# Trends and statistics of Solar PV Distributed Generation in South Africa

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**Background and Introduction**

Rising electricity prices, potential for power outages awareness on the need to reduce greenhouse gas emissions, and decreasing technology costs have made investment into small scale embedded generation more attractive to many end-user consumers (residential, commercial, Industrial). Such installations are already commonplace in industrialised economies but developing countries, such as South Africa, are now observing a similar emerging trend as presented in this article. The installations reported here have capacities ranging from 1kW to 5MW and, as such installations continue to increase, the impacts are felt by multiple stakeholders across the energy sector. Such stakeholders include electricity distributors, municipalities, industry (manufacturers and installers), power system planners, the national grid operator, as well as policy-makers.

South Africa continues to experience an increase in consumers implementing this technology; a trend that can be traced as far back as 1992[1]. The trend of increased installation has only recently accelerated in earnest given the low electricity tariffs offered by Eskom prior to 2010. The trend in installations is visible across all segments of consumers including industrial, agricultural, commercial and residential. Solar PV costs are forecasted to decline and continue along this trajectory well beyond 2020 as shown below.

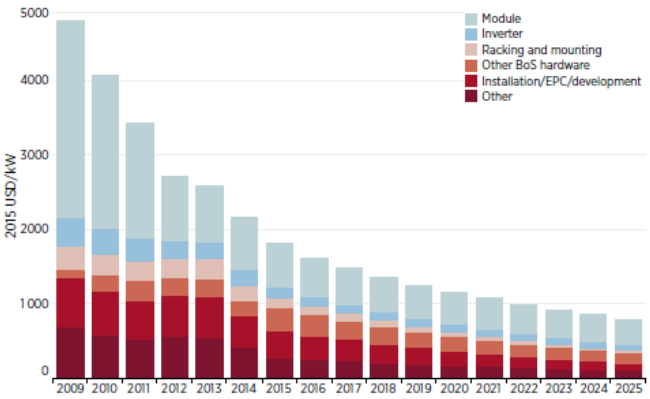


**Figure 1**: Forecasted cost trajectory for utility scale solar PV systems (Source: IRENA/Photon Consulting)

As solar PV and battery storage costs continue to decline, rooftop solar PV will provide an increasingly attractive business case to supply own consumption and as a backup intervention, with the inclusion of storage, when grid-based power supply is not available. Currently, statistics for the penetration of solar PV are based on industry estimates and can neither be regarded as comprehensive nor official. There is therefore a need to institutionalise the collection, verification, and validation of such statistics. The current statistics do, however, indicate that the rapid growth of

[1] SAPVIA; South Africa Solar Energy Technology Road Map - Solar PV Baseline Report 2013

rooftop PV is a reality in South Africa. As long as there is no official or effective SSEG[2] registration process for low-voltage connected customers in place, uncertainty about these numbers will remain.

**SSEG Registration and impact of installations**

The National Energy Regulator of South Africa (NERSA) has confirmed that they will be initiating a formal national registration process for SSEG, however, this process will most likely only be fully operational in the next 2 to 3 years. In the interim, certain municipalities have taken the initiative to establish their own registration processes to allow connection to their distribution grid infrastructure and, in some cases, as a prerequisite to qualifying for an embedded generation feed-in/net metering tariff. The South African Department of Energy (DoE) has recently released Schedule 2 to the Electricity Act of 2006[3] which revised the licencing and registration requirements for categories of generators. In accordance with these new rules, generators smaller than 1MW are exempt from having to obtain a licence but need to be registered with NERSA. The schedule 2 amendments allow customers to install small scale embedded generators (<1MW) without having to acquire a generating license from NERSA even if all or a portion of the energy is sold to other parties.

This article estimates the quantity of rooftop PV Embedded Generation (EG) installations between 2003 and December 2017 based on information collected from 3 sources namely: Eskom, municipalities with a formal registration process for these installations and Power Quality Renewable Service also known as PQRS (a South African private sector firm that tracks such installations).

