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Report

Regulatory and Safety Requirements for Solar PV Water Heating

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Executive Summary

This short report seeks to summarize the applicable regulatory and safety requirements for solar PV water heaters in South Africa. It also seeks to dispel confusion and misinformation relating to these.

Summary of requirements

Requirement	Applicable regulation	Section(s) in this document	PowerOptimal Elon compliance
It is illegal to sell a product covered by a compulsory specification that does not have a valid LoA	NRCS VC Standards (such as VC 8055 and VC 9006)	1.2	The Elon 100 has a valid LoA issued by the NRCS
It is illegal for an electrician to install a device into the fixed wiring or issue a CoC for an installation where the device has no valid LoA	Electrical Installation Regulations – 2013, issued by the NRCS	1.2	The Elon 100 has a valid LoA issued by the NRCS.
All appliances and devices (including solar PV water heaters) must comply with SANS 222:X (no interference with licensed radio bands). If the product includes wifi or GSM, it needs to be registered with ICASA and have a type approval number.	ICASA Act 13 of 2000	1.3	The Elon 100 does not have a wifi or GSM modem & has been tested against CISPR 11 & IEC 61000-6-1 to show no interference with licensed radio bands.
At least 50% (volume fraction) of the annual average hot water heating requirement for new buildings must be provided by a non-grid source.	National Building Regulations & SANS 10400:XA	1.4 & 6	Determined by the size (power) of the solar PV array installed. See Section 6 for an example Rational Design calculation.
PV panels must be earthed with a minimum of 2.5 mm^2 (preferably 4 mm^2) earth conductor & mounting components must not cause galvanic corrosion	SANS 10142-1:2020 SANS 10142-1-2:202X DRAFT	3.1	This is the responsibility of the electrician signing off on the CoC.
The control device's enclosure must be non-flammable.	SANS 10142 & SANS 60335	3.2	The Elon 100 enclosure is from the Allbro Enlec range, which passes the glow wire flammability test at 960 degrees and passes the UL94 Test with a score of 'V0'.
Switch disconnectors for geysers must be dual pole	SANS 10142	3.3	This is the responsibility of the electrician signing off on the CoC.
Fitting of earth leakage is only required on the AC inputs to the geyser.	SANS 10142	3.4	This is the responsibility of the electrician signing off on the CoC.
For solar PV installations, continuous monitoring for breakdown of insulation between the device and earth is required. Either the solar PV water heater must do this, or a separate device needs to be fitted.	SANS 10142	3.5	The Elon 100 continuously monitors for isolation faults and disconnects the DC power source from the geyser when an isolation fault is detected.

Requirement	Applicable regulation	Section(s) in this document	PowerOptimal Elon compliance
Solar PV water heaters are 'change-over switching devices' that switch between AC & DC power supply. These devices must *maintain isolation between the DC and AC portions at all times*.	SANS 10142	3.6	The Elon 100 uses a 'double-pole, double-throw, break-before-make' change-over relay, which ensures that AC and DC portions can never be connected at the same time.
Whilst resistive elements are fully compatible with DC power, commonly used geyser thermostats such as TSE or Thermowatt thermostats are not compatible with DC power and will fail over time when used with DC power at typical geyser voltage and current levels.	VC 9006	4.1	The Elon 100 does not direct the DC current from the solar PV array through the thermostat. It connects to the thermostat separately and only uses a sensing current in the milli-amps range to determine thermostat open or closed state.
Since all geyser elements are electrically insulated from the surrounding water, no electrolysis reactions take place when either AC or DC electricity is used to power the element.	N/A	4.2	The Elon 100 uses standard geyser elements, which are all electrically insulated.
DC installations (including solar PV installations) must be signed off by an installation electrician.	OHSA Regulations	5	A registered electrician must sign off on the CoC for the installation.
At least about 600 W_p (low-cost housing) or 1 kW_p (any other housing) of solar PV is required to provide 50% of the annual hot water requirement in South Africa. This typically translates into at least 2 solar PV modules.	Rational design calculations based on SANS 10252-1 and SANS 10400-XA	6	The total power rating of the solar PV installation is specified by the property developer and/or architect.

