thereby reducing the amount of electricity they will produce.

Tracking systems are used to maximise the exposure to sunlight by following the movement of the sun, however, they come at a higher cost and require more maintenance. Tracking is usually used for larger installations as part of a ground-mounted system. The most common type of mounting is a roof-mounted PV system, which involves securing the modules on the roof of a building at a fixed angle using an aluminium frame. The most suitable placement is north-facing if you are in the southern hemisphere, located away from possible shading.

There are different kinds of PV technologies, such as mono (single) crystalline, poly (multi) crystalline and thin film technologies. Each operate in the same way, but contain different additives or are manufactured using different manufacturing techniques. This results in different properties for different technologies, such as temperature sensitivity, conversion efficiency and cost.

Electricity is distributed through networks to users in the form of alternating current (AC). The DC electricity generated by a PV cell is therefore not compatible with the electricity found in homes or offices. Special equipment, called inverters, are needed to convert the DC electricity from the PV cells to AC electricity found in buildings. The major components for any PV installation consist of the PV modules, that supply DC electricity to the inverters, which in turn supply AC electricity to the balance of system, which consists of the different electrical and safety equipment.

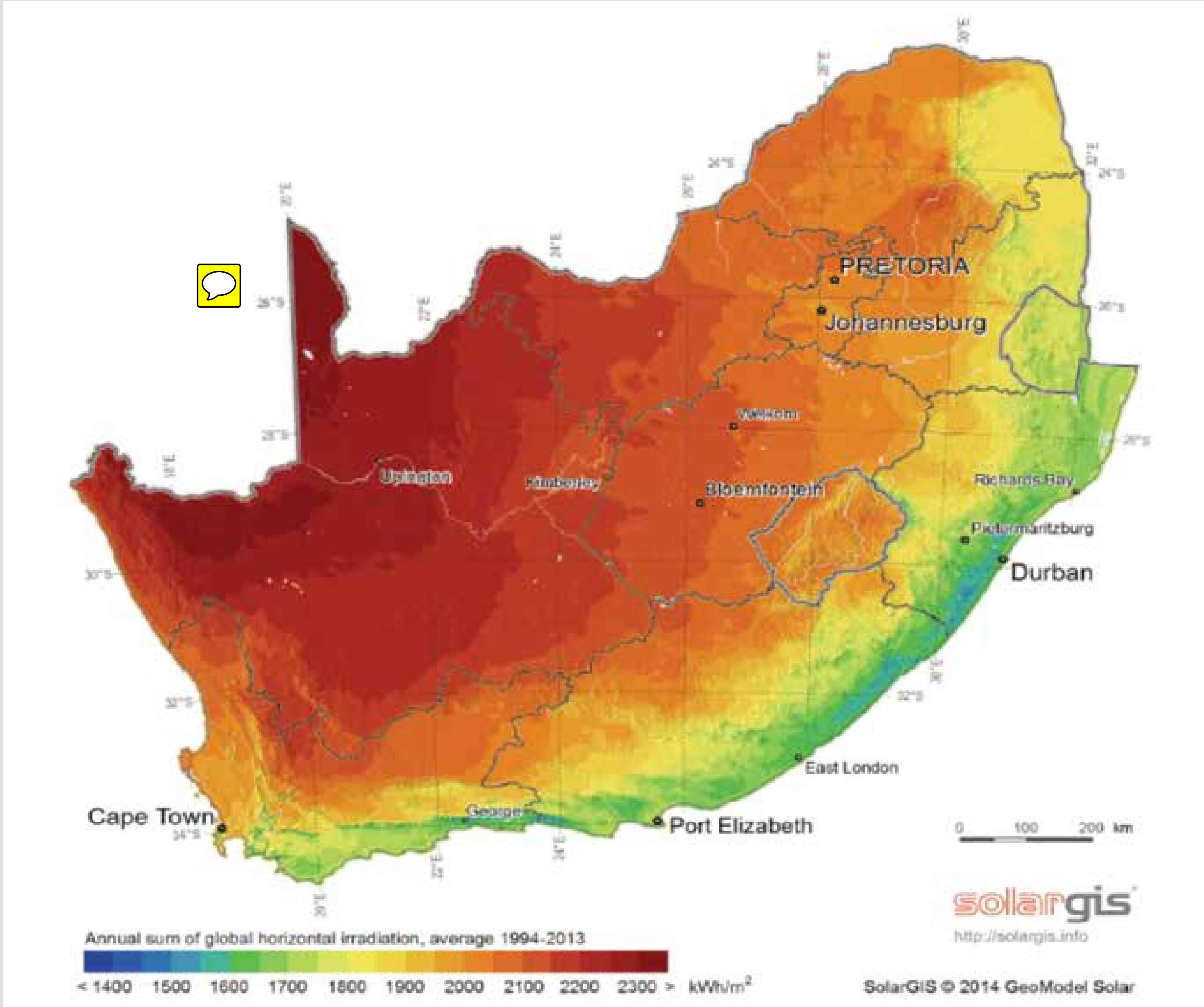
Inverters that work in conjunction with the standard grid connection are referred to as grid-tied inverters. Almost all commercial rooftop PV installations are of this type.