These rooftop PV installations impact various stakeholders on several levels, such as revenue loss to municipalities and distributors, impact on the electricity grid and system operations in terms of forecasting residual load and the accuracy of short and long term net demand forecasts. As more South African customers install rooftop PV, the following engineering challenges could surface:

- Power quality issues due to harmonics from generation sources using power electronics.
- Voltage variations due to reverse power flow in the distribution network.
- Thermal stress of distribution network equipment due to potential increased loading during periods of peak generation.
- Protection and safety concerns due to possible islanded operation and protection mal-operation.[4]

**Growth in Small-scale Embedded solar PV installations**

Ministerial Determinations gazetted in 2011, 2012, and 2015 allow for the procurement of electricity from utility and small scale renewable generation. The utility scale projects have been procured via the Department of Energy Independent Power Producer Programme and formal statistics are available for these utility scale plants. Embedded generators fall outside of the formal government procurement programme and are not accounted for in the utility scale program statistics.

[2] Small-scale Embedded Generation
[3] South Africa Gazetted DOE; Electricity Regulation Act 2006 - Schedule 2, Licensing Exemption & Registration Notice 2017
[4] Farhoodnea, Masoud; Mohamed, Azah; Sharreef, Hussain; Zayanderhoodi, Hadi; Power Quality Analysis of Grid-Connected Photovoltaic Systems in Distribution Networks 2013

There are currently 34 municipalities in South Africa who have an approved registration process designed for grid connection of small scale embedded PV installations. Seven municipalities have NERSA approved feed-in tariffs as summarised in Table 1. These tariffs demonstrate that several municipalities are in fact allowing export of energy into their distribution grids and compensating customers accordingly.

**Table 1:** Net-Metering schemes used in municipalities

| Municipality | Feed-in tariff |
|---|---|
| **City of Cape Town** | 70.08c/kWh for every kWh exported |
| **Theewaterskloof** | 48c/kWh for every kWh exported |
| **EThekwini** | 68c/kWh for every kWh exported |
| **City of Tshwane** | 10c/kWh for every kWh exported |
| **City Power** | 36.14c/kWh - 42.79c/kWh for every kWh exported |
| **Nelson Mandela Bay** | Net-metering (compensated at import tariff) |
| **Overstrand** | 65.25c/kWh for every kWh exported |

Data received from various sources shows that there is approximately 285$MW_P$[5] (DC) of small scale solar PV (rooftop and ground-mounted) installed in South Africa as at December 2017. This figure is calculated using data received from PQRS, SMA inverters (a local distributor of PV inverters), municipalities and Eskom registered installations. The total number of installations equates to approximately 139,556 units. The installed capacity of small to medium scale solar PV installations results in a market share percentage of 0.65% of the total national generation capacity of 44.134GW[6]. In addition to these grid-based installations, there are 87 150 off-grid systems with a total installed capacity of 14.35$MW_P$. A depiction of the yearly growth from 2003 to 1 December 2017 is represented in Figure 2, where the green bar represents the annual increase in installed capacity. As is evident from Figure 2, installation rates have been accelerating over the last 5 years and this trend that is likely to continue as customer business cases for such installations further improve.

[5] Eskom Research, Testing and Development study by Aradhna Pandarum, 2018
[6] Eskom; Eskom Integrated Report 2017