General note: Installations with valid Certificates of Compliance (CoCs) issued before promulgation of new regulations remain valid.

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1. Regulatory Frameworks

1.1 Occupational Health and Safety Act 85 of 1993

"Electrical installation Regulations – 2013" issued in terms of the Occupational Health and Safety Act 85 of 1993 mandates that residential low voltage installations must comply with SANS 10142-1: 2020.

"5.1 No person may authorise, design, install or permit or require the installation of an electrical installation, other than in accordance with a health and safety standard incorporated into these Regulations under section 44 of the Act." [1]

"2.4.1 - Notes: 1 . The incorporated health and safety standard referred to is the SANS 10142-1 Code of practice for the wiring of premises as published in Government Notice No. R.243 of 6 March 2009 or any updated revision of the standard." [2]

The regulations also specify who can install and work on the fixed wiring in such an installation. Different types of installation require different types of electrician or registered professional engineer to sign them off and issue a ”Certificate of Compliance.”

SANS 10142-1-2:202X (part 2 of the standard covering PV installations) is still in draft and will not form part of the regulatory framework until it is promulgated and referenced in the regulations. SANS 10142-1 currently covers DC installations and in terms of standard law practice, installations that have valid Certificates of Compliance (CoCs) issued before promulgation of the new regulations referencing SANS 10142-1-2 will remain valid.

In this document, where SANS 10142-1-2:202X provides additional insight into how a PV installation should be managed, this will be noted. If there is any conflict between the draft SANS 10142-1-2:202X and the current SANS 10142-1:2020, the current SANS 10142-1:2020 must be followed until part 2 is promulgated.

1.2 National Regulator for Compulsory Specifications (NRCS)

The scope of SANS 10142 is limited to the fixed electrical wiring of an installation. This includes the physical wires but also how the protective devices, fittings and switches of the installation are installed. Fixed appliances as defined in SANS 10142 are the ambit of the National Regulator for Compulsory Specifications (NRCS). The NRCS is responsible for ensuring the safety and function of any appliance used in the home. This includes geysers which are deemed to be fixed appliances by SANS 10142:

> ***“6.16 Fixed appliances***
>
> *...*
>
> *6.16.2 Water heaters NOTE Water heaters include geysers, instantaneous water heaters including units for boiling water, heat pumps, solar systems, induction water heaters and the like (see also 6.16.1).”* [3]

The NRCS ensures safety by issuing compulsory specifications known as VC standards. It requires any product covered by the specification to be tested by a SANAS accredited laboratory. The test report must then be submitted to the regulator who will issue a Letter of Authority (LoA). **It is illegal to sell**

a product covered by a compulsory specification that does not have a valid Letter of Authority (LoA).

In terms of the "Electrical installation Regulations - 2013" it is also **illegal for an electrician to install a device into the fixed wiring or to issue a certificate of compliance for an installation where such a product with no valid LoA is installed**.

> *"5.2 No person may use components within an electrical installation unless those components comply with the standards referred to in the relevant incorporated standard referred to in subregulation (1), and proof of compliance shall be identifiable on the components or certification shall be available from the manufacturer or supplier of the materials or components in terms of the National Regulator for Compulsory Specifications Act, 2008 (Act No. 5 of 2008)."* [1]

This brings up a critical distinction. The internal wiring of a fixed appliance is not regulated by SANS 10142, it is covered by conformance to the safety standard stipulated by NRCS in the relevant compulsory standard. Two VC standards are of interest to solar PV water heaters, VC 8055 [6] which covers appliances and VC 9006 [7] which covers geysers.

Some of the standards have implications for manufacturers of Solar PV water heater solutions and need to be taken into account. However, from the point of view of the electrician, his/her duty ends with ensuring that the solar PV water heater has a valid letter of authority issued by the regulator.

