Policy Brief: Solar Photovoltaic Technologies

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LIST OF ABBREVIATIONS

CSP	Concentrated solar power
CRSES	Centre for Renewable and Sustainable Energy Studies
dti	Department of Trade and Industry
EPP	Electricity Pricing Policy
ERA	Electricity Regulation Act
IEP	Integrated energy plan
IRP	Integrated resource plan for electricity
NERSA	National Energy Regulator of South Africa
MFMA	Municipal Finance Management Act
PFMA	Public Finance Management Act
PV	Photovoltaic
RE	Renewable Energy
REIPPPP	Renewable Energy Independent Power Producers Procurement Programme
SA	South Africa
SOE	State owned entity
SSEG	Small scale embedded generation
SWH	Solar water heater
TOU	Time of use
UK	United Kingdom
USA	United States of America

Introduction

This brief provides an overview of solar photovoltaic (PV) technologies to inform policy. Although an overview of the international market and large-scale installations is provided, the focus of this document is on rooftop PV installations specific to South African circumstances.

History of PV

There are two main ways in which solar energy can be harvested for useful energy;

- the light can be converted into heat. This heat can then be used directly as process heat or it can be used to generate electricity, or;
- the light can be converted directly into electricity with photovoltaic (PV) panels. The word "photovoltaic" is in fact a combination of the words "photos" (the Greek word for light) and "volt" (or voltage, the unit of potential difference in an electric circuit).

The French physicist, Edmond Becquerel was the first person to identify the photovoltaic effect. He published a paper in 1839 mentioning that battery voltage is increased when its silver plates are exposed to sunlight (Boyle, 2012).

After an initial slow growth in development, the installations of PV technologies really started taking off a century and a half later, with an exponential increase over the past decade. For a timeline of the development of PV, see Figure 1.

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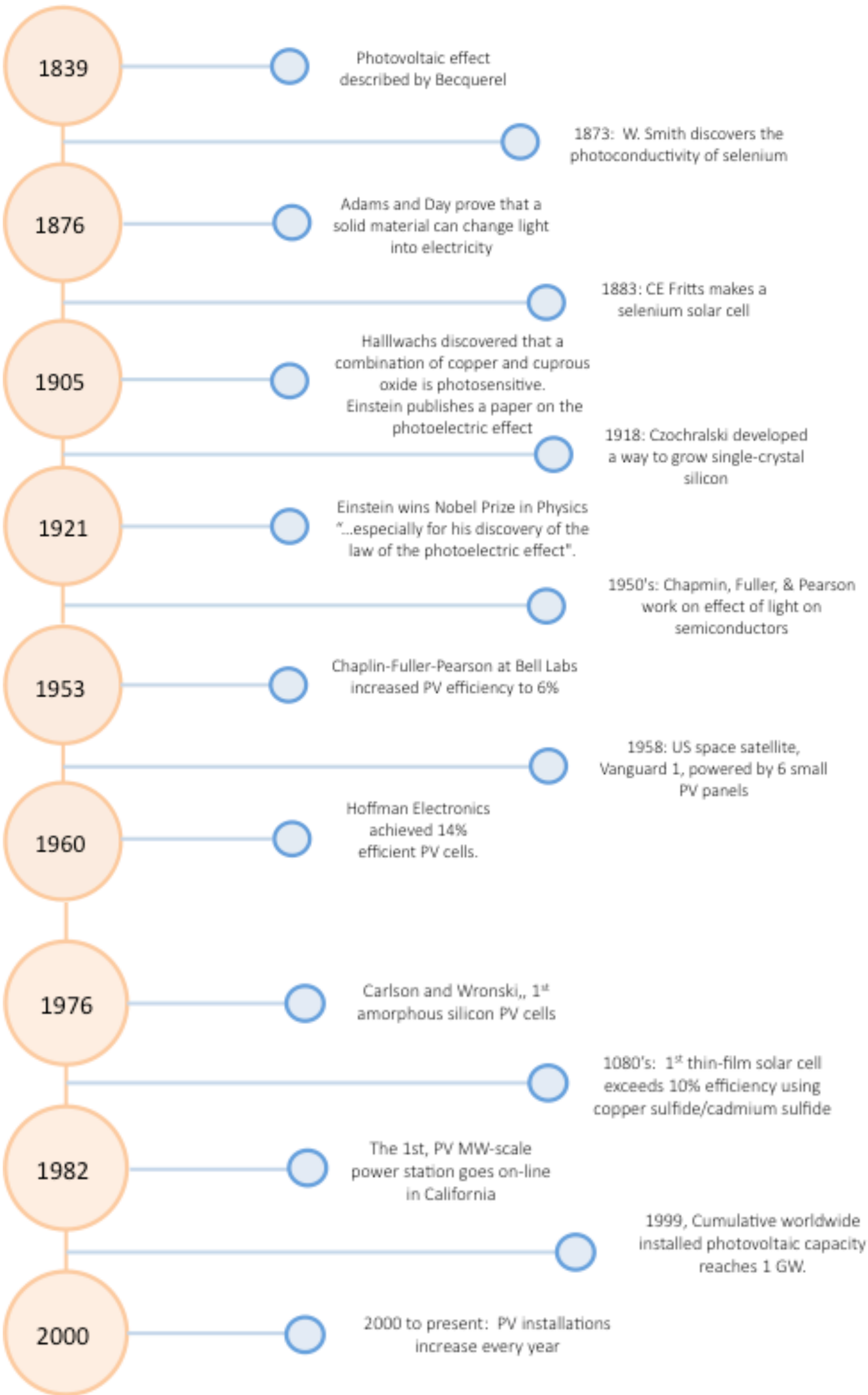

Figure 1: Timeline of the development of PV panels

Adapted from (Boyle, 2012)

1: PV installations internationally

The global cumulative PV installations increased from ~7GW in 2006 to ~303GW by the end of 2016, a ~40 times increase in only ten years (REN21, 2017). See Figure 2. As a result, PV capacity made up 1.5% of the global electricity capacity by 2016. This share is envisioned to further increase to 16% by 2050 (IEA, 2014).