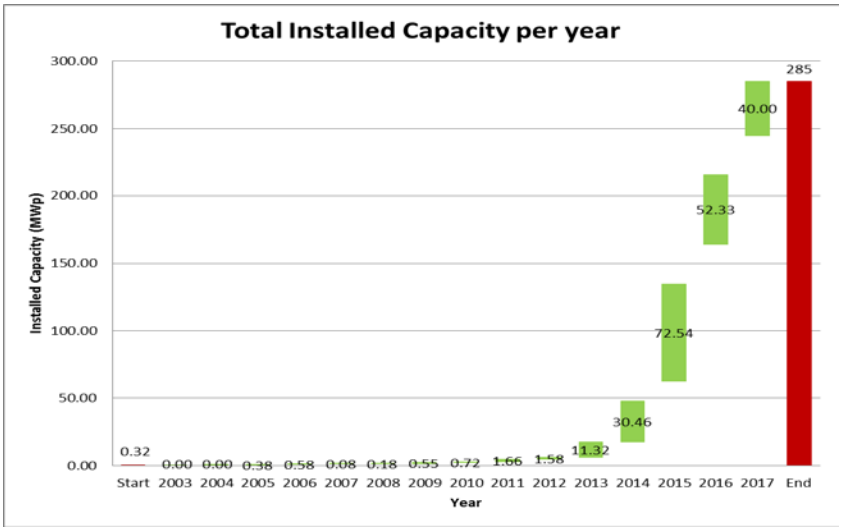


**Figure 2**: Annual total installed capacity ($MW_P$)

**Small-scale embedded solar PV by sector and province**

Figures 3 and 4 respectively illustrate the total installed capacity and number of installations in each sector per province. The highest penetration of installations is in the Gauteng and the Western Cape provinces, predominantly due to a combination of significant commercial and industrial sectors in these provinces and enabling policies and feed in tariffs in selected municipalities. The commercial and industrial sectors contribute to 69.8% of the total installed capacity, followed by a 22.5% and 7.7% contributions from the agricultural and residential sectors respectively. The main driver for the installation of solar PV in the commercial and industrial segments is that their electricity demand profile follows a similar profile as the solar PV production profile allowing the generated electricity to be self-consumed without the need for any energy storage. Self-consumption of electricity generated from embedded installations is particularly valuable in South Africa since the feed-in tariffs offered by municipalities are generally lower than applicable electricity retail rates when purchasing electricity from the municipality. Another major factor driving the uptake of embedded solar PV includes the desire for longer term electricity price certainty particularly for energy intensive users. Such installations are also facilitated via general access to roof space in commercial and industrial parks/buildings.

The statistics also show that small-scale embedded solar PV has a valuable contribution to make in the agricultural sector. In light of national electrification targets and the statistics in Figures 3 and 4, it is clear that embedded installations are already making inroads in at least some remote agricultural settings where the cost of service may be prohibitively high for Eskom and municipalities. Small scale on-site generation should therefore be encouraged particularly in these situations where conventional grid-based approaches may not be optimal.

