SOLAR PV AND EMBEDDED GENERATION IN SOUTH AFRICA

Status Quo Assessment

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CONTENTS

1. INTRODUCTION

The aim of this report is to produce a status quo summarising the solar PV market internationally and locally. The report forms part of a broader initiative to develop a solar PV programme in Cape Town, eThekwini Municipality and Ekurhuleni's inner city areas. A number of sub-programmes are attached to this programme including solar PV resource potential assessment, clarifying the legal framework as well as assisting in implementation of solar PV systems in each of the three municipalities. The status quo report reviews solar PV price and technology trends as well as the current status with national and local government regarding embedded generation.

2. PV PRICE AND TECHNOLOGY TRENDS, LOCALLY AND INTERNATIONALLY

In recent years, there has been a huge uptake of photovoltaic (PV) systems internationally, primarily due to the declining cost of PV systems and set against the backdrop of the increasing electricity prices and the trajectory towards low carbon development.

In South Africa, the recent price escalations announced by Eskom and NERSA (National Energy Regulator of South Africa) have further incentivised the usage of small scale embedded generation such as solar PV installations. Currently, there are few incentives provided by government, primarily due to the tariff structure and the cross subsidisation opportunity which electricity provides.

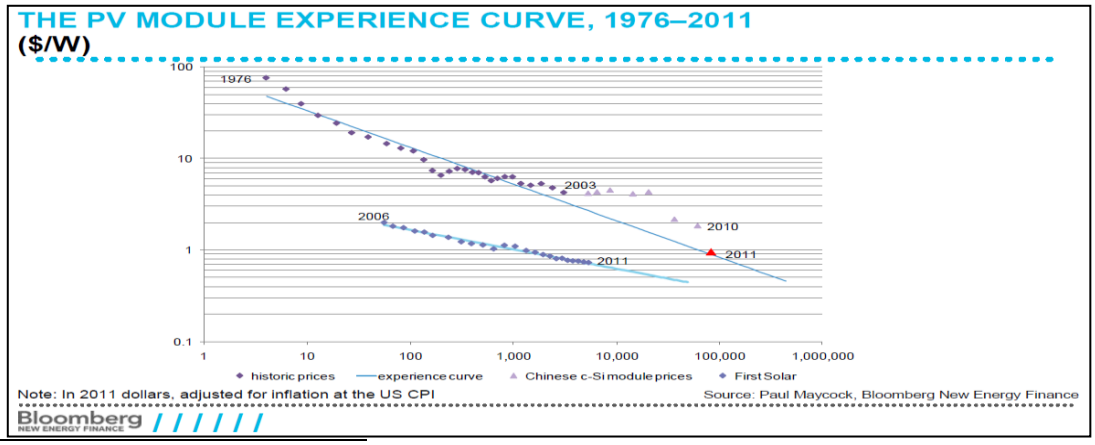
According to several researchers from The National Renewable Energy Laboratory and Lawrence Berkeley National Laboratory in the United States, the best way to analyse the price of PV systems is by looking at its capacity. As the capacity of the system increases, the price per Watt produced will decrease. Another way of viewing this is that the scale of savings will generally be higher for commercial sector installations as opposed to residential ones due to the scale of the system. For this report, a holistic investigation of pricing system is taken, not specifically just the impact of capacity.

2.1 International Price Trends

Internationally, the price of a PV system has decreased between 5% and 7% year on year from 1998-2011, and even faster at 11%-14% between 2010 and 2011. The figures exclude installation costs, which are expected to increase at a rate which is in line with a country's prevailing inflation rate.. The general price decrease internationally is attributed to solar PV activity in China where several large factories (commissioned in 2010) started producing high quality, cheap PV panels.

Further reductions in the order of 25% are expected year on year from 2013 onwards for several years, also due to China's increased production. In March 2013 there was a 4% increase in the price of PV panels coming out of China's largest manufacturer, attributed to demand temporarily exceeding supply during that period[1].

The graph below shows the international price curve on a logarithmic scale, and has plotted the price of the cheaper, Chinese panels separately, showing a very steep decline in price (Bloomberg, 2012).