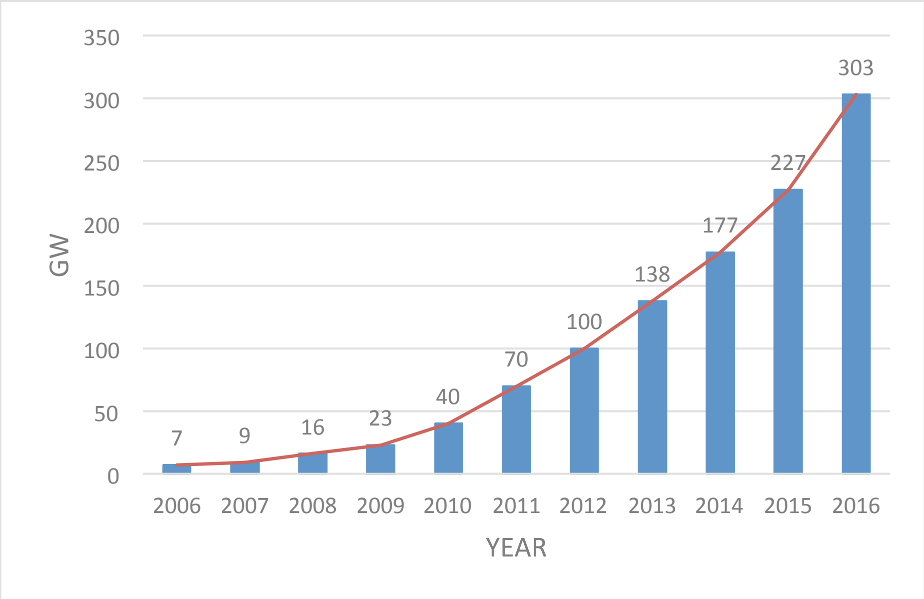

Figure 2: Global trends of PV capacity from 2006 to 2016

(REN21 Secretariat, 2017)

Presently, China is the world leader in PV installations with a total of ~77GW installed in 2016. This is ~5% of their net electricity capacity and ~26% of the global PV installations. Japan had a total capacity of ~43GW installed in 2016, accounting for ~14% of their net capacity. Germany, USA and Italy are next in line, with total capacities of ~42GW, ~41GW and ~19GW respectively, accounting for ~21%, ~4% and ~16% of their net electricity capacity. Together, the top five countries accounted for ~73% of global PV installations. Other countries with a considerable amount of PV installed include the UK, India, France, Australia and Spain (REN21, 2017).

2: PV installations in South Africa

South Africa introduced the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) in 2011. Since then utility scale renewable energy (RE) has made a notable difference in the energy mix of South Africa. From the REIPPPP, there are a total of 33 operational PV power plants in South Africa at present, with another 12 projects from bid window 4 that are awaiting sign off. For the details of all of these power plants, see Appendix A (Forder, 2017).

There has also been a significant rise in installations of small-scale embedded generation (SSEG) PV systems on the roofs of residential, commercial and industrial premises at a cost to the owners. As of February 2017, the estimated privately owned rooftop PV capacity in SA amounted to ~280MW, with ~120MW installed in 2016 alone (PQRS, 2017). This increase in installations is most likely due to the declining capital cost, rising electricity prices, increased environmental awareness and energy security. Although the South African government acknowledges any impetus to reduce carbon emissions, increase in SSEG could present technical challenges on both distribution and transmission networks.

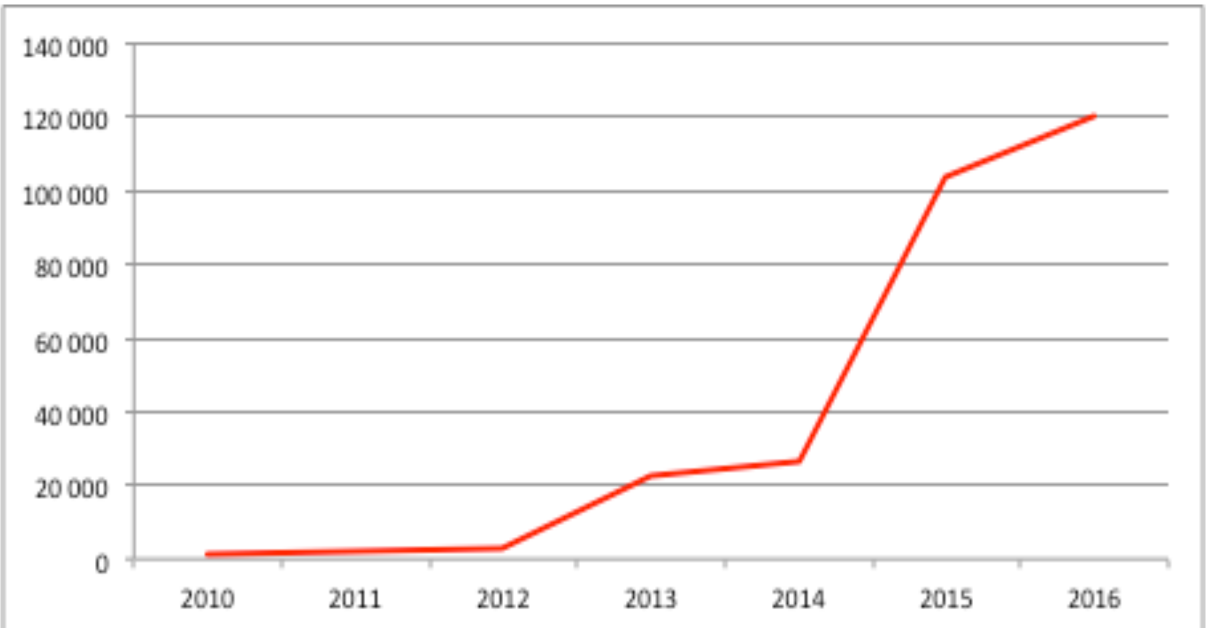

Figure 3: Estimated total rooftop PV installations in South Africa

(PQRS, 2017)

3: Relevant South African laws and regulations

The process from discussions, through plans and policies to acts and regulations, followed by the South African government as it relates to SSEG is shown in Figure 4.

