Solar rooftop PV generation in municipalities

FREQUENTLY ASKED QUESTIONS

FOR MUNICIPALITIES, INSTALLERS AND CUSTOMERS

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SAGEN | SOUTH AFRICAN-GERMAN ENERGY PROGRAMME

SOUTH AFRICAN LOCAL GOVERNMENT ASSOCIATION
SALGA
Inspiring service delivery

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GLOSSARY AND DEFINITIONS

Alternating current (AC)	Voltage and current changes polarity at a fixed frequency – 50Hz in South Africa. Most residential and commercial users of electricity require alternating current (AC).
Anti-islanding	Ability of a small-scale embedded generator (SSEG) installation to instantly and automatically disconnect from the municipal electrical grid when there is a power outage at the utility municipal electrical grid, thus preventing the SSEG from exporting electricity to the municipal grid. This is primarily to protect municipal workers working on the grid who may be unaware that the grid may still be energised by SSEG.
Bi-directional meter	A meter that measures electricity flow independently in both directions (import and export or consume and produce).
Cogeneration	The sequential or simultaneous generation of multiple forms of useful energy (usually mechanical and thermal) in a single, integrated system. Embedded generation (EG) is preferred for solar PV and SSEG.
Customer	A person who buys and uses electricity supplied by a utility (Eskom, municipality). In this document, producers and generators who generate less than 1MW are also referred to as customers. In the Distribution Code, NERSA defines 'customer' as: *A person or legal entity that has entered into an agreement with a Distributor for the provision of distribution services. An entity may be an Embedded Generator, another Distributor, an end-use customer (including generators), an international customer, a retailer or a reseller.*
Dedicated supply	A section of the utility network or grid that exclusively supplies a single customer.
Direct current (DC)	The voltage and current are a steady value, e.g. from a battery. Direct current (DC) is typically converted to alternating current for practical purposes because most modern uses of electricity require alternating current. Batteries and solar PV modules are examples of DC power sources.
Embedded generator (EG)	An electrical generator interconnected with the municipal network. The generator operates in parallel with the network and should be synchronised with the grid supply.
Embedded generation installation	A legal entity that operates or desires to operate any generating plant that is or shall be connected to the network service provider's network. This definition includes all types of connected generation, including co-generators and renewables. Alternatively, the item of generating plant that is or shall be connected to the network service provider's network
Generating capacity	The maximum amount of electricity, measured in kilovolt Amperes (kVA), which can flow out of the generation equipment into the customer's alternating current wiring system. This is therefore the maximum AC power flow which can be generated by the generating system.
Grid limiting	When an SSEG is installed in such a way that export of excess power is limited or prevented by throttling the inverter power output. When the export of excess power is prevented it is also known as 'reverse power flow blocking'.
Grid-tied	An SSEG connected to the municipal electrical grid either directly or through a customer's internal wiring. The export of energy onto the municipal electrical grid is possible when generation exceeds consumption at any point in time and no grid-limiting is applied.
Hybrid system	A hybrid system is an EG installation that can operate in island mode (island on the customer side only). See *island system* and *islanding.*
Inverter	A device that converts DC to AC at a voltage and frequency that can be used to power AC appliances.
Island system	An island system uses an island inverter to provide AC power from DC power as an isolated system. This means that even though there is AC power available from the local grid, the system can function apart from and independently within the network.
Islanding	When a particular section of the electrical network and/or internal wiring is energised separately from electricity sources other than from the utilities.
Isolated	A section of a municipal electrical grid or electrical wiring which is disconnected from all possible sources of electrical potential is said to be isolated.
Levelised cost of energy	The levelised cost of electricity (LCOE) is a measure of a power source which attempts to compare different methods of electricity generation on a consistent basis.
Load profile	The profile or curve showing the variation of the customer's rate of electricity consumption (or demand) over time.
Low voltage (LV)	Voltage levels up to and including 1 kV. (1 kV= 1000 Volts)

Medium voltage (MV)	Nominal voltage levels greater than 1 kV and less than 44kV.
Net consumer or net customer	Someone who purchases (imports) and uses more kilowatt hours (kWh) of electricity than they export (sell) over a given period.
Net generator	A user with an installation or system that generates more electricity than it consumes on-site over a given period and exports more power into the municipal network than it draws.
National Regulator for Compulsory Specifications (NRCS)	The NRCS is mandated to develop and administer technical regulations and compulsory specifications and ensure compliance with the requirements of the compulsory specifications and technical regulations via market surveying.
Off-grid	A generator that is physically separated and electrically isolated from and will never be connected to the utility's electricity grid – either directly or through a customer's internal wiring. The consumer's loads cannot be simultaneously connected to the utility grid and the off-grid generator. Export of energy into the utility grid by the generator is therefore not possible. A generator that is connected to the grid or to the customer's internal wiring through a reverse power flow blocking relay is not considered to be off-grid, but rather as an EG.
Performance ratio	The performance ratio gives an indication of the performance output one can expect from a certain solar PV solution referenced to the installed capacity. To achieve 80% or more is ideal. The latter is influenced by the way the system is designed, components chosen and how it will be installed.
Point of common coupling (PCC)	The nearest point on the electrical network where more than one customer is or can be connected.
Power factor (PF)	The ratio between the VA (i.e. rms volts x rms amps) and Watts.
Pr. Eng, Pr. Tech Eng, Pr. Techni Eng, Pr Person	A professional engineer, professional technologist or professional engineering technician registered with the Engineering Council of South Africa (ECSA).
Reverse power flow	The flow of energy from the embedded generator into the municipal electrical grid (i.e. export) as a result of the instantaneous generation exceeding the instantaneous consumption at the generation site.
Reverse power flow blocking	A device which prevents power flowing from an embedded generator back into the municipal electrical grid.
Shared network	A section of the utility grid that supplies more than one customer
Small-scale embedded generator (SSEG)	A small-scale embedded generator for the purposes of these guidelines is an embedded generator with a generation capacity of less than 1000 kW (1MW). See Embedded generator.
Solar irradiation	Total amount of solar radiation energy received on a given surface area over a given period. Irradiation is also referred to as insolation and is normally measured in kWh per m^2 per year or kWh per m^2 per day.
Standalone generator	A generator that is not connected to the municipal electrical grid, similar to an off-grid inverter. See *off-grid.*
Standby generator	Standby generators are used as an alternative supply. That means that the consumer is either supplied by the utility OR the standby generator. A change over switch (break before make) is required for these and other alternative supplies.
Throttling device	Device used for grid limiting to reduce power output from grid-tied inverter; see *grid limiting*.
Utility	The electricity distribution service provider responsible for the electricity supply and grid infrastructure to which the customer is connected. In South Africa, the municipality and Eskom are both responsible for portions of the electricity network within municipal boundaries.
Utility network (also utility grid)	The interconnected network of wires, transformers and other equipment, covering all voltage ranges. The utility network is the property of a municipality and supplies customers in the municipality distribution area with electricity.
Wheeling	The deemed transportation of electricity, over a utility's electrical network from an EG in one place to a third party or customer in another place.

ABBREVIATIONS

ADMD	after diversity maximum demand
AC	alternating current
AGM	absorbent glass mat
Ah	ampere hour
AIA	approved inspection authority
AM	air mass
AMEU	Association of Municipal Electricity Utilities
AMI	advanced metering infrastructure
CCT	City of Cape Town
CFL	compact fluorescent lamp
CoC	certificate of compliance
CPUT	Cape Peninsula University of Technology
CPV	concentrated photovoltaic
CRSES	Centre for Renewable and Sustainable Energy Studies
CSP	concentrated solar power
DC	direct current
DGS	Deutsche Gesellschaft für Sonnenenergie
DGSL	dead grid safety lock
DoL	Department of Labour
DSD	distribution system development (sub section of electricity services department)
ECSA	Engineering Council of South Africa
EE	energy efficiency
EG	embedded generator
EGI	embedded generation installation
ERA	Electricity Regulation Act
ESD	Electricity Services Department (City of Cape Town)
eWASA	e-Waste Association of South Africa
GTI	grid-tied inverter
IDP	integrated development plan
INDC	intended nationally determined contribution
IPP	independent power producer
Isc	short circuit current
kVA	kilovolt Ampere (unit of apparent electrical power, often similar in magnitude to kW)
kvar	kilovolt amperes reactive
kW	kilowatt; 1000W = 1kW (unit of electrical power)
kWp	kilowatt peak; 1000Wp = 1kWp (the rated peak output of solar PV panels)
kWh	kilowatt hour; 1kWh = 1kW x 1hour
LCOE	levelised cost of energy
LSM	living standards measure
LV	low voltage
MV	medium voltage
MVA	mega-volt amperes (1 MVA = 1000 kVA)
MW	mega-watt (1 MW = 1000 kW)
MPPT	maximum power point tracking
NERSA	National Energy Regulator of South Africa
NMD	notified maximum demand
NMU	Nelson Mandela University (Also NMMU)
NRCS	National Regulator for Compulsory Specifications
OHSA	Occupational Health and Safety Act
PF	power factor
PCC	point of common coupling
PoC	point of connection
PPA	power purchase agreement
PPE	personal protective equipment
PQ	power quality
PWM	pulse width modulation
PV	photovoltaic
PVT	photovoltaic and thermal
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
RCD	residual current device
RPP	renewable power plant
SARETEC	South African Renewable Energy Technology Centre
SSEG	small-scale embedded generator
STC	standard test conditions
UCT	University of Cape Town
UPS	uninterrupted power supply
VAT	value added tax
Voc	open circuit voltage
VRLA	valve regulated lead acid

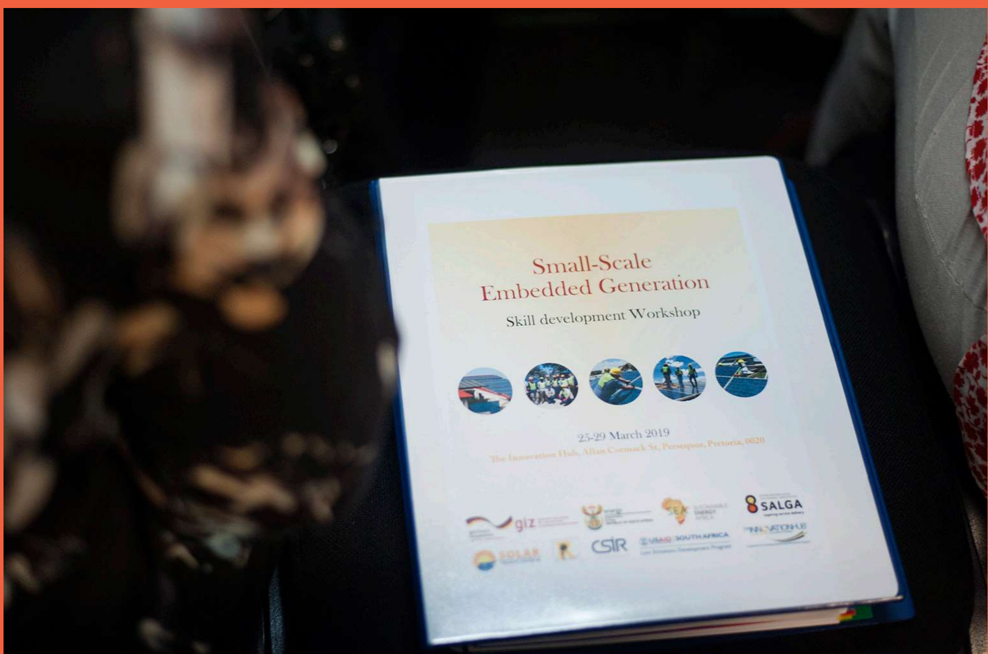
INTRODUCTION

The aim of this book is to share the frequently asked questions (FAQ) about solar rooftop PV. During the solar PV training sessions for municipalities held by GIZ and SALGA in 2016 - 2018, certain questions were regularly asked by the participants. These questions inform the content of this FAQ document.

Throughout this document, references to relevant resources with more detail can be accessed via the links provided, or on the Solar Support websites for municipalities (*www.solar-support.org* and *www.sseg.org.za*).

We invite the readers of this book to send through any comments and/or suggestions identified to *info@solar-support.org* so that the FAQ book is always revised and up to date to ensure a relevant and accurate resource for municipalities.


SALGA
Welcome to SSEG Training Workshops


Small-Scale Embedded Generation
Skill development Workshop
25-29 March 2019
SALGA
giz
CSIR

TOP FAQS

Here is a list of the 19 most frequently asked questions. To jump to the answer, follow the link (Ctrl + left click).

SECTION 1
SOLAR PHOTOVOLTAICS (PV)

A. General questions about solar PV

QUESTION 1.1 What is a small-scale embedded generator (SSEG)?

Electrical generators that connect (by synchronising with the grid) or operate in parallel with a grid or network are embedded generators (EG). Embedded generators smaller than 1MVA (1000kVA) are defined as small-scale embedded generators (SSEG). In South Africa, solar photovoltaic (solar PV) is the most common technology type used as a SSEG. Wind, biogas, hydropower and diesel generators connected to the grid are also forms of embedded generation.

QUESTION 1.2 What is solar photovoltaics (PV) or solar electricity?

The word *photovoltaic* (PV) translates as 'light-electricity'. Photovoltaic materials and devices convert light energy into electricity. PV-generated electricity is a renewable energy source. Consumers can use it to save on normal grid electricity consumption or to replace their grid consumption entirely to become grid independent.

***Additional content:** Introduction to PV solar_v12*

QUESTION 1.3 Why solar PV? What about hydropower, gas, biogas and other forms of SSEG?

Because most SSEGs reported and recorded by municipalities are solar PV – and the fact that solar PV makes financial sense and is scalable – best practice and processes for solar PV have been used as a baseline for other technologies. The standards and specifications currently available, as well as those being developed, do not exclude other types of generation, but do not explicitly address their requirements in detail. More comprehensive standards and specifications which address specific issues of non-PV SSEG are planned for the future. Some municipalities already have this documentation in place.

QUESTION 1.4 Why has there been an increase in the number of solar PV installations in South Africa?

With the increase in utility electricity prices and the decrease in price for solar PV energy, it is becoming financially viable for citizens to invest in solar PV solutions that will save them money and serve as an investment in the long term (a PV system typically has a life of more than 20 years).

Some users install solar PV to meet their electricity needs and go completely off the grid. They may do this because of load-shedding, poor power quality, grid power price increases or just because they want to be grid independent.

***Additional content:** PV solar in the world and SA_v3*

QUESTION 1.5 What are the environmental benefits of solar PV?

South Africa's national energy mix includes significant amounts of coal-fired generation, which results in high carbon emissions by world standards. Electricity from PV systems is renewable and has low carbon emissions, which reduces the generator's contribution to global warming. Water usage by solar PV is also very low compared to other forms of generation (see Figure 1).

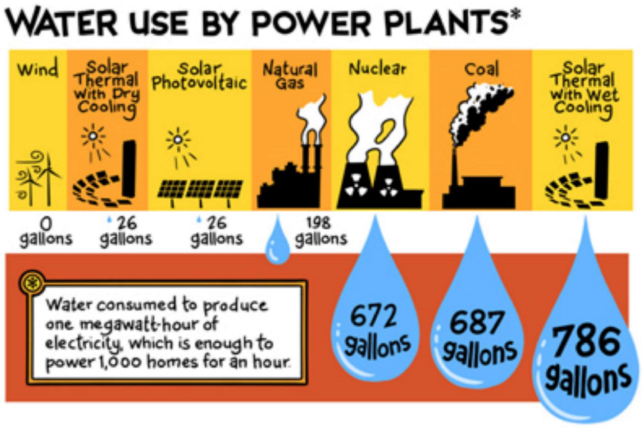


Figure 1: *Water use by power plants (SAPVIA PV GreenCard Training Material 2017)*

In South Africa, for each kilowatt hour (kWh) produced by solar power, at least a kilogram of CO_2 emissions from a coal-fired power station is prevented (see Annexure 1). Each installed 1 kilowatt peak (kWp) of solar PV can produce between 3.6 and 5.5 kWh per day, which means between 3.6 and 5.5 kg of CO_2 can be prevented for each kWp of solar PV installed.

QUESTION 1.6 Is it true that solar panels take more energy to make than they will ever produce?

According to research by the National Renewable Energy Laboratory (NREL) in 2004: "Energy payback estimates for rooftop PV systems are: four years for systems using current multicrystalline-silicon PV modules, three years for current thin-film modules, two years for anticipated multicrystalline modules, and one year for anticipated thin-film modules. With energy paybacks of one to four years and assumed life expectancies of 30 years, 87 to 97 per cent of the energy PV systems generate won't be plagued by pollution, greenhouse gases, and depletion of resources."[1] In Italy, which has similar solar irradiation levels to South Africa, the energy payback period decreases significantly (see Figure 2).

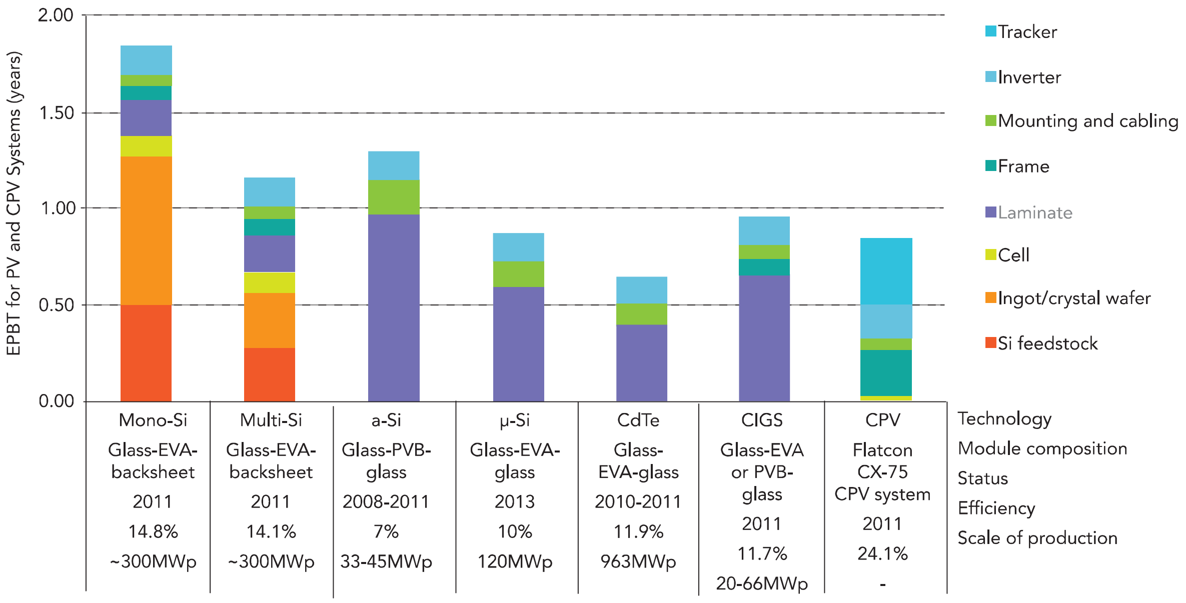


Figure 2: *Energy payback period for PV and CPV systems for different technologies (Catania, Sicily)* [2]

1 PV FAQs, NREL, US Department of Energy, 2004 (https://www.nrel.gov/docs/fy04osti/35489.pdf)

2 Photovoltaics Report, Fraunhofer Institute for Solar Energy Systems, 2018 (https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf)

QUESTION 1.7 South Africa has defined carbon-emission-reduction targets. Are there penalties in place for not reaching these targets?

Many municipalities have carbon-emission-reduction targets in their integrated development plans (IDPs), energy and climate change strategies, or city visions. These targets usually align with national intentions.

South Africa has committed to an *intended nationally determined contribution (INDC)* of 42% carbon emission reductions by 2025. This commitment forms part of its ratification of the Paris Agreement, a treaty under international law with incentives to achieve agreed targets. There are, however, no penalties locally or globally for failing to meet the targets.

QUESTION 1.8 What are the basic components or elements of a solar PV system?

A solar PV system is made up of different components. For an *embedded generation installation* (EGI) system, components include:

- PV modules that consist of a group of PV cells, which are also referred to as PV or solar panels.
- Grid-tied inverter(s).
- Wiring.
- Mounting hardware and/or a framework for the equipment.

For non-feed-in EGI (systems with reverse power-flow blocking), a reverse power-flow blocking device is also needed (see figure 3).

For EGI with storage, additional components could include:

- One or more storage devices, e.g., batteries.
- A charge regulator or controller.
- A battery inverter when alternating current (AC) rather than direct current (DC) is required.