1.3 Independent Communications Authority of South Africa (ICASA)

ICASA is mandated by the Independent Communications Authority of South Africa Act 13 of 2000 to manage the radio spectrum of South Africa**. Any solar PV water heater solution (or any other appliance or device) that incorporates any electronics has to comply at a minimum with SANS 222:X [6]** to ensure that it does not interfere with any licensed radio bands. If the product includes a radio of any sort including Wifi or GSM modem, it needs to be registered with ICASA who will require further testing to be performed before they issue a type approval number. The ICASA type approval number needs to be affixed to the device and be clearly visible.

1.4 National Building Regulations and Building Standards Act 103

Regulations promulgated in terms of the act require new building to comply with SANS 10400:XA. Part of the requirement is that **at least 50% (volume faction) of the annual average hot water heating requirement will be provided by a non-grid source**, such as solar thermal, heat pumps, PV, etc. What is important to note is that volume of hot water for a given number of occupants is standardised and specified in the regulations. This has implications on the minimum sizing of the solar PV installation required to meet the SANS 10400:XA based regulatory requirement.

2. Installation requirements of SANS 10142-1:2020

The geyser is a fixed appliance in terms of SANS 10142-1. SANS 10142 specifically excludes the fixed appliance and its internal wiring from the ambit of SANS 10142:

> *"6.16.1.1 Fixed appliances do not form part of the electrical installation other than their positioning in relation to the supply and the wiring carried out between different parts of the appliances." [3]*

Where the wiring between components of the fixed appliance is longer than 3m it is deemed to form part of the fixed wiring and fall under SANS 10142. DC wiring of the panels always falls under SANS 10142, though there may be other allowances made within SANS 10142 with regards to protection requirements.

3. Installation of Solar PV Water Heating Components

Generally, solar PV water heating systems consist of three major components:

- the geyser (fixed appliance);
- the PV panels; and
- a control device.

3.1 Mounting of PV panels

The PV panels are required to be securely mounted. Care must be taken ensure the metals used in the mounting brackets, nuts, screws and bolts are compatible with the aluminium of the PV panel frame and will not cause galvanic corrosion.

> *"**6.12.1.7** Earth continuity conductors shall be suitably protected against mechanical damage, chemical or electrochemical deterioration, electrodynamic forces and thermodynamic forces."* [3]
>
> *"**5.4.5.2.2** PV Mounting Structures*
>
> *.....*
>
> *The connection to the array frame shall be in line with the manufacturer's instructions, and shall be designed and constructed to minimize the effects of corrosion. This shall include selection of materials and components that minimize the effect of galvanic corrosion. Plated or unplated copper tubular cable lugs shall not be used for connection onto aluminium rails."* [4]
>
> *"**5.4.4.7.3** A designed earth connection to the array frame, methods to minimise the effects of corrosion shall include: a) use of stainless steel crimped lugs between cable and frame; b) use of bimetallic washers between crimped lugs and array frame; and c) if the joint includes more than one type of metal, it should be sealed to prevent ingress of water using a suitable weatherproof coating or taping system."* [4]

The PV panels are required to be earthed with a minimum of a 2.5mm^2 conductor (SANS 10142-1) or 4mm^2 conductor (SANS 10142-1-2). The connection can be to any suitable earth terminal in the installation.

> *" **6.13.1** Bonding conductors*
>
> *A bonding conductor shall a) have a nominal cross-sectional area of at least 2,5 mm^2 copper or equivalent, and b) be so arranged that it cannot be tampered with."* [3]
>
> *" **5.4.4.3** Earthing cables sizes*
>
> *The cross-sectional area of earthing and bonding cables of the DC installation shall be equivalent to both the cross-sectional areas of the positive and negative live (current-*

carrying) conductors. However, the earthing and bonding cables shall have a minimum cross-sectional area of 4mm^2 ." [4]

3.2 Mounting of Control Device

SANS 10142 specifically mentions that the **control device needs to have its own enclosure that is non-flammable** and mounted near the geyser or the panels. This is also covered by SANS 60355 as part of the safety requirements for meeting VC 8085.