Government Process	Examples
Discussions	White Paper on Energy Policy (1998) White Paper on Renewable Energy (2003) White Paper on National Climate Change Response Policy (2011)
Plans	Integrated Energy Plan (2003) Integrated Resource Plan for Electricity (2010) Integrated Energy Plan (2016)
Policies	Electricity Pricing Policy (2008- DME)
Acts	Electricity Regulation Act (2006) National Environmental Management Act (1998) Municipal Finance Management Act (2003) Public Finance Management Act (1999)
Regulations	Electricity Regulations on new generation capacity (2009)

Figure 4: SA government process from Discussions to Regulations

(Reinecke et al., 2013)

The Electricity Pricing Policy (EPP), the Municipal Finance Management Act (MFMA) and the Public Finance Management Act (PFMA) gives directive as to the maximum tariff that municipalities can compensate SSEG generators for electricity fed back into their network. This tariff cap is generally agreed to be at the blended tariff that the municipality buys electricity from Eskom.

The Integrated energy plan (IEP) and the Integrated resource plan for electricity (IRP) provides the energy mix needed to meet the demand for South Africa. Both the IRP and the IEP were updated in 2016, but these have not been signed off by parliament yet. The 2016 draft IRP includes a cap on SSEG installations, however it does not provide guidance as to how this will be enforced.

The electricity regulation act (ERA) was updated in late 2017. The updated ERA exempts the following generators from needing a licence from NERSA;

- Generators less than 1MW (needs a use-of-system agreement with grid operator and capped by the IRP allocation)
- Demonstration facilities (cannot operate for more than 36 months)
- Existing facilities
- Electricity resellers (tariff is less or equal to existing tariff, agreement in place with distributor and approved by NERSA)

The maximum generation capacity that is allowed is set out in the connection criteria for different network configurations shown in Figure 5.

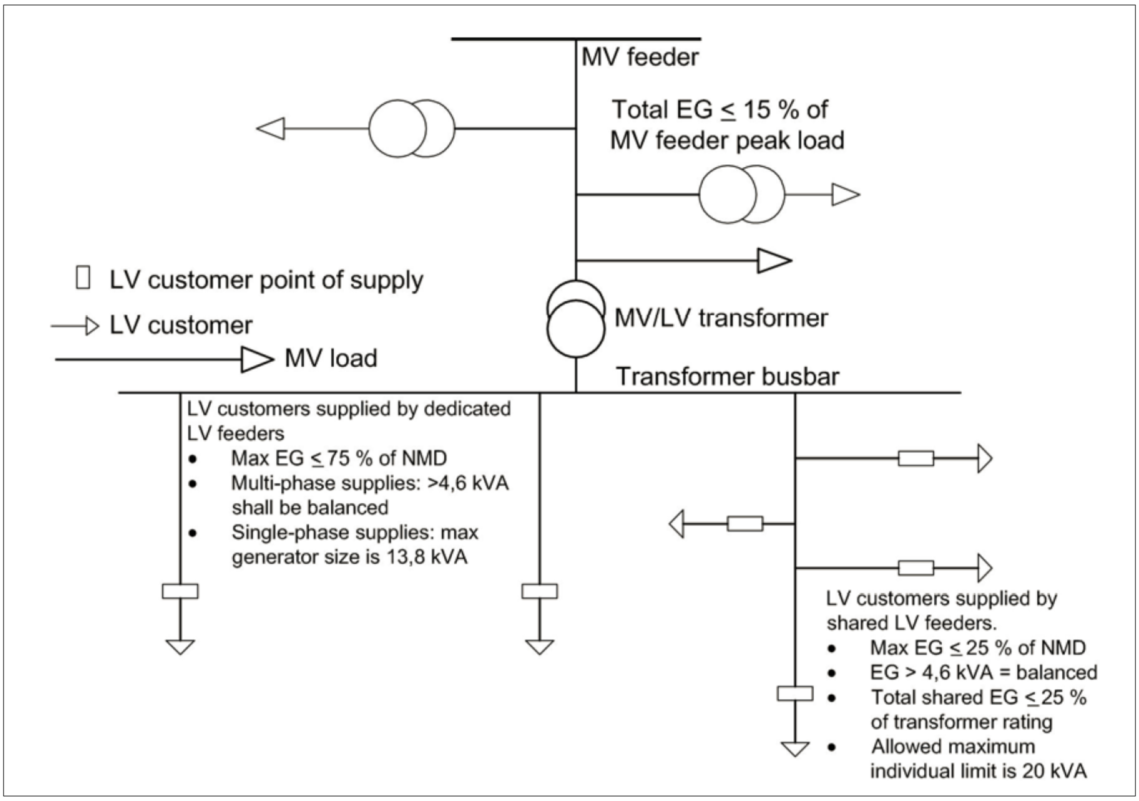

Figure 5: Summary of MV/LV connection criteria set by NRS 097

(Reinecke et al., 2013)

If the PV is installed on government buildings or by state owned entities (SOE), the local procurement rules of the department of Trade and Industry (dti) need to be abided by (dti, 2017).