Additional content: ***Introduction to PV solar_v12***
Additional content: ***Solar PV Systems and Integrations_v9***

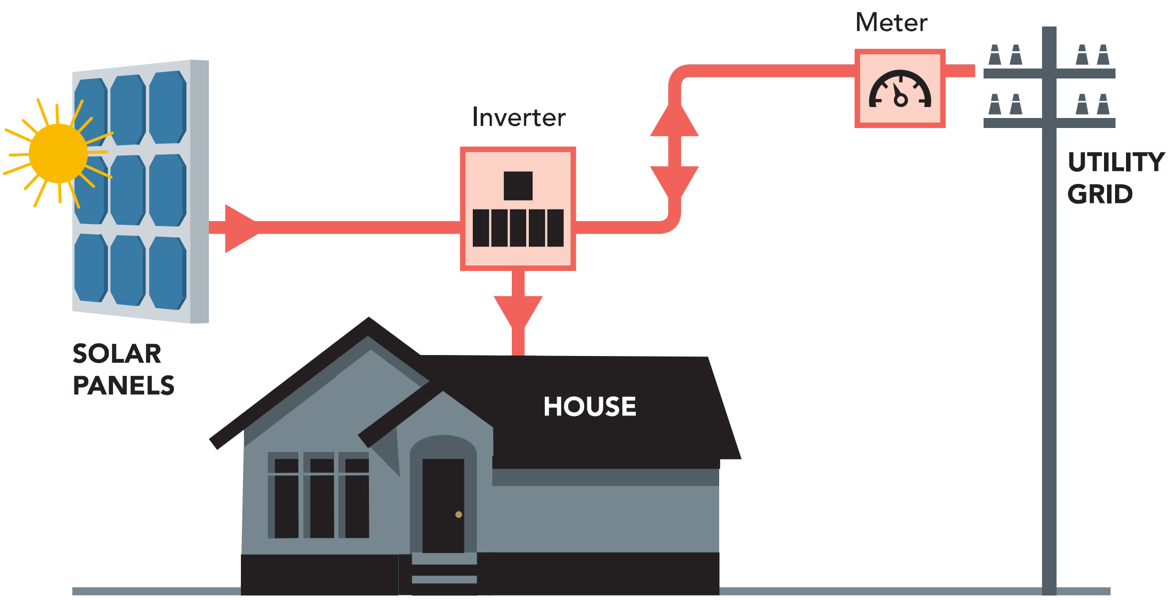


***Figure 3: A** basic grid-tied system*

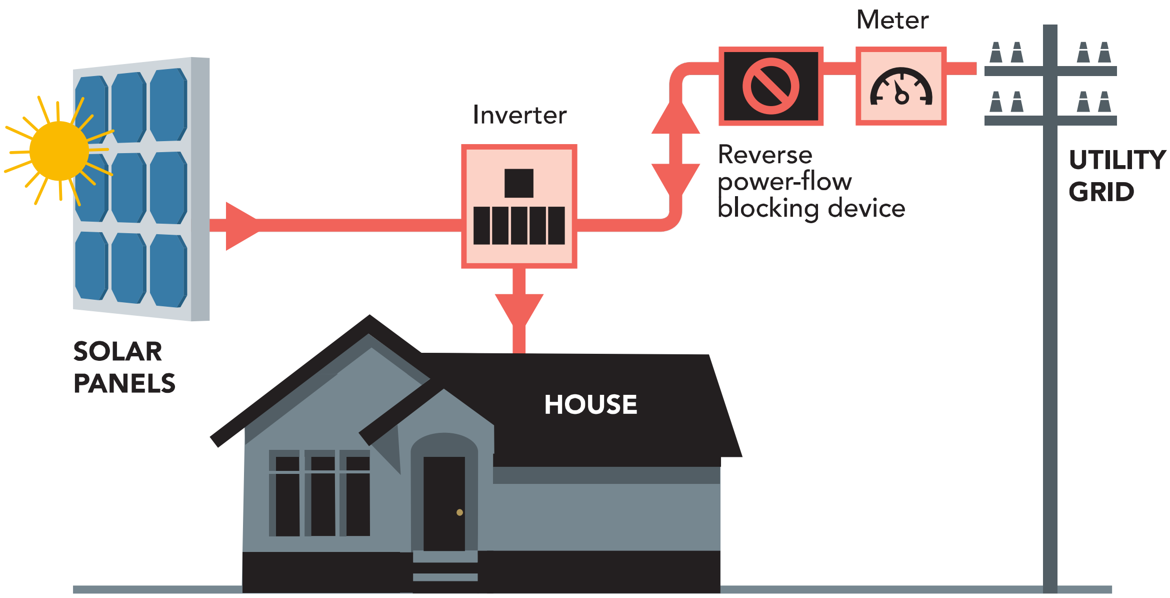


***Figure 4: A** basic grid-tied non-feed-in system*

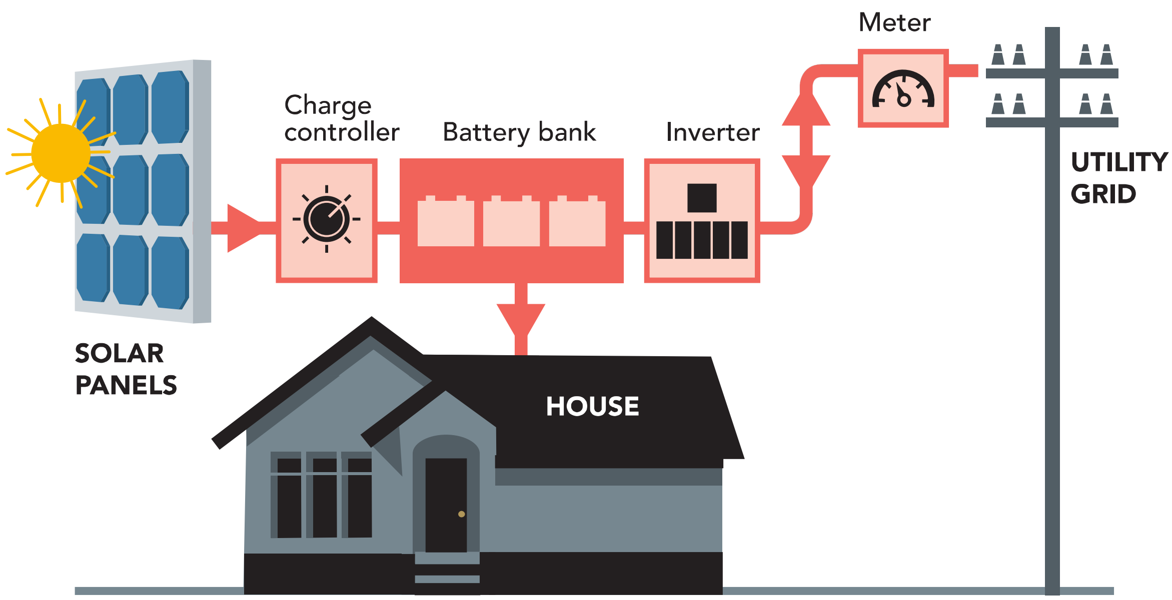


***Figure 5:** EGI with batteries*

QUESTION 1.9 What is the price trajectory for SSEG components? What are the typical system costs? Which trends are these costs following?

The cost of solar PV is decreasing. Research shows that this trend is likely to continue (see figure 5). In South Africa, the current (2018) typical turnkey cost (all equipment and labour costs included) per kWp installed is between R16/Watt and R24/Watt for residential systems. For commercial systems, the cost may be from R13/Watt to R21/Watt. (Example: The cost of installing a 2kWp solar system at R20/Watt is R40 000.) Prices are influenced by type and difficulty of installation, the quality of products used and economies of scale.

Additional content: *Least-cost Electricity Mix for South Africa 2040_3Nov2016*

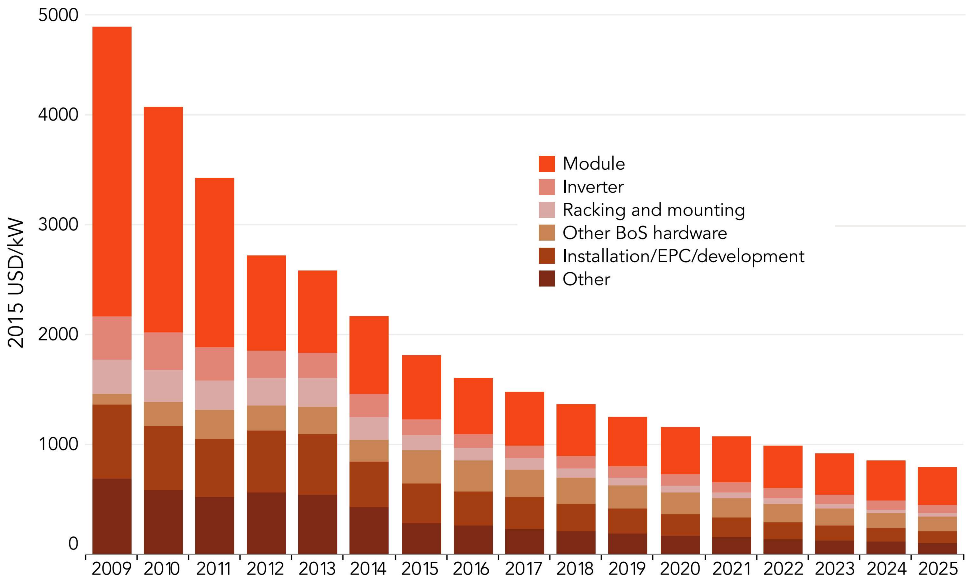


Figure 6: *The decrease in the cost of solar PV projected until 2025*

QUESTION 1.10 Solar thermal (solar geysers) and solar PV: what's the difference?

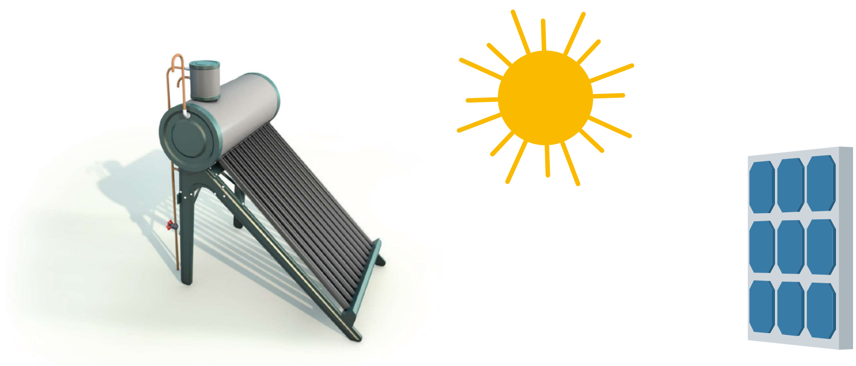


Figure 7: *Energy conversion between solar thermal and solar PV (https://www.electricradiatorsdirect.co.uk/news/solar-thermal-is-our-favourite-renewable-energy-under-threat/)*

Although solar geysers (also known as solar water heaters) and solar PV use the same input – solar radiation – their energy output is different.

- *Solar geysers* (solar water-heating systems) contain a solar collector that faces the sun and either heats water directly from the sun's rays or heats a 'working fluid' which in turn is used to heat water. No electricity is generated. Electricity is used as an alternative when there is not sufficient solar heating from the sun.
- *Photovoltaic (PV) systems* convert sunlight directly to electricity using PV cells made from semiconductor materials. No water is involved in the functional operation of solar PV.

Other solar technologies include:

- *Concentrating solar power (CSP) systems* concentrate the sun's energy using reflective devices such as troughs, tubes or mirror panels to produce heat that generates electricity via steam turbines. Solar geysers that concentrate sunlight are an example of a CSP device.
- *Transpired solar collectors or 'solar walls'* use solar energy to preheat ventilation air for a building.

QUESTION 1.11 Can solar PV panels heat water?

Solar PV converts light from the sun into electricity, whereas solar water heater panels (or collectors) use the heat of the sun to heat water.

Ideally, solar PV generated electricity should ***not*** be used to heat water; it is much more efficient to use a solar water heater for this purpose.

Although a combination of solar PV and solar water heater technology will produce hot water, a geyser or collector component is still needed to produce hot water. This hybrid solution is called photovoltaic and thermal (PVT).

Additional content: ***Cape Town's first PVT project_23March2018***

QUESTION 1.12 How does a grid-tied solar PV system work?

Here is a basic overview of how grid-tied solar power systems work:

1. During the day the sunlight that shines on your solar panels/modules is converted into DC electricity (the semiconductor material in the PV module performs this conversion).
2. This DC electricity is conducted to an inverter which converts it into AC electricity.
3. The inverter feeds the AC electricity into the switchboard of your house.
4. This AC electricity is used to power your house.

Any surplus power will be fed onto the local grid (reverse feed-in). If you have reverse power-flow blocking, the power will not be fed back onto the grid. If there is a power outage at the power utility, the EG will switch off and stop operating until the grid is switched back on. This safety requirement is discussed in the section *Safety and Standards for SSEG Installations (page xx).*

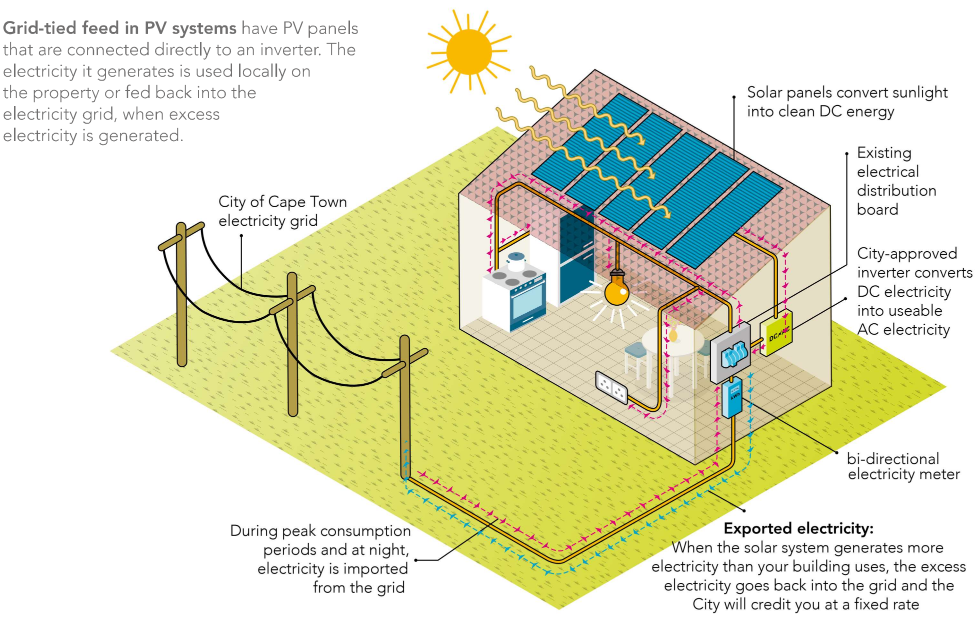


Figure 8: *Diagram showing how a grid-tied EG works (City of Cape Town Guideline for safe and Legal Installations)*

NOTE: Compensation for reverse feed-in is only available in some municipalities. As of July 2017, 18 municipalities had NERSA-approved SSEG-compensation tariffs. The tariff for reverse feed-in also varies according to the municipality. Some areas stipulate the need for reverse power-flow blocking.

Additional content: ***Introduction to PV solar_v12***

QUESTION 1.13 How much space does a solar PV system need?

The rule of thumb is 1.8m² for each standard 250Wp module installed flat on the roof's surface, and 2.6m² for 250Wp modules installed at a tilted angle different to the roof surface. This will vary based on the efficiency of the module. Alternatively, 10m² is required for each kWp of PV. Spacing is required in-between the rows of tilted angle modules to avoid one module shading another (also known as inter module or mutual shading).

Example: If you want to install 2kWp of solar PV on your roof at a tilt angle, you need 8 modules of 250W x 2.6m² = 20.8m² OR 2kWp x 10m² = 20m² of space.

Spacing between the rows of tilted angle modules prevents modules from shading one another (also known as inter-module, or mutual, shading). It is not advisable to install PV on roof areas with regular shading because this will limit the overall performance of the system.

Additional content: ***Effects of Shadowing on solar PV panels_2012***

QUESTION 1.14 How long will a solar PV system and its components last?

A PV system that is well designed, properly installed and regularly maintained can keep working for 20 years or more and PV modules, which have no moving parts, can last for more than 30 years. Good quality, well-installed inverters can last 10 years or more.

The best way to ensure and extend the life and effectiveness of a PV system is to have it installed and maintained properly. Most problemsusers have are caused by faulty installations and/or substandard components.

QUESTION 1.15 What typical guarantees and warranties are there for solar PV components?

Modules/Panels

- 10–15 year product warranty
- 25–30 year performance warranty

Inverters

- 2–5 year product warranty
- Warranty can be extended up to 25 years at an additional cost

Mounting structure

5–10 year warranty

Batteries

2–15 year warranty

NOTE: These are estimates intended to provide a rough idea. The numbers of years differs for each supplier and may increase or decrease over time.

QUESTION 1.16 When should batteries be installed?

Because grid-tied EG systems do not need batteries they are seldom installed for these systems. However, if a user wants to store excess energy and/or have alternative energy when the grid is down, they will need a battery with a charger and a battery inverter. Users who want to be independent of the grid (i.e. a standalone PV system) may need batteries, depending on what they intend to use the system for.

QUESTION 1.17 What is the difference between kW and kWh?

Solar PV system power output is measured in kilowatts (kW) and is an instantaneous measured value while kilowatts per hour (kWh), or energy, is kW measured over time (generating 1 kW for 1 hour produces 1 kWh).

The performance of a solar PV system is not measured in kW output but rather by *how much electric energy is produced over time (measured in kWh).*

Monetary savings or *levelised cost of energy (LCoE) is calculated by* considering the amount of kWh produced by a solar PV system.

QUESTION 1.18 Why is PV rated in kWp and transformers or generators in kVA?

Kilowatt peak (kWp) is the maximum or peak power output that can be obtained from a specific solar panel at standard test conditions (STC). For example, a 250Wp solar panel will generate 250W of output if the irradiance (sunlight) is 1000W/m², the cell temperature (the panel itself) is 25˚C and the angle of sunlight is almost 45 degrees (and Air Mass (AM) of 1.5).

The convention with transformers is to use a kVA rating, but because they will not supply the equivalent kW (active power) due to a power factor loss, the kW rating of the transformer is less than the kVA rating. The kVA and kW size of solar grid-tied inverters are normally equal, because the power factor is Unity (one).

NOTE: The ratio between the VA (Volts-Amps) and Watts is called the power factor (PF). In other words, VA x power factor = watts. Similarly, kVA x PF = kW, or kilovolt-amps times power factor equals kilowatts.

QUESTION 1.19 Can solar PV systems be dangerous? What design errors can result in damage to a solar PV system?

As with all electrical systems electrical shock, arcing and fire are risks when a system is incorrectly installed.

The following errors should be avoided:

- A solar PV system voltage output that is higher than the module/inverter/charger/other equipment voltage/current rating.
- Incorrect cable type or cable size too small.
- Improper connections or connection devices, especially on the DC side.
- Improper earthing of solar PV system.
- Continuous shading on part of the PV array.
- Incorrect weight loading calculations when installing on the roof.

For systems with batteries:

- A solar PV generator that is not big enough to charge the batteries fully.
- Incorrect battery charging settings.
- Operating batteries in an poorly ventilated area.
- Operating batteries in very hot conditions.
- Poor or incorrect connections.

B. Solar modules and solar panels

QUESTION 1.20 What is the difference between a solar panel and a solar module?

In South Africa, the term *solar panel* is used more often but has the same meaning as *solar module*, which is a more formal term.

QUESTION 1.21 What is the difference between a PV string and PV array?

A PV string is a set of modules connected in series. A PV array is a group of modules that may consist of one or more string.

Additional content: ***Introduction to PV solar_v12***

QUESTION 1.22 What is the voltage of a single panel?

Standard PV panel voltage is high enough to charge a 12V battery, rated 18V DC. However, because the voltage of a solar panel depends on the number of solar cells connected in series, the voltage output may be between 0.6V DC and 50V DC or more.

QUESTION 1.23 What is best: monocrystalline, polycrystalline, multicrystalline or thin-film solar PV panels?

- **Monocrystalline solar cells** are slightly more efficient than poly- or multi-crystalline solar cells.
- **Polycrystalline or multicrystalline solar panels** are slightly cheaper to manufacture than monocrystalline panels.
- At high temperatures, thin film performs best, monocrystalline solar panels second best, followed by polycrystalline or multicrystalline panels.
- Monocrystalline and thin film have a uniform appearance; poly- or multi-crystalline has a speckled, non-uniform appearance.