Resource

PV systems use solar radiation to generate electricity. More specifically, it is the radiation component referred to as the Global Horizontal Irradiance (GHI). South Africa has an abundance of solar resources – even the more cloudy regions are more suitable for PV than the best regions in some of the leading countries that use PV installations at the moment, such as Germany and Japan.

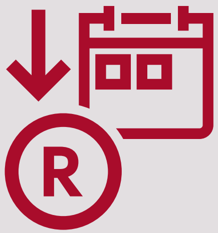
The above map indicates the available solar resources in South Africa for one year. It is important to note that the areas with lower levels does not have lower radiation, it is merely less available throughout the year due to weather conditions, such as cloud cover.



Financial considerations

Low operation and maintenance costs (higher with tracking systems)

Long useful life (panel warrantees of up to 25 years)



Declining cost of technology over years

Higher tariffs

The price of PV systems have declined significantly in the last decade. Despite this reduction, the initial capital costs of PV systems are relatively high when compared to non-renewable energy sources, such as diesel generators. However, unlike non-renewable energy sources, PV has no fuel costs and low operation and maintenance costs. It should therefore be considered as a long-term investment.

With exception to the formalised independent power producers, PV systems do not generate income; their financial feasibility is calculated through the offsetting of the electricity consumed from the local network, which results in a reduced electricity bill. Higher electricity prices will result in a more feasible financial model for a PV system. The cost of energy (R/kWh) from PV systems will vary depending on the size of the system and the total cost (including capital costs and O&Ms) over the system's lifespan. Typically, larger PV systems offer lower energy costs over the PV system's lifespan when compared to smaller systems, due to the lower installation costs (R/kWp PV installed). The financial feasibility of PV systems will depend on the cost of energy from the PV system over its lifespan and it being lower than the energy costs that one would incur when consuming this energy from Eskom or the local municipality over the same time period, while also taking into account the expected annual increases.

PV systems are modular, meaning that they can be implemented in a variety of sizes, from a single module that can generate a few watts of electricity, to multiple modules in large plants producing hundreds of megawatts (1 megawatt = 1 000 000 watt) of power. The cost of a PV system is dependent on the size and type of installation, with large systems having a lower cost. The cost of a PV system is typically represented as a cost per watt installed. As an example, if a PV system installed on a shopping centre costs about R14/W, and if the system is a 500 kWp installation, the total cost of the installation is thus R14/Wp x 500 000 W = R7 000 000. In the case of a smaller PV system, for example a 50 kWp system at a filling station, at an installation cost of R16/Wp, the total cost of the installation will be R800 000.

PV installations can qualify for tax deductions as per Section 12B of the Income Tax Act No. 58 of 1962. This section of the Act provides for up to 100% accelerated capital depreciation in the first year of operation on the cost of the PV system.

Operation and maintenance:

Most solar PV modules on the market today come with a warranty of 25 years, meaning that the power output will not be below 80% of the rated power until after 25 years of service (note: this varies depending on the manufacturer and solar panel materials). However, other components, such as the inverters, must be replaced after every 10 years of service – an important cost to consider. It is common practice to base the financial calculations on a system lifespan of 20 years. Rooftop and fixed ground-mounted PV systems require minimal maintenance and associated costs, other than occasional cleaning. However, the maintenance costs can be expected to be more significant with tracking PV systems for the servicing of trackers.

Suitable implementation

PV systems can operate as stand-alone units or tied to the local electricity network. Small-scale stand-alone units are commonly used in remote areas that are not connected to the grid. In typical stand-alone units, battery packs are installed for night-time operation. The electricity from small-scale stand-alone units is used for powering domestic appliances such as radios and refrigerators.

Grid-tied systems are connected to the national power grid (Eskom), whether directly or indirectly, through local municipal or other networks. Grid-tied systems are becoming increasingly popular in urban areas, with many households installing small PV systems. It is also implemented increasingly in the commercial and industrial sector to offset electricity usage from the grid. Municipal areas have higher electricity tariffs than Eskom, which improves the financial feasibility of PV systems. Since PV systems only generate electricity when the sun shines, facilities with high electricity consumption profiles in midday are generally able to accommodate larger PV systems.

There are limitations to the sizes of PV systems and various regulations governing the feeding of electricity from the PV modules to the local electricity network. Most systems are limited in size to below 1 MW – anything larger will require an electricity generation licence, which is mostly issued as part of the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP).

Regulatory

The national regulations are not yet comprehensive enough to provide clear guidance on PV systems, especially relating to feeding electricity onto the electricity grid. As such, most municipalities in South Africa in major towns and cities have their own bylaws concerning the renewable energy tariffs and system configuration, which include aspects such as net metering and embedded generation. Embedded generation refers to connection of electricity produced into the national grid, such as the case for PV systems.