3.1: Types of rooftop PV installations

Rooftop PV installations are differentiated by the connection to the grid. The most common types of installations are;

Grid Tied / Connected With Reverse Power Blocking, where the property is connected to the grid and buys electricity from the utility when the PV system is not producing, but the surplus electricity that is generated by the PV system is prevented from being directed back into the grid.

Grid Tied / Connected, where the **e**lectricity generated can be used at the property and any surplus can be directed back into the grid. In some cases, this feed-back is compensated for.

Off-Grid / Standalone, where the PV system generates electricity for use on-site and operates completely independent of the national grid. In this case, it necessary to have additional components such as a charge controller and battery storage (PV Greencard, 2017).

The Centre for Renewable and Sustainable Energy Studies at Stellenbosch University developed a two page leaflet to assist in the decision making of installing a rooftop PV system (CRSES, 2015). See Appendix B.

3.2: Impact on the utility

Utilities are impacted by installations of rooftop PV systems by their customers in a few ways;

- The installations might have a negative impact on the revenue of the utility;
- the PV systems might have an impact on network stability and;
- the utility might have a added administrative burden due to the regulations that the PV systems need to comply with.

However, the installations of PV systems are widely seen by utilities and electricity customers alike as having a net positive impact on energy security and the mitigation of climate change. For this reason most utilities worldwide embrace the growth in the installation of these systems and are actively working towards finding solutions to accommodate these new systems on their network. This is seen in South Africa as well, with many municipalities already having connection rules and SSEG tariffs in place (GreenCape, 2016).

The electricity demand profile for each electricity customer is different. Large customers with a high aggregated electricity demand can take advantage of this by installing PV systems that mitigate their electricity use and typically do not feed electricity back into the grid. Residential customers have less aggregated and more fluctuating demand profiles and typically tend to self consume less electricity than they expect. These residential customers will either have energy storage systems installed to absorb the excess electricity, be on a special SSEG tariff from the municipality, or have an unregulated connection that feeds electricity back into the grid while the electricity meter runs backwards. South African municipalities are trying to clamp down on these unregulated installations for safety reasons, but are finding it increasingly difficult with the rate of installations. The policing of these unregulated systems also adds an additional administrative burden on already overstretched municipal officials.

4: The business case for rooftop PV in South Africa

4.1: Incentive Structure for SSEG in South Africa

The accelerated depreciation 12B tax incentive for RE installations allows businesses to deduct the full cost of their PV systems from their taxable income in the year of installation (SAPVIA, 2015). This incentive is, however, not available for private persons.

The 12L Tax incentive provides an allowance for businesses to implement energy efficiency savings. The incentive allows tax deduction for all energy carriers (not just electricity). However, this incentive excludes the energy generated from renewable energy sources.

4.2: Cost of PV

The cost of PV has come down rapidly in the last decade, coinciding with the major growth in installations. This decline is seen across the world and across all types of installations. The cost decline in the USA for different installation types can be seen in Figure 6.

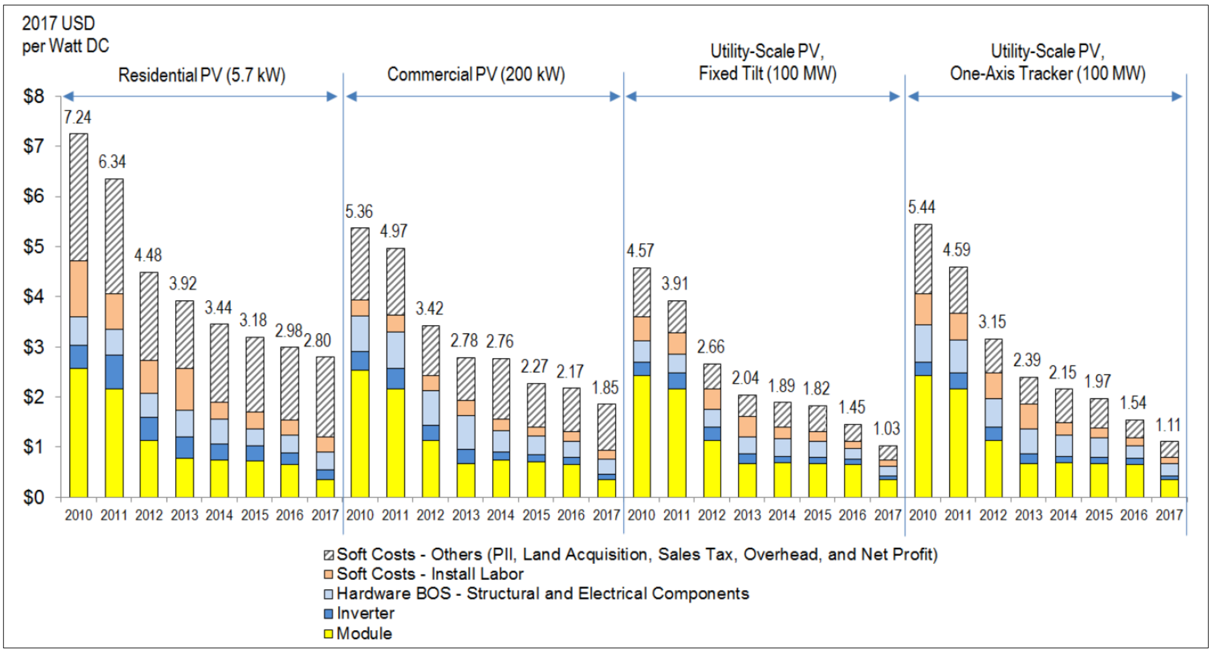

Figure 6: PV system cost benchmark summary, inflation adjusted, 2010 – 2017

(Fu, Feldman, Margolis, Woodhouse, & Ardani, 2017)

This cost reduction was also seen in South Africa, with the declining electricity cost from PV installations across the four bid windows in the REIPPPP. See Figure 7.

