Sustainable energy solutions for South African local government

A practical guide

HEINRICH BÖLL STIFTUNG SOUTHERN AFRICA
SEA SUSTAINABLE ENERGY AFRICA
SAMSET Supporting Sub-Saharan Africa's Municipalities with Sustainable Energy Transitions
USAID | SOUTH AFRICA Low Emissions Development Program
Brot für die Welt Bread for the World – Protestant Development Service

Produced by Sustainable Energy Africa

The Green Building

9B Bell Crescent Close

Westlake

7945

tel: 021- 7023622

fax: 021-7023625

email: info@sustainable.org.za

website: www.sustainable.org.za

August 2017

Report citation

SEA. 2017.

Sustainable energy solutions for South African local government: a practical guide

(Cape Town: Sustainable Energy Africa).

Design and layout: dotted line design
www.dottedlinedesign.co.za

Overview

How do Solar Photovoltaics work?[1]

'Photovoltaic' means the direct conversion of light into electricity. This happens at the atomic level. Some materials have photoelectric properties because they absorb sunlight and release electrons When these free electrons are captured, an electric current results. For solar photovoltaic cells, specially treated semiconductor materials are used for this purpose.

A solar module is a collection of individual cells. Multiple modules can be wired together to form a larger panel, or an array. In general, the larger the area of a module or array, the more electricity will be produced. Photovoltaic modules and arrays produce direct-current (DC) electricity. They can be connected in both series and parallel electrical arrangements to produce any required voltage and current combination.

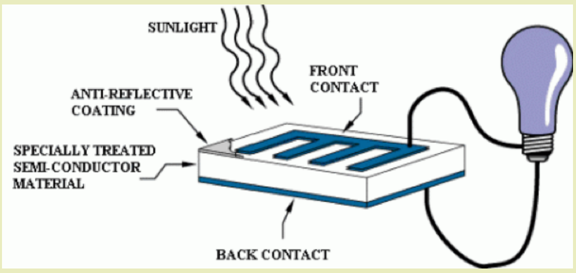
The DC current from the solar array is then often fed into an inverter to convert the power to AC – the type of power in a normal electricity network. AC power is generally preferred because most appliances are designed for AC electricity. While they are sophisticated electric systems, PV systems have few moving parts, so they require little maintenance. The basic PV module can last more than 30 years.

Where are solar PV systems used?

Solar PV systems can be installed on house or other building roofs to provide electricity needs, or they can be installed as ground-mounted arrays. The most common practice is to mount modules onto a north-facing roof. PV systems likewise can be blended into virtually every conceivable structure for commercial buildings. You will find PV used outdoors for security lighting as well as in structures that serve as covers for parking lots and bus shelters. It is used for rural water pumping, to

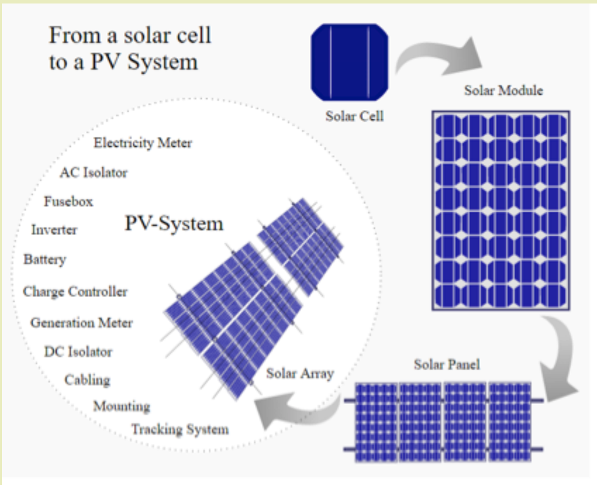
1 Sources: Wikipedia Photovoltaic System; NASA How do photovoltaics work?

Figure 1: how a basic solar photovoltaic cell operates



Source: https://science.nasa.gov/science-news/science-at-nasa/2002/solarcells

Figure 2: From a solar cell to a PV system



Source: https://en.wikipedia.org/wiki/Photovoltaic_system

Source: SEA

'Kilowatt-Peak' (kWp) rating of solar PV

Solar PV panel sizes are rated in kilowatt-peak (kWp): a 1 kWp panel will produce 1 kilowatt at midday on a sunny day (officially, the kWp rating is when solar radiation is 1000 watts per m^2 – which is roughly the sunshine power at midday in summer).

provide power to poor rural households, to power large malls, on government buildings, and for many other applications.

Systems can be grid-connected – where the inverter synchronises the PV power with the local grid and feeds PV power into the grid, or stand-alone, where there is no link to the local grid and a battery is charged by the PV array to enable electricity use (e.g. for lighting) at night and during cloudy weather.

Sunlight Requirements for PV Systems

Since solar photovoltaic (PV) systems require a significant capital outlay, it is best that they have unobstructed access to the sun's rays for most or all of the day to produce maximum output for the investment. Shading on the system can significantly reduce energy output. Most parts of South Africa have abundant year-round sunshine by world standards, enabling relatively high solar electricity output from these systems.

Different Scales of Solar PV Systems: Single house to large power station

Solar PV systems can be of any size, from one panel to charge a battery for lighting in a small rural house, through to a 'solar power station' using thousands of panels to feed hundreds of Megawatts of power into a national electricity grid. The size depends on several factors such as how much electricity is needed, the size of the roof on which it is to be mounted, available funding, and how much energy is required.

Implementation of SSEG

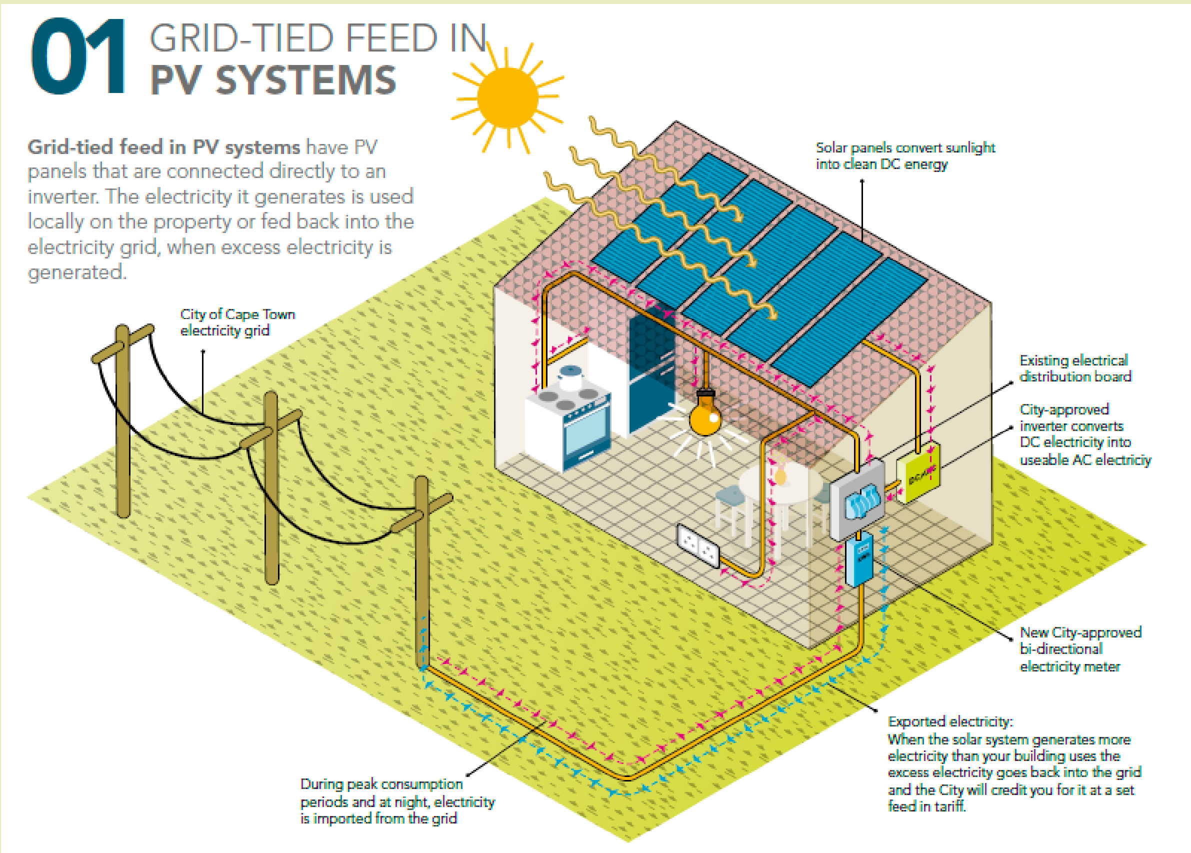
Solar Photovoltaic Small-Scale Embedded Generation Systems

Municipal distributors are facing the fact of accelerating grid-connected solar generation systems within their networks, and many have implemented processes to regulate the situation so that safety and various technical standards are not compromised. This section explains the technology, drivers and standards of relevance, as well as the impact on municipal revenue, and how the challenges can be met in a way that works for the customer and the municipality.

What is a solar photovoltaic small-scale embedded generation (SSEG) system?

A solar Photovoltaic (PV) system that is connected to the distribution grid, is called an 'embedded' generator. It is also often called a 'grid-tied' generator. 'Small-scale' generally is taken to be < 1 Megawatt (MW). SSEG systems are often installed on building rooftops. A key component in the system is the grid-tied inverter, which takes the DC power generated by the solar PV panels and converts it to AC power which is synchronized with the distribution grid power in frequency and other parameters, and feeds it into the normal building distribution board.

Figure 3: Components of a PV SSEG system



Source: City of Cape Town (2016) Safe and Legal Installation of Rooftop PV systems.

When the panels are generating less electricity than the building needs, the extra power is automatically drawn from the distribution grid as normal. At night all power needs would be drawn from the grid. When the panels are generating more than is needed by the building, the extra power is exported to the distribution grid for use elsewhere. A specially installed bi-directional meter records all power drawn from the grid and exported to the grid for billing purposes. PV SSEGs generally have no battery backup, and when the grid fails, for example, the SSEG is required to shut down operation for safety reasons.

Stand-alone solar PV systems

Stand-alone solar PV generators, on the other hand, have no physical connection to the grid and so must have batteries for night time electricity use or other periods when the solar power is not enough to meet the demand.

International trends

Solar PV panel prices have been falling steadily for at least the last decade, and this decrease is expected to continue. This has led to solar PV power becoming cost-competitive with conventional generation technologies in many countries around the world, and there has been an associated exponential increase in solar PV installations globally.