Some municipalities do not allow for the installation of PV systems, where others are willing to purchase electricity from the client at attractive rates. There are some national regulations that govern aspects of PV systems, which include the following:

- **The Electricity Regulations Act, 2016** exempts the requirement for a generation licence when installing a PV system if the installed PV capacity is less than 1 MW, and permission has been received from the relevant network owner (municipality or Eskom).
- **SANS 10142** is a technical standard that relates to the wiring of premises and includes a section on the connections of PV systems. South African regulations state that all electrical equipment must be SABS approved, however, the rapid changing technology and lack of testing capacity results in key PV equipment, such as PV modules and inverters, not having approval. The quality of the equipment is reliant on European (IEC) or American (ASTM) testing standards.
- **PVGreenCard** is not an official regulation. It is, however, a useful tool developed through the South African Photovoltaic Industry Association (SAPVIA), the South African Renewable Energy Training Centre (SARETEC) and the German Development Cooperation (GIZ). It is a checklist for installers and owners designed to ensure high quality installations.

Renewable energy Short reports 2021

Solar thermal (industrial scale application)

Technology

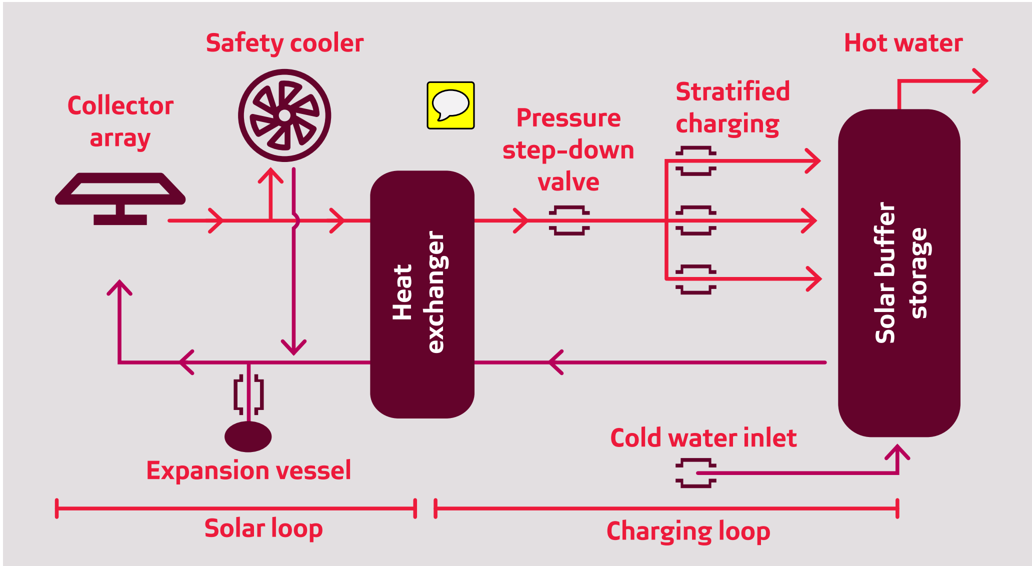
Solar thermal (ST) technologies, also known as solar water heating (SWH) systems, extract heat energy from the solar radiation. ST technologies operate through active heating, meaning it relies on the sun's solar irradiation for heating a working fluid. This operates by absorbing solar irradiation from the sun and uses it to heat water flowing through a collector. This heated water is typically transferred to a storage tank and consumed throughout the day. The storage tank acts as a buffer, allowing hot water to be available throughout the day when needed. The most common solar thermal technologies are evacuated tube and flat-plate collectors, shown in the figure below, which is used in low-temperature applications (< 100 °C).

ST systems can either be passive or active. For active systems, the fluid heated by the sun is circulated by means of a pump, typically seen in large-scale application, whereas in passive systems, the fluid circulates through natural means, also known as a thermo-syphon system. This is typically seen in small-scale residential installations.

Thermo-syphon systems, typically installed on households, makes use of either direct or indirect heating. Direct thermo-syphon systems heats water in the collector, which flows directly into the tank from which it will be used. In indirect systems, the heated water, flowing from the collector, moves through a separate circuit within the tank to transfer the heat to the water inside the tank for use.

Therefore, the water in the collector and tank never mixes. Indirect systems are typically used in a colder climate, where freezing could be a risk. This allows for a water-glycol mixture to flow through the collector to prevent freezing.

Typically, pumped systems operate on the principal of indirect heating, when used for commercial and industrial applications, where water is heated by the collector and pumped through a heat exchanger or heating coil within the tank to heat the water. The heat exchanger transfers the heat to a separate circuit of flowing water, which is fed into a storage tank. The basic layout of a large-scale solar thermal system is shown in the image below.