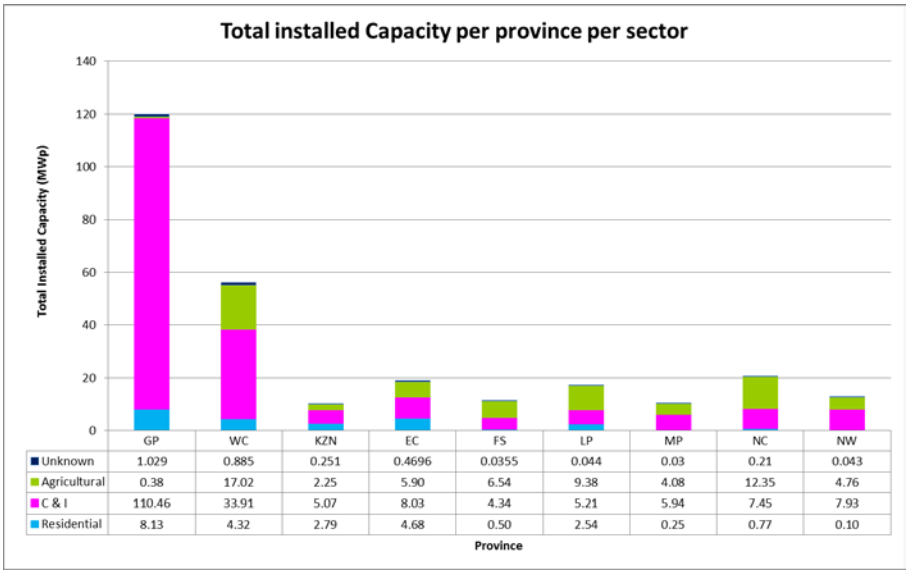


**Figure 3:** Total capacity installed in each sector per province

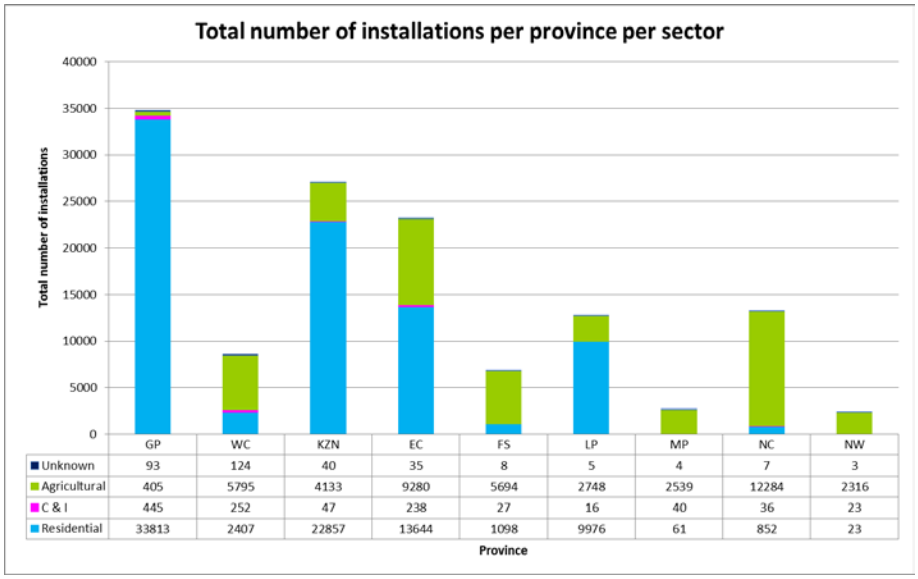


**Figure 4:** Total number of installations in each sector per province

The charts above demonstrate that the growth in the small scale market for solar PV will not necessarily mirror what has so far been observed with utility scale PV projects. As shown in Figure 5, the majority of utility scale solar PV projects in South Africa are based in the Northern Cape primarily due to good solar irradiation resource which is essential for any competitive project under the national Renewable Energy Independent Power Producers Procurement Programme (REIPPPP). This demonstrates that for utility scale projects in South Africa, the most important drivers are the REIPPPP competitive bidding process and auction design that encourages project developers to locate projects where there factors combine for the lowest levelised cost of electricity (i.e. highest solar resource, no grid congestion and low grid connection cost)

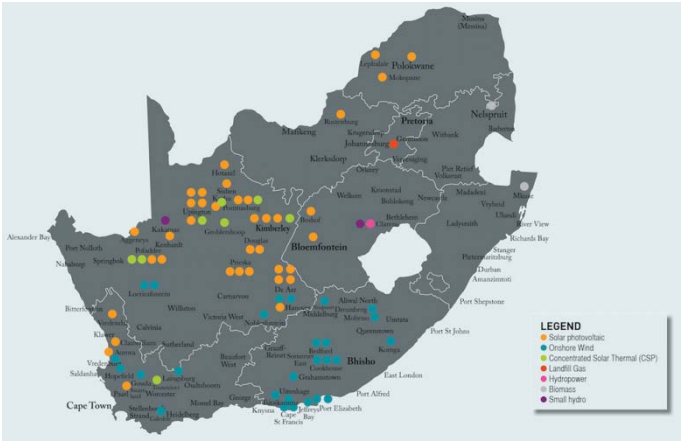


**Figure 5**: Geographical distribution of renewable energy projects under the REIPPPP (Bid Windows 1 -4)

The customer business case and hence growth of the embedded solar PV market is dependent on a range of factors that are not identical to those under the REIPPPP - these include: distributor retail tariffs, distributor feed-in tariffs, customer load profile, magnitude of the solar irradiation resource, return expectations, green energy aspirations and available land or rooftop area. These markets factors influence the distribution of projects across sub-sectors. In terms of installed capacity, the commercial and industrial sectors clearly dominate the small-scale embedded generation market. Within this subsector, the available statistics as depicted below show that retail, factories, and offices make up the majority of installed capacity.