Figure 4: Price per Wp of Solar PV: 2007 – 2022

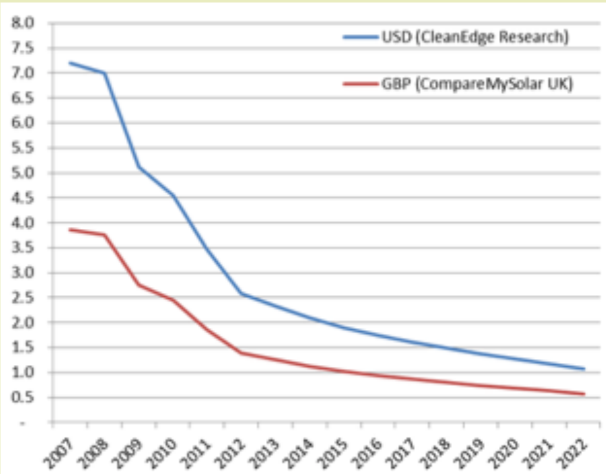
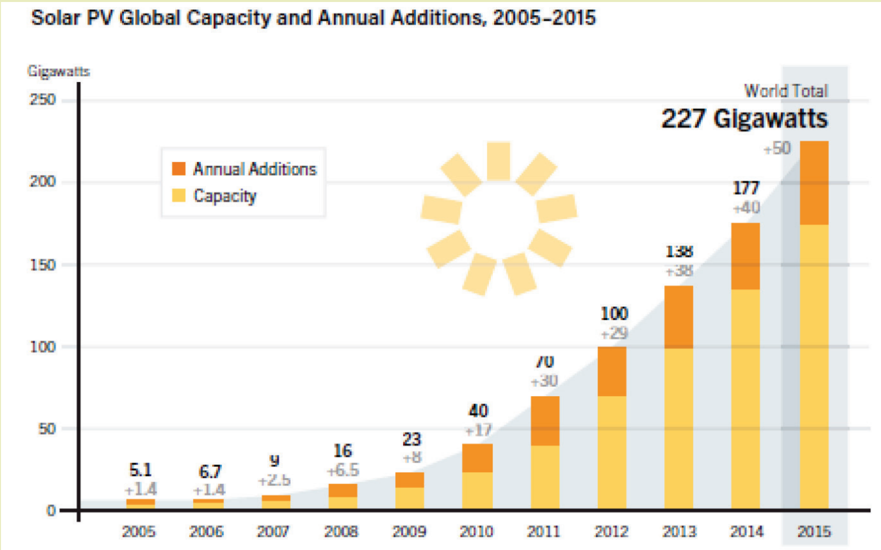


Figure 5: PV technology is developing fast – these roof tiles are actually solar generators, and are expected to be cost-competitive with conventional solar PV panels in the near future

Source: http://www.cornwallsolarpanels.co.uk/solar-panel-aesthetics/

Figure 6: Solar PV global capacity and annual additions from 2005 to 2015

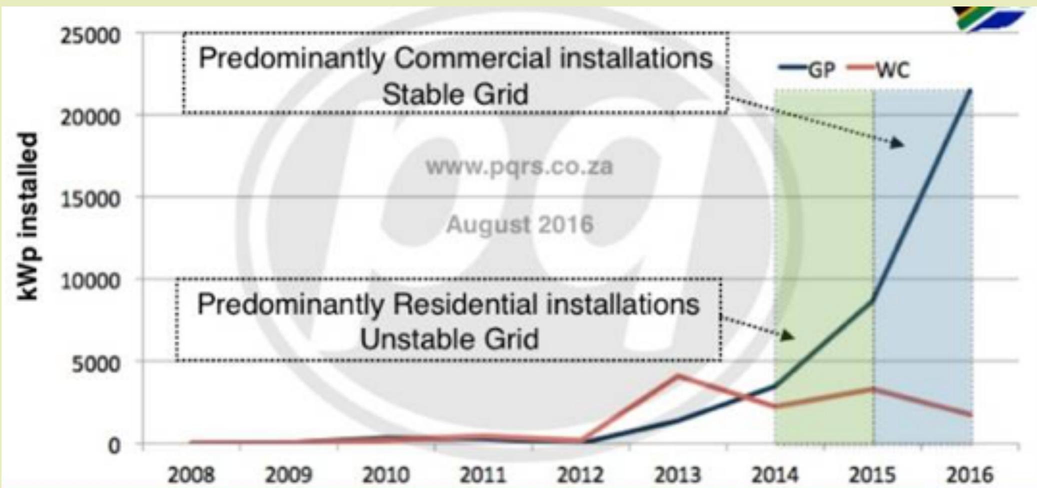


Source: REN21 Renewables (2016) Global Status Report

Local trends in urban areas

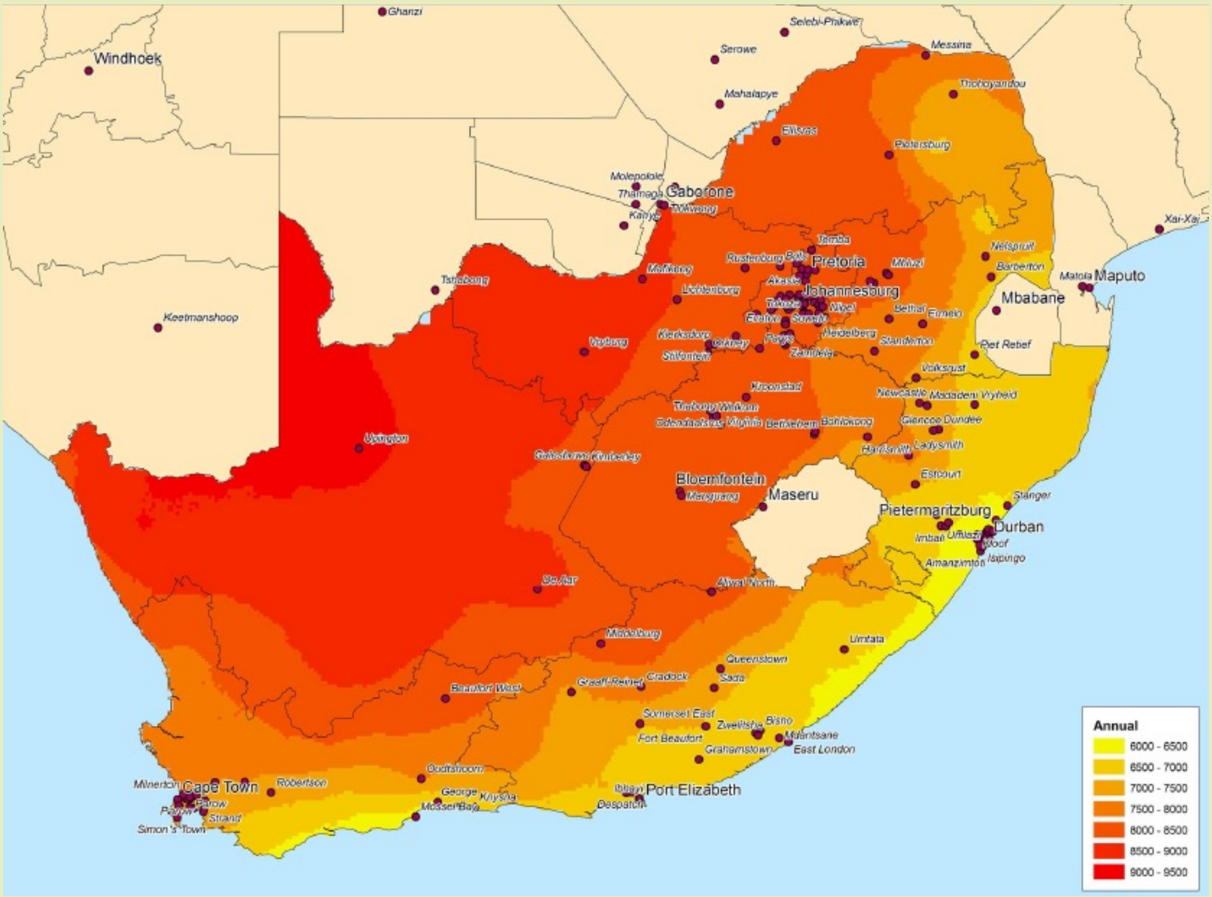
Associated with global PV price reductions as well as a strong solar radiation resource in the country, and spurred on by high annual grid power price increases as well as load shedding, SSEG installations in South African municipal areas has also been accelerating. This is taking place in residential, commercial and industrial sectors, where customers deem the investment worthwhile in the longer-term. Many of these installations have been undertaken without official approval (which is necessary to connect to the grid) often because municipal distributors have not had procedures in place to engage with to obtain permission.

Figure 7: supplier data on PV installations in Gauteng and Western Cape



Source: www.pqrs.co.za

Figure 8: Solar resource map

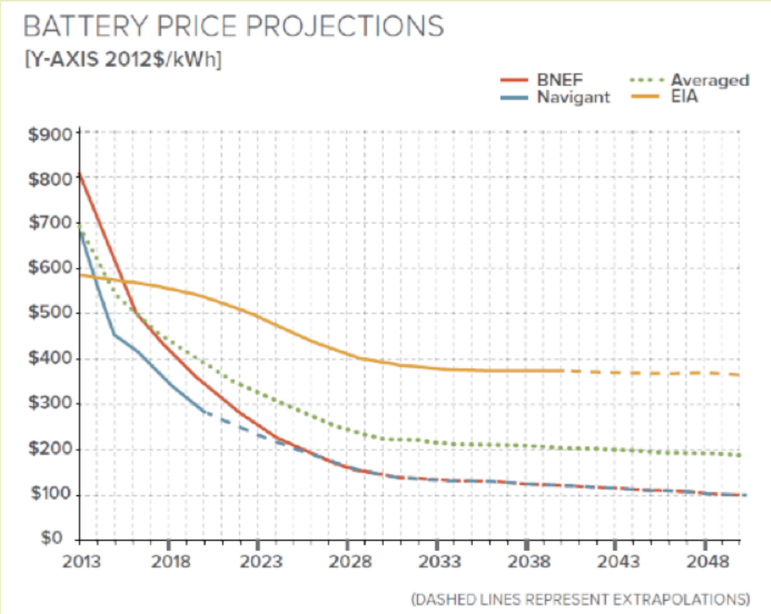


Source : http://www.aaamsa.co.za/images/Matrix/2015/TIASA/Annual%20Solar%20Radiation%20Map%20as%20provided%20by%20the%20CSIR.pdf

Battery storage price reductions: The Game Changer?

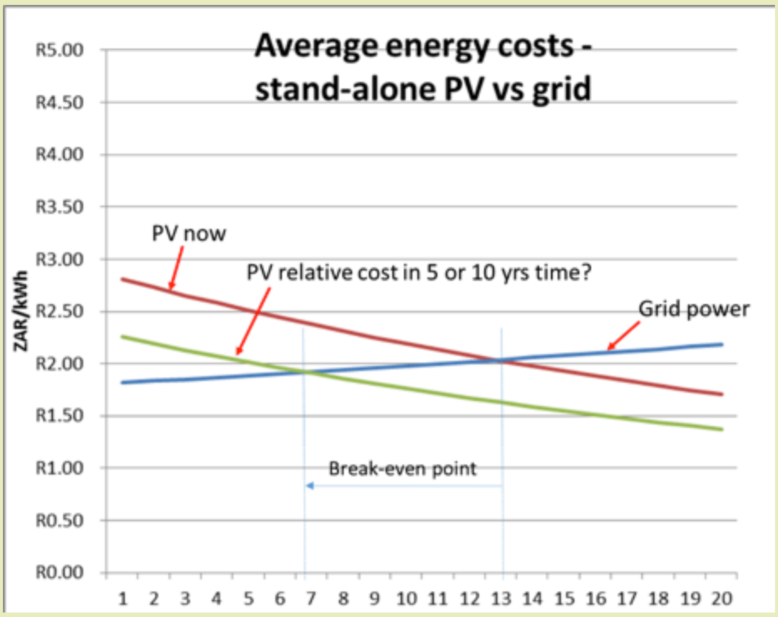
Battery storage prices have been declining fast in the recent past – with almost a 30% reduction in the past 3 years – and this trend is expected to continue (see on next page). This means that stand-alone, off grid solar generation could become viable sooner than we think, leading to potentially significant 'defections' from the grid (households and businesses disconnecting from the grid and generating all the power they need through their private solar PV-battery system). For many municipal distributors this may be disastrous: How will they obtain much needed revenue when many wealthier customers are disconnecting from the grid? How will the poor consumers be cross-subsidised? What funds will maintain the distribution grid? Unfortunately this trend is not in municipal control. The best they can do is to make user-friendly procedures and tariffs for existing customers to stay on the grid as long as possible, including for existing and new PV SSEG customers, and to adjust municipal business models to prepare for these radical shifts in the external environment.