When choosing a technology, users need to weigh price against how much energy they will get from the panel over its lifetime. If space is an issue the most efficient technology should take preference.

Additional content: ***Introduction to PV solar_v12***

QUESTION 1.24 What is the decommissioning process of a system when the life span of a panel or system is reached?

In Europe, PV modules are part of a PV cycle or 'take-e-way' programmes that make sure decommissioned PV modules are recycled in a responsible way.

South Africa does not yet have a programme specific to solar PV, although this is expected to change in the near future. The e-Waste Association of South Africa (eWASA) is a good starting point when it comes to recycling electronic waste. Some municipalities have provisions for decommissioning solar PV systems.

QUESTION 1.25 Do solar panels still work in the shade?

Solar panels produce significantly less power in the shade, although they still produce a small amount. It is very important to place panels where they will receive as much full sunlight as possible.

Additional content: ***Effects of Shadowing on solar PV panels_2012***

QUESTION 1.26 What is the effect of dirt on panels?

Soil, debris and dirt not only significantly reduce the power output of a solar PV system but also create small 'hot spots' that reduce the performance of the PV panels over time. Because output power loss can be around 30%, maintenance cleaning is vital, especially in the dry season.

Although quality solar panels are designed to self-clean when it rains, even with regular rainfall it is best to check the condition of the solar panels to make sure they are clean. A tree branch or bird droppings can significantly decrease the power output of a system.

QUESTION 1.27 Can solar panels withstand hail?

Quality solar panels are made from tempered glass – like the windscreen of a car – and can withstand hail under most conditions. Tempered glass (also safety glass or toughened glass) has up to six times the strength of normal plate glass. It is created by thermal or chemical means and is tested to withstand the impact of normal hailstones and snow loads on the panels. When tempered glass breaks, it shatters into small pieces rather than large shards like standard plate glass.

QUESTION 1.28 What are Bloomberg's tiers 1, 2 and 3 for solar modules?

Bloomberg New Energy Finance has developed a tiering system for PV module producers based on bankability to allow for transparent differentiation between the hundreds of manufacturers of solar modules. Because this basic categorisation has been used for advertising by some manufacturers, the tiers should never replace due diligence in product selection.

TIER 1
(Top 2% of solar manufacturers)
- Vertically integrated
- Intensive investment in research and development (R&D)
- Advanced robotic manufacturing processes
- In production for more than 5 years

TIER 2
(Small- to medium-scale manufacturers)
- No or little investment in R&D
- Only partially robotic; reliant on manual labour
- In production for 2–5 years

TIER 3
(Assembly only; 90% of new solar PV)
- No investment in R&D
- Assembly panels only; does not manufacture silicon cells
- Human production lines for soldering of solar cells

Figure 9: *Bloomberg's ranking system (Pikes Research)*

Additional content: ***Not all PV panels are created equal_16Jul2012***

QUESTION 1.29 Is it really a tier 1 module?

Your supplier should be able to provide proof that their modules come from a tier 1 manufacturer. Alternatively, *Solar Insight* magazine publishes an up-to-date tier 1 list. The magazine can be subscribed to via Bloomberg: sales.bnef@bloomberg.net.

NOTE: Bloomberg advises module purchasers and banks not to use the tier 1 list as a measure of quality, but instead consult a technical due diligence firm such as OST Energy, Sgurr Energy, DNV GL, Black & Veatch, TÜV, E3, STS Certified, Clean Energy Associates, Solarbuyer, Enertis or Leidos Engineering. PI Berlin is one example of independently verifying that the solar PV module in question is good quality. Based on their testing of PV modules, it seems to indicate that very large PV module manufacturers tend to produce much higher quality PV modules than others as seen in the figures below:

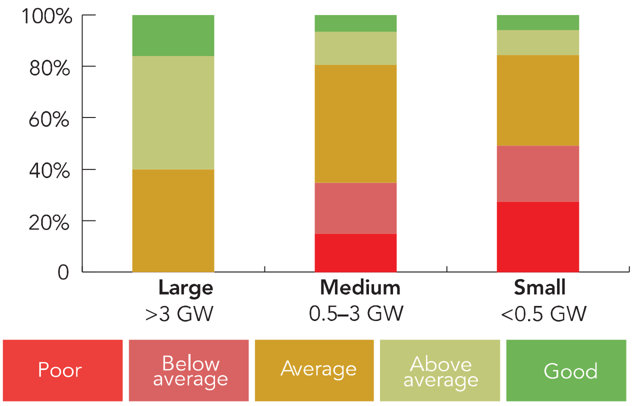


***Figure 10:** Quality ratings compared to factory size (based on 2017 industry-wide audit results)* [3]

Additional content: ***Not all PV panels are created equal_16Jul2012; Bloomberg New Energy Finance PV Module Tiering System_12Mar2018***

QUESTION 1.30 What are solar PV bypass diodes?

If a section of a solar panel is not producing power as it should (due to shading, dirt, damage, etc.), the affected cells become reverse-biased diodes and the rest of the interconnected solar cells will try to feed power into that section, which will result in a hotspot. Because bypass diodes have a lower resistance, the current can bypass the affected cells and thus minimise damage from local overheating.

Additional content: ***Introduction to PV solar_v12***

QUESTION 1.31 Which installation will perform best: solar panels mounted on the roof or ground-mounted solar PV?

Roof-mounted PV normally has less ventilation and more exposure to heat than ground-mounted or free field PV. However, rooftop PV is often preferred because roof structures are already available and are usually the highest point in the area (which minimises shading). Also, there may not be enough space for a ground installation. Exact losses can be quantified by undertaking computer simulations.

With ground-mounted and roof-mounted systems with a significant tilt angle from horizontal, you also have additional irradiation due to the albedo light (reflected solar energy) from the surroundings. See **Figure 11**.

3 PI Berlin dispels long-held views on solar panel quality, PVTEch, 2019 (http://www.pi-berlin.com/images/pdf/publication/White%20 Paper%20-%20%20Industry%20Trends%20in%20PV%20Module%20Quality.pdf)

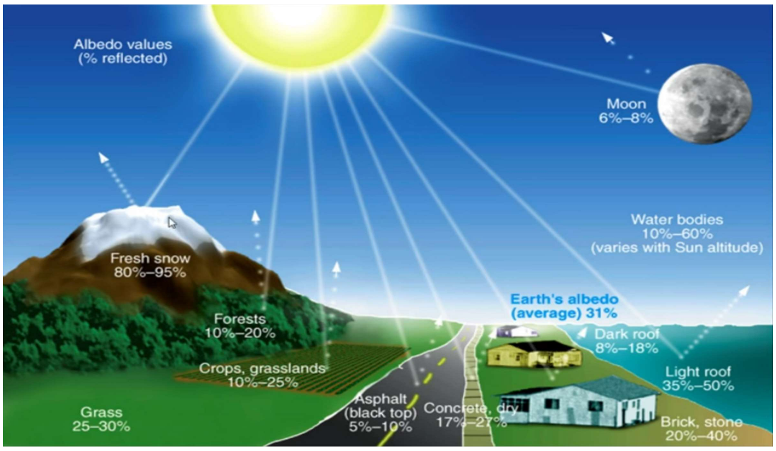


Figure 11: *Albedo light percentages*
(Goetsch, S. 2014. Energy from Sun and Heat Transfer)

QUESTION 1.32 What happens when a panel is installed in an elevated (tilted) position rather than flat on a roof?

Solar PV modules installed in an elevated position improve the yield production of the solar PV system because an appropriate elevation/tilt angle harnesses more solar radiation. The albedo will also enhance the performance of an elevated PV system.

On the other hand, if the elevated panel is installed on the roof, it will increase the dead (weight) load and wind load on the roof structure. It is therefore important for a PV mounting structure supplier or structural engineer to confirm the strength of the roof before installing a roof-mounted solar PV system.

QUESTION 1.33 Will the roof be able to take the weight of the solar PV?

Before a solar panel system is installed on a roof it is important to make sure the roof is strong enough. On average, a flat solar panel system (solar PV) will add an additional 16 kg/m² to the deadweight load of the roof. Also, since the system is fitted only on one side of the roof, a weak structure may become unbalanced under the uneven added weight.

Example: A roof structure can carry a minimum of 100 kg/m². The first weight to consider is the roof covering – roof sheets weigh 25 kg/m², roman tiles weigh 50 kg/m² and large concrete tiles weigh 75 kg/m². Roof structures usually also allow a 15% tolerance for additional loads such as hail, which means that even with large concrete roof tiles a roof should support the additional 16 kg/m² that a solar PV system adds.

Local planning authorities generally allow you to install a solar PV system. Some municipalities require that the panels are no more than 200 mm above the roof and do not extend above the ridge. However, planning consent does not mean that your roof is strong enough. When you are planning a solar panel system, the solar installer/surveyor must report any safety issues regarding the structure of the roof. This is an important part of the pre-installation survey. The surveyor will need access to your loft to inspect the roof structure, building plans, and will need to take photographs to assess the structure in detail off-site.

QUESTION 1.34 What are building-integrated photovoltaics and are they a legitimate alternative to roof-mounted PV panels?

Building-integrated photovoltaics are built into the structure of a home; they merge with, or replace, standard construction materials and features. Windows, roof shingles/tiles and glass walls can all be constructed with power-generating solar cells and fully integrated into the supporting structural materials, which takes solar energy generation to a new level of streamlined efficiency. This technology is still in its infancy and is generally too expensive to be practical for most people who would like to install solar PV.

QUESTION 1.35 Do solar roof tile panels perform well?

There is limited information on solar roof tiles and their performance. Some internet sources claim that the payback period for solar roof tile is between 3 and 5 years longer than more cost-competitive standard solar systems. It may make financial sense to install solar roof tiles when they are installed in place of very expensive roof tiles. Although this technology has yet to prove itself, it holds promise.

Additional content: ***The economics of Tesla's solar roof_08Nov2016***
Tesla Solar Roof makes sense_19May2017

QUESTION 1.35 Is the internal resistance of a PV panel purely resistive or measured as an impedance?

Because DC involves no reactive energy, solar PV modules only have an internal resistive component. The internal resistance of the panel changes with weather conditions. Maximum power conversion is achieved when the external resistance is equal to the internal resistance.

QUESTION 1.36 Is it acceptable for the peak power output of the solar PV panels to be greater than the inverter rating?

Yes, a solar PV system can be 1.15 to 1.25 times larger than the inverter rating. A larger solar PV array compensates for power losses incurred during non-ideal conditions (low irradiation, high temperatures, shading and bad angle/orientation of modules) by using the full capacity of the inverter. However, voltage output must stay within the voltage rating of the inverter, modules and other connected equipment to prevent damage.

QUESTION 1.37 Is the system size measured according to the size of the PV array or the size of the inverter?

Inverter size determines the size of the system. The peak or maximum power output from a solar PV SSEG cannot normally exceed the inverter rating, even if the solar PV array has a larger output capacity than the inverter.

QUESTION 1.38 What happens if disconnected solar PV modules or strings are left in the sun?

Although disconnected solar PV modules or strings can stand in the sun, ideally this should not be for longer than 3 months (some modules degrade faster when left open-circuited in the sun) and the open connectors must be safely enclosed or covered. If you do decide to short-circuit the strings, close and/or open the circuit at night or during no-load/non-operational conditions.

QUESTION 1.39 What anti-theft options are there?

Theft of solar PV panels is a problem in parts of South Africa. The following solutions can help to safeguard against this:

- Standard alarm systems (Trip wire, beams, cameras, electric fencing)
- Bolts and nuts that require unique tools to loosen them
- Permanently fixing the modules with steel glue or welding the mounting structure
- Installing the panels out of sight, e.g. installing PV modules on a water surface, which will also increase the energy yield
- Installing an optical fibre cable through all the panels, which is triggered by movement and/or disconnection.

C. Types of solar PV SSEG systems

QUESTION 1.40 What are the different types of solar PV SSEG system?

There are 4 basic types of PV SSEG system. Other systems are hybrids or combinations of these systems.

Off-grid

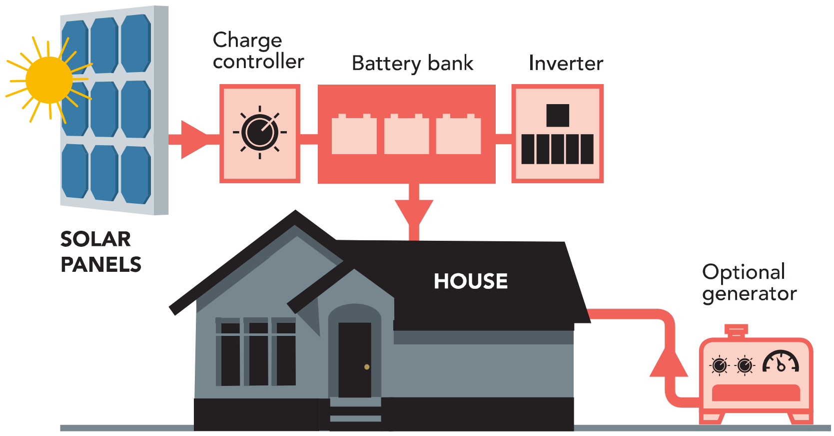


Figure 12: *EGI with batteries*

Off-grid or standalone systems operate continously, independent of the local utility grid. There is thus no utility connection and batteries are used as a base supply.

Solar energy charges the batteries; the DC power from the batteries is converted to AC using a battery inverter. The generator can be used to charge the batteries or supply the house when there is insufficient solar power. In an urban setting, off-grid systems may be used for specific applications such as a pool pump not connected to the internal wiring of the house.

Grid-tied (feed-in)

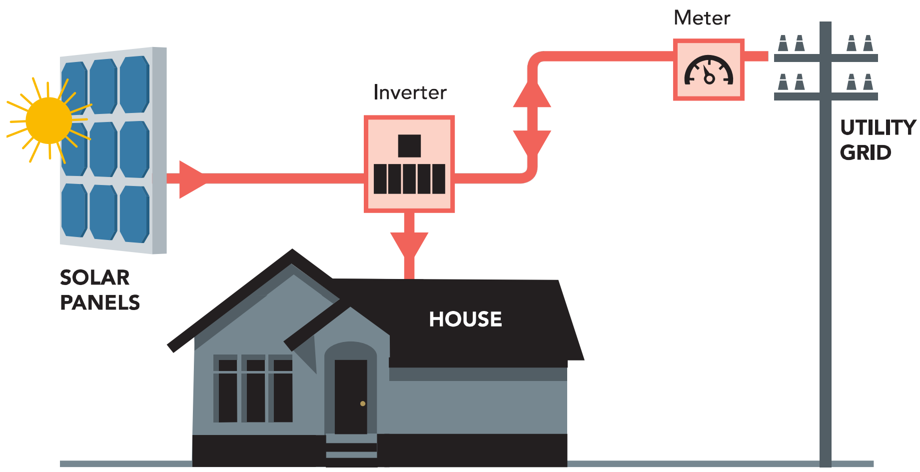


Figure 13: *Grid-tied feed-in EGI*

Grid-tied feed-in systems need the utility grid to connect and operate. Solar power is converted to AC by the grid-tied inverter. The house uses solar power first and uses power from the grid if there is not enough energy coming from the PV modules. Surplus solar energy that is not needed by the house is exported back onto the grid.

Grid-tied non-feed-in (with reverse power flow blocking)

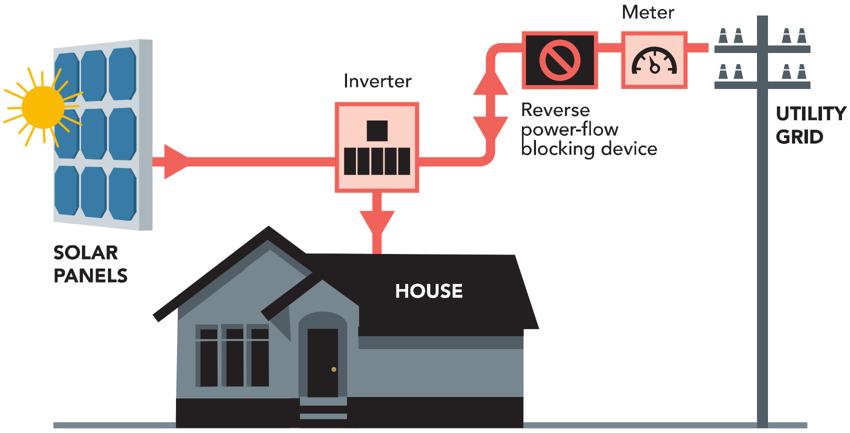


Figure 14: *Grid-tied EGI with reverse power-flow blocking*

Grid-tied non-feed-in systems need the utility grid to connect and operate. Solar power is converted to AC by the grid-tied inverter; the house uses the solar power first and obtains power from the grid if there is not enough energy coming from the PV modules. Surplus solar energy is not needed by the house is prevented from being exporting back onto the grid by a reverse-power-flow blocking device.

Island system

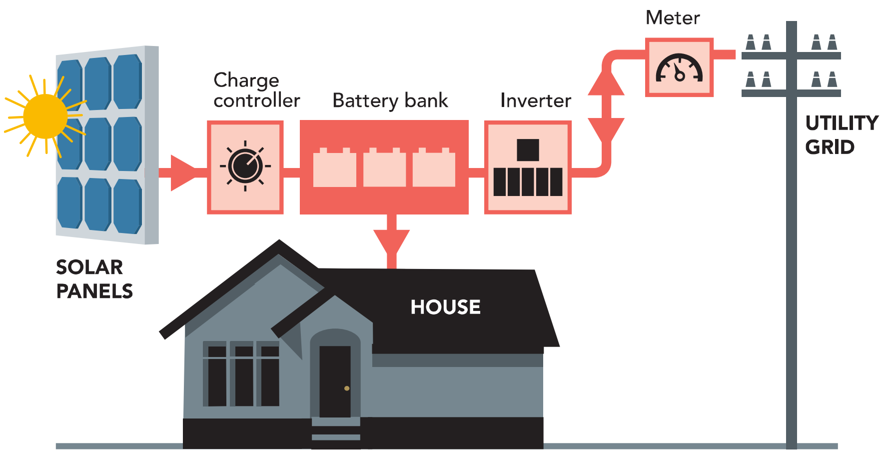


Figure 15*: EGI with batteries*

Island or hybrid systems are connected to the grid, but can function like an off-grid system when needed. An island system can provide AC power from DC power source as *an isolated system*. Even if AC power is available from the local grid, the system can temporarily diconnect from the grid and function *independently*.

Additional content: ***Solar PV Systems and Integrations_v9***

QUESTION 1.41 Will a grid-tied solar system work if there is a power failure or load shedding?

In general, if there is no other base supply of electricity (like batteries or generator), the PV panels of a grid-tied system will not work or generate electricity. Grid-tied solar systems need a reference supply to connect, synchronise and supply electricity. For safety and technical reasons grid-tied inverters or EG are also required to have anti-islanding capabilities to disconnect the generator from the grid and stop producing power.

QUESTION 1.42 What is the difference between grid feed-in systems, grid-limited systems and off-grid systems?

Grid feed-in systems are grid-tied solar PV systems that partially or fully feed solar energy production into the local network.

Grid-limited systems (also known as systems with reverse power-flow blocking or non-feed-in systems) are grid-tied solar PV systems that do not feed electricity back onto the grid. A reverse power-flow blocking device, grid-tie limiter or grid feedback limiter–preventer must be installed to to prevent or limit reverse power flow.

Because **off-grid systems** are not connected to the grid, grid feed-in is not possible.

Additional content: ***Solar PV Systems and Integrations_v9***

QUESTION 1.43 Why are single phase inverters sized only up and equal to 5kVA?

To manage voltage unbalance on the grid, utilities go to great lengths to spread single-phase customer loads as evenly as possible across three phases of the distribution grid.. Larger single-phase loads may cause problems if they are not properly detected and managed. In a similar way, EG may add to the complex problem of keeping loads balanced.

Single-phase supply is limited to a certain size before it switches to three-phase (Normally 80A or 18.4kVA). According to NRS 097-2-3, which includes residential SSEG size limitations, no more than 25% of the customer's demand should be installed when the customer is supplied from a shared feeder (4.6kVA for an 80A supply). Taking the above mentioned into account one should rather use a 3-phase inverter when installing more than 5kVA of capacity.

D. Batteries

QUESTION 1.44 Where and when are batteries used in a solar PV installation?

If a user wants to store excess energy or have alternative energy when the grid is down, they will need batteries with a battery charger and inverter. As long as the grid is energised, the grid-tied system does not need batteries to operate.

QUESTION 1.45 Can batteries be part of SSEG installations?

Batteries can be included in SSEG installations to store excess energy for later use.

QUESTION 1.46 What is the C-rating of a battery?