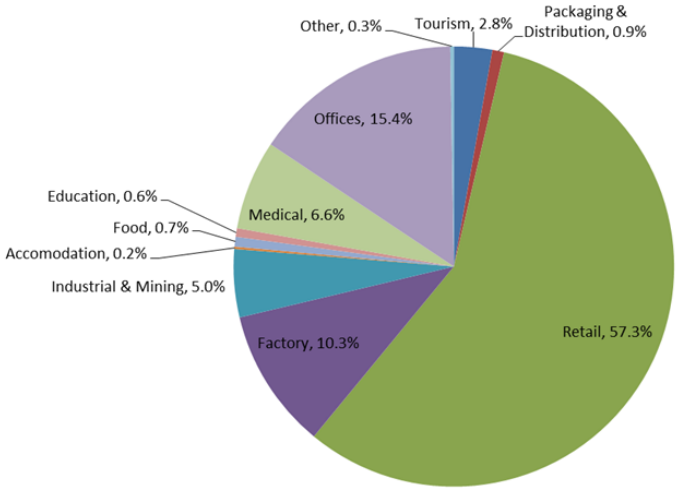


**Figure 6:** Sub-sector analysis by installed capacity for the commercial and industrial sector

### Growth prospects for small scale embedded solar PV

The current drivers for further growth of small scale solar PV are expected to remain at least over the medium term of 5-10 years. With wholesale and retail electricity tariffs not expected to decrease; solar PV technology prices set to continue decreasing; and more distributors offering feed-in tariffs; conditions will support small scale embedded solar PV. This is reflected in the expected growth for the uptake of small to medium scale solar PV for years 2018-2025 as represented in Figure 7. This figure illustrates that by 2025 there will be an installed capacity for small to medium

scale solar PV of 2.33GW[7] based on extrapolating current installation trends, increasing customer awareness of embedded generation, and upward cost trajectory of conventional grid based power supply.

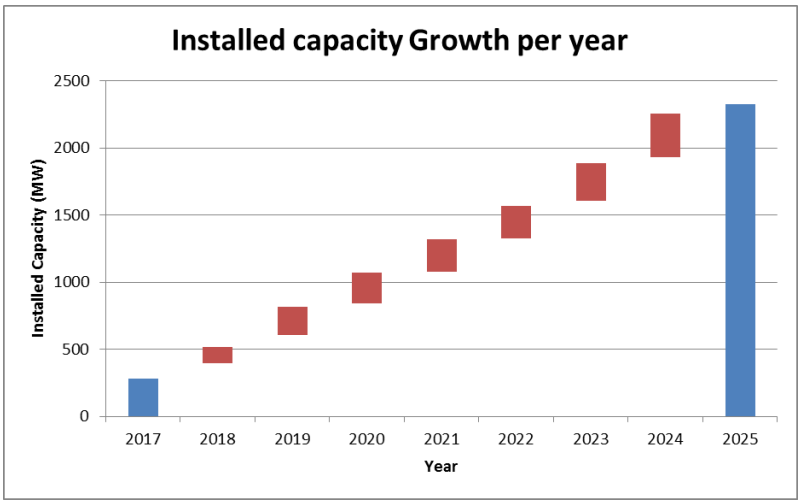


**Figure 7:** Growth in capacity for small to medium scale PV from 2018 to 2025

**Conclusion**

As small-scale embedded generation continues to grow, various stakeholders need to position themselves for a power supply mix that is more diverse in terms of technology options as well as size of generation units. This re-positioning will require more accurate tracking of small-scale installations to ensure deeper understanding of this market. The aggregated impact of thousands of installations will also eventually become visible to the national power system operator while becoming a major consideration for power system planners. The current efforts to register installation should therefore be viewed as a first step in managing wider effects that are yet to come.

Several complementary technologies are also emerging that may further accelerate deployment of small scale solar PV such as batteries. In the future, mandatory information for registrations will need to expand to include not only the PV manufacturer, inverter, and location, but also include details on the use of batteries and any tariff structures applicable or used by the customers using small scale embedded solar PV. This information should be updated on a regular basis – at least at 6 month intervals and potentially be made publicly available. With this added information in the registry, trends and statistics for solar PV installations will shed light not only on market share, but also on municipal revenue impact, as well as net residual demand that will be further impacted by deployed battery technologies. Ultimately, this allows observation of trends by jurisdiction thereby informing policies to further support or regulate these installations.

[7] Eskom Research, Testing and Development study by System Dynamics, 2018