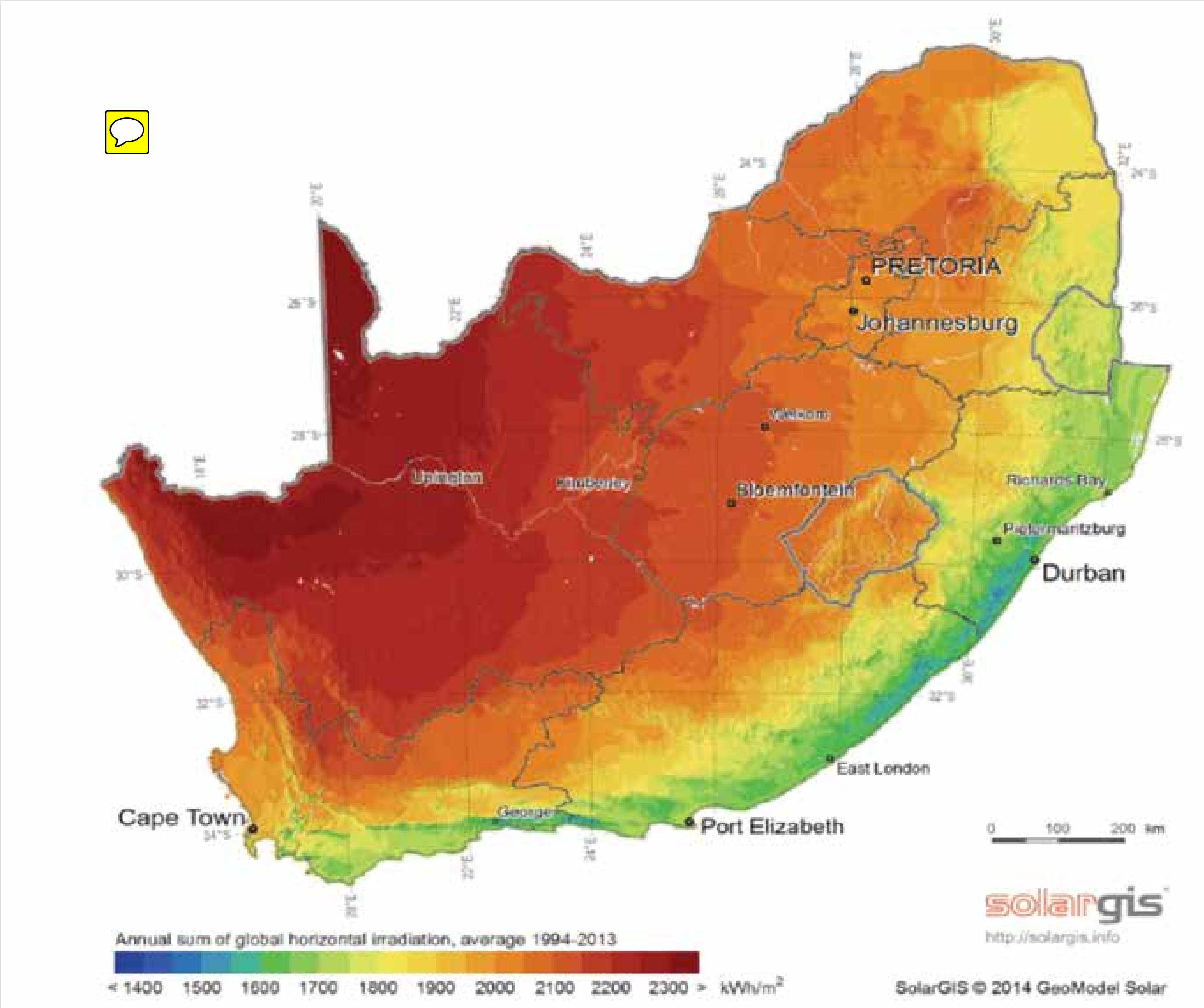


In most large-scale applications, a backup heat source is implemented to generate hot water when the solar resource is low (consecutive days of cloudy weather). For residential systems, the tank is typically equipped with an electrical resistive element. In large-scale systems, electrical elements, heat pumps or boilers that use conventional fuels, such as coal, gas, paraffin, etc, provide the heat. For industrial processes with higher temperature needs (steam), ST systems are typically installed for preheating. Preheating allows for the ST system to heat the cold-water supply and feeds this hot water to a storage tank, before being fed into a boiler for steam production, allowing for significant reduction in the use of conventional fuels by boilers, which in turn leads to associated financial savings.

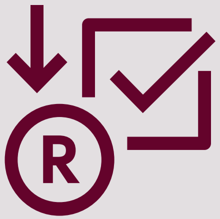
Resource

ST systems use solar radiation to generate hot water. More specifically, it is the radiation component, referred to as the Global Horizontal Irradiance (GHI). South Africa has an abundance of solar resources – even the more cloudy regions are more suitable for PV than the best regions in some of the European countries leading in SWH installations, such as Germany and Austria.