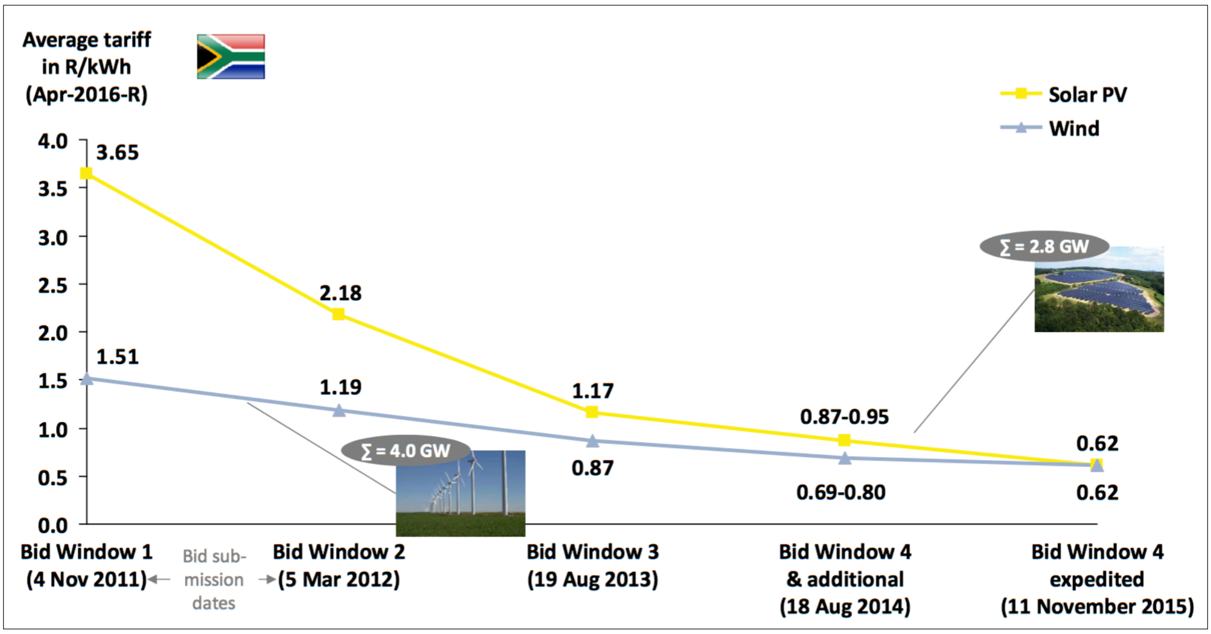

Figure 7: Competitive tender outcome: new wind/solar projects in South Africa

(Bischof-Niemz & Fourie, 2016)

The costs of rooftop PV installations in South Africa have come down in line with these reductions. Rooftop installation costs range from ~R10 000 per kilowatt peak (kW_p) for large installations that don't use state of the art technologies up to ~R30 000 per kW_p for small residential installations or installations that are particularly complicated or use state of the art technologies. If an energy storage system in included in the installation, these costs can double, depending on the size of the storage system.

4.3: Electricity tariffs

The history of electricity billing dates back to very first power stations operated by Thomas Edison. In those days there were no meters and customers were billed according to the amount of light bulbs they had. These days electricity billing is slightly more sophisticated, with most customers paying for electricity according to the amount of energy used over time (the active energy charge in kWh) plus the maximum amount of power they are able to use at one time (the capacity charges in kVA). Some customers also pay a specific monthly or daily charge on top of this. The kWh charges will typically be higher if there are no other charges added. Larger customers are also most often on a rate that charges for both active energy and capacity, while many residential customers in SA still only pay for their active energy use.

All charges can be billed at a flat tariff, or it can be differentiated according to when and how much used. The time differential makes electricity consumed in peak hours in the winter much more expensive than the same amount consumed in off peak hours in the summer. The Eskom TOU times can be seen in Figure 8.

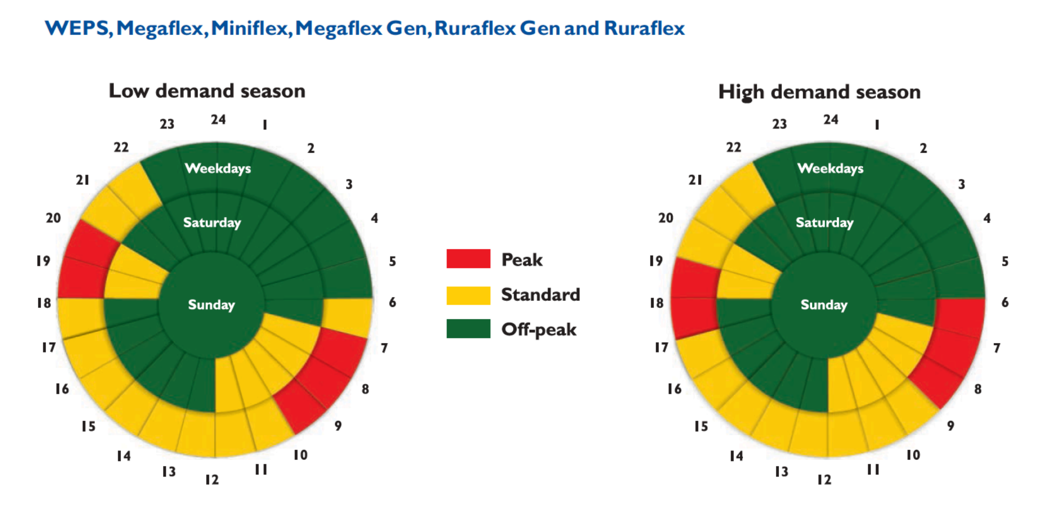

Figure 8: Eskom's defined time periods for most TOU tariffs

(Eskom, 2017)

It is also possible to charge customers according to a dynamic TOU. This implies that the applicable charges don't change according to a pre-set timing, but according to demand and supply of electricity at any given time. This type of billing usually forms part of a "smart grid" or "smart meter" scenario with real time information exchange. It is not available in SA as yet, but is gaining popularity worldwide.