[1] Also attributed to a delayed shipment to Europe according to Feldman et. al, 2012).

2.2 South African Price Trends

South Africa price trends mirror those internationally, with a slight delay. Solar panels in South Africa which are imported from China are generally affected by the exchange rate, and therefore the price will fluctuate, but the price trend is generally decreasing.

As the price of solar PV technology is on a decline, so too is the price at which generators are feeding their produced electricity back into the national grid as part of the Renewable Energy Independent Power Procurement Programme (REIPPP). According to the South African Photovoltaic Industry Association, the cost to produce renewable energy has dropped by around 40% since the programme began and has gone from an average tariff of R2.75/kWh in the first round bidding process to an average of R1.65/kWh in the second round. This has mainly been attributed to technological advances of solar PV. This shows evidence of decreasing costs of solar PV energy production and can be translated to the private sector for embedded solar PV generation.

2.3 PV technologies

PV was first developed in the 1950s to power satellites. Since then, the fundamental design of PV systems and specifically the PV cell has not changed. The intensity of the sunlight on the cell and the cell's temperature are the major factors which determine the output of the cell. However, the efficiency of a PV cell has doubled over the last 30 years.

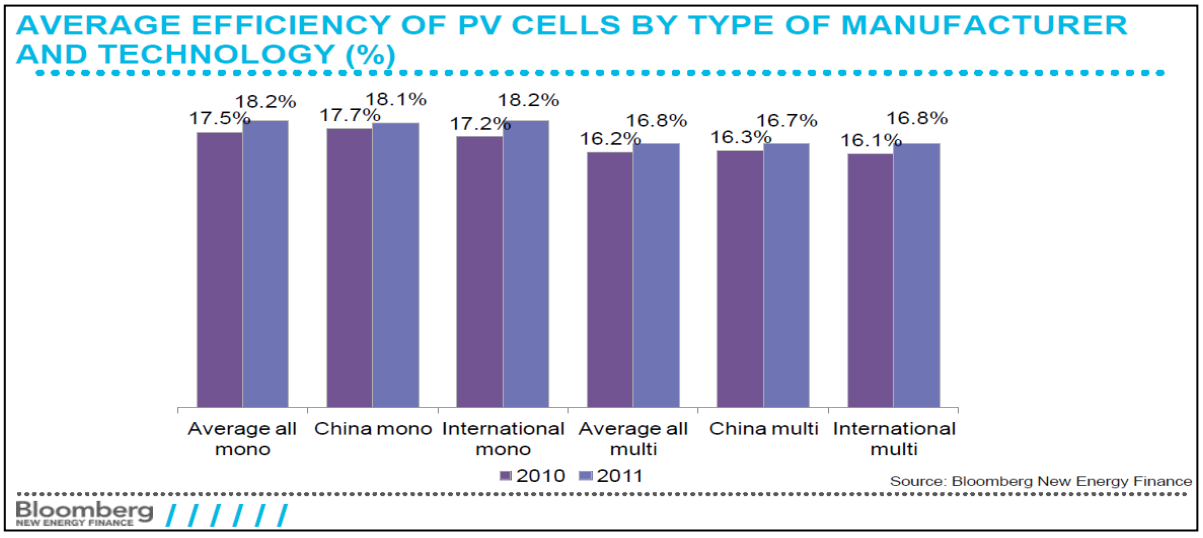
2.3.1 Crystalline silicon cells versus thin film

The most predominant types of PV systems are either mono- or poly crystalline silicon cells or thin-film solar modules. The pure silicon required for the mono- or poly-crystalline systems usually come at an inhibitive price, and often thin film systems are used. These thin-film systems are not as efficient but they are significantly less expensive and are therefore gaining market share.

2.3.2 Difference in efficiencies

The majority of thin-film modules have efficiencies in the region of 8-12%, with the most efficient module available being a mono-crystalline pure silicon module which is 22.1% effective.