Figure 9: Blended battery price projections



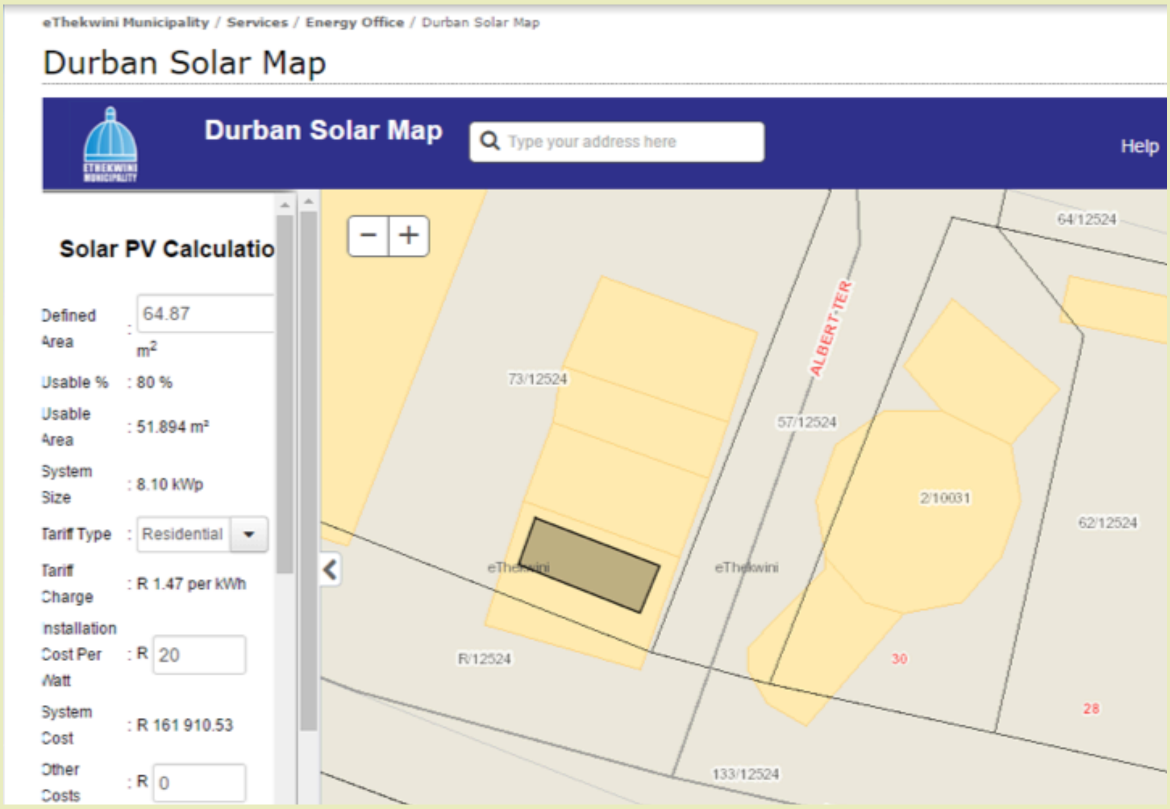
Source: Rocky Mountain Institute

Figure 10: Illustrative impact of relative reductions in stand-alone PV (panel and battery) prices on system financial viability (assuming loan financed at 13%, 8% grid tariff escalation)



Source: SEA

Figure 11: eThekwini municipality have developed an interactive map to help prospective SSEG customers assess the feasibility of such systems, and link them with installers



Source: http://gis.durban.gov.za/solarmapviewer/

The price and payback of solar SSEG

Typical SSEG system costs[2]

- Smaller systems <100kWp: From R20 000 to R25 000 per kWp installed
- Larger systems >100kWp: From R15 000 to R17 000 per kWp installed

Table 1: typical cost breakdown for an SSEG system *

	SMALL system (4kW)		Larger system (160kW)	
	ZAR	% of total cost	ZAR	% of total cost
PV panels	R41 430	50%	R1 656 960	56%
Inverter	R17 470	21%	R611 520	21%
Balance of system equipment	R11 900	14%	R452 350	15%
Installation	R6 900	8%	R207 000	7%
Bi-directional meter	R3 000	4%	R9 000	0.3%
Commissioning, sign-off	R2 000	2%	R4 000	0.1%
TOTAL	R82 700	100%	R2 940 830	100%

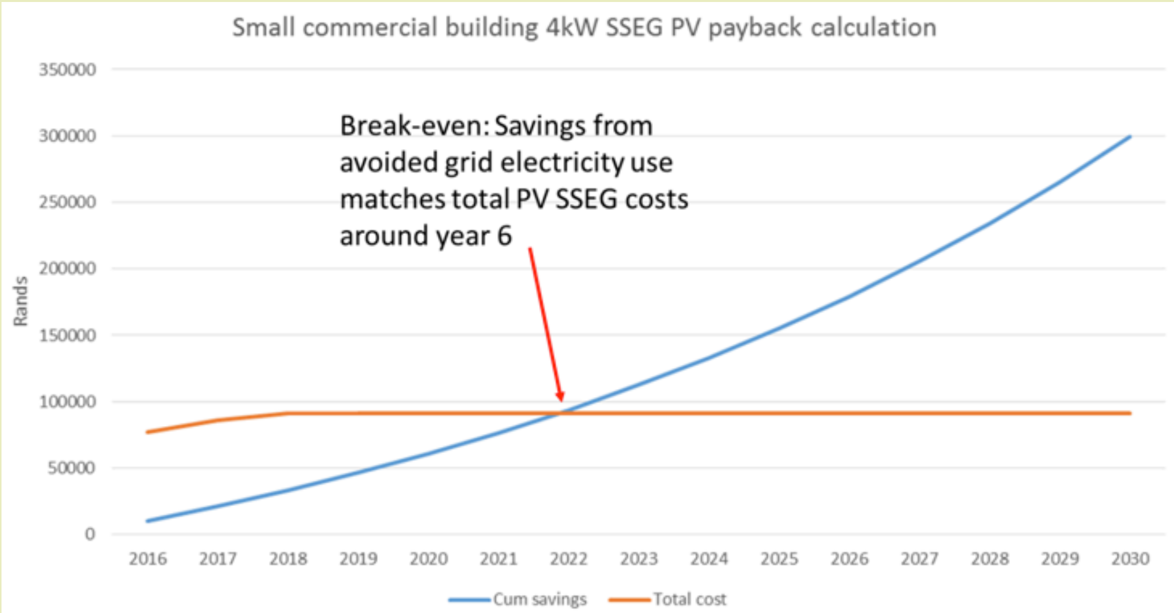
* derived from actual quotes, excluding VAT

2 GreenCape Market Intelligence Report (2016) Energy Services: Energy efficiency and embedded generation. www.greencape.co.za

Commercial and industrial system payback for the customer

Payback varies depending on the tariff the customer is on. Most commercial and industrial customers are on tariffs that have a significant fixed demand charge component. Since generally commercial and industrial customers are daytime loads, most, if not all, of the solar power generated will be used on site (i.e. there will be little export power onto the grid, and mainly at weekends if at all). Even without compensation for this, typical payback periods are in the region of 6 to 9 years currently, although this is tariff dependent. Many commercial and industrial customers currently consider a PV SSEG system a good investment with sound returns. New developments such as malls are starting to install PV SSEG as a matter of course. One mall developer noted that it provided them with an 18% internal rate of return, whereas they decide to develop malls based on a 10% rate of return.[3]

Figure 12: Example of small commercial PV system payback calculation from developer (based on a 3 year loan, not discounted)



Source: SEA

Residential SSEG payback for the customer

The residential SSEG payback is highly dependent on the tariffs. One important difference between most residential systems and commercial or industrial SSEG is that residential SSEG customer will often generate more solar energy than the household needs (i.e. when people are at work during the middle of the day and solar generation is at its maximum), so system payback usually becomes very dependent on the export tariff provided by the distributor (see more under 'Revenue impact' section).

3 Personal communication Moeketsi Thobela, SAPVIA.

Table 2: Comparing different billing principles for residential SSEG systems

Billing principle	Explanation	Comment
Net Metering	The meter does not record export power separately, but effectively 'reverses' when solar power is exported* – the customer is charged based on the total kWh consumed minus the exported power (i.e. the export power is compensated for at the same c/kWh as the power purchased from the distributor). ** Note that while some spinning-disc meters are able to reverse, they are not designed for this and municipalities therefore do not permit their use as a net meter.*	Municipal distributors would find it difficult to justify this approach as it would be cheaper to purchase power from Eskom at the Megaflex rate than purchase export power from the SSEG customer at the same rate at which they sell power to the customer. This is effectively subsidizing the SSEG customer. The only reason to follow this route would be to specifically boost PV SSEG uptake for economic or clean energy reasons.
Net Billing	The meter records power consumed from the distributor separately from solar power exported onto the grid, and bills these at different rates (e.g. grid power is purchased by the customer at R1.50/kWh and solar power export compensated at 85c/kWh).	This is considered sound practice for distributors, as they are purchasing power from the SSEG at rates comparable to Eskom Megaflex/bulk purchase rates.
No reverse feed (export)	Excess solar PV generated by the SSEG customer is not allowed to flow back onto the grid. Reverse–feed blocking is required, and no bi-directional meter is necessary. Existing meters can be retained (even prepayment meters).	Some distributors are not allowing reverse feed, although generally this is a temporary measure. This is often a significant disincentive for households to install SSEG, and is not recommended as it leads to systems being installed without the customer seeking official permission from the distributor. It also has a distinct municipal revenue disadvantage over net billing (see Revenue Impact Section).

Table 3: Typical payback periods for residential SSEG customers[4]

Net metering ('reversing' meter):	6 to 8 years
Net billing (separate export tariff):	12 to 15 years
No reverse feed or no compensation:	13 to 20 years

4 This is illustrative, as it is very tariff dependent. Values informed by the GIZ/Genesis Revenue Impact Modelling spreadsheet (available on www.cityenergy.org.za) and financial model developed by eThekwini Energy Office (available on: http://www.durban.gov.za/City_Services/energyoffice/projects/Pages/RenewableEnergy.aspx)

Figure 13: Solar energy changes for different orientations (azimuth) and tilt angles for a site at latitude 27 degrees South (Gauteng is 25-26 degrees South, eThekwini 29 degrees, Cape Town 34 degrees).