The map on the right indicates the available solar resources in South Africa for one year. It is important to note that the areas with lower levels do not have lower radiation, it is merely less available throughout the year due to weather conditions such as cloud cover.



Financial considerations



Declining costs

Long functional life span (warranties up to 10 years)

Require regular and proper maintenance

Cost dependent on design requirements and size

The cost of ST systems has declined steadily over past years, although the cost of large-scale systems can vary significantly depending on the size and the design requirements. For example, large-scale systems may require special components (tanks, controls, etc.) to be effectively integrated into existing industrial processes, which may significantly increase overall costs. The cost of large-scale ST projects is usually presented on a specific cost (ZAR/m2) basis. The specific cost represents the total cost of the project per square meter of collector area installed. As an example, a 125 m2 ST system with a total project cost of R1 000 000, will have a specific cost of 8 000 ZAR/m2.

Studies have shown that large-scale ST projects have an average specific cost of approximately 9 300 ZAR/m2 in South Africa. However, this estimate may vary with respect to economies of scale and is dependent on specific design requirements. Large-scale ST systems can be expected to have high upfront capital costs when compared to other non-renewable energy sources, such as heat pumps. These studies have also shown that ST systems can generate heat at a lower cost than most conventional fuels used in boilers for process heat, including heavy fuel oil (HFO), paraffin, electricity, diesel, petrol and liquid petroleum gas (LGP). This substantiates its financial viability as an attractive investment for offsetting the use of conventional fuels, reducing the carbon footprint and generating savings.

There are currently two funding initiatives available in South Africa for subsidising large-scale ST projects, namely the Southern African Solar Thermal Training and Demonstration Initiative (SOLTRAIN) and the Solar Payback project. SOLTRAIN is a regional initiative for capacity building and demonstration of solar thermal systems in the SADC region that started in 2009. The initiative is funded by the Austrian Development Agency and co-funded by the Opec Fund for International Development. The initiative provides subsidies of up to 50% of the total project cost, depending on the size and cost thereof, and have already provided funding over 200 large-scale ST systems throughout the SADC region. Find more info at **www.soltrain.org**

The Solar Payback project is a three-year initiative (October 2016 to September 2019), which is supported by the German Federal Environment Ministry and funded by the International Climate Initiative. The project is implemented in South Africa, Mexico and Brazil, and is aimed at increasing the use of solar thermal energy in industrial processes. The project is coordinated by the German Solar Association (BSW-Solar) and 11 partner organisations. Find more info at **www.solar-payback.com/**.

Operation and maintenance:

Typically, ST collectors are expected to have a functional lifespan of between 20 and 25 years, depending on the specific technology and manufacturer. There are existing systems that have been in operation for longer periods. This could be attributed to regular and proper maintenance. However, other smaller components of ST systems, such as the pumps, controllers and valves, might need more frequent replacement due to shorter service life and unexpected failure. Typically, well-established ST collector manufacturers provide warranties of up to 10 years on their products. Other smaller components (pumps, valves, etc.) of ST systems can be expected to have shorter warranty periods.

Solar thermal (industrial scale application)

Suitable implementation

ST systems are commonly used in households to generate hot water for daily domestic needs, but is also frequently installed on a larger scale for generating hot water for commercial and industrial activities. Commercial activities with a good potential for the implementation of ST technologies can be identified as businesses/buildings where large volumes of hot water at low temperatures (< 100 °C) are consumed on a daily basis, such as hospitals, hotels, apartment blocks and laundromats, among others. The application of ST technologies could be a practical solution for many industrial activities with a high demand for process heat, for example, the food and beverage, manufacturing, agriculture and textile industry, among others.

Solar heat for industrial processes has proven feasible and has been implemented in many cases around the world. For industrial processes where steam is required (> 100 °C), large-scale ST systems could be used for preheating. The ST system is used to raise the temperature of the cold- water supply before being fed into a boiler to generate steam. This allows significant reduction in the use of conventional fuels and carbon emission, and at the same time generates financial savings.

Regulations

There are a number of South African National Standards (SANS) that are directly and indirectly associated with the installation of ST systems to which both small-scale (household) and large-scale installations should conform.

These SANS regulations are listed below:

- **SANS 151:** Fixed electric storage water heaters
- **SANS 181:** Thermostats for electric storage water heaters
- **SANS 198:** Functional-control valves and safety valves for domestic hot- and cold-water supply
- **SANS 514:** Immersion heaters for electric storage water heaters
- **SANS 893-2:** Legionnaires disease – Part 2 (the control of Legionella in water systems)
- **SANS 1299:** Tempering valves for hot-water storage systems
- **SANS 1307:** Domestic solar water heating systems
- **SANS 10106:** The installation, maintenance, repair and replacement of domestic solar water heating systems: requirements
- **SANS 10252-1:** Water supply and drainage for buildings – Part 1
- **SANS 10400 (SABS 0400):** The application of the National Building Regulations
- **SANS 60335-2-21:** Safety of household and similar electrical applications – Safety – Part 2-21

Renewable energy Short reports 2021

Wind Energy (Small-scale)

Technology

For many years, small-scale wind turbines have been used for electricity production in remote communities and for charging batteries on boat and holiday cabins in European countries. In South Africa, windmills have been used on farms for pumping water and electricity production. There are two types of small-scale wind turbine technology, namely vertical-axis wind turbines (VAWT) and horizontal-axis wind turbines (HAWT).