> *"**6.16.1.8** Control components of fixed appliances that form part of the installation, including their input terminations and associated protective switchgear not mounted in the distribution board, shall be incorporated in a suitable enclosure(s) that comply with the requirements of 6.6.1 and 6.6.4, unless they are part of the appliance or self-contained in their own enclosure. Enclosure(s) shall be:*
>
> *a) **non-flammable**,*
>
> *b) located as near to the appliance(s) as is practicable,*
>
> *c) permanently installed,*
>
> *d) such that they cannot be opened without the use of a tool, and*
>
> *e) readily accessible."* [3]

3.3 Installation of Disconnectors

SANS 10142 requires that a fixed appliance be fitted with a switch disconnector that is separate from the appliance and within arm's reach (1.5m) of where the appliance is installed. The switch disconnector for a geyser **needs to be a dual pole device**.

> *"**6.16.1.2** The power supply to every fixed appliance, except luminaires, shall be supplied through a) a disconnecting device that disconnects both live conductors in a single-phase supply and all phase conductors in a multiphase supply, or"*
>
> *"**6.16.1.4** The disconnecting device shall be positioned a) within 1,5 m from the appliance, or"* [3]

A solar PV solution that can be powered from both AC and DC requires 2 switch disconnectors: one for AC and one for DC. Each disconnector needs to have a label specifying that there is another switch disconnector that must be disconnected before the appliance is isolated.

> *"**6.9.3.2** All supply circuits to equipment and interconnected devices (such as appliances with remote control or alarm) shall be capable of being disconnected. Where more than one disconnecting device is used, each device shall have a notice fixed next to it, giving the location and function of the other disconnecting device."* [3]

If a circuit breaker is used as a switch disconnector it need to be labelled as such. It is recommended to use a circuit breaker as a switch disconnector for the DC side to ensure compliance with:

> *"NOTE 4 Where a control device (such as a home automation device) is installed, each circuit that feeds from such device needs an overcurrent protective device if not protected in the supply."* [3]

3.4 Fitting of earth leakage

Earth leakage is only required on the AC inputs to the geyser.

> ***"6.16.2.1** All water heaters shall be bonded in accordance with 6.13 and a.c. supply circuits shall be protected by earth leakage protection with I not exceeding 30 mA"* [3]

3.5 Fitting of Insulation Monitoring Device

SANS 10142-1 is concerned with safety and ensuring an electrical installation cannot pose a hazard to human occupants.

Three primary mechanism are used to provide safety in an installation:

1. Extra low voltage;
2. Earthing with earth leakage and overcurrent protection devices;
3. Electrical separation of circuits with an insulation monitoring device.

Extra low voltage is only applicable to systems supplied by a safety transformer or other voltage source and whose peak voltage is below 120V DC. The appliance safety standards specified in the compulsory VC 8085 standard further limit this to **60V DC maximum**. SANS 10142 also limits this to 60V where the circuit is in contact with liquid.

A Solar PV installation with 2 panels in series has a peak open circuit voltage of greater than 60V DC. Thus, **this method cannot be used to ensure conformance in a solar PV system** where the PV panels are connected in series.

Solar panels can supply limited current which means using normal over currentprotection devices have limited effectiveness. The normal operating point of a panel is within 10% of the short circuit current. A circuit breaker requires the fault current to be many multiples of the operating current to provide fast enough operation to provide protection against electric shock. Earth leakage protection for solar PV installations requires separate earths and careful installation to work correctly and is generally not feasible in solar PV installations.

Hence, the only method that can be reliably used to provide protection against shock in a solar PV installation is "**Electrical separation of circuits**" where **the DC circuit is isolated from the earth and the installation is continually monitored for any breakdown of the insulation** between the device and earth. SANS10142 states that:

> *"One fault will reduce the effectiveness of "electrical separation of a circuit" as a protective measure; a second fault can be dangerous. To be able to rely on "electrical separation of a circuit" as a protective measure for a long circuit, a specially designed device should be used to monitor the circuit, and, if a fault occurs, the device should disconnect the circuit or give an audible or a visible warning of the fault."* [3]

Either such a device needs to be fitted separately or the solar PV water heating solution needs to contain the monitoring function.