Heading / Azimuth

Tilt Angle	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90
5*	-8%	-8%	-8%	-7%	-7%	-6%	-6%	-6%	-6%	-6%	-6%	-6%	-6%	-7%	-7%	-8%	-8%	-9%	-9%
10	-9%	-8%	-7%	-6%	-5%	-5%	-4%	-4%	-4%	-4%	-4%	-4%	-5%	-5%	-6%	-7%	-8%	-9%	-10%
15	-9%	-8%	-6%	-5%	-4%	-3%	-3%	-2%	-2%	-2%	-2%	-3%	-3%	-4%	-5%	-7%	-8%	-9%	-11%
20	-10%	-8%	-7%	-5%	-4%	-3%	-2%	-1%	-1%	-1%	-1%	-2%	-3%	-4%	-5%	-7%	-9%	-10%	-12%
25	-12%	-9%	-7%	-5%	-4%	-2%	-1%	0%	0%	0%	0%	-1%	-2%	-4%	-5%	-7%	-9%	-12%	-14%
30	-13%	-10%	-8%	-6%	-4%	-3%	-1%	0%	0%	0%	-1%	-1%	-3%	-4%	-6%	-8%	-11%	-13%	-16%
35	-15%	-12%	-9%	-7%	-5%	-3%	-2%	-1%	-1%	-1%	-1%	-2%	-3%	-5%	-7%	-10%	-12%	-15%	-18%
40	-17%	-14%	-11%	-8%	-6%	-4%	-3%	-2%	-2%	-2%	-2%	-3%	-5%	-7%	-9%	-11%	-14%	-17%	-20%
45	-19%	-16%	-13%	-10%	-8%	-6%	-5%	-4%	-3%	-3%	-4%	-5%	-7%	-9%	-11%	-14%	-16%	-19%	-23%
50	-22%	-18%	-15%	-12%	-10%	-8%	-7%	-6%	-5%	-6%	-6%	-7%	-9%	-11%	-13%	-16%	-19%	-22%	-25%
55	-24%	-21%	-18%	-15%	-13%	-11%	-10%	-9%	-8%	-8%	-9%	-10%	-12%	-14%	-16%	-18%	-21%	-25%	-28%
60	-27%	-24%	-20%	-18%	-16%	-14%	-13%	-12%	-12%	-12%	-12%	-13%	-15%	-17%	-19%	-21%	-24%	-27%	-31%
65	-30%	-27%	-24%	-21%	-19%	-17%	-16%	-16%	-15%	-16%	-16%	-17%	-18%	-20%	-22%	-25%	-27%	-31%	-34%
70	-33%	-30%	-27%	-25%	-23%	-21%	-20%	-20%	-20%	-20%	-20%	-21%	-23%	-24%	-26%	-28%	-31%	-34%	-37%
75	-37%	-33%	-31%	-28%	-27%	-26%	-25%	-24%	-25%	-25%	-25%	-26%	-27%	-28%	-30%	-32%	-35%	-38%	-41%
80^	-41%	-37%	-35%	-33%	-31%	-30%	-30%	-30%	-30%	-30%	-31%	-31%	-32%	-33%	-34%	-36%	-38%	-41%	-44%

Tariffs for PV SSEG[5]

Residential SSEG Tariffs

Residential SSEG tariffs are necessary because most municipalities' normal residential tariffs are based only on a c/kWh charge. Such normal tariffs become unsound with SSEG systems, as customers can end up paying very little towards the operation and maintenance of the distribution grid infrastructure, yet they rely on this infrastructure when SSEG output is low and at night. For this reason a fixed charge component is necessary with residential SSEG tariffs to ensure all customers are sharing costs more equally. A typical residential SSEG tariff is comprised of three parts:

- A fixed charge covering both service and network charges:
  - Network charges ensure that fixed costs associated with maintaining and operating the municipal electrical grid are recovered
  - Service charges are associated with providing a retail service network (metering, billing, customer call centre)
- Electricity consumption charges per kWh consumed from the grid – this may be simple (Flat or Inclining Block tariff) or complex (Time of Use or other tariff).
- An export compensation rate per kWh at which the municipality purchases SSEG excess generation exported to the grid.

5 This part of the chapter draws extensively from the report: GreenCape Requirements for Embedded Generation and AMEU Standard SSEG documentation (available from www.greencape.co.za, www.cityenergy.org.za). Unless referenced otherwise, information is sourced from this document.

Different approaches to 3-part SSEG tariff setting

Municipalities have chosen their 3-part SSEG tariffs very differently – some opting for high fixed charges and low export compensation charges (which will discourage prospective SSEG customers and increase the rate of 'unofficial' installations), while others have SSEG tariff regimes which incentivise prospective SSEG customers, both to stimulate the industry and embrace green energy, as well as to reduce the incidence of 'unofficial' installations. The spread of tariff approaches is illustrated in Table 4.

Table 4: Residential Normal and SSEG tariffs in selected Metros

(excluding VAT)	Johannesburg (City Power)	Cape Town	eThekwini	Nelson Mandela Bay
Current 'normal' residential c/kWh (high IBT)	145	200.05	129.39	170
Residential SSEG fixed charge/mth (R) (1-ph)	R440	R342	R220	R60
Residential SSEG energy charge (c/kWh)	140.65	200.05	129.39	175 peak 170 std 125 off-pk
SSEG feed-in tariff (c/kWh)	42.79	61.47	62	150

Source: 2016 tariff documents from each municipality

Commercial and Industrial SSEG Tariffs

Commercial and industrial customers are generally on tariffs which already have a fixed service charge and network demand charge as well as a variable energy charge, and therefore only an export generation tariff component needs to be added. Customers on a tariff that does not include fixed service charge and demand charge will need to be changed to an appropriate tariff.

Although Commercial and Industrial SSEG customers sometimes expect a reduced demand charge because of their SSEG system, this is usually not the case: because of cloudy days there can seldom be a long-term reduction in customer peak demand, and therefore most distributors will charge the same demand charge as previously because they still need to ensure that the supply infrastructure capacity can meet the peak demand without the solar SSEG contribution.

Time of Use tariffs are considered best practice for both consumption and export (feed-in) tariffs, and municipalities may increasingly move to such tariffs over time.

National regulatory and policy situation

The national regulatory and policy situation has catered for SSEG systems inadequately in the past, but is being amended to rectify this. Although many of the key technical standards are now in place, the relevant national acts and regulations are in the process of being finalized.

Electricity Regulation Act, Act 4 of 2006 (ERA)

The act states that no person may, without a license issued by the regulator (NERSA), operate any generation facility. The current proposed amendment of the ERA Schedule 2 exempts systems which are 1MW or smaller in generation capacity from obtaining a license.

NERSA SSEG regulations

NERSA regulations around SSEG will be developed during the course of 2017, once the ERA amendment above has been finalised.

Standards of Importance

The below standards are the most important for embedded generation, and they set the majority of regulatory requirements that municipalities need to ensure are complied with in their SSEG application and approval processes.

NRS 097-2-1 (Part 2: Small Scale Embedded Generation, Section 1)

This document serves as the standard for the interconnection of SSEG's to the utility network and applies to embedded generators smaller than 1000kVA connected to LV networks of type single, dual or three-phase. The document covers thorough all key safety concerns (anti-islanding and response to abnormal grid conditions) and power quality criteria (harmonics, over-under-voltage, over-under-frequency, DC injection, flicker etc.). Municipalities are advised to require SSEG inverters to have test certificates from accredited test houses for compliance with NRS097-2-1.

NRS 097-2-3 (Part 2: Small Scale Embedded Generation, Section 3)

This document provides simplified utility connection criteria for low-voltage connected generators. Some criteria for 'simplified utility connection' in this standard include:

- Systems up to 350KVA size
- Shared LV feeders: systems up to 25% of circuit breaker size, with a maximum of 20kVA
- Dedicated LV feeders: systems up to 75% of notified maximum demand

There are many other criteria in the standard which should be consulted. If SSEG installations comply with the criteria herein, municipal distributors are able to approve SSEG applications relatively quickly. If not, municipalities should still look to approving installations, but may consider requiring special grid impact studies before such approval.

Wiring standards: SANS 10142-Part 3: The Wiring of Premises – low voltage embedded generators (under development, due end 2017)

This standard will regulate the DC wiring on the customers side of the meter (SANS 10142-1 permits DC wiring but does not deal with it in adequate detail).

South African Renewable Power Plants Grid Code (SARPPGC)

This document is also considered a foundational standard for SSEGs, although in practice the vast majority of requirements for SSEGs are laid out in the NRS097 series of standards (which are substantially based on the SARPPGC). Systems above 1MW (and therefore not small-scale) will need to comply with the SARPPGC, as the NRS097 series does not apply.

Further information on Standards and Legislation

OCCUPATIONAL HEALTH AND SAFETY ACT, 1993

The Occupational Health and Safety Act provides for the health and safety of the people by ensuring that all undertakings are conducted in such a manner so that those who are, or who may be, directly affected by such an activity are not negatively harmed as far as possible and are not exposed to dangers to their health and safety.

NRS 097 PART 1: DISTRIBUTION STANDARD FOR THE INTERCONNECTION OF EMBEDDED GENERATION

The specification sets out the minimum technical and statutory requirements for the connection of embedded generators to **medium-voltage and high-voltage** utility distribution networks. The specification applies to embedded generators **larger than 100 kVA**. (under development)

SOUTH AFRICAN RENEWABLE POWER PLANTS GRID CODE (SARPPGC)

This document is also considered a foundational standard for SSEGs, although in practice the vast majority of requirements for SSEGs are laid out in the NRS097 series of standards (which are in fact substantially based on the SARPPGC). It sets out the technical and design grid connection requirements for renewable power plants (RPP) to connect to the transmission or distribution network in South Africa. This guideline is of concern to embedded **generators of Category A that are connected to a low-voltage (LV) network.**

Category A: 0 – 1 MVA (Only LV connected RPPs)

This category includes RPPs with rated power of less than 1 MVA and connected to the LV voltage (typically called 'small or micro turbines'). This category shall further be divided into 3 sub-categories:

Category A1: 0 – 13.8 kVA

This sub-category includes RPPs of Category A with rated power in the range of 0 to 13.8 kVA.

Category A2: 13.8 kVA – 100 kVA

This sub-category includes RPPs of Category A with rated power in the range greater than 13.8 kVA but less than 100 kVA.

Category A3: 100 kVA – 1 MVA

This sub-category includes RPPs of Category A with rated power in the range 100 kVA but less than 1 MVA.

SANS 10142-1 THE WIRING OF PREMISES – LOW-VOLTAGE INSTALLATIONS

This document serves as the South African national standard for the wiring of premises in low-voltage networks. The aim of the document is to ensure that people, animals and property are protected from dangers that arise during normal as well as fault conditions, due to the operation of an electrical installation. Compliance to the standards and regulations as laid out SANS 10142-1 is required and proof should be provided via an electrical installation certificate of compliance.

SANS 10142-2 THE WIRING OF PREMISES – MEDIUM-VOLTAGE INSTALLATIONS ABOVE 1 KV A.C. NOT EXCEEDING 22 KV A.C. AND UP TO AND INCLUDING 3 000 KW INSTALLED CAPACITY

This document serves as the South African national standard for the wiring of premises in medium-voltage networks. The aim of the document is to ensure that people, animals and property are protected from dangers that arise during normal as well as fault conditions, due to the operation of an electrical installation. Compliance to the standards and regulations as laid out SANS 10142-2 is required and proof should be provided via an electrical installation certificate of compliance. The implication is that a qualified electrician is required to sign off on your system.

SANS 10142-3 THE WIRING OF PREMISES – LOW VOLTAGE EMBEDDED GENERATORS (UNDER DEVELOPMENT, DUE END 2017)

This standard will regulate the DC wiring on the customers side of the meter (SANS 10142-1 permits DC wiring but does not deal with it in adequate detail).

SANS 474 / NRS 057 CODE OF PRACTICE FOR ELECTRICITY METERING

SANS 474 specifies the metering procedures, standards and other such requirements that must be adhered to by electricity licensees and their agents. It refers specifically to new and existing metering installations for the purpose of billing. It further specifies the initial calibration and certification requirements as well as compliance testing of metering installations and the subsequent procedures to ensure continued compliance. It specifies the procedures for the manipulation and storage of metering data and sets a standard format for the numbering of electricity meters.

NRS 049: ADVANCED METERING INFRASTRUCTURE (2015)

This standard ensures that AMI metering follows interchangeable protocols and features thus preventing utility lock-in to particular suppliers. It covers all devices and systems in a 'smart' metering system, including head-end, vending point-of-sale, meter, customer interface, data concentrator, auxiliary meter, and appliance control systems.

NRS 048: QUALITY OF SUPPLY

The **NRS 048** series covers the quality of supply parameters, specifications and practices that must be undertaken to ensure correct and safe operation. The NRS 048-2 and NRS 048-4 have the most relevance to the operation and connection of SSEG's to the utility network:

NRS 048-2: 'Voltage characteristics, compatibility levels, limits and assessment methods' sets the standards and compatibility levels for the quality of supply for utility connections as well as for stand-alone systems. It is intended that generation licensees ensure compliance with the compatibility levels set in this document under normal operating conditions.