The C-rating is an indication of how fast a battery can discharge (C/x) or at what current rate the battery will be able to discharge (xC). Solar PV batteries are normally rated at 0.01C or C100 – the energy delivered for full discharged over 100 hours. The following table summarises the meanings of different C ratings:

C-rate	Time to full discharge
5C or C/0.2	12 min
2C or C/0.5	30 min
1C	1h
0.5C or C/2	2h
0.2C or C/5	5h
0.1C or C/10	10h
0.05C or C/20	20h
0.01C or C/100	100h

Example: A 110Ah battery with a C/2 rating means the capacity of the 110Ah battery can be delivered over a period of 2 hours. This means one can draw 55A/h. For 2C means one will withdraw two times the Ah rating of the battery in Amps, that is 2 x 110Ah = 220A which means the battery will not even last half an hour.

Here are some design C ratings typical of different applications for guidance:

- C100: For off-grid sites that needs to supply power for more than 3 days.
- C10: As a standard reference.
- C5: For batteries that will only supply electricity for back-up purposes.

NOTE: The actual available capacity that can be used for charging or discharging is technology-specific. For example, in most cases, lead acid cannot discharge more than 50-80% of its rated capacity (as this will permanently damage the battery), while in most cases the capacity of lithium ion batteries can be fully utilised. The effective battery capacity normally decreases when the discharge rate (withdrawing much more current) increases; for example, a lead acid 12V, 100Ah battery, rated at C10, can be seen as a 80Ah battery at C5 (withdrawing much more current to discharge the battery in 5 hours instead of 10 hours). Always ask your battery supplier for relevant datasheets and documentation to clarify the above mentioned.

Additional content: ***What is a battery C-rate?***

QUESTION 1.47 What is the cost of including batteries in an SSEG system?

Although the cost of batteries may come down, at current prices they are a very expensive component of a solar PV system. In some cases it makes financial sense to include batteries but in most cases, batteries are a 'nice to have' for those who already have power supply from Eskom or the municipality. For remote or off-grid application, the decision to include batteries depends on the intended use of the system.

QUESTION 1.48 What is the future outlook for batteries/storage?

Battery storage of electricity is still very expensive compared to municipal supply. Batteries only make sense if the user is located far away from any electrical supply (like on a farm), if the power is continuously down and/or if the utility's fixed charge is high compared to the energy cost. Research has shown that the prices of storage will decrease significantly in the future and while the price of electricity will be on the rise, storage will most probably become more and more relevant.

QUESTION 1.49 Is the capacity of a battery an indication of the load? Can it be quantified?

The capacity of a battery can give some indication of what size load it would be able to supply within a certain time and at a certain discharge rate.

Example: If you only discharge or use 50% (Depth of Discharge (DoD) = 50%) of a 24 x 910Ah Hoppecke OpzS 2V cell battery system, it will deliver 21.8kWh over a period of 100 hours. A constant/ average load of 218W can be maintained over 100 hours.

If you wanted to discharge 50% of the same battery system over 10 hours, the effective capacity of the same system drops from 21.8kWh to 16.5kWh and an average/constant load of 1 650W can be maintained over 10 hours.

The capacity of all batteries can be quantified, but how and what type of batteries will be used must be factored in to obtain an accurate value. Normally, the exact value of back-up time should be available from the battery supplier.

QUESTION 1.50 What type of batteries are compatible with uninterrupted power supply (UPS) systems?

Although most types of batteries can be used for UPS systems, it is preferable to use one that does not have too many cycles (Not Deep Cycle) to save on costs, is sealed/VRLA (to minimise gassing and prevent spilling) and can supply a lot of current in a short period (High Cycle type), because you want to be able to supply energy to a large load within a short period (10min to 4 hours).

QUESTION 1.51 What requirements are there for battery ventilation?

All batteries should have some form of ventilation. Exact ventilation or air flow requirements can be calculated for the battery system type and size to be used or installed. The supplier or installer should be able to help with these calculations.

QUESTION 1.52 What is the reason to have a level floor when installing batteries?

A level floor prevents tension on the connection plates (when copper plates are used) and makes it easier to compare the electrolyte levels of cells (for wet or flooded cells). Bad connections due to a non-level floor could cause improper charging, hotspots and damage to the battery terminals, which will reduce the lifespan of the battery.

E. Operation and maintenance of solar PV

QUESTION 1.53 What are the risks and benefits of feeding electricity back to the grid?

Feeding electricity from an SSEG system back to the grid has benefits but also poses risks when power is fed to the grid from an uncontrolled or unmanaged system.

Risks:

- Damage to the installed meter or prevent it from working.
- Incorrect electricity measurements and difficulties reconciling meter readings.
- Negative effects on the quality of the network (for systems that do not adhere to the NRS 097-2-1). For more information see **Section 4: Power Quality**.
- The system may continue to energise the network when is down for maintenance, posing a safety risk to technicians. For this reason, adhering to the NRS 097-2-1 anti-islanding requirements is essential.

Benefits:

- Excess electricity can be resold at a profit.
- EG may improve the power quality and/or the operation of the network.
- Replacing the meter gives the utility the opportunity to upgrade their metering system.
- Electricity fed onto the grid is carbon clean.

The customer does not need to install additional equipment to limit or cap the electricity being produced, which will:

- Help save on the capex cost for the consumer,
- Maximise utilisation of solar production,
- Prevent wastage of energy
- Prevent a scenario where the load and generation match, which could increase the chance of Islanding and energising the grid by mistake.

QUESTION 1.54 Can a grid-tied inverter distinguish between grid and other sources?

A grid-tied inverter cannot distinguish between the grid and other sources. However, depending on the control or protection modes and settings, a grid-tied inverter may not be able to operate correctly when connected to an alternative generator such as a backup petrol generator.

Two main control modes – passive and active anti-islanding – are of interest.

If a grid-tied inverter has only **passive anti-islanding**, it will continue to operate as long as the voltage and frequency remain within acceptable bounds. If the combined generation capacity is sufficient to supply the load, and the other source can control both voltage and frequency within acceptable bounds, the grid-tied inverter does not know the difference.

If a grid-tied inverter has **active anti-islanding** implemented, it will attempt to change the voltage or frequency and if successful, would disconnect; it could be described as measuring the source impedance. Therefore, if the other sources are too small, the grid-tied inverter detects the high-source impedance and disconnects. However, this could also happen if the grid-tied inverter is connected to a weak network; the grid-tied inverter does not know whether it is connected to the grid or to another source, merely that something is 'not right'.

QUESTION 1.55 How to isolate a PV system? (Main circuit)

- **Step 1:** Disconnect at night if possible or cover PV modules or panels with a blanket during the day.
- **Step 2:** Disconnect the main circuit breaker between the inverter(s) and the electrical electrical distribution board on the AC side.
- **Step 3:** Disconnect the main energy source (i.e. solar PV modules) using the DC disconnector switch (load-breaking capability) located closest to the PV modules.

Note: Step 3 should precede steps 1 and 2 in emergency cases only.

QUESTION 1.56 How do you isolate a panel or module when it needs to be replaced or undergo maintenance?

To replace a PV module:

- **Step 1:** Disconnect at night if possible or cover PV modules or panels with a blanket during the day.
- **Step 2:** Disconnect the main circuit breaker between the inverter(s) and the electrical distribution board on the AC side.
- **Step 3:** Disconnect the main energy source (i.e. solar PV modules) using the DC disconnection device located closest to the PV modules.
- **Step 4:** Wait for the internal capacitors to discharge (approximately 10 minutes) before opening inverter if required by inverter manufacturer (check the installation manual).
- **Step 5:** Disconnect strings and/or PV arrays from the inverter
- **Step 6:** Measure string current to make sure it is not under load or operation conditions.
- **Step 7:** Wear personal protective equipment (PPE) when disconnecting a DC connector within the string to install the new solar panel.

QUESTION 1.57 What is the importance of component (inverter) test certificates?

Component test certificates give assurance to both customer and the utility owner that the component meets certain minimum criteria, e.g. safety aspects or technical network impact.

Additional content: *Standards and Specifications_v11*

Additional content: *List of Approved inverters_22Sep2016*

Additional content: *Inverter CoC for According to NRS 097-2-1 Example_ 2017*

QUESTION 1.58 Does the temperature affect how much power solar panels produce?

Despite popular belief, the power output of a solar panel decreases as its temperature increases. The listed or rated power of a solar cell is the power measured under ideal laboratory conditions, which prescribes a temperature of 25 °C. However, on a typical hot summer's day, it is not uncommon for a solar cell to reach a temperature of 75 °C. The efficiency of some cheap solar cells can decrease more than 0.5% for every 1 degree above 25 °C. This means that on a hot summer's day, the efficiency of a solar cell could drop as much as 25%.

It is important for solar panels to be well-ventilated. The wind must be able to cool the panels from all sides.

Additional content: *Introduction to PV solar_v12*

QUESTION 1.59 I have solar PV system already. Can I add more solar panels?

Whether you are able to add extra solar panels to your system depends on a number of factors. For systems without micro-inverters or optimisers, factors include:

- Does the current inverter have extra capacity for the new panels?
- Are the new panels identical to those already installed?
- Do you have unshaded space for the additional panels?
- What is the connection size limit defined by your utility?

If a system uses micro-inverters more panels can easily be added as long as utility requirements in terms of total PV system size are adhered to. Optimisers allow installation of panels that are more shaded than the rest of the system.

QUESTION 1.60 The output of some panels drops to 1V if they are not used. How does this work and should this not be standard for all installations?

Some manufacturers include optimisers per one or two panels which are interconnected in series. Each optimiser supplies 1V output (instead of 18-100V) when there is an error in the string or when the inverter is being switched off or maintained. Although this function is a good safety add-on, because it is product-specific it would not be fair to make it compulsory. Including optimisers also increases the price.

QUESTION 1.61 What can be done to prevent, or at least limit, power being fed back onto the grid (when required)?

- Directional relay on utility side. This removes reference supply from inverter and PV supply from inverter will trip.
- Control of inverter by throttling the output from the inverter, known as grid limiting. In the case of 3-phase, the system will respond to the least loaded phase to throttle and therefore SSEG can be underutilised.
- Load control using demand side management and battery storage. The demand side management will switch loads in and out to match SSEG output and/or diverting excess power to charge batteries. There is therefore a high chance of some limited feedback.

QUESTION 1.62 What does reverse power-flow blocking entail?

Municipalities require SSEG systems to be installed with devices to block reverse power-flow back to the municipal grid. This is a conservative measure taken when a municipality is taking the first steps to allow SSEG onto their distribution grid, because it prevents potential technical complications and tariff changes.

There are pros and cons for installing reverse power-flow blocking devices.

Pros: If no power is fed onto the grid from the EGI, the municipality does not have to change the existing meter or place the customer on a different tariff structure (as is done in City of Cape Town). The blocking devices ensure that it is not possible for power to be fed to the grid.

Cons: For an EGI **not** to feed onto the grid, the customer or installer must take the necessary steps to ensure that the EGI does not generate more than what will be consumed on site. This includes:

- Installing grid limiting or throttling devices (controller reducing power output of inverter in cases where the load is less that the generation).
- Applying additional load-management (schedule loads to run during daytime when solar PV energy is being produced).
- For 3-phase systems, ensuring load balancing between phases as the EGI will be limited/throttled according to the least-loaded phase.

Although potential energy is lost by realising the above requirements and the additional devices may add to the cost of the total system it can be prevented by making the EGI system small enough so that it does not produce more than the base or minimum load.

Another drawback for cases where grid-limiting devices are installed, is that the load and the generation may match at times. Anti-islanding of the EGI may fail due to generation load-matching, which in itself is a risk to municipalities.

QUESTION 1.63 What protection can be installed to protect the EG?

AC and DC surge-arresters as well as DC fuses for systems with three or more solar PV strings can help protect the EG. AC surge-arresters are installed between inverter and supply and the DC surge-protection is installed between panels and inverter.

For large solar systems (for example >30kVA) lightning protection may be required. A lightning risk assessment will determine if this type of protection is needed. Security against theft measures would also be recommended.

Additional content: ***Solar PV Systems and Integrations_v9***

QUESTION 1.64 Does a solar power system require maintenance?

To ensure a solar power system continues to work as effectively as possible it is recommended that it is checked regularly.

DC-to-AC inverters will probably need to be replaced every 10 years or so and the lifespan of the average battery in a solar PV system is between 5 and 10 years.

Maintenance contracts could be negotiated and agreed to between the installation company and the owner. A **PV GreenCard** ***(see page 27)*** provides for documentation of this agreement and attachment of maintenance reports.

SECTION 2

QUALITY ASSURANCE FOR SOLAR PV SSEG

A. Solar PV training

QUESTION 2.1 What formal renewable energy qualifications are available in South Africa?

The South African Renewable Energy Technology Centre (SARETEC) recently obtained a SAQA ID number for the formal qualification of **solar PV service technician** at the end of 2016. In addition, with assistance from Deutsche Gesellschaft für Sonnenenergie (DGS) and Cape Peninsula University of Technology (CPUT) SARETEC developed the following short courses:

- **PV service technician** (PV farms)
- **PV service technical** (standalone/off-grid installation)
- **PV installer** (liaises with clients, conducts site visits, obtains and analyses data, designs or customises or compiles a PV system, selects appropriate components, installs, commissions and tests a PV system for functionality)
- **PV mounter** – (mounts pre-designed PV systems according to instructions from either a PV installer or designer.)

Additional content: ***PV GreenCard Launch_2017***

Additional content: ***Career Path Training Modules_2016***

QUESTION 2.2 What is the SAQA number for the 5-day short course for electricians to cover the 20% non-electrical content?

Currently there are no numbers for the part qualifications, only for the full qualification – Solar Photovoltaic Service Technician, Curriculum Code 313109001, NQF Level 5, SAQA Qualification ID 99447.

QUESTION 2.3 How does the Solar PV Technician qualification work?

- 80% of the qualification is based on Quality Council for Trades and Occupations (QCTO) electrician work
- 20% is solar PV (can be covered by the 5-day short course for those who already have their electrician qualification)
- The installer must pass the assessment to become an SAPVIA endorsed installer with 80% competence.
- The installer must be registered with DoL, pass theassessment and be a qualified electrician to obtain part qualification as a Solar PV Technician.

Additional content: ***Course Development Background_Jun2016***

QUESTION 2.4 Where does a qualified Solar PV technician fit in as a trade-tested electrician?

Someone with a 2-year Solar PV Service technician qualification is a QCTO technician that can only do PV, i.e. they may not do other electrical work, or sign off a CoC. Part qualification is SAQA ID 99447. A Solar PV technician still has to complete an electrical trade test path to become fully qualified and be allowed to complete, submit and sign off the PV GreenCard and CoC.

B. The PV GreenCard and quality assurance

QUESTION 2.5 What is a PV GreenCard?

A PV GreenCard is a customised quality report that documents the installation of rooftop PV systems. It covers all relevant installation steps and important information on the equipment used such as PV modules and PV inverters. It serves as a lifelong companion for a PV system and will capture all future maintenance activities in your personal PV GreenCard.

NOTE: The PV GreenCard is no replacement for any manufacturer warranty.

Additional content: *PV GreenCard FAQ*

QUESTION 2.6 What is the difference between a PV GreenCard and a certificate of compliance (CoC)?

The CoC is a legal requirement for LV wiring of premises, whereas the PV GreenCard is optional. The PV GreenCard is complementary to the CoC as it serves as an additional quality assurance of the EGI. The PV GreenCard is a quality checklist that cites the CoC as a basic requirement for the installation process. The PV GreenCard can also be seen and used as an as-built report, i.e. a record of the SSEG system as it has been installed, which may deviate from the pre-design in some respects.

Additional content: *PV GreenCard Form Explained_20Jun2017*
PV GreenCard Form_Example_Oct2016

QUESTION 2.7 What is the legal status of a PV GreenCard?

The PV GreenCard is a comprehensive document of your PV system installation and components. It is a voluntary industry quality declaration that encompasses the processes and procedures of the Department of Labour's Occupational Health and Safety Act (OHSA), amongst others.

QUESTION 2.8 How is a PV GreenCard issued?

A PV GreenCard is linked to a person, not a company; a person may be linked to more than one company.

- The PV GreenCard is the document handed to the customer when an installation is completed.
- The installer (person) is assessed and certified by SAPVIA.
- The installation company is endorsed only when they have an assessed and certified installer and a DoL-registered person.

QUESTION 2.9 How does the SANS series standard fit in with the PV GreenCard?

Existing SANS standards are included in PV GreenCard training and must be applied during an installation. New and updated standards are automatically integrated and must be applied by the PV GreenCard installer.

QUESTION 2.10 How will the SSEG system comply with requirements set out by the PV GreenCard?

Installation by a SAPVIA-endorsed PV GreenCard installer, capturing the details on the PV GreenCard 'as-built' report and the client/municipality approval for the GreenCard to be issued ensure that the SSEG system complies with the requirements set out by the PV GreenCard.

QUESTION 2.11 How will the Association of Municipal Electricity Utilities (AMEU)–South African Local Government Association (SALGA) SSEG application process fit in with the PV GreenCard, and vice versa?

Currently there a overlap of the AMEU-SALGA SSEG application process, and the documentation required. The intention is to integrate the two to ease and streamline application and documentation. For now they will be done in parallel.

QUESTION 2.12 How will contractor competence be checked under the PV GreenCard scheme? What happens when work is sub-contracted?

To obtain a SAPVIA endorsement, an installer will be formally assessed, must be registered with the DoL as an electrician and must pass the assessment. A SAPVIA-endorsed installer may sign a CoC and a PV GreenCard form.

When work is sub-contracted, the same rules will apply as when normal electrical work is sub-contracted; the work should be done under the supervision and control of a registered DoL electrician who has passed the PV GreenCard assessment and will sign off on the CoC and PV GreenCard form.

QUESTION 2.13 How does the PV GreenCard help ensure safety?

Safety can be addressed to a large extent by:

- Procuring and installing good quality solar PV components (independent certification to be provided by supplier).
- Installing solar PV components that adhere to appropriate specification/standards.
- Realising the installation with a competent installer (ideally a SAPVIA-endorsed installer).
- Going through the official application process for SSEG set out by the local network operator (AMEU-SALGA application forms).
- Issuing a PV GreenCard which checks for all of the above.
- A CoC for the installation from a registered electrician.

QUESTION 2.14 How can the PV GreenCard police installations and systems?

Once an installation is completed, the customer will receive a unique PV GreenCard installation number via SMS or email. The customer visits the PV GreenCard website customer page, insert their unique number and reviews the details of the installation. The customer is requested to accept the PV GreenCard.

If a client is not happy with the installation, they can decline or RedCard the installation. Once SAPVIA is alerted of this RedCard installation, an approved inspection authority (AIA) registered with the Department of Labour will be asked to do an independent inspection. Should the AIA find that the installation was done against recommended standards, the installation company will need to rectify the installation at their own cost. Should the AIA find that the installation was done correctly, the customer will be responsible for the cost of the AIA.

For more detail see section Error! Reference source not found.

Additional content: ***PV GreenCard FAQ***

QUESTION 2.15 Who is liable for safe operation and maintenance of the installation?

The DoL-registered PV installer who signed the CoC is liable for the safe operation and maintenance of the installation. Once the CoC is signed and presented to the customer, the customer is liable for safe operation of the installation. The PV GreenCard provides an extra layer of comfort and accountability.

QUESTION 2.16 What happens to non-electricians who are listed as a PV GreenCard endorsed installer?

Non-electricians may do the installation under the supervision and control of the registered electrician, but the completion and submission of the CoC itself can only be done by DoL-registered electrician. Both can complete and submit the PV GreenCard.

QUESTION 2.17 What will happen with red-carded sites?

1. SAPVIA will decide on the merits of a Red Card being issued.
2. An approved inspection authority (AIA) registered with the Department of Labour (DoL), will be sent out to check the site.
3. The customer pays for the inspection if there is no mistake.
4. If there is a mistake, the installer must pay for the inspection and correcting the mistake.

QUESTION 2.18 How many times can a supplier or installer be red-carded?

There is a 3-tier warning, whereafter the supplier or company will be disallowed from holding GreenCard accreditation.

QUESTION 2.19 Is the PV GreenCard applicable for large independent power producers (IPPs)?

The PV GreenCard is for SSEGs <1MW. Large IPPs have their own streamlined processes and regulations under the Renewable Energy Independent Power Producer Programme (REIPPP).

QUESTION 2.20 Who will review the as-built drawings and details on the PV GreenCard system?

The PV GreenCard is for documentation purposes only. SAPVIA may share this documentation with interested and affected parties should the need arise.

QUESTION 2.21 Can a PV GreenCard be issued or controlled by municipalities?