Residential electricity customers in South Africa are typically charged at an inclining block tariff for their active energy use, most often making the additional electricity consumed above 600kWh for a specific month the most expensive. Most indigent South Africans have access to 50kWh of free basic electricity per month and are also typically on a lower electricity tariff for additional electricity purchased than other customers.

Electricity is distributed by either Eskom or the local municipality in SA, although some areas are serviced by private distributors. This most often happens in housing estates and commercial- or industrial parks, where the electricity is bought in bulk from the utility (either Eskom or the municipality) and resold to customers.

Municipalities in South Africa are allowed to cross subsidise other services from their income from electricity sales. This practice tends to make municipalities overtly aware of the revenue they might lose from customers installing rooftop PV systems.

For some customer types, the electricity tariffs are higher in areas serviced by the municipalities than the areas serviced by Eskom. This is especially true for larger commercial and industrial customers charged at Megaflex rates. These Eskom rates are similar for large customers as for municipalities and the municipalities have to add additional charges to cover the cost of distribution.

Many municipalities in SA now also offer SSEG tariffs. These tariffs typically include a higher monthly charge and a lower per kWh charge. The pricing for the electricity fed back into the grid (where this is allowed) is typically similar to the blended tariff that the municipality pays to Eskom.

4.4: The business case

The feasibility of a PV installation will depend on; the space available (strength, suitability, size); the design of the system (in relation to the space and resource available); whether an energy storage system is included; the system installation cost; the system operation and maintenance cost; financing options (such as grant or debt and tax incentives); the electricity usage profile of the site; the generation profile of the plant; the plant availability and; the applicable electricity tariffs (before and after the installation of the plant) (Scholtz, Muluadzi, Kritzinger, Mabaso, & Forder, 2017). These factors differ substantially between sites, so the specifics can only be determined with certainty through a pre-feasibility study. An example of such a study is the one conducted for Drakenstein Municipality in the Western Cape (Kritzinger, Meyer, van Niekerk, & Scholtz, 2015).

The most important of the factors influencing the feasibility of a PV system are;

- the **capital cost** of the system;
- the **active energy charge** of electricity (kWh)[1] and;
- the **electricity generated** by the system.

In some very specific cases, there will also be a saving on capacity charges (KVA) due for the PV installation. This will typically be in cases where the peak demand falls in the middle of the day. Take note however that some peak demand charges are only measured in the Eskom high demand times.

Even though the cost of PV installations has dropped significantly over the past few years, these still represent a significant investment. Total installation costs typically range from ~R11 per kW_p for very large, easy systems to ~R30 per kW_p or even higher for more complex and smaller systems.

Electricity tariffs differ significantly between areas and also per customer type. High use residential customers tend to pay the most per kWh, especially those customers who routinely use more than 600 kWh per month. This can be as high as R2,80 per kWh. Some small commercial customers are charged at an active energy charge only and this can be as high as R2.60 per kWh. Large commercial and industrial customers tend to have higher fixed and maximum demand charges and typically pay less for the active energy. This rate can be as low as 35c in the low demand, low season time.

Both the Eskom tariff and all municipal tariffs are approved by NERSA on an annual basis. This presents a significant risk to the electricity customer wanting to install a rooftop PV system as their electricity tariff might change significantly

[1] This active energy charge is often difficult to predict due to inclining block tariff for residential customers, TOU tariffs and the amount of electricity self-consumed vs. electricity fed back into the grid.

The solar resource also differs significantly according to location. See Table 1 for the yearly electricity generation per kW_p installed for different areas in South Africa. As expected, Kimberley, with its many sunny days, has the highest solar resource of these locations and Durban, with many cloudy days, the lowest. However, Durban still has a higher resource than Germany that has a high penetration of rooftop PV.

Table 1: Electricity generation per kW_p per area

Location	Annual PV output (optimally inclined)
Kimberley	1854 kWh/ kW_p
Pretoria	1731 kWh/ kW_p
Cape Town	1621 kWh/ kW_p
George	1423 kWh/ kW_p
Durban	1409 kWh/ kW_p

If only these three factors (cost of the system, cost of electricity and solar resource) are considered, a first stab as to the feasibility of a specific project can be easily calculated. The feasibility of a system installed in an area with 1 500 kWh/kW_p PV generation potential per year is shown in Table 2 for different installation costs and different active energy charges. The green blocks indicate projects that can be investigated further. The yellow blocks indicate projects that will only be feasible if there are additional incentives that affect the investment decision. The red blocks are not financially feasible options.

In the first column, a project at an installation cost of R10 000 per kW_p, will be feasible at an active energy charge of more than 90c/kWh. However, in the last column, a project at an installation cost of R30 000 per kW_p will only be feasible at an active energy charge of more than R2,70/kWh.

At an active energy charge of R1.00/kWh (row 7), a project will only be feasible at a capital cost of R10 000 per kW_p or lower. However, in the last row (at an active energy charge of R3.00/kWh) a project will be feasible even at a capital cost of R30 000 per kW_p.

If a project seems feasible with this first simple calculation, a more detailed study can be undertaken.