NRS 048-4: 'Application guidelines for utilities' sets the technical standards and guidelines for the connection of new consumers. It also sets the technical procedures for the evaluation of existing consumers with regards to harmonics, voltage unbalance and voltage flicker.

SSEG: Challenges and concerns of municipal distributors

Municipalities are realizing that there is a need to be proactive in developing appropriate procedures and standards for SSEG integration to support the green economy as well as to avoid unregulated proliferation of installations. Some municipalities already have procedures in place to guide prospective SSEG installers regarding system criteria and standards to be followed, and have developed associated tariffs. Municipal distributors have to balance the following pressures:

- On the one hand they are obliged to ensure that the distribution grid power quality and safety standards are upheld – and are under threat of extreme penalties if they do not. This puts pressure on them to enforce demanding standards on SSEG installations, which in turn has a cost implication for SSEG installers.
- On the other hand they realise that unless they have a user-friendly framework around installation application and approval, SSEG systems will simply be installed and grid connected by one of the solar PV supply companies on behalf of customers without official approval.
- A further issue for municipalities revolves around potential revenue loss from reduced sales due to PV SSEG uptake amongst customers. The concern is that revenue losses may threaten their ability to cross-subsidise poor households and support other city functions. Current residential tariffs in particular are not designed to accommodate SSEGs, raising uncertainty about revenue loss. For this reason specific SSEG residential tariffs are generally introduced.

Municipalities may typically express their concerns as follows:

- Safety: "What about when the grid goes down and the SSEG is still powering a section thereof? What about the safety of our staff working on the lines?"
- Power quality: "We don't want all sorts of devices putting variable quality power onto our network."
- Revenue loss: "We will lose revenue because of reduced sales resulting from people generating their own SSEG electricity. And if they put power back onto the grid, it is during midday when we don't really need it."

These concerns have all been addressed through various standards and research undertaken. The first two are dealt with below, and revenue impact is covered in a subsequent section.

Figure 14: Example of safety labelling required by the NRS097-2-1 (at distribution board)

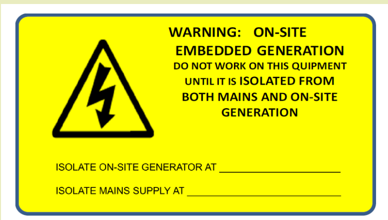
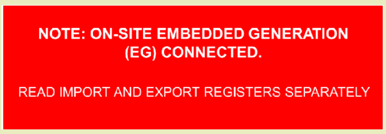


Figure 15: Example of safety labelling required by the NRS097-2-1 (at metering points)



Safety

Concerns around safety are no longer merited as long as systems comply with the NRS097-2-1 standard and are certified as such from an accredited test house. This standard requires a range of safety disconnection responses from the SSEG inverter to protect both people and equipment. Prevention of islanding[6] is amongst these, and the inverter is required to use both passive and active detection of grid power methods (active detection involves an attempt to vary an output parameter such as voltage or frequency, which will elicit no response if the grid is powered up, and will receive a response if the grid is down).

Power quality

The NRS097-2-1 standard deals with power quality thoroughly, drawing on the Renewables Grid Code as a reference. Amongst other parameters, it covers:

- Permissible voltage ranges, changes and unbalance
- Fault levels
- DC injection
- Frequency operating range

6 Islanding: continued generation on a portion of the grid when the main grid is down due to faults, maintenance or load shedding.

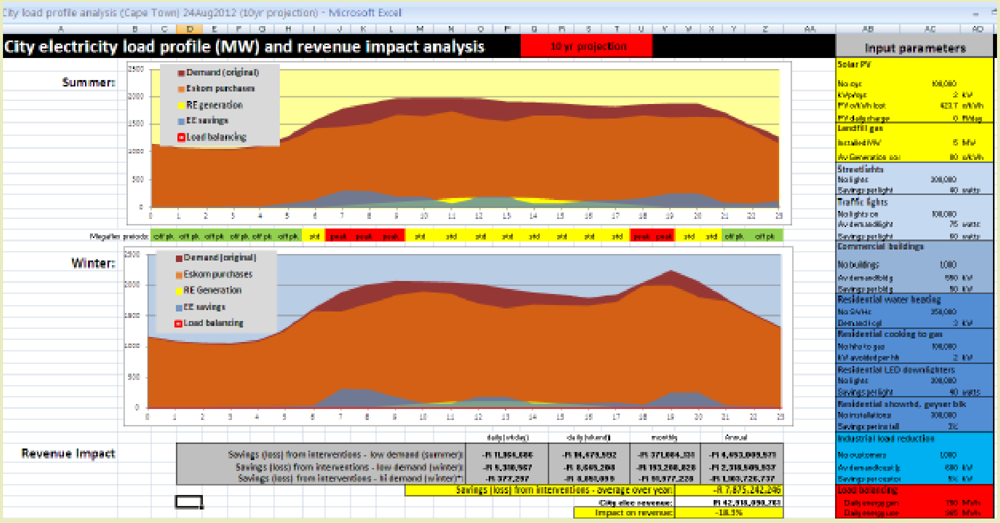
- Harmonics and waveform distortion
- Power factor
- Synchronization methods
- Electromagnetic compatibility

The challenge is therefore not one of poor power quality, but rather one of ensuring that inverters are compliant with and standards are certified as the NRS097-2-1. As long as this certification is in place, power quality need not be a concern.

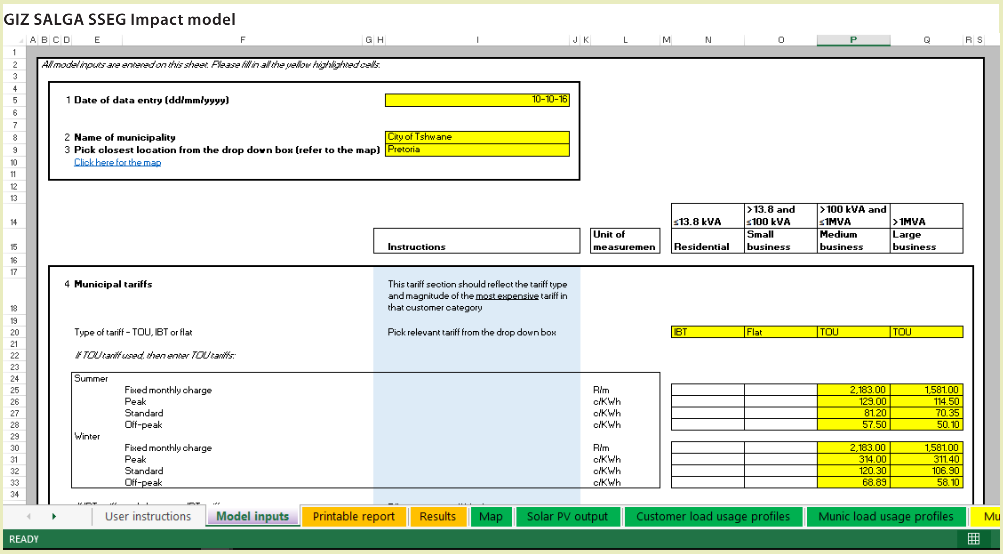
Revenue impact

Because it has been such a long-standing concern to municipal distributors, SSEG revenue impact assessment work has been underway since 2012.[7] Since this time detailed analyses have been undertaken in at least six major urban areas,[8] and, in spite of perceptions to the contrary, all analyses have indicated that revenue impact under feasible SSEG penetration scenarios is not a major concern. This section will outline the revenue impact methodologies and present typical results.

Figure 16: Two of the SSEG revenue impact models in existence. They are user-friendly and come with user manuals, and can be used for revenue assessments with specific tariffs to support tariff setting.



Source: Sustainable Energy Africa and GIZ/GENESIS respectively



Source: www.cityenergy.org.za

7 The potential impact of efficiency measures and distributed generation on municipal electricity revenue: Double whammies and death spirals. Sustainable Energy Africa. AMEU conference, September 2012.

8 Including eThekwini, Ekurhuleni, Polokwane, Cape Town and Tshwane

Factors in a revenue impact assessment

The following are important factors in assessing the revenue impact of SSEG introduction:

Commercial and industrial demand charges: Because most months have at least one cloudy day in much of the country, there is generally no consistent, long-term reduction in demand charges due to installation of PV SSEG systems. PV SSEG therefore generally has no demand charge revenue impact.

Figure 17: Demand charge reductions are negligible due to SSEG installations because of the incidence of cloudy weather most months of the year.

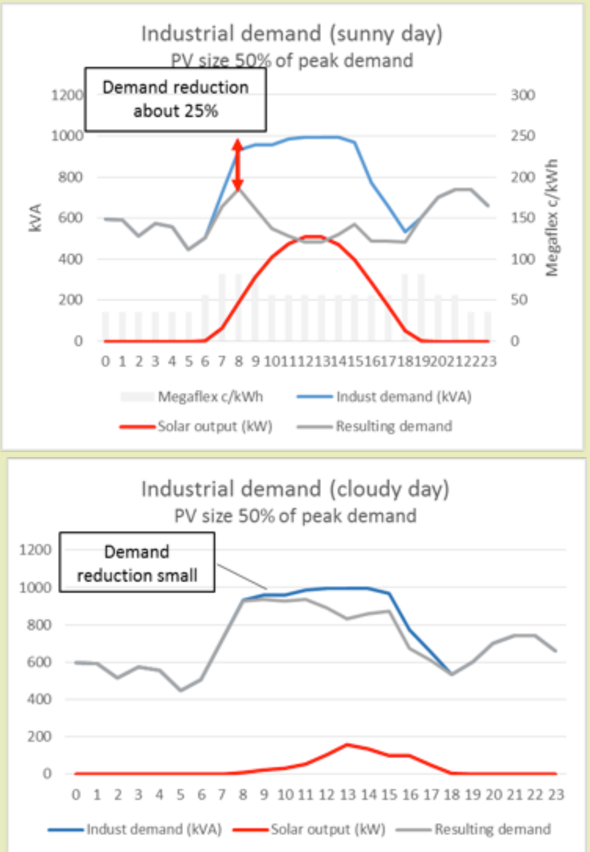


Figure 18: Revenue impact considerations for industrial SSEG customers

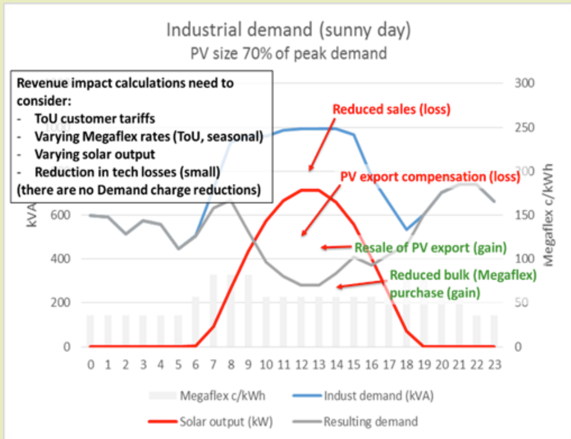
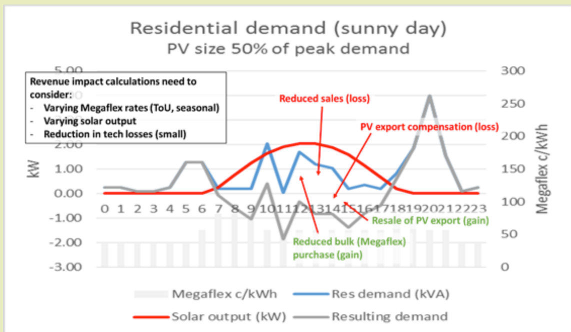


Figure 19: Revenue impact considerations for residential SSEG customers



Electricity sales reduction because of SSEG generation: this will result in a revenue loss for the municipal distributor.