Municipalities are welcome to integrate the PV GreenCard as a requirement into their SSEG processes. SAPVIA is willing to discuss possibilities and partner with municipalities on this. SAPVIA can allow municipalities to obtain a copy of the PV GreenCard and give permission for it to be used in their **SOP.** This needs to be discussed, defined and agreed to between the municipality and SAPVIA.

Additional content: *PV GreenCard and Municipalities_20Jun2017*

Additional content: *Benefits of the PV GreenCard_20Jun 2017*

QUESTION 22 Will the AIA also undergo PV GreenCard training?

The AIAs may undergo the training and assessment in order to provide a value-added service.

QUESTION 23 What happens to the PV GreenCard and CoC when the house is sold?

The PV GreenCard will be handed over to the new owner and is valid for the lifespan of the installation. A new CoC will be issued, as with any sale of property.

QUESTION 24 What test(s) should municipalities do after the PV GreenCard has been issued?

No additional test is required but for peace-of-mind, municipalities may apply the commissioning tests set out in the AMEU-SALGA SSEG forms. The main test is to see if power will not be fed back during power outages.

See Commissioning section under municipal processes.

Additional content: ***SSEG Commissioning Report with Tests_v1.1***

QUESTION 25 Does PV GreenCard training cover hybrid systems and batteries?

Although PV GreenCard training covers hybrid systems and batteries, these require specialised provider training.

QUESTION 26 Who created the assessment tool for PV GreenCard trainees?

A panel of experts under the leadership and guidance of SAPVIA, GIZ, GreenCape and SARETEC created the assessment tool for PV GreenCard trainees.

QUESTION 27 What costs are involved with the PV GreenCard and PV GreenCard installers?

- 2018: R1000.00 annual registration fee per installation company (subject to change)
- 2018: R50 submission fee per installation (subject to change)
- Training and assessment cost as per the training/assessment centre

QUESTION 28 How do I choose the right installer?

If an installer does not have a good track record, some form of formal qualification or registration with the DoL as an electrician, we advise using a SAPVIA PV GreenCard installer. A list of installers can be found at *www.pvgreencard.co.za*.

Installers listed with the South African National Energy Development Institutes (SANEDI) who are registered as Tier 1 Energy Service Companies (ESCo) - *http://www.sanediesco.org.za/* , will also provide a certain level of reassurance.

SECTION 3
SAFETY AND STANDARDS FOR SSEG INSTALLATIONS

QUESTION 3.1 Why are rules and regulations necessary for SSEG?

EG can influence the power quality and the safety of the network if improper equipment is used or if the generator-system is not properly installed. If an installation is not done according to certain rules and standards, there are potential risks with negative impacts on the community, including death. For example, an EG could cause the voltage to rise too high, resulting in damage to the customer and neighbours' appliances.

Additional content: ***Standards and Specifications_v11***

QUESTION 3.2 Can SSEG systems generate and feed electricity back onto the grid when the grid is down?

A correctly designed and installed system will not generate power and feed back onto the grid when the grid is off. The anti-islanding function, according to the NRS 097-2-1 specification of the SSEG, disconnects the system under these conditions.

NOTE: No system is a 100% reliable and appropriate training should be given to e.g. line workers to know how to work safe should there be a failure of certain components or functions.

QUESTION 3.3 What is the role of disconnection devices and anti-islanding functions?

Anti-islanding functions, which disconnect the SSEG system from the network under certain conditions (such as when the network is down or various power quality parameters are out of bounds), are typically embedded in an inverter and activate automatically. The NRS097-2-1 standard requires such functions of inverters, and compliance must be demonstrated by inverter manufacturers.

NOTE: Maintenance procedures in South Africa are different from those elsewhere because a safety earth can often not be applied due to our network configuration. In these cases, it may be prudent to install additional disconnection devices, e.g. an isolator under the utility's control or even a dead grid safety lock (DGSL). These options are being finalised in the ***SANS 10142-1-2: Specific Requirements for Embedded Generation Installations connected to the LV Distribution Network in South Africa*** standard currently being developed.

QUESTION 3.4 Which standards, specifications and regulations apply to solar PV SSEG?

Key specifications are the NRS 097-series, which defines basic requirements at the interface. This series also references safety requirements, e.g., those in the IEC 62109-series. Installations are regulated by the wiring code, i.e. SANS 10142-1. The SANS 10142-1-2 is under development for SSEG installation requirements.

Additional content: ***Standards and Specifications_v11***

Additional content: ***Standards and guidelines for the PV GreenCard_ Jun2016***

QUESTION 3.5 In terms of SSEG, where does the NRCS fit in?

The role of the National Regulator for Compulsory Specifications (NCRS) is development and administration of technical regulations and compulsory specifications. At the time this document was compiled, there was still uncertainty about whether NRCS would play an active role when it comes to the components used for SSEG.

QUESTION 3.6 If someone wants to connect on the medium voltage (MV) side, which requirements and standards apply?

Wiring regulations are provided for MV installations up to 22 kV and up to 3 MVA in SANS 10142-2. The LV side of the installation remains the domain of SANS 10142-1. Installations larger than 3 MVA or connected to voltages above 22 kV require the services of a professional engineer and may also require a grid impact study.

QUESTION 3.7 Where are SANS documents located?

SANS documents are available from the South African Bureau of Standards (SABS). It is recommended that municipalities evaluate group subscriptions to selections of SANS documents to ensure adequate and cost-effective access to these documents.

QUESTION 3.8 Overheating can cause fires. How important are thermal ratings in this context?

As with any electrical component, thermal ratings of Solar PV components are important. Depending on the application and environment where these components will be used, applicable thermal ratings should be requested and applied. A competent installer will take this into consideration.

QUESTION 3.9 Are fireman's switches required for SSEG?

A fireman's switch is a specialised switch that allows firefighters to quickly disconnect power from high voltage devices that may pose a danger in the event of an emergency. The new standard will confirm requirements in terms of the fireman's switch. Whether fireman's switches are installed or not, because solar PV panels generate electricity as long as there is sufficient sunlight, the situation should always be regarded as live. It is thus important for fire departments to educate and train their personnel on how to handle fire where there is solar PV installed.

Additional content: ***Fire Brigade information for Solar PV-2017***

Additional content: ***Fire Safety Risks at PV systems-27Mar2012***

Additional content: ***Solar PV System Safety and fire ground Procedures-2012***

QUESTION 3.10 How are phase changes, phase failures and generator connections handled?

If there is a phase change (rotation of connection at source, e.g. after maintenance), most inverters will automatically sense the phase rotation and adapt the control to follow the network. Rotational generators (synchronous and asynchronous) will have to be reconnected by an electrical competent person.

NOTE: The same applies for motor loads; the utility should communicate with 3-phase customers to check rotation of their loads. A phase rotation relay is always recommended for 3-phase motor loads.

QUESTION 3.11 What are the quality and safety requirements of the DC components?

For now, only best practice and current DC-related standards of the SANS 10142-1 can be applied, until SANS 10142-1-2 is finalised and formalised.

QUESTION 3.12 What is the minimum height at which a DC disconnection device should be located? What are the safety requirements for a DC disconnection device?

The SANS 10142-1-2 (forthcoming) will make provision for a suitable DC disconnection device. In the interim, the system designer should indicate where it should be positioned or the municipality should request that it be positioned appropriately.

QUESTION 3.13 Does the size of the fuse depend on the wire size?

DC wires are sized based on the maximum short circuit current (Isc) of the string or array. A DC cable should take at least 1.25 times the current of the Isc of the string or array.

Overcurrent protection (protection against excessive currents or current beyond the acceptable current rating of equipment) is not required for a PV string and PV array cables when the continuous current-carrying capacity of the cable is equal to or greater than 1.56 x Isc STC of the relevant PV string or array [NEC 690.9(A)].

Reverse current protection can be achieved with DC fuses. The device should be rated to equal or greater than 1.56 x ISC STC [NEC 690.8(B)(1)(a)]. The applicable temperature correction factor needs to be applied (see [NEC 690.8(B)(1)(c)].

DC fuses must be installed on positive and negative conductors, because both cables would be subjected to damage during a fault condition.

QUESTION 3.14 Does a Pr. Person have to sign off installations or is it merely a preference?

For customers, sign-off by Pr. Eng (or Pr. Tech Eng or Pr. Techni Eng) may be a challenge because it is expensive (e.g. on residences). For installation of EGI, a PV GreenCard installer is a good alternative to a non-PV GreenCard electrician. However, for sign-off on the NRS 097-2-1 requirements, the legal recourse of municipalities is limited if it is not done by a Pr. Person. It is proposed that until the South African legislation and regulations are not formalised in terms of who can take legal responsibility for ensuring the NRS 097-2-1 is adhered to, a Pr.Person sign off should be required for all installations.

All systems require a Certificate of Compliance (CoC) in terms of SANS10142-1 (and SANS10142-1-X when it is released).

QUESTION 3.15 Are diesel generators that operate in parallel with the grid also seen as SSEG? If so, how should they be managed?

The current edition of NRS 097-2-1 states that all EGs connected parallel to the grid must comply with all the requirements, including e.g. diesel generators that operate in parallel for a short period. The requirement is set both for technical and safety reasons.

NOTE: A utility may amend the requirements of their networks if they have appropriate safety devices or procedures in place to ensure that back-feeding to a dead grid cannot happen. Dependent on potential technical impacts, a very short time period for parallel operation may also be set, e.g. 100-200 ms.

QUESTION 3.16 What should be done in terms of labelling (inside and/or outside of premises)?

The main purpose of labelling is for safety of maintenance personnel and the fire brigade, i.e. to ensure that all sources of electricity are switched off before work commences on any part of a system. A minimum requirement is for labelling at the distribution board (DB) where the EG feeds in, as well as any other DBs up to the point of control.

The above principles can be used to guide appropriate labelling locations until publication of SANS 10142-1-2.

QUESTION 3.17 What is required in terms of earthing and bonding of solar panels?

All exposed metal parts must be bonded to earth, i.e. PV panel frames as well as the mounting structure. The recommended minimum size of bonding and/or earthing cable is 6 mm².

QUESTION 3.18 What type of earthing arrangement is appropriate for grid-tied systems?

The rule of thumb is to follow the existing installation's earthing system, e.g. terra neutral separate (TNS). A grid-tied system does not need its own earthing system or earth rod, unless it is a hybrid system that can be operated off-grid.

QUESTION 3.19 In the case of additions, should the new CoC only cover the new EG installation or should it cover the whole electrical installation of the building?

Current law and standards requires a CoC for the new installation only. When the house is sold, a CoC for the whole electrical installation is needed.

QUESTION 3.20 Are there safety requirements that are applicable to only large systems and not small?

From the point of view of utilities, large systems (currently this distinction is 30 kVA) may require an additional disconnection device.

NOTE: Larger systems imply more energy with potential for larger currents and ultimately greater damages, if something goes wrong. Installation requirements may be stricter in terms of protection devices, e.g. fuses on DC cables etc. These requirements will be finalised in SANS 10142-1-2.

QUESTION 3.21 Should a load-bearing certificate be provided to the planning department?

It would be a good idea to include this in the final sign-off of a PV system installation. The City of Cape Town has set some regulations, where a customer may install a PV system without the need to supply a load-bearing certificate.

QUESTION 3.22 Is AC surge protection needed on the AC side of the inverter?

AC surge protection requirements are generally determined from a risk analysis, e.g. network power quality, lightning density etc. Given the potential safety impacts of an inverter's disconnection switches failing, the current recommendation is that the AC side of the inverter may need AC surge protection to protect the safety disconnect devices internally to the inverter. If an external safety disconnection device, such as the DGSL, is used, this safety disconnection device will need AC surge protection.

QUESTION 3.23 Does SA have independent quality testing facilities for solar equipment?

Independent quality and type testing for solar PV components is, for the most part, done abroad. The following third-party testing institutions have offices in South Africa:

- PV-insight (Nelson Mandela University)
- SGS
- TUV Rheinland
- TUV SUD
- Bureau Veritas

QUESTION 3.24 How does direct or indirect lightning affect solar PV installations?

Direct lightning will destroy an installation just as it does anything that gets hit directly. The bigger concern is generally the impact of indirect lightning.

Insurance companies may insist on adequate lightning protection, i.e. surge arrestors. According to SANS/IEC 61643-12, surge protection devices (SPDs) are mandatory at the main distribution board. The new SANS 10142-1-2 standard will give more clarity in terms of what needs to be done.

For now, it is advisable to do a lightning risk assessment, especially for large systems, to give a customer an indication whether they need to protect their investment. The insurance broker also plays a significant role in terms of specifications for lightning- and surge-protection requirements.

QUESTION 3.25 What is a type B residual current devices (RCD) breaker and when is it needed?

The key reason for specifying type B residual current devices (RCDs) is to detect residual DC current. These devices are required when there is no galvanic isolation (i.e. transformer) between the DC and AC side of the PV installation, e.g. when transformerless inverters are used.

NOTE: Type B RCDs can respond to higher frequency current as well as combinations of AC and DC.

QUESTION 3.26 Is anti-islanding protection and grid safety lock protection graded?

No, anti-islanding protection (including the proposed DGSL) is not overcurrent protection and therefore not graded.

QUESTION 3.27 Will the network continue to operate without problems when the NRS 097-2-3 is applied?

The NRS 097-2-3 is a guideline for utilities based on international best practice as well as basic system simulations. It is anticipated that no significant voltage rise problems will be experienced when the guideline is applied.

NOTE: The real test of these guidelines lies in their application, and documenting any problems that occur for future updates to the document.

Additional content: ***Application of NRS 097-2-3_v7***

QUESTION 3.28 Will the network be well maintained once the NRS 097-2-3 is applied?

The network and network drawings must be well maintained to effectively apply the NRS 097-2-1. NRS documents can be obtained free of charge from the Eskom Technical Documents website at the following address: *https://scot.eskom.co.za/*

NOTE: Users are required to register annually.

QUESTION 3.29 Explain more about the 3.6 kVA and 4.6 kVA requirement between phases and for 3-phase balancing.

The NRS 097-2-3 recommends that customers do not exceed 25% of their NMD (breaker size) when installing EG. For a customer with a 60 A breaker, this evaluates to 3.45 kVA, which has been relaxed to 3.68 kVA as a standard upper limit for customers with a 60 A breaker.

The 4.6 kVA balancing limit relates to the imbalance between phases where a customer has a multiphase supply. A single-phase customer may install up to 13.8 kVA, but an EG larger than 4.6 kVA must be balanced between phases when a customer has a multiphase supply (dual and three-phase). The 4.6 kVA is also the standard upper limit for customers with an 80 A breaker.

Additional content: ***Application of NRS 097-2-3_v7***

QUESTION 3.30 What happens to SSEG systems that do not meet the simplified criteria set out by the NRS 097-2-3, like SSEGs larger than 350kVA?

The guideline states that grid-impact studies need to be done for EG systems larger than 350 kVA, or any other EG system that does not meet the simplified connection criteria. The purpose of these studies is to evaluate the potential impact on protection coordination, network voltage levels and a basic estimate of power quality impacts. See Annex A of NRS 097-2-3.

Eskom provided the main inputs into the NRS 097-2-3 and draws a distinction between major and minor small projects at 350 kVA – hence this upper limit..

Further, the largest standard MV/LV transformer that Eskom uses is 500 kVA. As per the flow chart in the NRS097-2-3, the maximum size of an EG on a dedicated feeder is 75% of the transformer size, which is 375 kVA, roughly the same as the upper limit for the simplified connection criteria in NRS 097-2-3.

Additional content: ***Application of NRS 097-2-3_v7***

QUESTION 3.31 To what extent do the limitations between NRS 097-2-1 and 2-3 and the grid code match or overlap?

The NRS 097-2-series aligns with the grid code as far as possible, since the grid code is the legal document. Any discrepancies have to be followed up with both the grid code secretariat and the NRS 097-2 working group to resolve.

QUESTION 3.32 How does the requirement of 4.2.2.4.4 fit it with sites like hospitals?

NRS 097-2-1, clause 4.2.2.4.4 states: 'An islanding condition shall cause the embedded generator to cease to energise the utility network within 2s, irrespective of connected loads or other embedded generators. The embedded generator employing active islanding detection shall comply with the requirements of IEC 62116 (ed.1).'

The anti-islanding requirement is a safety requirement on the utility side. A hospital, or any other load that wants to remain connected when the grid is off, needs a hybrid system.

SECTION 4
POWER QUALITY

QUESTION 4.1 Can SSEG systems have an impact on the power quality (PQ) of the local grid and to what extent?

SSEG systems will affect the PQ of the network. PQ limits have been specified in NRS 097-2-1 in line with international requirements in order to minimise this potential impact.

The level of PQ pollution contributed by an inverter depends on many factors, but it is anticipated that the impact would be benign in the majority of cases. Experience and measurements in Belgian residential networks have shown a beneficial impact of inverters, since they mostly cancel distortion caused by some customer loads, e.g. compact fluorescent lamps (CFLs).

Any voltage imbalance caused by SSEG mostly affects 3-phase loads. Motors are less efficient during high voltage unbalance and may overheat. Harmonic current emissions from rectifier loads, such as motor drives, may increase.

Voltage unbalance may lead to over- or under-voltage on one of the phases, which could negatively affect customers connected to that phase.

Power quality emission limits for SSEG are provide in NRS 097-2-1 for current harmonics, voltage flicker and voltage unbalance. Power quality requirements in South Africa are defined by the NRS 048-series of documents. Most of the requirements are identical to European requirements contained in e.g. the EN 50160 and IEC 61000-series of documents.

NOTE: Power quality is regulated in terms of compatibility levels, rather than limits due to the statistical nature of disturbances.

QUESTION 4.2 Should the PQ be measured before installing an EG?

Measuring the quality of the power supply will help to determine if any future PQ issues are due to the EG or other reasons.

QUESTION 4.3 What will happen to the power factor (PF) if EG is installed?

The actual PF rating at the point of supply will stay the same but a there will be a lower PF reading at the utility's meter because the meter is unaware of the active power being delivered by the EG (measured in kW). When EG is installed, the utility will be supplying less active power but the same amount of reactive power (measured in kvar). The utility therefore supplies proportionally more reactive power than before, which causes the PF reading to decrease.

QUESTION 4.4 Should SSEG inverters or systems be frequency sensitive?

Good quality inverters are programmed to operate with a certain tolerance to frequency changes. In South Africa inverters that operate and produce power based on the frequency requirements set out by the SA Grid Code and NRS 097-2-1 are recommended.

Additional content: ***Standards and Specifications_v11***

QUESTION 4.5 What is the harmonics content of grid-tied inverters and what effect does the size of the SSEG have in terms of the harmonics?

Harmonics of grid-tied inverters are limited by relevant standards. The NRS 097-2-1 follows the harmonic emission limits of the IEC 61727: Ed1 (similar to IEEE 1547).

From a statistical point of view, it is expected that different inverter sizes would have similar impacts on the network, since larger inverters can only be connected to stronger networks, i.e. larger harmonic currents should only be seen on stronger networks, where the impact is smaller. It is anticipated that harmonics from inverters can be managed in a similar way to consumer loads, where the combined effect is limited to reasonable levels due to the diversity.

However, the real impact of harmonics will only be fully understood once more inverters are connected and appropriate monitoring takes place.

QUESTION 4.6 What happens when over-frequency occurs?

Over-frequency in a power system occurs when the load is smaller than the generation. This may occur during some system contingencies where large loads suddenly disconnect or trip.

Alternatively, if there is an excess of generation and the required load is very small, on public holidays, for example, over-frequency may result.

According to the South African Grid Code for Renewable Power Producers, all renewable generators must assist the system by reducing output power when the frequency starts to exceed 50.5 Hz. There is a linear reduction of 50% per Hz, so that the power output is halved when the system frequency reaches 51.5 Hz. However, should the system frequency exceed 51.5 Hz, all generation must stop to energise the system.