In terms of SANS 10142-1-2:202X earthing of the Solar DC side will not be allowed as the primary protection mechanism except in very specific circumstances and electrical separation of circuits with an insulation monitoring device is required.

> *"**6.2.4.1 General***
>
> ***6.2.4.1.1** The inverter shall:*
>
> *a) be able to measure and monitor insulation resistance using residual current monitoring (RCM) in accordance with IEC 62020…"* [4]

SANS 10142-1-2:202X gives the minimum resistance for the insulation fault to earth as 30 kohms for an array less than 20kW.

3.6 Additional requirements for DC where it is used as an alternative to the main supply

SANS 10142 does not discriminate between DC and any other alternative supply. This is important because the same principles apply to generators, batteries, inverters, etc.

> *" **7.12.2.5** Where an alternative supply is provided to an installation or part of an installation as a switched alternative to the main supply, **the change-over switching device shall disconnect the main supply before the alternative supply is switched in**. The change-over switching device shall be interlocked in such a way that the main supply and the alternative supply cannot be connected to the installation or part of the installation at the same time.*
>
> ***7.12.6.1** ... d) an automatic changeover switching device with suitable interlock "* [3]

This means that internally **the device needs to maintain isolation between the DC and the AC portions** of the device and that it is sufficient that the element is switched between AC and DC supplies using a C contact dual pole relay. This relay maintains separation between the AC and DC circuits using an air gap and provides the required mechanical interlock.

Ensuring that there is sufficient separation of the different voltage zones within a device is the ambit of NRCS and is verified as part of the testing done to ensure compliance with VC 8055 (compulsory safety specification for appliances).

The actual testing is done against "SANS 60730-1:2016 Automatic Electrical Controls Part 1" which is included via a normative reference to SANS 60355-1 which is in turn referenced in VC 8055 Standard.

SANS 60730 specifies in its scope:

> *"**1.1 Scope***
>
> *In general, this part of IEC 60730 applies to automatic electrical controls for use in, on, or in association with equipment for household and similar use. The equipment may use electricity, gas, oil, solid fuel, solar thermal energy, etc., or a combination thereof.*
>
> *NOTE 1 Throughout this standard the word "equipment" means "appliance and equipment."*
>
> *EXAMPLE 1 Controls for appliances within the scope of IEC 60335."* [5]

4. Using DC with AC Geyser Elements

4.1 Thermostat compatibility

Geysers are covered by VC 9006 [7], which requires that each resistive element be fitted with a thermostat control and a thermal cut out. All AC resistive elements can be driven by DC. The problem with driving AC elements with DC arises from how the bi-metal thermostat and thermal cut out are manufactured. Most thermostats are implemented using a normal switching contact - when the thermostat reaches temperature, the contact opens and an arc forms. Under AC this arc extinguishes in under 20 milliseconds.

When the element is driven by DC the arc is not extinguished and continues for relatively long periods of time. This degrades and eventually melts the contacts, leading to the destruction of the thermostat. In many cases the contacts weld on closure. This results in failure of the temperature regulation function and can result in the geyser failing due to over boiling. Solar PV water heaters that drive the element need to either quench the arc within 20ms of formation or ensure that switching is done in such a way that the arc never forms.

Some methods are more effective than others. If the solar PV water heater does not have a LoA (Letter of Authority) issued by NRCS, it is unlikely that the mechanism to deal with the DC arc has been independently verified by a testing house. The safety standard for controls (SANS 60730:2016) requires testing to minimum of 30 000 switching cycles without failure or contact weld.

4.2 Electrical insulation of geyser elements

Since electricity is present inside geyser elements and these elements are in contact with water, ALL geyser elements are electrically insulated from the surrounding water.