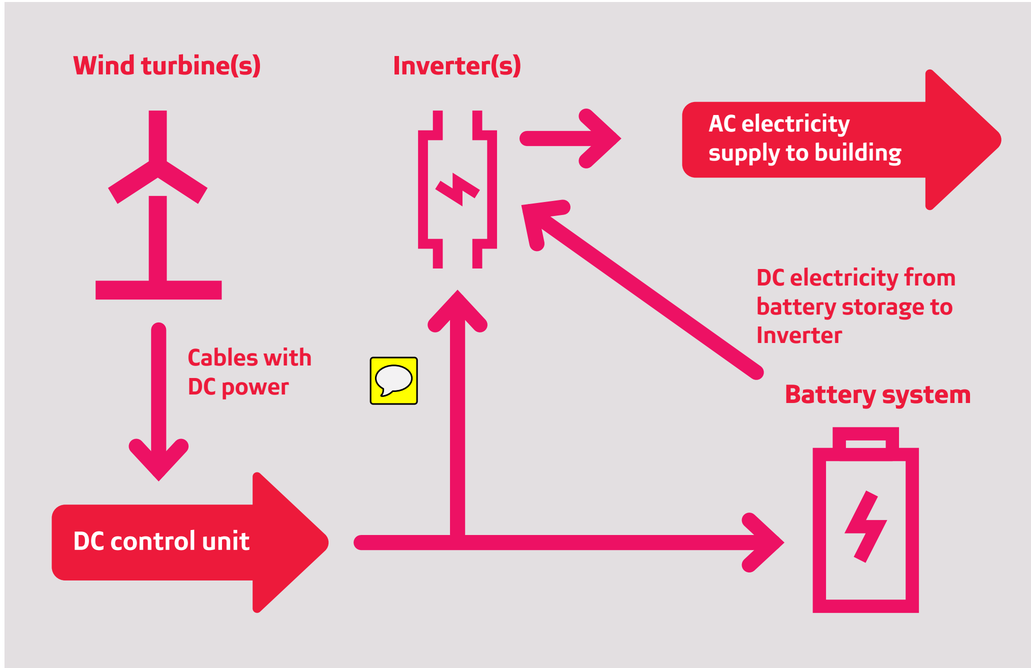
Since wind is basically moving air, energy contained in it is in the form of kinetic energy. The energy from the wind is extracted by the rotor blades of the turbine, causing the rotor and drive shaft to rotate within the turbine. This rotating shaft has mechanical energy which is converted into electrical energy within the generator of a turbine. For large-scale wind turbines a gearbox is used to increase the low rotating speeds of the rotor blades required for electricity production within the generator, however, small-scale wind turbines have direct-drive generators and do not require gearboxes.

Small-scale wind turbines used for producing electricity for households, generate DC power and must be converted to AC power through the use of an inverter to supply most household appliances. Wind speeds can vary rapidly and may cause rapid fluctuation in the power produced by wind turbines. For this reason, small-scale wind turbines are typically installed with some sort of buffering system such as capacitors or batteries to store energy and feed electricity into a household at a steady rate. The diagram on the right shows a typical layout of the installation of a wind turbine system to supply electricity to a household.

Small-scale HAWTs have rotor diameters ranging from 1.5 m to 3.5 m and are mounted on towers which are 10 m in length and longer. These turbines typically only start operating (generating electricity) at a wind speed of 2.5 m/s, have a power rating of 1 kW to 10 kW and require an average wind speed of 4 m/s to operate effectively.

VAWTs extract energy from any direction and unlike HAWTs, don't need to orientate the rotor blades in the direction of oncoming wind. A benefit of VAWTs is that they have less moving parts and have the ability to operate effectively under turbulent and gusty wind, allowing them to be mounted at lower elevations from the ground (no tall towers). Furthermore, they can be installed between high buildings and in close proximity to one another, minimising the space requirement when more than one unit is installed.

Horizontal-axis wind turbines require change in the direction the rotor faces as wind direction varies, to achieve optimum operation. These variants are the most popular since they can be mounted on towers to take advantage of high wind speeds. In small-scale applications, the wind turbines can be mounted on roofs (VAWTs) or on towers (HAWTs) in the field.