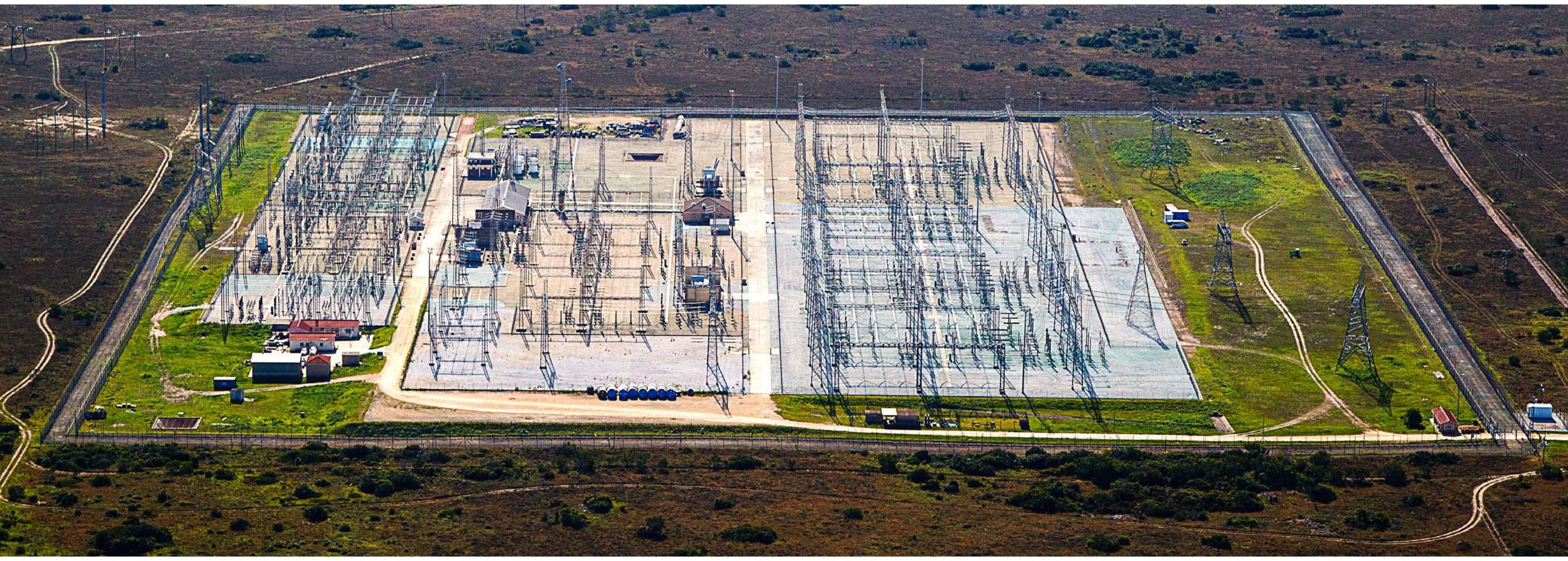
Additional content: ***Standards and Specifications_v11***

QUESTION 4.7 What should the technical specifications of SSEG equipment be?

The technical specifications for SSEG at the point of connection are provided in NRS 097-2-1.

QUESTION 4.8 What happens to the PQ when there are multiple embedded generators?

Multiple embedded generators generally increase power quality deviations, e.g. harmonics. However, the increase is not linear, but with smaller increments for each additional device.



SECTION 5
METERING

Additional content: ***Metering and Billing done in NMBM_Nov2017***
Additional content: ***Metering & Monitoring Requirements_v8***
Additional content: ***Metering & Billing done at Ekurhuleni_25Oct2017***

QUESTION 5.1 What is net metering and is it available in South Africa?

Net metering is a policy that allows home owners to receive the full retail value for the electricity that their solar energy system produces and feeds to the grid. Net metering refers to the method of accounting for the PV system's electricity production. Net metering allows home owners with PV systems to use any excess electricity they produce to offset their electricity bill. As the homeowner's PV system produces electricity, the kilowatt-hours are first used for any electric appliances in the home. If the PV system produces more electricity than the homeowner needs, the extra kilowatts are fed onto the utility grid.

Most municipalities in South Africa make provision for net billing instead of net metering. Differences between the two are covered in the next question.

QUESTION 5.2 What is the difference between net metering, wheeling and net billing?

Each of the following metering or billing methods apply when an EG is installed.

- **Net metering** – Both the import (usage in kWh) and export (excess in kWh) of electricity is measured and the net effect (difference between the two) is indicated or displayed. The value of the exported kWh vs the imported kWh is 1:1. For example, if 250 kWh was used and 30 kWh exported, the net metering will show 220 kWh used and the customer will pay for the 220 kWh used.
- **Net billing** – The same as net metering, except that the value of kWh being exported is smaller than the value of the kWh imported. For example, if 250 kWh was used (for R1.50/kWh) and 30 kWh was exported at R1.00/kWh, the customer will pay R345.00 – R375 (250 x R1.50) minus R30 (30 x R1.00). The price difference between imported and exported power is due to the non-energy cost of electricity in the tariff, such as grid operations and maintenance.
- Wheeling-billing – The billing of the transportation of electricity, over a utility's electrical network from an EG in one place to a third party/customer in other places. For example, a generator generates electricity for R0.80/kWh, the utility charges a R0.20 wheeling charge for using their network and the generator sells it for R1.00 or more to another customer.

Additional content: ***Metering & Monitoring Requirements_v8***

QUESTION 5.3 What is the most basic meter that can be used for SSEG?

A 4-quadrant or bi-directional meter that measures both import and export of kWh can be used for SSEG. One example for single-phase installations is the Elster AS230. An example of a 3-phase meter is the Echelon MTR 3000.

It is possible to programme pre-paid meters to measure both import (supplied by the utility) and export (excess power being fed onto the grid) and allocate a tariff for each but the tamper-alert function for swapping input and output will be lost in the process.

Additional content: ***Metering and Billing done in NMBM_Nov2017***

QUESTION 5.4 What is the view of prepaid meters in terms of exporting?

Current prepaid meters are problematic with SSEG. These issues include:

- Prepaid meters breaking when power is being exported.
- Prepaid meters switching off due to tamper settings.
- Prepaid meters deducting units for exporting electricity.

QUESTION 5.5 What happens if a consumer is unsure whether the installed system will export?

A meter may either give credits or charge the customer for exporting power. In some cases a meter will shut down due to a 'tampering' error or be damaged. It is ideal to install a bi-directional meter (4-quadrant), so that import and export can be measured separately. Some municipalities allow for the continued use of a prepaid meter with a reverse power-flow blocking system.

QUESTION 5.6 Is compensation available for exporting?

Financial compensation for exporting depends on the utility (e.g. municipality or Eskom). Once NERSA's regulations are finalised, there will be a more formalised compensation value. This will most likely be offset against the usage bill, at a different (lower) tariff. The lower tariff reflects the energy portion only, i.e., what the municipality pays Eskom and not any local grid costs.

QUESTION 5.7 Who should be responsible for the meter in terms of cost and maintenance when SSEG is installed?

If it is decided that the customer must pay for installing and maintaining the new meter, it would be advisable to only charge a portion of the cost as the meter stays the property and the responsibility of the network service provider. The financial responsibility of the new meter is dependent on the municipality and may also depend on the type of meter.

QUESTION 5.8 How to manage meter-tampering due to the installed SSEG?

Most municipalities have processes in place to deal with meter-tampering. The best option would be to have the customer go through the formal application for SSEG if the tampering was done due to an EG. Some municipalities require SSEG owners to go through an authorisation process before they begin generating and will treat unauthorised installations as tampering.

QUESTION 5.9 Can meters be automated and centrally controlled?

Meters can be automated and centrally controlled but they come at a cost which not all municipalities can afford. These types of meters would be ideal for SSEG.

QUESTION 5.10 How is SSEG metering monitored and controlled? What are the cost implications?

There are different ways and levels of detail that could be measured for SSEG systems and the cost will be determined by what type of meters and/or measurements are to be be done. Meters for SSEG installations should at least be able to measure both import and export.

QUESTION 11 Is a 4- or 6-channel meter required to do proper metering?

A 4-channel should be sufficient for billing. The 6-channel on a few installations may be useful for internal analysis purposes.

QUESTION 15.2 If measurement is done on the medium voltage (MV)/heavy voltage (HV) side, is the measurement still correct and applicable when a SSEG exports?

As long as the metering setup meets the prescribed accuracy requirements, the measurement is correct and applicable. Note that the meter must also be at least bi-directional so that exports can be measured separately.

QUESTION 5.13 How long should data for meters be stored?

It is recommended that data for meters is stored for six months to a year.

SECTION 6

THE DISTRIBUTION NETWORK OR GRID

QUESTION 6.1 What is the relationship between the municipality and Eskom with regard to SSEG?

If the municipality owns the network, it is good practice for the municipality to advise Eskom that EG is installed. SSEG installations should be reported to NERSA, who should make that information available to the system operator. The reporting requirements of the latter are still being defined by NERSA and will be published in the forthcoming SSEG regulatory rules.

Additional content: ***Eskom Application Form_2013***
Standard for Interconnecting EG_10Nov2015

QUESTION 6.2 What happens or what if the municipal network exports to Eskom?

When power is to be exported, even in a net-consumption scenario, the municipality needs a contract with Eskom, with a power purchase or banking agreement. Eskom needs to be informed of any potential impact on their network and NERSA must advise on regulations for this scenario.

QUESTION 6.3 What is after diversity maximum demand (ADMD)?

ADMD is used when designing networks. The expected demand is aggregated over a large number of customers and as such accounts for the coincident peak load a network is likely to experience. ADMD prevents oversizing of transformers and feeder conductors, since few customers use peak load at the same time.

QUESTION 6.4 Does ADMD specify the amount customers per transformer?

ADMD is used to select transformer size. NRS034-1 recommends a 7- or 15-year planning horizon for selecting the ADMD to allow for future growth, with associated expected ADMD values per living standards measure (LSM) customer. Internal planning policies may require an additional margin on the equipment capacities, i.e. transformer size, cable ratings etc.

QUESTION 6.5 What are shared and dedicated feeders?

A **shared feeder** or network connects multiple customers using the same infrastructure. A typical example is residential areas, where one transformer may supply several LV feeders, which in turn each supply several customers.

A **dedicated feeder** contains a significant portion of network for the benefit of a single customer. This portion may be only the MV/LV transformer, or could include a section of LV feeder to the customer's point of supply, e.g. agricultural or small industrial loads.

QUESTION 6.6 Is the cable criterion included in shared LV feeder p46 of NRS 097-2-3?

When considering an EG application on a shared network, the cable impact is not a requirement (as per flow chart on p12).

Table 2 on p9 and Table 3 on p10, show that a feeder with a small conductor (25 mm^2) has a small upper size limit at distances of more than 400 m from the MV/LV transformer. However, it is unlikely that a larger customer (e.g. one with a 60 A or 80 A breaker) would be connected at such a distance using such a small cable. It is thus unlikely that the cable criterion will affect the flow-chart results.

QUESTION 6.7 If a 3-phase EG supplies a balanced output per phase, is it acceptable for the neutral cable to be smaller than the other phase conductors?

Existing standards make it clear that for generators the neutral cable must be the same size as the phase conductors. No exclusions will be made.

QUESTION 6.8 Is the supply capacity or notified maximum demand (NMD) affected by SSEG installations?

Because most SSEG installations are not controlled by the utility, the number and total size of EG installations should not increase the supply capacity. In other words, the utility must still design the network so that it is able to supply the maximum load.

NOTE: Supply capacity may be increased under certain conditions if special agreements are put in place, e.g. when a customer links their consumption to a specific EG installation's production.

QUESTION 6.9 What is the potential renewable energy penetration municipalities can accommodate or allow without making major upgrades to their network?

A rough order of magnitude estimate is 10–15% of the total network capacity but this calculation depends on a number of variables that include the following:

- Tariff structure and availability of a feed-in tariff to recuperate revenue.
- Current status of infrastructure.
- Processes and policies.
- Status of by-laws to govern implementation.
- Impact on power quality of existing system.
- Current power utilisation profiles in terms of time of use to determine impact during generation times and revenue impact.

QUESTION 6.10 What happens when the weather is cloudy? How does the municipality cope with the extra demand when SSEG systems are not generating?

As explained in a previous question, the utility must design the network to meet the total demand. This is one example why the network must be able to meet the total load, irrespective of the number and total size of EG installations.

QUESTION 6.11 Who should undertake grid-impact studies and how can they be paid for?

Since there is no standard approach to grid-impact studies municipalities may differ in how they deal with them.

Because a grid-impact study requires detailed information from the municipality on technical parameters and hardware some municipalities feel they should do the study themselves. However, their capacity to undertake such studies is usually limited. If this route is chosen, a municipality should charge the customer a flat fee, or a fee based on the magnitude of the assessment to be undertaken.

A second option is to make it the customer's responsibility to undertake the study and enlist and pay for the necessary technical skills. The municipality will still have to provide most of the input information, which is not a small job (unless the distribution system is already on a software package, which is seldom the case).

Municipalities who have done grid-impact studies in the past formed a task team consisting of professional consultants form the SSEG customer and technical assistance from the municipality.

QUESTION 6.12 Are impact studies on models costly and time-consuming? Should they be outsourced?

A typical impact study would include the following aspects:

- Utility network simulation model compilation and/or checking
- Simulation and evaluation studies
- Reporting of results
- Feedback and discussions between client and utility

Grid-impact studies may need to be outsourced if the municipality does not have enough capacity. As explained in the previous question, the municipality can make it the responsibility of the customer.

QUESTION 6.13 What can be done to assist smaller municipalities with impact studies?

The best solution may be to make it the customer's responsibility, as explained in question 11.

QUESTION 6.14 What determines if an installation should be medium voltage (MV) or low voltage (LV)?

NRS 097-2-3 recommends that installations larger than 350 kVA be connected at MV, i.e. the customer needs to own the transformer.

If the customer is already supplied from MV, the EG installation is regarded as an MV installation.

If the network is too weak, e.g. small transformer or cables, the best solution may be to provide the customer with an MV supply point.

SECTION 7
EG INSTALLATIONS AND THE LAW

QUESTION 7.1 What is considered an illegal installation?

An installation is illegal if:

- There is no connection agreement between the municipality (Licenced distributor) and the customer prior to the installation and commissioning of the SSEG.
- The system is not authorised by the municipality.
- The system is not registered (where there are municipal processes in place for registration).
- The meter installation is tampered with.
- There is unauthorised reverse feed, i.e., disc meters spinning backwards.
- The EGI does not comply with relevant existing regulations or standards.
- An existing legal installation has been altered.
- The system is not registered in terms of the Licensing Exemption and Registration Notice, published on 2017/11/10.
- There is no license for a system >1MW.
- There is no connection agreement for a system <1MW.
- There is no CoC for the installation.

Additional content: ***Licencing Exemption and registration Notice_ 10Nov2017***

QUESTION 7.2 What is a legal installation?

An installation is legal if:

- It complies with NRS 097-1-2 and NRS 097-2-3.
- Is an off-grid, standalone installation or non-grid-tied system with a valid CoC (for systems with AC circuits).
- The customer has a generation license from NERSA, or, in cases where licensing requirements are exempted, the SSEG system is registered with the municipality or NERSA.
- Appropriate procedures have been applied and processes followed, and the municipality has given permission.
- The points listed in the previous question are complied with.

QUESTION 7.3 When is an off-grid installation regarded as illegal?

An off-grid installation is illegal if:

- It is not registered in terms of the Licensing Exemption and Registration Notice, published 2017/11/10.
- It does not comply with the requirements of SANS 10142-1, which includes having a valid CoC for systems with AC circuits.
- It does not follow local regulations and standards.

Additional content: ***Licencing Exemption and registration Notice_ 10Nov2017***

QUESTION 7.4 Is it legal to go off-grid?

At the time of writing, the authors were not aware of any laws prohibiting the practice of going off-grid. However, in terms of the Licensing Exemption and Registration Notice, published 2017/11/10, generators with a capacity less than 1 MW still need to register with NERSA, even if they are not connected to the grid.

QUESTION 7.5 Is an installation illegal when it is in breach of a municipal contract?

SSEG contracts are put in place to stipulate the rights and obligations of the SSEG customer and the municipality, and confirm the SSEG tariffs and billing arrangements between the customer and the municipality. In addition, a municipality generally adopts a policy clarifying what they do and do not allow with respect to SSEG systems. A bylaw is needed to legally enforce the SSEG policy. SSEG systems that violate the contract, bylaw or policy are generally illegal.

Additional content: ***AMEU SALGA SSEG Contract_30Jan2017***

QUESTION 7.5 What can be done in terms of unapproved – and thus illegal – SSEG solar PV systems within the municipal border?

The following guidelines will help prevent unapproved systems:

- Inform the general public (how it should be, safety, make existing laws clear).
- Formal processes and by-laws must be in place.
- Communication channels should be open and available.
- A supportive and feasible way to encourage illegal installation to become legal is to allow and amnesty period.
  - Users are asked to switch off their EG and switch on only after municipal approval is granted following the application process.
  - A fine for those who do not comply with corrective measures.
  - The supply is disconnected once the amnesty period expires. The customer will have to re-apply for connection.
- If the installation is unsafe in any way, the supply should be disconnected immediately.
- Inform the public about the PV GreenCard initiative, which has built-in quality assurance processes, including how to install legal EG.

QUESTION 7.6 What is the implication for the consumer if exporting is prohibited?

If power exporting is prohibited due to safety reasons, the obvious course of action is to disconnect the consumer, with reasonable steps like giving a warning and allowing time to respond. However, if the restriction is a regulatory requirement, or another technical requirement, the implications and best possible solution to the situation should be negotiated.

Additional devices and equipment to prevent exporting (grid-limiting devices) can have a financial impact on the consumer and may result in decreased benefit from the solar PV system. This can be prevented by installing appropriately sized systems with reverse power-flow blocking devices. Systems such as these should not generate much more than the property demands and do not require grid-limiting devices.

QUESTION 7.7 Is there a way to provide on-site assistance to check if standards and processes have been applied and to help with investigation?

The Solar Support website *www.solar-support.org* provides support with standards and processes. To post a request or question please register on the site and visit: *http://www.solar-support.org/forums/what-would-you-like-to-know-*

QUESTION 7.8 What should happen if an existing SSEG system size is exceeded?

If a system was installed before the necessary processes and procedures were in place, the utility must work with the customer to legalise the installation. If an existing installation is larger than the NRS 097-2-3 guideline allows, for example, the utility will have to evaluate the impact of the installation on the network and other network customers, to ascertain whether it can be accommodated. If the network cannot adequately deal with the SSEG system, possible solutions include:

- An upgrade to the network, e.g. a larger transformer or cable.
- Moving the customer to a dedicated network.
- Limiting the maximum power output from the SSEG system.

NOTE: The solutions listed here all carry financial implications for the utility or the customer. Negotiation will be necessary to find the optimal solution.

QUESTION 7.9 What happens when clients have no power or have power problems because of a user with EG?

The supply of electricity to customers is the responsibility of the utility, i.e., the customer with EG has no accountability towards other customers. The utility must identify such problems as quickly as possible and resolve them within acceptable time-frames.

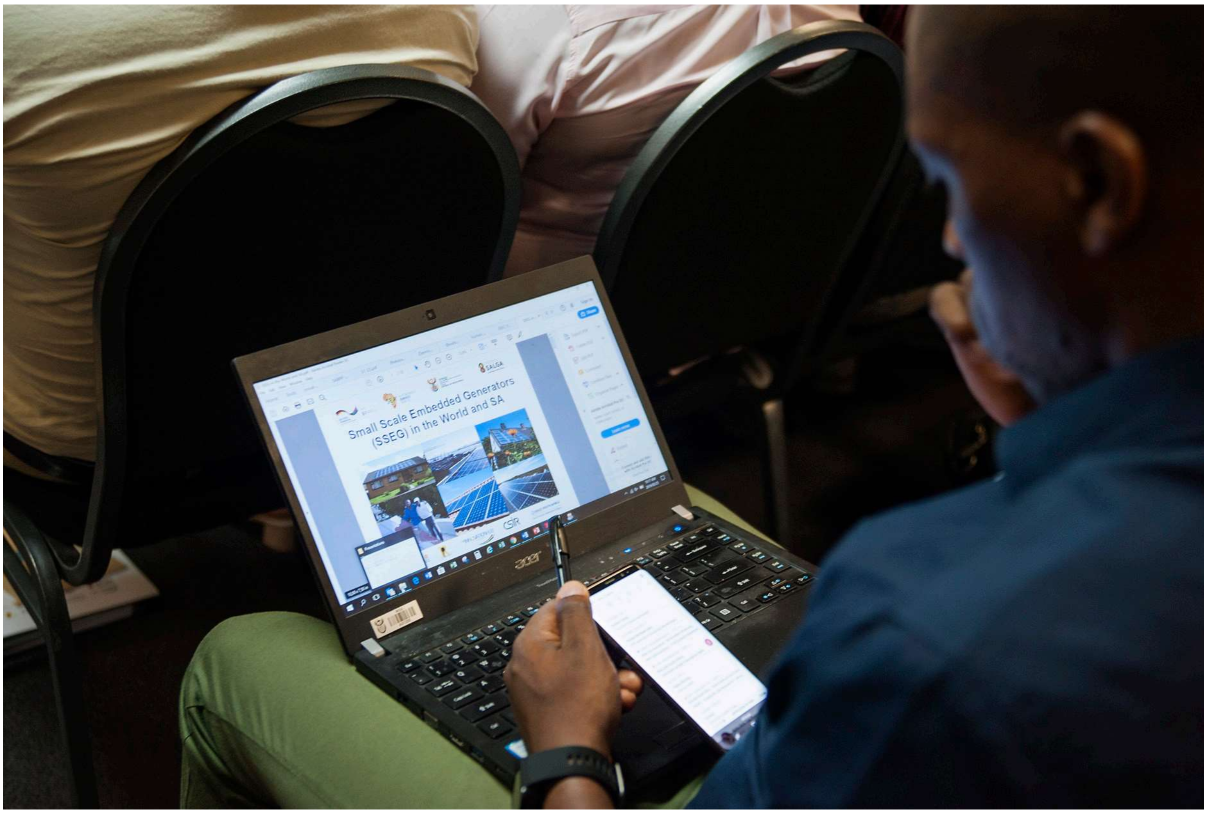
NOTE: Resolving a problem may include switching off the EG until certain conditions are met. The utility must have connection agreements in place with a SSEG customer, so that such situations can be managed.