SSEG export compensation: where distributors compensate SSEG customers for export power, this will also result in a revenue loss. It is sensible for such compensation to be related to bulk purchase tariffs, e.g. around 65 to 85 c/kWh currently.

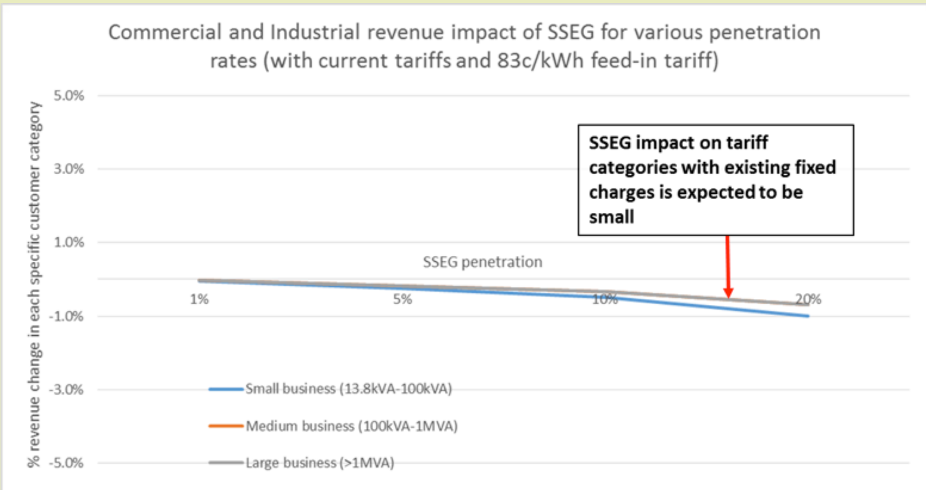
Resale of SSEG export power: SSEG export power should be resold at normal tariff rates, representing a revenue gain for the distributor.

Reduced bulk purchases: because less electricity is required by municipal customers, bulk purchases are reduced, which is a revenue gain. In addition to the above factors, a revenue impact analysis needs to consider the ToU tariffs that customers are on, the ToU and seasonal variations of bulk purchase tariffs, variations in solar SSEG generation with the weather, and the fact that decentralized SSEG generation will have some impact on reducing distribution losses, although likely to be small. Residential SSEG customers often generate a greater percentage of excess solar power for export than commercial or industrial customers whose demand is more daytime peaking (i.e. matching the solar generation profile better) than residential customers. Distributors should keep in mind that such SSEG customer export power represents a revenue opportunity for them, as they would typically compensate at a bulk purchase rate (e.g. 65c/kWh) yet re-sell at a normal midday tariff rate (e.g. R1.00/kWh).

Typical revenue impact results

Some typical revenue impact results are shown in the graphs below. Where customers are on a tariff which already has a fixed charge component, the impact is generally not significant. The more cost reflective such tariffs are (as determined by a 'Cost of Supply' study) the less revenue will be lost, as the actual fixed costs will be recovered through the tariff irrespective of SSEG penetration rates. This has been a consistent finding in all revenue impact analyses since the first such exercises in 2012.

Figure 20: The revenue impact from SSEG for different penetration rates (x-axis) for customers already on a tariff with a fixed charge is unlikely to be significant (note that a 20% SSEG penetration rate is an extreme scenario)

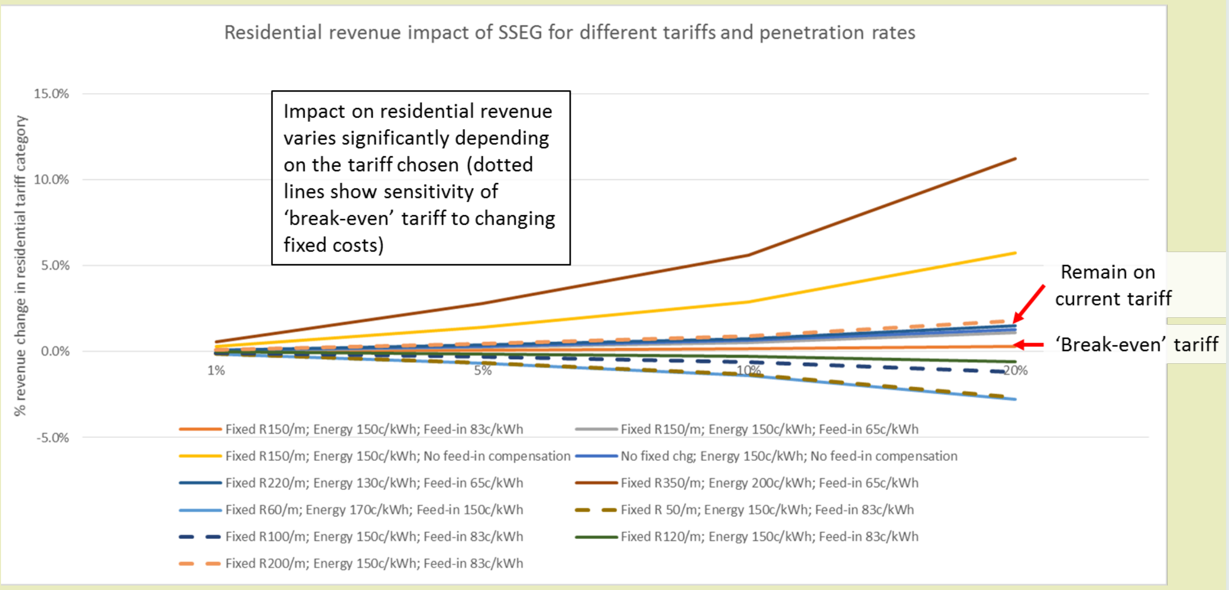


Source: SEA (2017) City of Tshwane Revenue Impact Study.

Residential SSEG revenue impact is sensitive to the SSEG tariff that is set by the municipal distributor. It is relatively easy to set a tariff that is both acceptable in terms of revenue impact and providing an adequate return on investment for the customer. As shown in the example in Figure 32, an appropriate tariff may be about R150 per month fixed charge, R1.50 per kWh electricity purchase charge, and R0.83 per kWh for export compensation. Even in the scenario where residential customers remain on current tariffs without a fixed charge, the revenue impact analyses show that the reduction in bulk purchases as well as revenue from resale of SSEG exported power will often result in minimal revenue loss for the distributor, if any [9].

9 Note that a 20% penetration rate is considered extreme. For example, in 2015 The Energy Supply Association of Australia published a report indicating that Australia was amongst the world leaders regarding residential SSEG penetration at 15%, with Belgium at 7%. A 2016 report indicates that 17% of all electricity customers (not just residential) in Hawaii have rooftop SSEG PV (Hawaii has been engaged in a programme to promote solar SSEG for over 10 years) (www.pv-magazine.com).

Figure 21: The revenue impact from residential SSEG installations for different SSEG penetration rates (x-axis) and different SSEG tariffs (coloured lines). Reasonable tariff setting can easily avoid revenue loss and still be acceptable to customers.



Source: City of Tswane Revenue Impact Study (SEA 2017).

The Business case for SSEG customers

It is important to understand the implications of their SSEG tariff on the business case for SSEG customers to avoid tariffs which weaken the financial returns on PV purchases excessively, as this is likely to increase illegal SSEG installations and encourage grid abscondment. Table 7 shows how tariffs can impact on SSEG investment payback periods, which can range from 9 years to over 20 years for residential systems. Even 9 years would be a daunting payback for many households, and estimates are that significant take-up of SSEG systems will only occur when payback is around 5 years[10]. A payback of 20 years is comparable to that for a stand-alone PV system (with batteries). It is therefore important to optimise residential SSEG tariffs so they keep payback periods as low as possible while still protecting municipal revenue. Payback for commercial systems is typically 10 years or less, which would often be considered a reasonable investment for businesses (e.g. giving an IRR of around 12-14%).

10 Sewchurran et al. (2016) See Drivers and Application of Small Scale DG on Municipal Distribution Networks, AMEU Conference.

Table 5: Payback (in years) for different customer characteristics and SSEG tariffs*

Residential	**Payback**		
SSEG Tariff	Small residential system (2kWp), 50% self-consumption, total consump 1000kWh/mth	Larger residential system (5kWp), 50% self-consumption, total consump 1000kWh/mth	Larger residential system (5kWp), 20% self-consumption, total consump 1000kWh/mth
Fixed R60/m; Energy 170c/kWh; Feed-in 150c/kWh (NMBMM)	13 yrs (cash) 20+ yrs (financed)	9 yrs (cash) 11 yrs (financed)	12 yrs (cash) 20+ yrs (financed)
Fixed R350/m; Energy 200c/kWh; Feed-in 65c/kWh (Cape Town)	20+ yrs (cash) 20+ yrs (financed)	20+ yrs (cash) 20+ yrs (financed)	20+ yrs (cash) 20+ yrs (financed)
Fixed R220/m; Energy 130c/kWh; Feed-in 65c/kWh (eThekwini)	11 yrs (cash) 19 yrs (financed)	11 yrs (cash) 17 yrs (financed)	12 yrs (cash) 20+ yrs (financed)
No SSEG tariff (and no export compensation)	12 yrs (cash) 20+ yrs (financed)	13 yrs (cash) 20+ yrs (financed)	20+ yrs (cash) 20+ yrs (financed)
Commercial	Payback		
Commercial (non-domestic 1-phase) Fixed R1102/m; Energy 130c/kWh; 100% self-consumption (no reverse feed)	8 yrs (cash) 10 yrs (financed)		

** Source: own calculations*

Assumptions for table 5:

Solar PV cost (grid-tied) /kW installed	R22,000
Solar PV O&M cost/year	1% of cap cost p.a.
Finance rate	11%
Financed over (years)	20
Grid Elec tariffs inflation (nominal)	7%*
Discount rate	0%

* Note that a 7% escalation of grid power costs is considered conservative by some, as municipal tariffs have escalated by well over 10% over the past 10 years. A higher escalation rate here would reduce system payback period.

Some key points emerging from all the revenue analyses undertaken for municipalities to date

- Solar PV SSEG revenue impact is not likely to pose a significant threat to municipal distributors, and is generally likely to be below 2% of total revenue for anticipated SSEG penetration rates.
- Expected revenue loss from substantial penetration of solar PV (even up to the extreme scenario of 20% penetration) is not significant in tariff categories where there is a fixed (R/kVA) and variable (c/kWh) charge already in existence (i.e. most commercial and industrial tariffs).
    - Note that it is important that tariffs are cost reflective such that fixed costs are recovered irrespective of SSEG penetration rates.
- An appropriate 'break even' residential SSEG tariff may be in the region of R150/month fixed charge, 150c/kWh energy charge, and 83c/kWh feed-in compensation (although an analysis of the situation in each municipality is recommended before deciding on a tariff).
- Municipalities should be careful not to reduce the business case for households to install SSEG solar PV by levying too high a fixed charge, or too low an export compensation charge, or making it difficult to obtain official approval through excessive bureaucratic hurdles. An attractive SSEG tariff and a simple application procedure guard against unofficial installations, with associated safety and power quality issues which are undesirable for a municipality. They can also guard against grid defections – 'chasing' prospective SSEG customers off grid by making stand-alone (off-grid with battery storage) solutions more feasible. As municipal operations currently stand, a trend of defections would represent a serious threat to financial sustainability.