Table 2: Feasibility of PV systems at different costs for an annual generation of 1 500 kWh / kW_p

Cost per kWp installed → / Tariff per kWh charged ↓	R10 000	R12 000	R14 000	R16 000	R18 000	R20 000	R22 000	R24 000	R26 000	R28 000	R30 000
R0.30	22	27	31	36	40	44	49	53	58	62	67
R0.40	17	20	23	27	30	33	37	40	43	47	50
R0.50	13	16	19	21	24	27	29	32	35	37	40
R0.60	11	13	16	18	20	22	24	27	29	31	33
R0.70	10	11	13	15	17	19	21	23	25	27	29
R0.80	8	10	12	13	15	17	18	20	22	23	25
R0.90	7	9	10	12	13	15	16	18	19	21	22
R1.00	7	8	9	11	12	13	15	16	17	19	20
R1.10	6	7	8	10	11	12	13	15	16	17	18
R1.20	6	7	8	9	10	11	12	13	14	16	17
R1.30	5	6	7	8	9	10	11	12	13	14	15
R1.40	5	6	7	8	9	10	10	11	12	13	14
R1.50	4	5	6	7	8	9	10	11	12	12	13
R1.60	4	5	6	7	8	8	9	10	11	12	13
R1.70	4	5	5	6	7	8	9	9	10	11	12
R1.80	4	4	5	6	7	7	8	9	10	10	11
R1.90	4	4	5	6	6	7	8	8	9	10	11
R2.00	3	4	5	5	6	7	7	8	9	9	10
R2.10	3	4	4	5	6	6	7	8	8	9	10
R2.20	3	4	4	5	5	6	7	7	8	8	9
R2.30	3	3	4	5	5	6	6	7	8	8	9
R2.40	3	3	4	4	5	6	6	7	7	8	8
R2.50	3	3	4	4	5	5	6	6	7	7	8
R2.60	3	3	4	4	5	5	6	6	7	7	8
R2.70	2	3	3	4	4	5	5	6	6	7	7
R2.80	2	3	3	4	4	5	5	6	6	7	7
R2.90	2	3	3	4	4	5	5	6	6	6	7
R3.00	2	3	3	4	4	4	5	5	6	6	7

Conclusions and Recommendations

The installations of PV systems are growing year on year internationally and also in South Africa. This is both true for large stand alone PV power plants and for SSEG or rooftop PV systems.

While the large scale PV power plants are regulated through the REIPPPP, rooftop PV is installed at the cost and risk of the electriicty customer.

The laws and regulations most relevant to rooftop PV in South Africa are the ERA, the EPP, the IRP, the MFMA, the PFMA and the tariff structure of the electricity customer. The instalation has to further comply to all the network regulations for generators and needs a generation licence from NERSA if it is bigger than 1MW. If the PV is installed on governemnt buildings or by SOEs, the local procurement rules of the dti need to be abided by.

The business case for rooftop PV is mostly influenced by the capital cost of the system, the active energy charge of electricity (kWh) and the solar resource at the specific location.

Rooftop PV installations will assist SA to reach the carbon emmision reduction targets and are embraced and encouraged by all relevant authorities.

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Appendix A: PV power plants in South Africa from the REIPPPP (Forder, 2017)

Name	Capacity (MW)	Programme	Nearest town	Status
Aries Solar	9.7	Window 1	Kenhardt	Fully operational
De Aar Solar Power	50	Window 1	De Aar	Fully operational
Droogfontein Solar Power	50	Window 1	Kimberley	Fully operational
Greefspan PV Power Plant	10	Window 1	Douglas	Fully operational
Herbert PV Power Plant	19.9	Window 1	Douglas	Fully operational
Kalkbult	72.5	Window 1	De Aar	Fully operational
Kathu Solar Energy Facility	75	Window 1	Kathu	Fully operational
Konkoonsies Solar	9.7	Window 1	Pofadder	Fully operational
Lesedi Power Company	64	Window 1	Postmasburg	Fully operational
Letsatsi Power Company	64	Window 1	Bloemfontein	Fully operational
Mulilo Renewable Energy Solar PV De Aar	9.7	Window 1	De Aar	Fully operational
Mulilo Renewable Energy Solar PV Prieska	19.9	Window 1	Prieska	Fully operational
RustMo1 Solar Farm	6.8	Window 1	Rustenburg	Fully operational
SlimSun Swartland Solar Park	5	Window 1	Swartland	Fully operational
Solar Capital De Aar (Pty) Ltd	75	Window 1	De Aar	Fully operational
Solar Capital De Aar 3	75	Window 1	De Aar	Fully operational
Soutpan Solar Park	28	Window 1	Mokopane	Fully operational
Touwsrivier Project	36	Window 1	Touwsrivier	Fully operational
Witkop Solar Park	30	Window 1	Polokwane	Fully operational
Aurora	10.35	Window 2	Aurora	Fully operational
Boshoff Solar Park	60	Window 2	Boshof	Fully operational
Dreunberg	75	Window 2	Dreunberg	Fully operational
Jasper Power Company	75	Window 2	Postmasburg	Fully operational
Linde	36.8	Window 2	Hanover	Fully operational
Sishen Solar Facility	74	Window 2	Sishen	Fully operational
Upington Solar PV	8.9	Window 2	Upington	Fully operational
Vredendal	8.8	Window 2	Vredendal	Fully operational
Adams Solar PV 2	82.5	Window 3	Hotazel	Fully operational
Electra Capital - Paleisheuwel Solar Park	75	Window 3	Clanwilliam	Fully operational
Mulilo Prieska PV	75	Window 3	Prieska	Fully operational
Mulilo Sonnedix Prieska PV	75	Window 3	Prieska	Fully operational
Pulida Solar Park	75	Window 3	Kimberley	Fully operational
Tom Burke Solar Park	60	Window 3	Lephalale	Fully operational
Aggeneys Solar Project	40	Window 4	Aggeneys	Approvals, planning & financing
Bokamoso	68	Window 4	Leeudoringstad	Approvals, planning & financing