QUESTION 7.10 Who should enquire about test certificates for inverters?

At this stage GreenCape and some municipalities keep a list of approved inverters with type test certificates in place and which conform to the NRS 097-2-1. Ideally, an independent entity should keep this list up-to-date and make it available to all municipalities.

Additional content: *List of Approved inverters_22Sep2016*

Additional content: *Inverter CoC for According to NRS 097-2-1 Example_ 2017*



SECTION 8
MUNICIPAL PROCESSES AND REGULATION

A. General

QUESTION 8.1 Is there a guideline or standard documented process for the application process for a municipality to follow?

To apply for SSEG a customer fills out standard forms from the AMEU-SALGA resource pack that provide the municipality with the necessary system information to assess a proposal and grant approval or not (or request changes or additional studies before approval). The municipality assesses a proposed system for safety, power quality, general grid impact and other issues before giving the customer the go-ahead.

Any customer intending to install a solar PV system which will be connected to the municipal distribution grid (including via their own house or building wiring) is required to go through the application process. Basic system design and other information is required in the process. Residential customers, in particular, are likely to need the support of a solar PV installer to complete the necessary forms.

Off-grid solar PV systems may not need to go through this application process although approval may be required from other departments such as building control and planning. Some municipalities require off-grid systems to be authorised before they begin generating to avoid mistaking them for grid-tied systems.

Additional content: ***AMEU-SALGA Resource Pack_30Jan2017***

QUESTION 8.2 How can I set up an SSEG application and approval system in my municipality?

Establishing an SSEG application and approval system involves:

- Obtaining the necessary official and political buy-in.
- The necessary forms and other documentation (all of which are available – see below).
- Deciding on a suitable tariff and enabling it on the municipal billing system (the GIZ/SALGA Revenue Impact tool can be used to inform tariff setting).
- Amending the electricity by-law to accommodate SSEG (a guiding document is available at the link below).
- Building the capacity of municipal staff to manage the SSEG application approval process.
- Informing the public that the SSEG system is operational and providing links to more information, e.g., the Requirements for Embedded Generators document (see below).

The AMEU and SALGA have developed a standard set of forms and documents to be used by municipalities to establish an SSEG approval process. These can be modified according to the needs of the municipality or used as they are. The documentation was drawn from that of leading municipalities in the SSEG area and has been through a process of review by a municipal steering committee. Documents include:

- **Requirements for embedded generation:** Specifies the parameters, and terms and conditions for SSEG from a municipal perspective. Municipalities can customise the document if necessary.
- **Application form:** To collect appropriate information to enable a proposed system to be assessed by the municipality.
- **Commissioning form:** Requires qualified inspection and sign-off of the installed SSEG system.
- **Supplemental contract:** Clarifies the rights and responsibilities of both the municipality and customer and makes the agreement legally binding.
- **Decommissioning form:** To be filled in by the customer should the SSEG system be decommissioned. Requires a certificate of compliance (CoC) to this effect.

In addition, the following will be added to the list of AMEU/SALGA documentation shortly:

- **Process checklist document or control document:** Accompanies the application form and clarifies the different steps to be taken and parameters to be scrutinised during the application approval process (to be customised by the municipality).
- **Process flow diagram:** A graphic representation of the process of assessing the SSEG application (to be customised by the municipality).
- **By-law amendment guideline:** Provides guidance on amendments necessary in the municipal electricity by-law.

Documentation is available at ***Urban Energy Support - www.cityenergy.org.za*** **or** ***AMEU-SALGA Resource Pack_30Jan2017***

In addition, GIZ is funding a municipal SSEG support programme to help municipalities establish such processes, which will operate from 2018 to 2020.

QUESTION 8.3 Where should municipalities start when implementing SSEG processes?

- Get buy-in from management (divisional and group head)
- Create a task team
- Create a Section 79 committee (Initiated by mayor or other) ad-hoc committee
- Create a Section 80 committee; to report to the electrical committee
  - Establish an application process for new and existing illegal SSEG connections
  - Establish amnesty period
- Request approval from Members of Mayoral Committee (MMCs) and/or municipal council
- Adoption of processes and documentation and a formal council resolution to amend by-laws
- Requirements document needs to be finalised before by-law is framed

Start early with tariffs and financial impacts

QUESTION 8.4 Are by-law amendments necessary for a municipality to accept SSEG systems onto their grid? What do the amendments cover?

Electricity by-law amendments are recommended for municipalities accommodating SSEG systems on their network as it makes the SSEG Policy legally binding. The Policy is necessary as it clarifies what SSEG systems the municipality will and will not allow, and the criteria and process for applying for permission to install an SSEG system. Not having such a by-law results in many areas of legal ambiguity and is therefore likely to result in more legal challenges and incidences of non-compliance.

A bylaw should cover the following basic requirements to ensure effective administration and allow the municipality to enforce legal sanctions:

- The functions administered by the municipality pursuant to the by-law, namely electricity reticulation services, which includes regulating the connection of a SSEG system to the municipality's distribution system;
- The delegation of powers and duties and state that the municipality may delegate any power or duty that has been conferred on the municipality to consider and approve or reject applications for connection to the municipality's distribution system in terms of the by-law to a suitably qualified official, agent or service providers of the municipality;
- Adherence by any customer to any SSEG policy issued by the municipality in terms of the bylaw relating to the connection and installation of SSEG system;
- Penalties imposed in the event that the SSEG customer fails to comply with the SSEG policy that sets out SSEG requirements;
- The electricity generation equipment provided by a customer in terms of any regulations or for his own operational requirements cannot be connected to any installation or the distribution system without prior written approval of the municipality.
- It is important to note that any bylaw issued by a municipality is authoritatively subordinate to, and must comply with, national legislation governing electricity, i.e., the ERA. A municipality has no legal mandate to impose conditions relating to the provision of electricity reticulation services that are in contradiction to the provisions of any national legislation (such as the OHSA and the ERA).

The following minimum requirements should be set out in the SSEG policy:

- The process to be followed when applying for connection as well as related timeframes which follow the application. Upon receipt of the application for connection to the distribution system, the distributor shall advise whether the applicant can be connected to the existing system and/ or what technical improvements are required to enable the new connection.
- Information requirements of the distributor from the customer to affect an appropriate connection i.e. capacity, locations, technical specifications.
- Requirements on the SSEG customer to hold a generation licence or provide proof that the SSEG customer has registered the SSEG system with NERSA and is exempt from having to hold a generation licence in terms of Schedule 2 to the ERA.
- A connection agreement entered into between the licensed distributor and the SSEG customer as required in terms of the Codes. The technical information provided as part of the application for connection should be included as annexures to the connection agreement.
- Compliance with the technical and safety standards set out in the Codes and any technical requirements, like the "Requirements for embedded generators" document, which are particular to the distribution network of the municipality.
- A certificate of compliance that the installation and all the installed equipment comply with the national and international regulations and legislation.

In addition to the above, the following can also be added

- Require that safety and power quality issues due to the SSEG 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 municipality staff as required.
- Assert that the municipality has the right to disconnect non-compliant SSEG systems.

- Assert that in cases where there are no national norms and standards the municipality has the right to set norms and standards and change these from time to time.
- Assert that the municipality has the right to set SSEG tariffs and billing arrangements, and change these from time to time based on NERSA's recommendations and approval.

NOTE: For more information on specific amendments see the document *Municipal by-law amendments for SSEG* which uses the GreenCape work.

Additional content: ***SSEG Processes at Municipalities_v7***
AMEU-SALGA Resource Pack_30Jan2017

QUESTION 8.5 Who should be involved with establishing and rolling out the application process for SSEG?

- Building department (Town Planning)
- Fire department
- Treasury/Finance/Budgeting and Tariffs
- Electrical department
  - Metering
  - Test and Protection
  - Planning
  - Network Control
  - Maintenance
- Legal department
- Town Secretary (Compliance)
- Environmental
- OHS department
- Economic Development department
- HR – Organisational Structure
- IT department
- MMC or portfolio councillors

Additional content: ***SSEG Application Process Flow_Jun2017***

QUESTION 8.6 The *Requirements for SSEG* document states that approval of SSEG systems is not guaranteed, which seems to contradict the Distribution Code that states that access to the grid should be open and non-discriminatory. Which is correct?

The Distribution Code requires the distributor to provide 'open and non-discriminatory access to all customer including embedded generators'. However, the Code does not imply that non-compliant systems must be connected. The municipality cannot approve systems that violate power quality, safety or other grid operational parameters.

Lack of clarity arises when a proposed SSEG system is compliant, but the number of SSEG systems already in that part of the network causes a system to exceed the parameters in the NRS097-2-3 (for example the total SSEG capacity installed should be less than 75% of the MV/LV transformer rating). How does the municipality handle this? To allow connection without a grid hardware upgrade jeopardises grid operation parameters, to deny connection may violate the code and if the grid must be upgraded to accommodate the new system, who should pay for it? The *Requirements for SSEG* document states that the municipality should ask the new SSEG customer to pay, but this may not be in accord with the Code as it appears to contradict the 'open and non-discriminatory access' principle. Currently these are grey areas, and rationalisation and harmonising of standards and approaches is necessary.

QUESTION 8.7 What is the role of the Department of Labour in SSEG application processes and in general?

Although the Department of Labour (DoL) plays no direct role in SSEG applications it holds the register of qualified electricians who may issue certificates of compliance for wiring and are involved in the process of extending these conventional wiring standards to include solar PV installations (in an addendum to SANS10142). In future, it is expected that suitably qualified electricians will sign-off SSEG systems rather than Pr. Eng or Pr. TechEng personnel, which will streamline SSEG commissioning.

The DoL is a key role-player in creating an efficient SSEG implementation environment. Currently Pr. Eng or Pr. TechEng sign-off is still required until the *SANS 10142-1-2: Specific Requirements for Embedded Generation Installations connected to the LV Distribution Network in South Africa codes* are adopted.

QUESTION 8.8 If a municipal requirement is changed what will happen to the existing installations that do not meet the new requirements?

Most municipalities make it clear in their by-laws or *Requirements for Embedded Generators* document that any changes to standards or other requirements (such as licensing) must be complied with by all systems, including existing systems installed before such requirements were in place, at the cost of the customer. This stipulation needs to be maintained, as some important revisions to standards which affect system safety are likely to emerge in coming years. However, if changes are costly to existing SSEG customers, it is reasonable to provide a grace period of up to a year within which compliance can take place. Making unreasonable demands on SSEG customers is likely to be met with non-compliance.

QUESTION 8.9 What are the typical barriers to SSEG processes and structures?

- Concern that revenue will be lost – this is easily remedied by implementing sensible 3-part SSEG tariffs
- Concern around safety of staff working on lines which are energised by SSEG systems unbeknownst to them – this is easily remedied by insisting that inverters are certified to comply with NRS097-2-1, which includes rigorous anti-islanding requirements
- Concern around the quality of the power being generated by SSEG systems – again, this is easily remedied by insisting that inverters are certified to comply with NRS097-2-1, which includes requirements around power quality
- Inter-departmental Communication – in larger municipalities, several sections need to be involved in developing an SSEG process, including network planning, tariffs, billing, and metering. One way to facilitate the necessary communication is to set up a working group with representatives from each.
- Buy-in from key role players – it is useful to have high level political and management support for SSEG adoption, as this encourages participation by the necessary officials. A Council resolution to this effect, for example by adopting an SSEG policy, is a route that many municipalities choose to this end.
- Negative perception from key role players – concerns of key municipal role-players can be addressed by sending staff on SSEG training or having external experts, SALGA or AMEU address staff on the fast developing SSEG trends and what other municipalities have done to accommodate this trend.
- Staff capacity – Because electricity departments are often understaffed, there may be resistance to including SSEG in the existing workload. Since SSEG implementation is inevitable, the municipality has to find a way around this. Some dedicate one or two staff to SSEG, others include SSEG application processing in existing job descriptions.

QUESTION 8.10 Can the AMEU/SALGA SSEG resource pack forms and reports apply to resources other than PV?

Current AMEU/SALGA standard forms are specifically for PV SSEG and are not suited other forms of EG generation even though much of the information and parameters applies to all forms of generation. The intention is to broaden the AMEU/SALGA documents to apply to all generation modes in the near future. Some cities have already done this.

QUESTION 8.11 Should municipalities require SSEG customers to sign supplementary contracts or new contracts?

Municipal approaches differ with regard to contracts. Standard non-SSEG power-supply contracts do not adequately address SSEG issues and additional contractual obligations are needed for the SSEG customer and the municipality. This can be done via a supplemental SSEG contract in addition to the existing contract (most municipalities choose this route), or by replacing the existing contract with one that includes SSEG in addition to normal electricity supply considerations. Administrative efficiency should be the deciding factor in choosing a way forward.

QUESTION 8.12 Are there any long-term planning considerations for SSEG integration?

The NRS097-2-3 standard considers potential SSEG penetration rates and sets system approval parameters to protect the grid. As long as this standard is adhered to, and proper grid impact studies are undertaken for systems that exceed the parameters in this standard, municipalities need not be concerned about broader grid impact and planning implications. However, over the years the criteria in this and other standards may need revisiting as we gain more information on actual penetration rates.

At a national generation planning level, the acceleration of SSEG will need to be factored into planning in revisions to the IRP.

B. Applications

QUESTION 8.13 What information is required in the SSEG application form and why?

The AMEU/SALGA application form for SSEG systems requires information relating to:

- The customer's location and electricity account details
- Information on the proposed SSEG installer
- Technical information on the proposed SSEG system (to enable an assessment in terms of NRS097-2-3)
- Inverter NRS097-2-1 certification
- Compliance with conditions of other municipal departments (e.g. Building Control)
- Other standards being adhered to

This information enables the system to be assessed in terms of standards such as the NRS097-2-3 (simplified connection criteria), enables checking that the system will comply with safety, power quality and other standards, checks that the customer will remain a net consumer (as opposed to a net generator, which is not permitted without relevant licensing) and collects information that NERSA requires periodically from the municipality.

QUESTION 8.14 What size SSEG systems should be applied for?

From a municipal perspective, sizes that are easily accommodated on the network are listed in the NRS097-2-3 simplified connection criteria standard (e.g. max SSEG capacity of 25% of maximum demand for a customer on a shared LV feeder). Although larger sizes than specified in this standard may be applied for, a grid-impact studies may be needed before it is approved or declined. Prospective SSEG customers need to be aware of this when they size their systems and stay within the NRS097-2-3 parameters where feasible.

Additional content: ***Application of NRS 097-2-3_v7***

QUESTION 8.15 How long should an SSEG application process take to be approved?

As a benchmark, the NRS047 provides minimum standards for distributor response times for providing customers with supply quotes (generally between 10 days and 1 month) and for connecting customers (1 month where no network extensions are required). These do not currently cover SSEG applications and it is understandable that such responses will be slower as municipal SSEG assessment systems are often not fully in place or are new and not yet streamlined.

Ideally, SSEG approval processes should be streamlined enough to grant approval within one month, but this is seldom the case in practice, and 3 months is more common, often longer. Municipalities differ greatly in the time taken to process applications due to staff capacity shortages and processes being newly established and not streamlined. Applications that do not meet the simplified criteria in the NRS097-2-3 also generally take substantially longer.

QUESTION 8.16 Should customers state their exporting status?

It is important to know what the expected exports of an embedded generator are, even if the customer remains a net consumer. This will assist with technical planning of networks and financial reconciliation.

QUESTION 8.17 Must a customer always re-apply when extending or replacing solar PV component? When is a new CoC required?

Currently, any change of the system requires a new application. An exemption may be granted by the supply authority where components are replaced without changing a component or equipment type or the size parameters of the system (for example replacing a faulty PV module, fuse or inverter).

QUESTION 8.18 Must network protection requirements be in place during the application?

The AMEU/SALGA application process and conditions specify all the requirements for SSEG applicants to ensure that safety and power quality issues are adequately addressed by the installation. As long as these processes are adhered to, protection concerns should be adequately covered.

NOTE: It is a good idea for utility staff to confirm protection settings and coordination, especially when the number of EG on a network increases.

C. Commissioning

QUESTION 8.19 Who can sign off commissioning reports?

Currently, most municipalities require that Pr. Eng or Pr. TechEng registered professional signs off SSEG systems on commissioning. Some municipalities accept and support the SAPVIA-endorsed PV GreenCard installers for installation of the system, but not the sign off on the NRS 097-2-1 requirements. An addendum to the SANS 10142 wiring code will enable registered electricians who have undergone the necessary training to sign off the full systems on commissioning (including NRS 097-2-1 requirements) in future. The draft addendum should be finalised by the end of 2018.

Additional content: ***Commissioning process and sign off_v10***

QUESTION 8.20 Should municipalities be present at commissioning of EG systems?

Municipalities can choose whether or not they want to be present at the commissioning of an EG system. They may conduct tests such as anti-islanding at system commissioning. Municipalities need to ensure that suitably qualified and registered personnel sign off systems at commissioning. As long as this requirement is mandatory (for example by specifying it in the municipal *Requirements for Embedded Generation* document) it is not necessary for them to be present at commissioning. Some municipalities choose to be present, particularly when larger SSEG systems are being commissioned; partly so they can learn about the commissioning process and be exposed to different types of SSEG systems. Given the rate at which SSEG installations are accelerating, it is unlikely that municipalities will have the staff to attend all, or even most, SSEG commissioning processes.

Additional content: ***Commissioning process and sign off_v10***

Additional content: ***SSEG Commissioning Report with Tests_v1.1***

QUESTION 8.21 Must the commissioning officer be qualified to sign off the system?

It is advisable for the people doing the sign off to have some form of qualification or competent understanding of SSEG. If municipalities do not have such a person available, the responsible person at the municipality needs to ensure that one of the individuals signing off (from the consumer side) has the accreditation to do so.

Additional content: ***Commissioning process and sign off_v10***

Additional content: ***SSEG Commissioning Report with Tests_v1.1***

QUESTION 8.22 How much responsibility should municipalities take for private installations?

The core responsibility of the municipality lies at the point of supply (up to the meter) to make sure that the connection is safe for maintenance work and that the quality and quantity of supply does not negatively influence the reliability of the distribution network. That means, municipalities may have compulsory requirements that the consumer has to abide to in order to ensure the above mentioned is achieved. The consumer, installer and/or accredited system designer must take responsibility for what happens on the customer's premises.

QUESTION 8.23 Who regulates off-grid installations?

Off-grid installations have no links to the local or national power grid and are thus not a concern of the municipal electricity distributor or Eskom. Other than normal wiring certificates of compliance – which also apply to off-grid installations – there is no regulatory framework for off-grid systems. Although SAPVIA provides a voluntary quality framework for PV installations, their current focus is on grid-tied systems.

Additional content: ***Declaration of Off-grid SSEG_22Nov2016***

D. Licensing and NERSA requirements

QUESTION 8.24 How should NERSA Electricity Distribution Forms (D-forms) be used in the context of new SSEG installations?

NERSA has released a list of information it requires for municipal SSEG installations and is developing a process to collect this information, to be further defined in the regulatory rules published for comment in 2018. Until such time, D-forms are to be filled in as normal.

The standard AMEU/SALGA SSEG Application Form isdesigned to collect the information NERSA is likely to require.

QUESTION 8.25 What regulations should be implemented when security complexes become exporters?

It is desirable that the municipality is aware of embedded generators inside security complexes (redistributors) irrespective of the exporting status. However, once exporting from such a complex takes place, even in a net consumption scenario, the redistributor will need a contract with the municipality, with a power purchase or banking agreement. NERSA also needs to advise on regulations for this scenario.

QUESTION 8.25 What are the current licensing requirements for generation?