Resource

The wind energy potential of an area is characterised by its average wind speed. The potential for harnessing energy to generate electricity is best determined through ground measurement at the elevation of the specific wind turbine for at least one year to better understand the available resource, potential energy yield from a wind turbine when installed and the financial feasibility thereof. This would be ideal for the implementation of wind turbine technologies. Unlike solar energy, the availability and frequency of wind in a specific area vary significantly from year to year.

The Wind Atlas for South Africa (WASA) was developed through the South African Wind Energy Project (SAWEP) by the South African National Energy Development Institute (SANEDI), South African Weather Services (SAWS), Council for Scientific and Industrial Research (CSIR), the University of Cape Town (UCT) and the Danish Research Institute (DTU Wind Energy). WASA provides the annual mean wind speeds at elevations of 50 m, 100 m and 200 m for the entire country. The WASA below shows the annual mean wind speeds at 100 m and serves as a visual representation of variation in average wind speeds throughout the country and regions with good potential for harnessing wind energy for electricity production.

It should be noted that the WASA is more representative of the potential for large-scale wind turbines than that for small-scale wind turbines, which position at much lower elevations where wind speeds and wind turbine performance will be largely affected by the surrounding terrain and infrastructure such as tall buildings.

As mentioned, small-scale turbines operate effectively with annual mean wind speeds of 4 m/s and higher and this is experienced throughout most of the country at a 100 m elevation, however, this could be significantly less at 10 m, where small-scale wind turbines will be mounted. This figure can be used to identify regions in the country with sufficient annual mean wind speeds to consider looking into the potential of wind energy for electricity production.

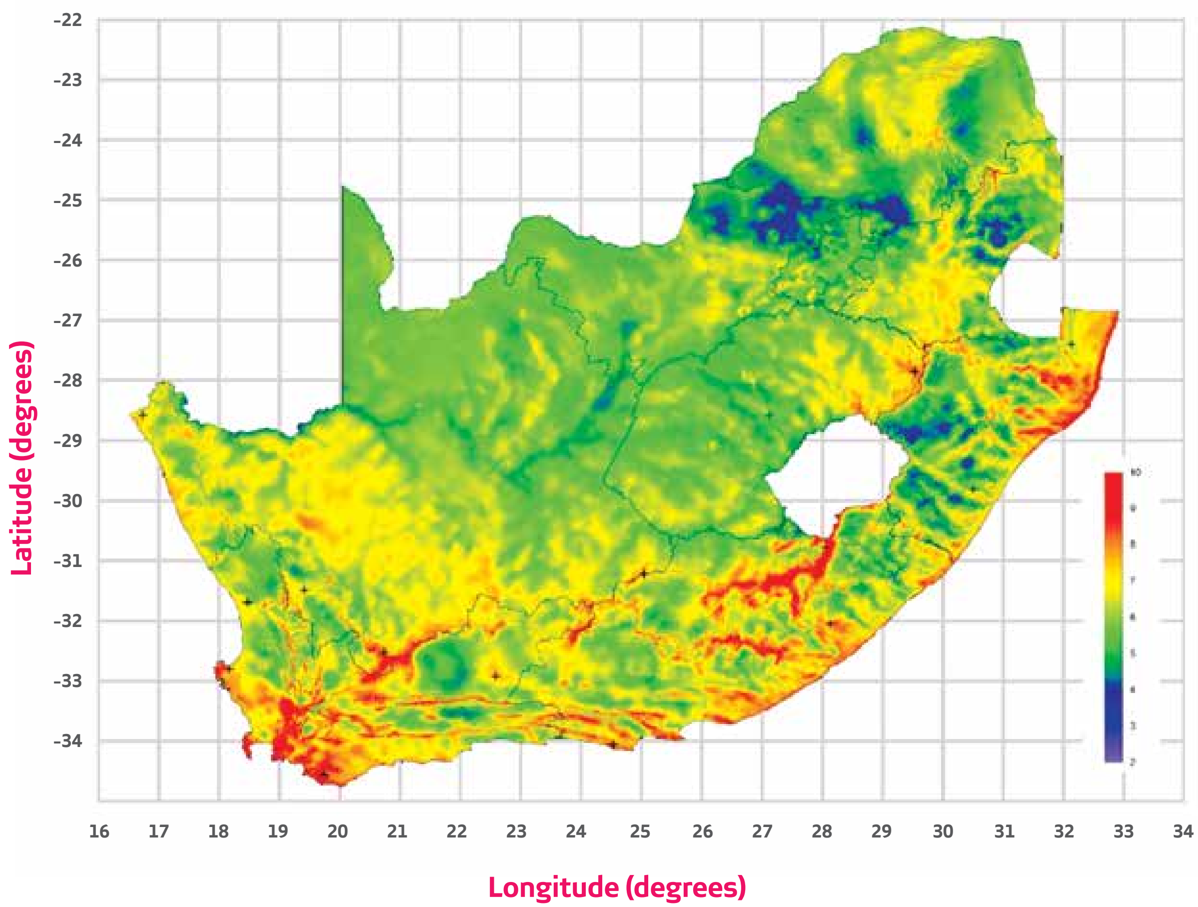


Figure 1: Interim high-resolution wind resource map for South Africa depicting the mean wind speed (m/s) at an elevation of 100 m above ground level (http://www.wasaproject.info/)