The broader economic case: although not directly related to municipal revenue, municipalities should keep in mind that there are economic benefits to enabling SSEG rollout, such as strengthening the clean energy business sector and job creation.

PV GreenCard: SSEG PV installer accreditation

The South Africa Photovoltaic Industry Association (SAPVIA), GIZ and GreenCape are partnering around the development of a voluntary certification scheme for PV installers, called PV GreenCard. This will be a significant step in providing comfort for customers, distributors and financiers around installation integrity and compliance, as well as strengthening the credibility of the PV industry. While it is principally designed to provide residential customers with comfort and cross-checks, it can also be used for larger installations. The GreenCard initiative provides a best practice guide for installers, as well as a checklist for customers to assess the installations. If the customer is not happy with the system they can 'Red Card' the installation. The PV GreenCard covers:

- System components
- DC installation
- Ac installation (especially grid codes, NRS standards)
- Lightning protection
- Fire safety
- Rooftop installation
- Safety at work
- Commissioning, operation and maintenance

PVGreenCard

Short training course curricula have been developed and approved by SAPVIA to enable PV GreenCard certification, and these will be run by endorsed training providers. The courses are based on the national QCTO Curriculum.
It is intended that electricians with PV GreenCard certification will be able to sign off residential systems in future, rather than requiring Pr Eng or Pr Tech Eng sign-off of such systems. Professional sign-off will still be appropriate for larger commercial or industrial systems. For more information see www.pvgreencard.co.za.

How to implement a balanced SSEG approval process

Municipal distributors wishing to establish systems for accepting and processing applications for SSEG installations now have significant supporting resources available to them. Most significant are the set of standard documentation and forms endorsed by the AMEU (see text box).

AMEU Standard SSEG documents and forms

A set of AMEU endorsed documents and forms is available for municipal distributors to use in establishing systems to accept and assess SSEG applications. These may be edited as necessary to suit individual municipal purposes. (available at www.cityenergy.org.za – see Electricity Services / SSEG section). The documents are:

AMEU SALGA: Requirements for Embedded Generation: This provides all the information an SSEG applicant needs. Specifies the conditions and system sizes that are acceptable, the standards that are to be adhered to, and the details of the application process to be followed.

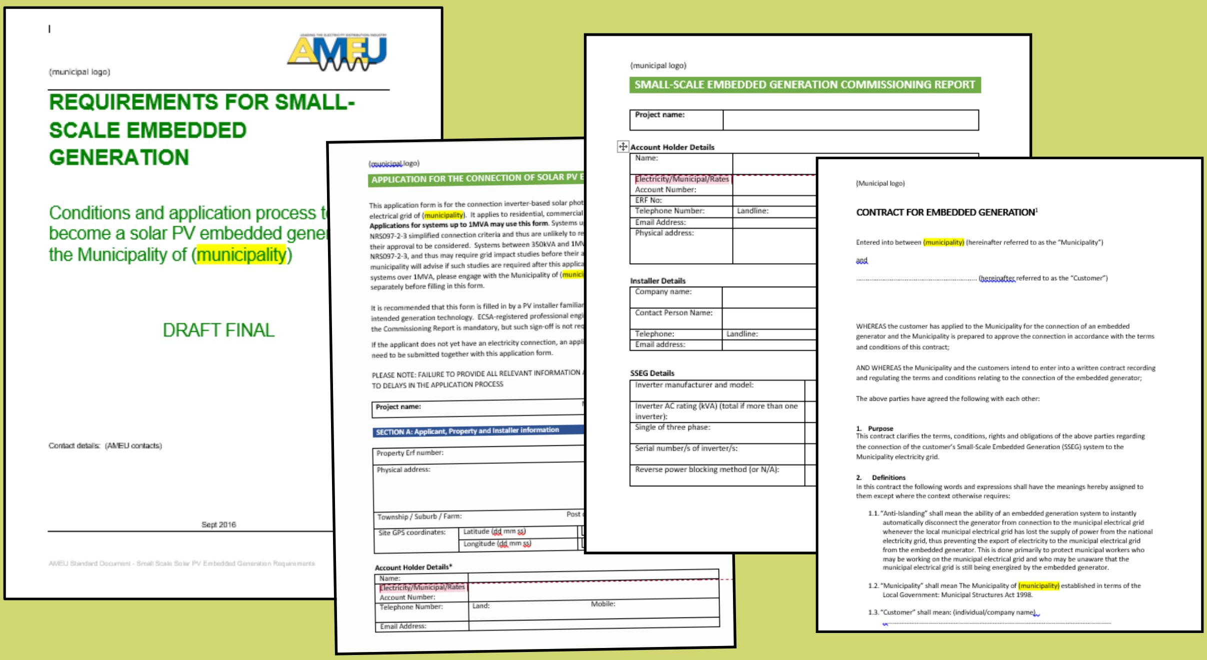
AMEU SALGA: SSEG Application Form: This form elicits all the information a distributor requires to process an SSEG application.

AMEU SALGA: SSEG Commissioning Form: This form lists the information that is to be provided on commissioning, and is to be signed off by a professional engineer or engineering technologist (this is a temporary measure until the necessary standards are in place, then a Certificate of Compliance will replace professional sign-off).

AMEU SALGA: SSEG Supply Contract: Before the SSEG can be activated, an SSEG contract needs to be signed, making the rights and obligations of both the SSEG customer and municipal distributor legally binding.

AMEU SALGA: SSEG Decommissioning form: This form requires that a Certificate of Compliance of physical disconnection be obtained for the municipality to register the decommissioning of the SSEG.

The documents were developed with input from a working group comprising all metros, and were based on equivalent documents developed by the City of Cape Town (who pioneered much of the SSEG application process) and GreenCape, who have developed a range of documents to support Western Cape municipalities.



Process within the municipality to adopt an SSEG application and approval process

Developing a procedure for approving SSEG systems may involve the following activities within municipalities:

- Review of the Standard AMEU/SALGA documentation and editing where necessary to suit individual municipal purposes.
- Capacity building workshops/meetings with management and other senior staff to provide information, allay safety and revenue concerns, and obtain buy-in.
- Tariff setting, especially for residential SSEG systems, potentially supported by revenue modelling tools (see Resources section at the end ofthis chapter).
- Some municipalities prefer to develop a policy around SSEG for political approval before activating the SSEG application system.
- Training of inspectors regarding key SSEG technical issues for compliance, and possibly participation to SSEG commissioning procedures for hands-on experience (although generally municipalities will not need to be present at system commissioning).
- Some municipal officials may want to attend short SSEG training courses (e.g. those organized by SALGA and GIZ)
- Municipal Electricity Supply by-law amendment will be necessary to adequately include SSEG systems (see text box).
- Develop a process flow (which section does what, and in what order) and associated checklist for each section specifying exactly what needs to be assessed. (examples available at www.cityenergy.org.za – see Electricity Services / SSEG section).
- Work with each section to ensure they are capacitated to undertake the tasks in the checklist.

Municipalities should note that NERSA is likely to require regular updates on existing SSEG installations (Table 6), and therefore the necessary information should be systematically recorded.

The existence of the SSEG application and approval process should be communicated to the PV industry and customers.

Table 6: NERSA is likely to require the following information on installed SSEG systems from municipalities

Information to be registered for each SSEG installation (and submitted to NERSA)
– PV system code (unique to system)
– PV system operator information (name of operator, email address)
– Location of PV system (street name, house number, city, zip code, GPS coordinates)
– Connection to LV or MV grid?
– Newly built system or extension to existing system?
– Installation includes storage system? If yes, what is the storage capacity in kWh?
– Circuit diagram and design showing major components
– Metering concept
– Type of system (Rooftop / Ground-mounted / Building integrated)
– Total nameplate capacity of PV modules
– Type/Model of PV modules installed
– Type/Model of PV inverters installed
– Day of commissioning

Amendments to Municipal Electricity Supply by-laws

Key areas where Electricity Supply by-laws generally require amendment to ensure the safe and compliant adoption of SSEG into the municipal electricity grid, are as follows:

- Require all prospective SSEG generators to obtain the written agreement of CoT to connect
- Require that the application process be adhered to, and conditions in the "Requirements for embedded generators" document by complied with.
- Require that safety and power quality issues be explicitly addressed and are the customers responsibility. This includes inverter safety and compliance certification.
- Obtain consent that the SSEG installation may be accessed by CoT staff as required.
- Assert that CoT has the right to disconnect non-compliant SSEG systems.
- Assert that CoT has the right to set norms and standards and change these from time to time.
- Assert that CoT has the right to set SSEG tariffs and billing arrangements, and change these from time to time.

More detailed by-law amendment information and text can be found in the GreenCape document *10 Questions Municipal Officials should be asking about the document titled 'Guidelines for Small Scale Embedded Generation in Western Cape Municipalities'* available at www.greencape.co.za.

Case study 1: Clearwater Mall in Johannesburg – 1.5MW rooftop PV system

Clearwater shopping mall is located in Roodepoort, western Johannesburg. In November 2014 Hyprop Investments Limited developed the first phase of the mall's grid-tied rooftop solar PV system, totaling 500kWp of capacity. Through a tender process, Hyprop contracted Solareff (Pty) Ltd, a specialist solar PV company, for the design, installation and commissioning of the system. The installation was complete in 7 weeks. Due to its success, Hyprop extended its partnership with Solareff to install a second phase of PV, adding an additional 1 000kWp of panels, making it the largest rooftop PV system in Africa at the time – 1 500 kWp. The second phase was completed over four months, finishing in August 2015. This increased the surface area from 4 000m^2 to an estimated 12 000m^2. The roof of the mall was specifically designed for the additional weight of the solar PV array. The grid-connected PV system now generates around 2 500 000kWh of power annually, and saves the mall about 10% of the electricity they would otherwise have purchased from the municipal grid. This is equal to the consumption of about 347 average households. It is also expected to result in about 2 790 tonnes less CO_2 emissions per year.

Hyprop's motivation for installing the rooftop PV system was to buffer against the rising costs of grid electricity, and reduce the mall's carbon footprint.

Solar PV installations are an ideal clean energy source for shopping malls because the energy yield from solar panels closely matches the electrical consumption curve, with the bulk of electricity being used during the daytime. Furthermore there is no wastage of solar energy over weekends as shopping malls operate seven days a week.

The performance of the system to date is above expectations, and is providing a 6% higher return on investment than anticipated. With current tariffs the return on investment is around 20%, making it a financially attractive option in current circumstances. Hyprop is embarking on a third phase of the PV system, adding another 1.4MW on the parking rooftop, taking the total system capacity to 2.9MW.

Figure 22: Clearwater Mall 1.5MW of rooftop PV panels – phases 1 and 2

Photo: Solareff

Figure 23: Clearwater Mall PV system inverter bank

Photo: Solareff

Figure 24: Clearwater Mall PV arrays

Photo: Solareff

The total system comprises 29 Kaco 60TL inverters and 5922 solar panels. It is configured in 3 x 500kWp blocks, each feeding into a different mall substation. This was done to optimize the feed-in point in relation to the PV modules on the roof and inverters. While the system output is grid-synchronised and accords with the necessary safety and power quality technical standards, there is no reverse feed into the municipal grid (the feed-in substations are the mall's, not the municipality's), as the load of the mall is consistently four times greater than the solar output.

Generation Licensing and Municipal interactions

Grid-tied PV systems require municipal permission to be connected to the distribution grid (even though not reverse feeding). At the time of project inception, City Power – Joburg's municipal distributor – did not have established processes in place to handle such applications. City Power and Solareff thus worked together to clarify necessary compliance conditions and enable the project to proceed (since this time City Power has established formal procedures for such applications, as have many other municipalities). Amongst the benefits for municipal distributors of such projects is that they bring relief to network constrained areas and enables development to proceed in places where the grid may not be strong enough to meet the power needs of the new facilities.