The efficiencies of solar cells is increasing but at a slow rate due to increased demand for cheaper products and development and growth within in the industry in general (Key, T., & Peterson, T. 2009). The graph below depicts some of the efficiencies which are available by manufacturer and type of solar technology (Bloomberg, 2012).



2.3.3 Life span of panels

Another factor which must be taken into account is the degradation of the different types of solar panels over time. The primary cause of solar panel degradation is the way that the panels are wired to one another and how they are grounded. Large, high voltage systems (generally over 600V) must be grounded in order to avoid excess voltage building up and damaging the system (Pingel, S., et al, date unknown). Solar arrays generally have guarantees in excess of 25 years, with mono- and poly-crystalline modules generally lasting longer than thin film modules. The fine print for these warranties generally state 80% of rated power generation available after 25 years, which is the norm (Vazques, M., & Rey-Stolle, I., 2009).

3. LOCAL EXPERIENCE IN SMALL SCALE EMBEDDED GENERATION

Embedded generation is included as an important area in the Integrated Resource Plan (IRP) and is seen as an important demand side measure for the government and particularly the Department of Energy (DoE). Policies which have been set up to enable its use in the national energy mix, although there is debate around the currently legality of connecting and feeding back to the national grid. The concerns from Eskom and NERSA are that the cost implications and infrastructure has not yet been set up for this. Municipalities in South Africa have interpreted the legislation around this differently, as explained in the following sections.

In the meanwhile the growth of the PV market has increased as confirmed by the South African Photovoltaic Industry Association (SAPVIA). SAPVIA's membership has grown from 7 in 2010[2] to 107 at present. SAPVIA holds together solar PV suppliers and manufacturers in South Africa. This is indicative of strong growth in the PV market segment in South Africa.

[2] Executive Manager Natalie Bezuidenhout, SAPVIA (Pers. comm. via Email, 11/7/2013)

4. CURRENT STATUS OF EMBEDDED POWER GENERATION IN SOUTH AFRICA

4.1 Background

South Africa has the high potential of using solar energy as a renewable energy source with some provinces having the insolation of about 4.5-6.5 kWh/m^2 (Chang *et al* 2011). Under IRP2010 the country has set itself a target of about 8400 MW of electricity generation using Solar PV by 2030. On 3 August 2011, the Department of Energy (DoE) published the Renewable Energy Independent Power Producers Procurement Programme (REI4P) which aims to award power purchase agreements (PPAs) to projects with an overall capacity of 3725 MW to be installed by the end of 2016 (SAGEN-GIZ 2013). The REI4P allows for large-scale renewable energy projects that have a peak capacity of around 10 MW. Small scale embedded generation is usually less than 1MW.

Small-scale renewable energy has been successfully implemented internationally to promote sustainable energy use as well as to reduce the demand on the national energy supply. In South Africa, Eskom and the National Energy Regulator of South Africa (NERSA) view small scale embedded generation (SSEG) of electricity for consumption on site as a measure to reduce the electricity demand placed on the national grid (Knox *et al* 2012). In 2012/13 Eskom commenced a three-year pilot which offered a rebate for small scale renewable energy projects under their Standard Offer Programme. The programme aimed to procure 10MW from various renewable energy technologies including solar PV. The programme targeted projects between 10kW and 1MW with the main offering being that Eskom would pay the developer R1.20 for each kWh of electricity produced on weekdays and during the day over a three year period. The rebate has been discontinued as of August 2013 when Eskom put a moratorium on the programme. With this vision NERSA has approved standard conditions for small scale embedded generation of less than 100kW (NERSA 2011) discussed below.

Sunny Portal is a website based monitoring system for PV installations whereby users are able to communicate their system outputs, which are then logged and viewable via the website. PV developers are able to choose whether they would like their information to be made publicly viewable or to be kept private from other users. The website provides an interactive user interface that allows for real-time monitoring of the electricity produced by the connected installations and allows guest users to view installations across the world based on their country and city of choice.

Based on the data available on Sunny Portal it is evident that there are currently no less than 63 installed PV systems in South Africa. The sizes of the individual projects range from a large number of small capacity of 1.2 kW installed at a primary school in Frasers to a few larger installations such as Vodacom Century City's 542.4 kW system.