De Wildt	50	Window 4	Brits	Approvals, planning & financing
Droogfontein 2 Solar	75	Window 4	Kimberley	Approvals, planning & financing
Dyason's Klip 1	75	Window 4	Upington	Approvals, planning & financing
Dyason's Klip 2	75	Window 4	Upington	Approvals, planning & financing
Greefspan PV Power Plant No. 2 Solar Park	55	Window 4	Douglas	Approvals, planning & financing
Konkoonsies II Solar Facility	75	Window 4	Pofadder	Approvals, planning & financing
Sirius Solar PV Project One	75	Window 4	Upington	Approvals, planning & financing
Solar Capital Orange	75	Window 4	Loeriesfontein	Approvals, planning & financing
Waterloo Solar Park	75	Window 4	Vryburg	Approvals, planning & financing
Zeerust	75	Window 4	Zeerust	Approvals, planning & financing

Appendix B: PV Installation information brochure (CRSES, 2015)

Photovoltaic

DO YOU WANT TO INSTALL A PV SYSTEM?

WHY PV?

A. Because there is no electricity supply where you live?
B. To reduce your monthly electricity cost?
C. To have power during load shedding?

Use the decision tree to help you understand solar PV installations better and how PV can help fulfil your energy needs

1. Have you implemented energy efficiency measures?

Energy efficiency is usually the most cost effective way to reduce your electricity cost. Always put energy efficiency initiatives in place first. For example, replace all conventional light bulbs with energy efficient light bulbs.

2. When do you use electricity? And how much?

Understanding your load profile is key in designing an optimal PV installation, you need to know:

- When do you need the electricity? Summer, winter, every day, only weekends, day time, night time? Remember PV panels only produce electricity when the sun is shining and you will require batteries to store the generated electricity for later use if you do not use it when it is produced.
- How much electricity do you need? The average South African household uses approximately 4 600 kWh/year, thus a 3 kW installation (10 PV panels; 25 m^2) could cover 80% of this consumption.

3. Do you have available space to place the PV installation?

You will need an open area (roof or ground) without shading or obstructions for your PV panels.

- For a 3 to 6 kW installation approximately 25 to 50 m^2 of space is required
- North facing areas are ideal for maximizing your electricity production

4. What can I expect the installation to cost me?

As a guideline, the price of an installed PV system, including panels, inverter and cables (<u>no batteries</u>) ranges between R 18/W and R 25/W. For example: a 3 kW installation will cost between R 54 000 and R 75 000 (VAT incl.).

A system <u>with batteries</u> is likely to range between R 36/W and R 50/W; thus for a 3 kW system expect to pay between R 108 000 and R 150 000 (VAT incl.).

5. Do I need permission from my local municipality to install PV?

Each municipality has its own regulations, find out about these prior to installation.

Next Step? Pick the system that suits your needs

A. I do not have an electricity supply and require an alternative source of electricity

Off-Grid system: For a home or business that does not have a grid connection (usually far from grid connection points) namely: holiday home, telecom repeater, lighthouse or farm.

B. I want to reduce my monthly electricity cost

Grid-Tied system: A grid-tied system can reduce your carbon footprint and electricity bill by providing part of the electricity consumed from the PV system.

C. I want to be unaffected by load shedding

Hybrid system: A grid-tied system with battery back-up has the same advantages as a grid-tied system. In addition, such a system allows you to use solar energy in the evenings and on cloudy days as well as during load shedding.

BASICS OF EACH TYPE OF PV SYSTEM

GRID-TIED SYSTEM

- ⇒ Electricity from this PV installation is consumed directly at home or business.
- ⇒ No batteries = No electricity from the PV installation when very cloudy or at night.
- ⇒ Low maintenance, depending on the dust in the area cleaning of the panels may be needed .
- ⇒ Approximately 20 year life span, but you may have to replace the inverter after 10 years .
- ⇒ Some municipalities allow you to feed electricity back into the grid and will compensate you for this. If you live in an area where this is not allowed, or should you choose a tariff structure with no grid feed back allowed, the generated electricity that is not immediately used, will be lost.

A grid-tied system requires an active grid connection to operate, thus the PV system will not produce electricity during load shedding.

OFF-GRID SYSTEM

- ⇒ The system consists of PV panels, invertor and battery pack.
- ⇒ The sizing of batteries depends on your required load (kWh used) and solar resource in the area (the number of days without sun you need to energize: the more cloudy days, the bigger the battery).
- ⇒ Batteries require regular maintenance. The batteries will need to be checked weekly by the owner. It is best to have your system serviced yearly.
- ⇒ Approximately 20 year life span, but you may have to replace the in-verter after 10 years. Batteries will last from 2 to 10 years, depending on the usage profile and maintenance record.

For off-grid systems use gas or solar thermal energy for heating applications to reduce the required battery capacity, for example use a solar water heater for water heating and cook with gas.

HYBRID SYSTEM

- ⇒ The hybrid system consists of PV panels, invertor, grid connection and battery pack.
- ⇒ Backup power is limited to the capacity of the battery bank.
- ⇒ Batteries require regular maintenance. The batteries will need to be checked weekly by the homeowner. It is best to have your system serviced yearly.
- ⇒ Approximately 20 year life span, but you may have to replace the in-vertor after 10 years. Batteries will last from 2 to 10 years, depending on the usage profile and maintenance record.

If you have a hybrid system installed, the batteries should only power essential loads, for example lights, computers and freezer/refrigerator.

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