As from 2017/11/10, generators smaller than 1 MW must register with NERSA when the requirements of the 'Licensing Exemption and Registration Notice' are met. All other generators need a generation licence. The process for registration will be defined by NERSA in the regulatory rules published for comment in 2018.

The operator, which in many cases is the owner as well, will own the NERSA licence.

Additional content: ***Licencing Exemption and registration Notice_ 10Nov2017***

QUESTION 8.26 For systems larger than 1MVA, a NERSA licence and a ministerial exemption are required. What does this entail?

All prospective SSEG systems, irrespective of size, need to go through the municipal application process. Systems larger than 1MW require a NERSA license in addition to requiring municipal approval via the standard municipal application process.

For systems over 1MW, an application for a generation licence must be submitted on the prescribed NERSA forms. NERSA will generally consider the allowance in the national Integrated Resource Plan (IRP) for this type of generation before they provide a license. A ministerial exemption is not necessary, but according to the Electricity Regulation Act (2006) Schedule 2, the minister may issue a notice stating that no more generation of a particular type may be licensed should the capacity stated in the IRP be reached. In such cases NERSA will not issue a licence.

Additional content: ***Licencing Exemption and registration Notice_ 10Nov2017***

QUESTION 8.26 What about staggered systems, for example, instead of going over 1MVA, building 2 x 1MVA?

This is a possible loophole. A key aspect would be the size installed per point of supply as provided by the utility. Depending on municipal by-laws, for example, a customer might have two points of supply, where each could be used for a separate generation installation. Note, however, that the necessary network studies will still be required on the utility side to ensure that the network can accommodate the total generation capacity.

SECTION 9
FINANCE AND IMPACT ON MUNICIPAL REVENUE

QUESTION 9.1 Do SSEG systems affect municipal revenue?

Although SSEG systems can affect municipal revenue this is easily compensated for. Revenue impact is usually not significant except at very high SSEG penetration rates (which are unlikely in the medium-term). Commercial and industrial customer categories have tariffs with fixed charges which protect revenue when kWh sales drop and in the residential sector, revenue impact can be neutralised with appropriate SSEG tariffs.

In general, electricity revenue from residential customers are affected by large numbers of SSEG installations (more than 5% of customers) in situations where the residential tariff is only an energy (c/kWh) charge without a fixed monthly charge. However, revenue impact modelling studies undertaken for municipalities around South Africa show that there is seldom a serious revenue loss from projected SSEG installation numbers, and an appropriate SSEG tariff easily compensates for any loss.

For commercial and industrial electricity customers with SSEG, revenue losses seldom occur, because municipal revenue is protected by the fixed-charge component of the customer tariff.

To clarify the potential revenue impact and appropriate SSEG tariffs for the residential sector in particular, it is recommended that municipalities undertake modelling studies, informed by a cost-of-supply studies (e.g. by using the GIZ SALGA SSEG Revenue Impact Model spreadsheet available at the link below):

Additional content: ***http://www.cityenergy.org.za/category.php?id=5#14***
Additional content: ***Revenue / Financial Impact Tool & Guideline***

QUESTION 9.2 How can negative revenue impact from SSEG systems be avoided?

To protect municipal revenue it is recommended that residential tariffs, which only have a c/kWh energy component, are changed when SSEG is installed to include a fixed component (R/month) as well. The fixed charge must however be affordable to the SSEG customer otherwise it could destroy the customer's SSEG investment return and may encourage illegal installations that have not gone through the municipal approval process.

Modelling exercises undertaken in South African municipalities show that it is possible to establish a suitable residential SSEG tariff that protects municipal revenue and preserves the SSEG business case for customers.

Revenue from commercial and industrial SSEG customers is already protected by a fixed charge component.

For an example of a detailed revenue impact analysis and exploration of potential SSEG tariffs, see the City of Tshwane report at *http://www.cityenergy.org.za/uploads/resource_431.pdf*

Additional content: ***Revenue / Financial Impact Tool & Guideline***

QUESTION 9.3 Is the threat that customers will leave the municipal grid and install standalone systems real? How can this be prevented from happening?

As PV panel and battery prices drop, and national electricity prices rise, so-called 'grid defection' is threatening municipal distributor business models. Because standalone systems are currently still much more expensive per delivered kWh than grid electricity, the threat is not imminent. However, grid defection will accelerate if municipal SSEG tariffs weaken the SSEG investment business case for customers, for example, by introducing fixed charges that are too high for residential SSEG customers.

Although grid defection trend is inevitable, forcing distributors to rethink their fundamental business model, it can be mitigated by setting SSEG tariffs that support customer SSEG investment return while protecting municipal revenue. The GIZ/Salga SSEG Revenue Impact Model spreadsheet can be used to explore a range of SSEG tariffs and assess their impact on municipal revenue and on the customer's business case available at *http://www.cityenergy.org.za/category.php?id=5#14*.

Additional content: ***Revenue / Financial Impact Tool & Guideline***

QUESTION 9.4 Why do electricity tariff fixed costs vary from municipality to municipality? How should fixed costs be calculated?

Municipalities set their own tariffs. Although NERSA releases tariff benchmarks, it is not prescriptive regarding tariff levels but requires a balance between preserving municipal financial integrity and fairness to customers. Because there is no mechanism to align municipal tariffs they vary considerably. Municipalities follow different methodologies, including how much revenue is recovered by fixed charges (R/month) and energy charges (c/kWh) in different tariff categories.

In theory, municipal tariffs should be based on rigorous 'cost of supply' studies that clarify actual fixed and variable (energy) costs incurred by the distributor and thus enable appropriate tariff-setting for each customer category, but these studies are not always undertaken. Political interference may further distort economically sound tariff-setting.

QUESTION 9.5 Do fixed charges increase by the same margin percentage as energy cost per annum?

Fixed charges and energy charges may or may not increase by the same percentage each year. Municipalities are constantly adjusting their tariffs to optimise their effectiveness and political acceptability in a fast-changing electricity sector. Different tariff components as well as customer tariff categories may increase at different rates within a municipality. NERSA approves tariffs annually to ensure that they are affordable to the customer and municipality.

QUESTION 9.6 What tariff can a SSEG customer expect and why is it designed in this way?

All SSEG tariffs should have a fixed charge (R/month and/or R/kVA), energy (c/kWh) component, and reverse feed-in tariff (in c/kWh) for power exported back to the municipal grid. This is called a ***3-part tariff***.

Existing non-SSEG residential tariffs have an energy component only. This is not suitable for SSEG customers because it will result in revenue loss for the municipality and limit the municipality's capacity to operate and maintain the grid. SSEG tariffs should be changed to include a fixed component as well as an energy component.

Example: A wealthy household installs SSEG and generate much of its own needs and purchases very little electricity from the municipality. The household remains on a normal residential tariff (with c/kWh only and no fixed charge). They contribute almost nothing to municipal electricity revenue but are still connected to the grid with all of the costs that such a grid connection entails for the municipality (network maintenance, staff costs, etc.). This is unfair on other customers who pay such costs and effectively cross-subsidise the wealthy SSEG customer. It is thus best practice for all residential customers to be on a tariff with a fixed charge as well as an energy charge when installing SSEG. In this way, even if the SSEG customer purchases very little electricity from the municipality, the municipality still recovers the fixed costs of maintaining the grid connection to that customer.

Most commercial and industrial customers already have a tariff with a fixed charge component. Installing SSEG generally has little revenue impact for the municipality and such tariff changes are not necessary (provided the fixed charge is a reasonably cost-reflective charge – as determined by a 'cost of supply' study). If commercial and industrial customers are *not* on a tariff with a fixed charge, their tariff should be converted to include a fixed charge.

More information on tariff setting can be found in the following document: *Basic tariff guiding principles – SSEG tariffs_22Sep2016*.

QUESTION 9.7 When fixed charges are implemented for an SSEG tariff, should they be the same for all sizes of SSEG system?

A SSEG fixed charge is the same for all SSEG customers in a particular tariff category, irrespective of SSEG system size. Some municipalities apply fixed charges in terms of R/kVA maximum demand. Fixed charges are intended to cover the fixed costs of customer grid connections. This is best determined by a 'cost of supply' study and is related to the connection type and size rather than the SSEG system size. Fixed charges are therefore usually different for different customer categories, but not for different SSEG sizes of customers in a particular category.

QUESTION 9.8 Will customers who do not install solar PV have to pay more to cover shortfalls from SSEG customers who are buying less power?

This should not happen if a suitable SSEG tariff is applied. With a tariff that includes a fixed charge to recover fixed costs of the SSEG customer's connection an SSEG customer pays for their share of the network and operational costs of the municipality. The municipality will not lose revenue and will not be forced to recover losses from non-SSEG customers.

QUESTION 9.9 Is there a wheeling costing example?

Nelson Mandela Bay Municipality (NMBM) in the Eastern Cape is applying wheeling with trading entity, PowerX. The approach is as follows:

- PowerX buys and sells green power to and from various entities.
- Metering and billing: For example, 200 units of brown electricity and 300 units of green electricity are consumed by customer and metered by NMBM.
- The cost of 200 units is paid to the municipality by the customer.
- The municipality bills PowerX for the wheeling charge (in May 2018: around 27c/kWh) and kVA charge.
- PowerX is paid for 300 units by the customer after billing confirmation by NMBM.

The municipality confirms generation and consumption. The third party may also do the metering, but the municipality must confirm and approve it. Once approved, the end consumer pays the seller (PowerX in this case) for the electricity used and the municipality for the network charge.

QUESTION 9.10 How can wheeling charges be calculated?

A 'cost of supply' study will determine a suitable wheeling charge by enabling reasonable determination of the cost to the municipality for utilising their grid infrastructure.

QUESTION 9.11 If sub-networks are disconnected while electricity is being wheeled, how is this dealt with contractually?

Wheeled energy is allocated after the close of the billing period to buyers spread across the metro, so it may be allocated to buyers who were not disconnected. The main condition is that generated and wheeled energies must balance, i.e., producers may not sell more than they produce within a billing period.

QUESTION 9.12 What are the financial implications if a wheeling supplier cannot generate electricity due to maintenance or similar reasons?

At this stage, nothing wheeled equals nothing to be allocated/paid for.

QUESTION 9.13 How will tariff structures be aligned with what Eskom is doing?

Currently municipal tariff structures are not specifically linked to Eskom tariffs and can vary considerably among municipalities. This also applies to SSEG tariffs. Although NERSA has approved these tariffs it does not aim to harmonise them to any significant extent and merely ensures that they are reasonable for both municipality and customer.

QUESTION 9.14 Should I buy or rent a solar panel system?

Many people are interested in solar energy but are unable to afford it. An option is to rent a solar PV system to reap the benefits of the technology without having to pay for it up front.

There are two types of third-party financing alternatives available for interested parties: power purchase agreements (PPAs) and conventional solar leases.

With a **power purchase agreement**, a system is installed at no cost and the customer pays a fixed rate for the amount of electricity provided each month, similar to what happens with a regular utility company except that PPA rates are generally lower than those charged by a utility (there would really be no point to the arrangement otherwise). At the end of a PPA contract, the customer has the option of extending the contract, terminating the relationship with the installer, or buying the system and keeping it in place.

Conventional solar leases require a contract for a predetermined length of time – usually 10 to 15 years – and essentially give the property owner the right to use the solar energy system as if it were their own. Purchase options are available at the end of the lease term, either at or below market value depending on how much interest the customer paid over the term of the contract (lease terms for a solar energy system are very similar to payback terms for a bank loan).

Additional content: ***Procurement of SSEG for Municipalities-Route Folder***

QUESTION 9.15 What government rebates or subsidies are available?

There are no government rebates or subsidies for small-scale solar PV in South Africa.

QUESTION 9.16 How does solar affect a residential property value?

An SSEG system improves property value; it is an asset with a long lifespan (over 20 years) that saves property occupants money for many years. It is not yet taken into account in municipal property valuations however, and therefore does not affect municipal rates.

QUESTION 9.17 What effect will SSEG have on the municipal cross-subsidy for poor customers?

Currently many municipalities cross-subsidise poor electricity customers from other tariff categories in addition to the Free Basic Electricity grant from national government. If wealthier residential customers who will be the first to afford it install SSEG there is a concern that they will contribute less to municipal coffers and thus reduce the ability of a municipality to implement such cross-subsidies. However, municipal electricity revenue need not drop because of SSEG installations. Suitable tariffs can be put in place to avoid revenue losses and still provide a reasonable business case for customers to install SSEG. It is important that the municipality implements appropriate tariffs in conjunction with allowing SSEG systems onto their distribution networks.

QUESTION 9.18 How do municipalities manage the notified maximum demand (NMD) applications in the light of EG reducing NMD usage in general?

Utilities cannot reduce their NMD because they need to maintain a fairly high reserve capacity on their network in case cloudy weather during periods of high demand causes load to suddenly come on line. In most cases, peak consumption occurs during the evening (when there is no daylight) in which case Solar PV systems will not reduce the NMD.

QUESTION 9.19 Can customers or municipalities reduce their NMD as EG is realised?

Normally, customers would not reduce their NMD due to having an SSEG installation, as they need to cater for cloudy weather conditions. If they choose to reduce their NMD, exceeding this on cloudy days can result in severe penalties by municipalities, who have an NMD commitment with Eskom that carries penalties if exceeded.

QUESTION 9.20 Can an off-grid installation be exempt from fixed municipal charges?

If a site is within a municipal urban boundary or within a serviceable distance from a supply node with capacity, a fixed 'availability' charge may still apply.

QUESTION 9.21 Can NERSA release tariffs that supersede or overrule export and feedback tariffs already set by the municipality?

NERSA needs to approve all tariffs set by municipalities before they can be implemented, including SSEG export tariffs. NERSA does not overrule tariffs they have already approved, but may establish guidelines for municipal tariff submissions in this regard. They have not yet produced such guidelines for SSEG tariffs.

QUESTION 9.22 Are municipalities legally allowed to buy electricity from producers other than Eskom?

Currently, despite the existence of some exceptions for historic reasons, all generators are required to sell power to the Single Buyers Office at Eskom (not embedded generators – who are considered net consumers). Municipalities could potentially buy electricity from anyone, as specified in the Municipal Finance Management Act; the challenge is for generators to obtain generation licences.

The City of Cape Town is arguing that it should be allowed to buy electricity from independent power producers because national generation is too expensive and it has an obligation to provide least-cost power to its constituency.

QUESTION 9.23 What are the socioeconomic benefits of allowing and supporting SSEG?

- Lower investment for realising energy generation.
- Power can be provided to remote areas.
- Power can be generated at a lower cost.
- Power is in the hands of the people.
- New green jobs are created.
- Reduces dependency on fossil fuels for energy and many other benefits.

Additional content: *Socio-Economic Benefits of SSEG in SA-Route Folder*

QUESTION 9.24 Can municipalities procure and install their own SSEG?

Yes, they can. Examples where municipalities have installed solar, biogas and landfill gas GE systems to supply their own operations include:

Solar PV:

- Cape Town ±250 kWp
- eThekwini ±300 kWp
- Ekurhuleni: ±500 kWp
- Landfill gas to electricity:
- Ekurhuleni: 1 MW
- eThekwini: 7.5 MW
- Johannesburg: ~18.6 MW

Waste to Energy:

- City of Tshwane: 3.5 MW

Additional content: *Procurement of SSEG for Municipalities*

SECTION 10
ENERGY EFFICIENCY

QUESTION 10.1 How does solar PV fit in with Energy Efficiency (EE)?

Solar PV and other SSEG solutions fit very well with energy-efficiency projects. Energy-efficiency solutions capitalise on free energy i.e., reducing the energy consumption and subsequently, paying less.

The aim is to reduce energy consumption via a number of energy efficiency solutions before installing solar PV or other SSEG solutions. This will reduce the size of the solar PV system that needs to be installed.

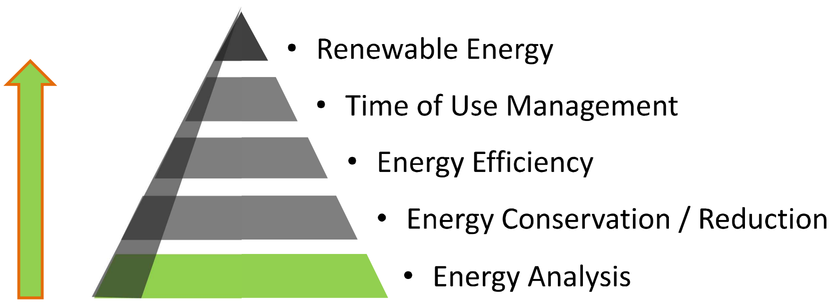


FIGURE 16: Energy pyramid

QUESTION 10.2 What approach should be followed when combining SSEG and EE?

When combining renewable energy and energy efficiency technologies it is best to begin by evaluating the life-cycle costing of the system. Start with an energy audit (which can include water and waste), followed by an energy analysis to identify quick wins and ensure sustainability.

Add energy reduction solutions such as switching off equipment when it is not needed or in use and then implement energy-efficiency solutions, where energy is used more efficiently via better control or more efficient equipment like LED lights, heat pumps etc.

Finally, SSEG systems are added to generate the remaining electrical demand.

Additional content: ***Energy Efficiency and SSEG_v6***

ANNEX ONE

ENVIRONMENTAL IMPLICATIONS OF USING OR SAVING ELECTRICITY

Factor 1 figures are calculated based on total electricity sales by Eskom, which is based on the total available for distribution (including purchases), after excluding losses through Transmission and Distribution (technical losses), losses through theft (non-technical losses), our own internal use and wheeling. Thus to calculate CO_2 emissions: 223.4Mt ÷ 216 274GWh = 1.03 tons per MWh.

Factor 2 figures are calculated based on total electricity generated, which includes coal, nuclear, pumped storage, wind, hydro and gas turbines, but excludes the total consumed by Eskom. Thus for CO_2 emissions: 223.4Mt ÷ (226 300GWh – 4 114GWh) = 1.01 tons per MWh.

Figures represent the 12-month period from 1 April 2014 to 31 March 2015

	Factor 1 (total energy sold)[1]	Factor 2 (total energy generated)[2]	If electricity consumption is measured in:			
			kWh	MWh	GWh	TWh
Coal use	**0.55**	**0.54**	kilogram	ton	thousand tons (kt)	million tons (Mt)
Water use[1]	**1.45**	**1.41**	litre	kilolitre	megalitre (Mℓ)	thousand megalitres
Ash produced	**159**	**155**	gram	kilogram	ton	thousand tons (kt)
Particulate emissions	**0.38**	**0.37**	gram	kilogram	ton	thousand tons (kt)
CO_2 emissions[2]	**1.03**	**1.01**	kilogram	ton	thousand tons (kt)	million tons (Mt)
SO_x emissions[2]	**8.48**	**8.25**	gram	kilogram	ton	thousand tons (kt)
NO_x emissions[3]	**4.33**	**4.22**	gram	kilogram	ton	thousand tons (kt)

1. Volume of water used at all Eskom power stations.
2. Calculated figures based on coal characteristics and power station design parameters. Sulphur dioxide and carbon dioxide emissions are based on coal analysis and using coal burnt tonnages. Figures include coal-fired and gas turbine power stations, as well as oil consumed during power station start-ups and, for carbon dioxide emissions, the underground coal gasification pilot plant.
3. NO_x reported as NO_2 is calculated using average station-specific emission factors, which have been measured intermittently between 1982 and 2006, and tonnages of coal burnt.

Multiply electricity consumption or saving by the relevant factor in the table above to determine the environmental implication.

Example 1: Water consumption

Using Factor 1
Used 90MWh of electricity
90 x **1.45** = 130.5
Therefore 130.5 kilolitres of water used

Using Factor 2
Used 90MWh of electricity
90 x **1.41** = 126.9
Therefore 126.9 kilolitres of water used

Example 2: CO_2 emissions

Using Factor 1
Used 90MWh of electricity
90 x **1.03** = 92.7
Therefore 92.7 tons CO_2 emitted

Using Factor 2
Used 90MWh of electricity
90 x **1.01** = 90.9
Therefore 90.9 tons CO_2 emitted

Further information can be obtained through the Eskom Environmental Helpline. Contact details are available on the inside back cover of the integrated report.

For CDM-related Eskom grid emission factor information please go to the following link:
http://www.eskom.co.za/OurCompany/SustainableDevelopment/Pages/CDM_Calculations.aspx or via the Eskom website: Our Company > Sustainable Development > CDM calculations.

NOTES

NOTES

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DEUTSCHE ZUSAMMENARBEIT

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SAGEN / SOUTH AFRICAN-GERMAN ENERGY PROGRAMME

SOUTH AFRICAN LOCAL GOVERNMENT ASSOCIATION
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Inspiring service delivery