This insulation is guaranteed by the requirement to fit a 30mA earth leakage and insulation failure monitoring devices.

> "***6.16.2.1*** *All water heaters shall be bonded in accordance with 6.13 and a.c. supply circuits shall be protected by earth leakage protection with I not exceeding 30 mA"* [3]

> "*One fault will reduce the effectiveness of "electrical separation of a circuit" as a protective measure; a second fault can be dangerous. To be able to rely on " electrical separation of a circuit " as a protective measure for a long circuit, a specially designed device should be used to monitor the circuit, and, if a fault occurs, the device should disconnect the circuit or give an audible or a visible warning of the fault. "* [3]

Thus, NO electrolysis reactions between the element's outer casing and the water or its contents in the geyser can take place (as has been falsely claimed in the South African market), no matter whether AC or DC electricity is used.

5. Who can Install

The OHSA Regulations [1] require all work on an electrical installation to be performed by a registered electrician or a person under his direct supervision.

> *"5.4 A registered person shall exercise general control over all electrical installation work being carried out, and no person may allow such work without such control."* [1]

Note the fixed appliance wiring is excluded from the electrical installation, so a plumber can install the geyser and the thermostat but can't wire the disconnect switch, DC cabling or AC cabling past the disconnect switch.

Authority for issuing a test report and a Certificate of Compliance

Amdt 7

Type of Installation	Single-phase	– Two-phase – Three-phase – DC	Specialized installations (hazardous, medical, explosive, petroleum, etc.)
May be installed by	electrical contractor or any person[a]	electrical contractor, or any person under control of – installation electrician, or – master installation electrician	electrical contractor, or any person under control of – master installation electrician
Test report and Certificate of Compliance may be issued only by	– electrical tester for single phase, or – installation electrician, or – master installation electrician	– installation electrician or – master installation electrician	– master installation electrician

Amdt 7

[a]Any person who undertakes to perform electrical installation work on behalf of any other person, but excluding an employee of such first-mentioned person, is legally required to register as an electrical contractor.

Note that an electrician is not allowed to issue a CoC for installation work that he has not done or supervised. Also, anyone working on the electrical installation needs to be either under the employ of said electrician or registered as an electrical contractor.

Figure 1: Who may install and issue COC for electrical installations [3].

Whilst single phase AC can be signed off by an electrical tester, **DC installations must be signed off by an installation electrician or master installation electrician**.

6. Sizing of a Solar PV Water Heater Installation

Functional regulation XA2, contained in Part XA of the National Building Regulations, requires at least

> *"50% (volume fraction) of the annual average hot water heating requirement shall be provided by means other than electrical resistance heating including but not limited to solar heating, heat pumps, heat recovery from other systems or processes and renewable combustible fuel".* [8]

The established practice by South African municipalities is to interpret the above as requiring means other than grid electricity to heat the water, which includes using solar PV as a power source via electrical resistance heating.

(Note: there is a new SANS 10400-XA:202X in development, to be published in 2021 or later. It is expected that this new version will bring better clarity in terms of acceptable power sources.)

To comply with the above, SANS10400-XA:2011 states in 4.1.1 (a):

> *"the volume of the annual average hot water heating requirements shall be calculated in accordance with tables 2 and 5 of SANS 10252-1:2004"* [9]

Compliance with the SANS 10400–XA Regulations requires that the design of new buildings satisfy certain conditions. There are three routes to compliance, namely:

- The Prescriptive Route as in paragraph 4.2.1 (b).
- The Reference Building Route as in paragraph 4.2.1 (c).
- The Performance Route as in paragraph 4.2.1 (a).

The third of these is not available for residential buildings (houses and apartments) and so the first or second option are used for compliance for new residential property developments. For the Prescriptive Route to apply, all aspects of the building design must comply with a prescribed set of rules.

This might, however, not be technically feasible and/or too expensive, and so **in most instances option 2 (the Reference Building Route) is followed**.