Financial considerations

Require high and consistent wind speeds

Long useful life span (up to 25 years)

Annual maintenance required

Likely to integrate with batteries

In most cases, small-scale wind turbines are not the most cost-effective renewable energy solution on a per kilowatt basis, however, its energy production in areas that experience high and consistent wind or where energy access is limited, may prove its application superior when compared to other renewable energy technologies.

Small-scale embedded generation (SSEG) applications of wind turbines can qualify for tax deductions as per Section 12B of the Income Tax Act No. 58 of 1962. SSEG refers to the power generation under 1 MW on residential, commercial or industrial sites where the electricity is also consumed. This section of the Act provides for up to 100% accelerated capital depreciation in the first year of operation on the cost of the wind turbine system.

Small-scale wind turbines are more expensive, based on per kilowatt capacity when compared to large-scale wind turbines. Furthermore, the need for energy storage devices, i.e. batteries, tends to increase the capital and overall cost of the systems over its lifespan. It should however be noted that the need for battery storage in wind turbine systems allows for dispatchable control of the energy generated, allowing excess generated energy to be stored, or consumption of generated energy from batteries during peak-demand periods of the day when electricity rates are higher. This allows owners to maximise savings when offsetting energy consumed from the grid.

Operation and maintenance:

All wind turbines have an expected lifespan of 20 to 25 years and should be serviced annually to ensure optimal performance. Servicing of wind turbines usually involves visual and noise checks for blade or component failure which could diminish its performance.

Servicing may also include the lubrication of components, if required. Most wind turbine systems use battery systems and inverters, which are also subject to maintenance and replacement after a number of years. Batteries require regular checks and maintenance and are also subject to replacement after a number of years depending on the specific type of battery technology used. Typically, inverters should be replaced after every 10 years of its service life. Servicing costs and warranty periods of all system components should always be checked in advance with the installer.

Suitable implementation

The target market for small-scale wind turbines includes households, small businesses and remote farms. Its application is well suited for battery charging, grid-tied. Farms are well suited for HAWTs since they are mostly in open areas with minimum obstructions, allowing wind to blow with ease, whereas VAWTs are suited for residential and commercial (businesses) applications in urban areas, where surrounding buildings could negatively affect the performance of HAWTs. VAWTs also have the benefit of being low and roof-mounted (less of a visual impact) and creating less noise when compared to HAWTs.

Due to its intermittent nature, wind energy requires another source of energy for stand-alone units in remote areas to smooth out the variability. Small-scale wind turbines is a favoured technology in stand-alone off-grid systems installed in remote rural areas, where it operates in conjunction with solar PV systems to generate electricity. This results in a hybrid system providing reliable power for off-grid electricity generation. When solar and wind technologies are together, they can be used simultaneously or sequentially, depending on the weather conditions. However, such a system is still prone to variability due to the stochastic nature of both the energy sources.

Regulations

The national regulations are not yet comprehensive enough to provide clear guidance on small-scale wind turbine systems, especially relating to feeding electricity onto the electricity grid. As such, most municipalities in major towns and cities in South Africa have their own by-laws concerning the renewable energy tariffs and system configuration, which includes aspects such as net metering and embedded generation. Embedded generation refers to connection of electricity produced into the national grid, such as the case for small-scale wind turbine systems.

Some municipalities do not allow for the installation of wind turbine systems, whereas others are willing to purchase electricity from the client at attractive rates. There are some national regulations which govern aspects of small-scale wind turbine systems. These include the following:

- **Electricity Regulations Act (Act No. 4 of 2006):** It exempts the requirement for a generation licence when installing a PV system if the installed PV capacity is less than 1 MW and permission has been received from the relevant network owner (municipality or Eskom).

- **NRS 097-2-3:2014 – Grid Interconnection of Embedded Generation:** It prescribes the conditions of grid interconnections for low-voltage (LV) SSEG, which relate to connected small-scale wind turbines, its applications and feeding energy into the grid. The document is intended to guide South African distributors in terms of the rules to be applied when applications of LV connected embedded generators are being assessed. Many municipalities have published documents providing the guidelines for the application process for connection of all forms of SSEG technologies such as PV and wind turbines to the municipal electricity network. In cases where electricity is supplied by the local municipality, these processes would have to be followed.

- **South African National Standard (SANS) 10142:** It is a technical standard that relates to the wiring of premises and includes a section on the connection of LV installations. South African regulations state that all electrical equipment must be SABS approved.

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Battery Energy Storage Systems

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Sample place holder only full references will need to drafted

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