The National Energy Regulator (NERSA) exempted the Clearwater system from electricity generation licensing requirements because the system was purely for 'own use' – i.e. no power is ever exported back onto the national grid.

Case study 2: Embedded PV on municipal buildings in Cape Town

Gallows Hill embedded solar PV and energy efficiency project: lessons

The City of Cape Town is in the process of implementing sustainable energy measures in some of its public buildings. The first of these was the Gallows Hill Traffic Department building, which has implemented smart metering, rooftop PV systems and LED lighting. There have been clear benefits in electricity consumption reduction and interesting lessons have emerged.

One of the objectives of City of Cape Town's Energy and Climate Change Action Plan (ECAP) is to reduce energy consumption by 10% in City-owned facilities. Gallows Hill Traffic Department, situated in Green Point, is one of 90 large administrative City-owned buildings. It is very visible and has a large public interface, and was therefore selected as an ideal building to implement and showcase the renewable and energy efficiency (EE) interventions to the public. The following were installed: a 10 kWp grid-tied solar photovoltaic (PV) system; a smart meter; and LED lighting technology with occupancy sensors. The PV system was funded by

Behaviour change

A further intervention, related to behavioural change, which is being rolled out in City buildings is the Smart Living workshop and campaign series. This campaign aims to create awareness around resource conservation and provides information and energy saving tips that can easily be implemented at home and in the workplace. The campaign is based on the Smart Living Handbook produced by the City and showcases both low cost and high cost technologies and interventions that can be used to reduce energy, waste and water and to conserve and protect the environment. The Energy and Climate Change Unit also invites facility and building managers to participate in an accredited Fundamental Energy Management training course, where key technical methods of optimising energy savings are showcased in practical teachings and assignments.

the City, while the energy efficient lighting and smart metering projects were funded by the Division of Revenue Act (DoRA) through the national Energy Efficiency Demand Side Management (EEDSM) programme.

The Energy and Climate Change Unit of the Environmental Resource Management Department implemented the interventions in a three phase approach. In the realms of energy management there is a saying: "If you can't measure it, you can't manage it"; therefore the City has implemented a phased city-wide project to install smart Advanced Meter Readers (AMRs) into City operations and facilities to record and monitor consumption of electricity over time. Gallows Hill's electricity consumption is being monitored through the City's online metering system, so data can be accessed at any point in time. The historical data is stored and the amount of electricity consumed can be monitored before and after interventions have been implemented. In this way, the true savings of the interventions can be calculated.

In March 2014, the City installed a 10kWp solar system on the roof of the building through a tender process. The system consists of 42 photovoltaic panels, which feed into a grid-synchronising inverter which interfaces with the normal electricity grid power. The annual generation is around 11 900 kWh, allowing the building to provide 2% of its energy from rooftop PV.

The third intervention to be implemented throughout the building, during the 2014/15 financial year, is a complete energy efficient lighting retrofit which replaced all the existing lighting in the building with light emitting diodes (LEDs). LED lights use up to 10 times less power for the same light output and last 25 times longer than inefficient incandescent bulbs.

Figure 24: The PV array on the Gallows Hill roof

Source: City of Cape Town

Solar PV challenges and lessons

The Energy and Climate Change Unit encountered a few challenges implementing the solar PV project:

- *The main lessons learnt were around procurement – using the relatively demanding FIDIC contracting for the first time, and developing a process in Supply Chain Management framework for contracting PV systems:*
  - *Developing the Request for Quotes for the installation of the 10kWp PV project triggered Supply Chain Management to tread cautiously, as this was the first time PV had been installed and processes for this were not in place. The Unit was encouraged to use the FIDIC (International Federation of Consulting Engineers) form of contracting, which is a more complex form of contracting for construction projects and ensures that the project meets all health and safety laws.*
  - *Developing a sound tender specification was also important, and assistance from an external expert was sought in this regard.*
  - *A structural engineer should be sought to sign off on the roof loading prior to any procurement taking place.*
  - *Waterproofing needs careful attention in the specifications and guarantees provided.*
- *Pr Eng are not necessarily the correct people to sign off on PV system commissioning, as they often are new to these technologies.*
- *Due to budget constraints it was decided to procure the system first and then undergo installation separately, which resulted in the cost of the entire system amounting to more than was budgeted for.*
- *Other important lessons include the need for engagement with the Electricity Department to get clarity on guidelines for Small Scale Embedded Generation (SSEG) applications – such processes were still relatively new in the City and were reasonably demanding to comply with.*
- *It is also important to understand the IT Department's requirements to ensure that they could access the data from the PV system, and thus allow system performance and diagnostic data to be on the City's intranet to alert staff regarding faults.*
- *Training of building staff to maintain the PV system was also necessary.*

Overview of Cape Town's 'own building' solar PV projects

Since the first investigations in embedded generation, a variety of Cape Town City departments have pioneered PV rooftop installation. These are relatively small installations to date and are electricity consumption offsets rather than generation projects. However, they provide important opportunities to demonstrate leadership by the City in terms of embedded, distributed energy service development, as well as to develop skills amongst municipal staff in relation to new forms of energy provision.

Table 7: Information on early 'own building' embedded generation projects in Cape Town

	Gallows Hill	Royal Ascot	OmniForum
ENERGY EFFICIENCY			
Energy Efficiency implemented prior to PV installation	LED lighting and occupancy sensors	LED lighting and occupancy sensors	LED lighting and occupancy sensors
EE demand reduction impact	20%	32%	33%
EE financial savings per year	R 142 797	R 119 933	R 142 706
EMBEDDED SOLAR PV			
Process duration (investigation to commissioning	March 2013 – March 2015	June 2013 – June 2015	June 2013 – August 2015
Roof mounting method	Bolted on flat concrete roof (sealed waterproofing)	Bolted to concrete slabs on flat roof (no waterproofing required)	Clasped tp corrugated roof sheet with 'SolarRoof Longline Interface' type clasp
Roof area	126m2	183m2	775m2
PV kWp installed	10 kWp	20 kWp	60 kWp
% of total demand met by PV	2%	7%	20%
Total cost of system	R 276 294	R 1 713 762 (2 systems on one tender)	
R / kWp installed	R 27 600 / kWp	R 21 400 / kWp	
kWh savings per year	11 921 kWh/yr	22 976 kWh/yr	61 346 kWh/yr
Financial savings per year	R 14 306	R 27 571	R 73 615

Table 8: City of Cape Town installation of rooftop PV on own buildings and facilities to date

Installed to date	Size (kWp)	Grid tied	Commissioned
Manenberg Housing Contact Centre	20	Yes	2012/13
Electricity Services Department building	100	Yes	2014
Gallows Hill	10	Yes	2015
Wallacedene taxi rank	20	No	2014
Khayelitsha Environmental Health Centre	17	Yes	2014
Royal Ascot	20	Yes	2015
Omni Forum	60	Yes	2015
Civic Centre (in process)	10	Yes	2017
Total	**257**		

Support organisations & resources

Resources

- AMEU standard documents: available at www.cityenergy.org.za – Electricity Services/SSEG section
- GreenCape municipal support documents: available at www.greencape.co.za
- A range of resources to support municipalities with SSEG processes are available at www.cityenergy.org.za
- Solar radiation map by the CSIR: http://www.aaamsa.co.za/images/Matrix/2015/TIASA/Annual%20Solar%20Radiation%20Map%20as%20provided%20by%20the%20CSIR.pdf
- Durban Solar map (interactive solar feasibility assessment map): http://gis.durban.gov.za/solarmapviewer/
- SAPVIA (South African Photovoltaic Industries Association) is involved with SSEG training and installer accreditation: www.sapvia.co.z
- SALGA (South African Local Government Association): www.salga.org.za
- South African – German Energy Programme (SAGEN)

The information below represents the best level of information on the uptake of SSEG processes and tariffs by August 2016. The sector is rapidly evolving and this information may easily become out-dated.

1. Overview per province

Province	Keeping track of existing installations	Official application system	Approved SSEG tariffs	Number of installations	kWp installed	Average size (in kWp)
Eastern Cape	2	2	1	191	1,454	8
Gauteng	4	2	1	77	24,813	322
KZN	1	1	1	18*	70*	4
Limpopo	2	0	0	3	265	88
Western Cape	14	12	9	322*	9,787*	30
North West	1	0	0	10*	2,000*	200
Mpumalanga	0	0	0	-	-	
Northern Cape	1	0	0	4	183	46
Free State	1	1	0	5	1,075	215
TOTAL (Aug 2016)	**25**	**18**	**12**	**621**	**38,389**	**62**
PAST DATA to track progress						
TOTAL (Aug 2016)	23	16	12	495	17,029	34
TOTAL (Feb 2016)	10	3	5	264	9,044	34

2. List of municipalities active on SSEG

Province	Municipality	Keeps list of installations	Approved SSEG application process	Allows feed back into the grid?	Status of SSEG tariffs	Website / Contacts
Eastern Cape	Nelson Mandela Bay	Yes	Yes	Yes	Approved and operational	http://www.nelsonmandelabay.gov.za/DataRepository/Documents/2-nmbm-requirements-for-small-scale-embedded-generation-sseg-1-july-2016.pdf http://www.nelsonmandelabay.gov.za/datarepository/documents/1-application-form-small-scale-embedded-generation-sseg.pdf
Eastern Cape	Buffalo City	Yes	Yes		No SSEG tariffs	
Free State	Mangaung	Yes	Yes	No	Under development	
Gauteng	City of Johannesburg	Yes	Yes	Yes	Approved and being rolled out	distributedgeneration@citypower.co.za
Gauteng	City of Tshwane	Yes	Under development	No	No SSEG tariffs	
Gauteng	Ekurhuleni Metro	Yes	Yes	No	No SSEG tariffs	
Gauteng	Midvaal	Yes	No	No	No SSEG tariffs	
KwaZulu Natal	eThekwini	Yes	Yes	Yes	Approved and being rolled out	http://pv.shisasolar.org.za/
Limpopo	Ephraim Mogale	Yes	No	Yes (pilots)	Under development	
Limpopo	Polokwane	Yes	No	No	No SSEG tariffs	
Northern Cape	//Khara Hais	Yes	No	No	No SSEG tariffs	
North West	Tlokwe	Yes	No	No	No SSEG tariffs	
Western Cape	Beaufort West	Yes	Yes	Yes	Approved and operational	
Western Cape	Bergrivier	Yes	Under development	Yes	No SSEG tariffs	
Western Cape	Breede Valley	Yes	Yes	Yes	No SSEG tariffs	
Western Cape	Drakenstein	Yes	Yes	Yes	Approved and operational	
Western Cape	George	Yes	Yes	Yes	Approved and operational	
Western Cape	Langeberg	Yes	Yes	Yes without compensation	No SSEG tariffs	
Western Cape	Mossel Bay	Yes	Yes	Yes	Approved and being rolled out	
Western Cape	Oudtshoorn	Yes	Under development	Yes	Under development	
Western Cape	Overstrand		Yes	Yes	Approved and being rolled out	
Western Cape	Stellenbosch	Yes	Yes	Yes	Approved and being rolled out	
Western Cape	City of Cape Town	Yes	Yes	Yes	Approved and operational	https://www.capetown.gov.za/en/cityforms/Pages/default.aspx http://savingelectricity.org.za/pages/pv_and_renewables.php
Western Cape	Saldanha Bay	Yes	Yes	No	Under development	
Western Cape	Theewaterskloof	Yes	yes	Yes	Approved and being rolled out	
Western Cape	Swartland	Yes	Yes	Yes	Approved and operational	