In the Reference Building Route a **Rational Design is done by a Competent Person - Energy**. This can be for example an architect or engineer "*who has the necessary education, training, experience and contextual knowledge to make a determination in terms of a functional regulation*" [9]

The **minimum size of solar PV array required** for any residential unit in South Africa can be estimated as follows (this also serves as an example of a Rational Design calculation for the purpose of meeting functional Regulation XA2 of the National Building Regulations):

Calculation step	Low rental flat	Medium to high rental flat / dwelling house	Units
1. From Table 5 of SANS 10252-1:2018 [10], the total hot water demand (mixed) at 40 °C is:	65 – 75	115 - 140	L/capita/day

Calculation step	Low rental flat	Medium to high rental flat / dwelling house	Units
2. If a cold-water temperature of 15 °C is assumed, then the total hot water demand at 60 °C is:	36 – 42	64 – 78	L/capita/day
3. Using the middle of the range and assuming an occupancy of 2, this means a requirement to heat the following amount of water from 15 to 60°C per day:	78	142	L/day
4. This translates into an annual requirement for hot water at 60 °C of:	28 470	51 830	L/year
5. At 5.22 kWh/100 litre (for heating from 15 to 60 °C), this is a requirement for heating of:	1 486	2 706	kWh/year
6. At least 50% of this heating requirement should be provided by solar PV. Thus, the solar PV system should provide at least:	743	1 353	kWh/year
7. Assuming a utilisation efficiency of 80% for solar PV energy production, the requirement is	929	1 691	kWh/year
8. **Durban** has the lowest annual solar yield of all the major cities in South Africa of 1 447 kWh/kW_p/yr. Thus, for an installation in Durban, the **solar PV string should have a total peak rated power of at least**	**0.64**	**1.17**	kW_p
9. For other cities, the requirement will be somewhat less. For example, **Johannesburg** has an annual solar yield of 1 756 kWh/kW_p/yr. Thus, for an installation in Johannesburg, the solar PV string should have a total peak rated power of at least	**0.53**	**0.96**	kW_p

As can be seen from the above table, the minimum requirement for low cost housing is about 0.6 kW_p, whilst the minimum requirement for any other housing is about 1 kW_p.

References

[1] *Occupational Health and Safety Act (act 85 of 1993) - Electrical Installation Regulations*, Department of Labour, website: https://www.gov.za/sites/default/files/gcis_document/201409/233230.pdf.

[2] *Explanatory notes on the Electrical Installation Regulations, 2009*, Department of Labour, website: https://www.gov.za/sites/default/files/gcis_document/201409/35180gen258.pdf.

[3] *SANS 10142-1:2020 The wiring of premises Part 1: Low Voltage installations*, South African Bureau of Standards.

[4] *SANS 10142-1-2:202X (DRAFT) The wiring of premises Part 1-2: Additional special requirements for low voltage small scale embedded generator installations connected in parralled to the normal electrical supply*, South African Bureau of Standards.

[5] *SANS 50730 -1:2016 Automatic electrical controls - Part 1*, South African Bureau of Standards.

[6] *VC8055 – Compulsory Specification for Electrical and Electronic Apparatus*, National Regulator for Compulsory Specifications, website: https://www.nrcs.org.za/siteimgs/vc/VC8055.pdf.

[7] *VC9006 - Compulsory Specification for Hot Water Storage Tanks for Domestic Use*, National Regulator for Compulsory Specifications, website: https://www.nrcs.org.za/siteimgs/vc/VC9006.pdf.

[8] *National Building Regulations Part X: Environmental Sustainability Part XA: Energy Usage in Buildings*, issued in terms of the National Building Regulations and Building Standards Act, 1977 (Act No. 103 of 1977).

[9] *SANS 10400-XA:2011 The Application of the National Building Regulations Part X: Environmental sustainability Part XA: Energy usage in buildings*, South African Bureau of Standards.

[10] *SANS 10252-1:2018 Ed3.2 Water supply and drainage for buildings Part 1: Water supply installations for buildings*, South African Bureau of Standards.