The PV installations are shown to be spread across the country with the dominant areas being Cape Town, Johannesburg (and surrounding areas) and Durban as well as a substantial number of systems in Stellenbosch with the type of developer or users ranging from schools, private residencies, farms, small businesses and large businesses.

4.2 Standard conditions for embedded generation in Municipalities

In summary the standard conditions require the municipalities to (NERSA 2011):

- Maintain a database of all small scale (<100kW) embedded generation within their area and report to the Regulator on an annual basis proving the following information:
    - number of installations for each technology
    - total capacity for each technology installed
    - the total energy each technology has generated onto their system in each "Time of Use tariff" metered time period
    - complaints that they have received from customers on the same circuit as the generation about quality of supply
    - all safety related incidents involving this generation
    - the tariffs applicable to these installations
    - the Standard Supply Agreement.

- Ensure safety of municipal operating personnel.
- Ensure that the NRS 097-2-1:2010 Grid interconnection of Embedded Generation is complied with.

4.3 Legislation and Standards

There is no clear policy at national level to promote embedded generation other than that recognizes embedded generation as a demand side measure (Knox *et al* 2012).

The Electricity Regulation Act 4 of 2006 amended in 2007 outlines regulations required when being involved in any electricity activity as well as those that are exempted to hold or apply for a license for electricity operations (DOE 2011). The details of this regulation can be found in the link in appendix A.

Small scale generators generating for own use and/or connected to the grid with an installed capacity less that 1 MW will be exempt from further compliance according to Schedule 2. However all EPGs (even those generating for own use and not connected to the grid) are requested by NERSA to at least submit the standard generation application form in order to notify/register with NERSA (Knox *et al* 2012). The submission of the application form will serve as a way to register and keep track of how many generators are generating what and how (Knox *et al* 2012). NERSA has recently stated that in areas where Municipal areas of electricity supply, Municipalities may submit these on behalf of the embedded generator.

4.4 Standards and specifications

The national standards that should be conformed for quality, safety and stable supply of electricity and connection to the grid, licensed distribution and generation are listed in Appendix 1(b) (Cited by Knox *et al* 2012).

5. EMBEDDED GENERATION IN THE CITY OF CAPE TOWN

5.1 Status

Project developers wishing to connect their renewable energy projects to the electrical grid are currently unable to do so in the City of Cape Town. The City will allow renewable energy projects provided that the energy is for own use. At present the Electricity department is in the process of allowing feedback to the grid but this is no date has been set for this. Small-scale embedded generation tariffs have been devised but this has not yet been implemented. In addition,

An application form is available on the Electricity Services page of City of Cape Town website http://www.capetown.gov.za. Electricity Services Customer Support Services East, South and North at Bloemhof,Wynberg or Ndabeni respectively may be contacted for more information.

The 2011 status of development of standards and policies and practices was permitted to only consider applications from non- residential generators of size **not smaller than 100kW** who wish to run their generation in parallel with the City's Distribution network on **condition that reverse power flow onto the distribution network is not possible** (COCT 2011)**.** The City is therefore not able to compensate generators for any net electrical power fed onto the distribution electrical grid, and was also not yet in a position to allow "net metered" connections where excess generation is offset against consumption of electricity on a unit for unit basis.

The local electricity grid's ability to absorb the generated power would be one of the factors determining whether the connection of the generator to the grid would be allowed. The city's electricity department provides the technical requirements to the aspirant generators who comply with the above and seek permission to connect their embedded generation parallel to the grid.

Proof of compliance with National Electricity Regulation Act [Act 4 of 2006] requirements regarding generator licensing will be required before applications to connect in parallel with the City's electrical grid will be processed.

Up to now City of Cape Town has not finalized the SSEG policies. According to the city report in 2011 the application for residential and non-residential SSEG smaller than 100kW would only be considered once the SSEG prepayment meters are available commercially and once the SSEG policies are finalized (COCT 2011), of which the SSEG prepayment meters are currently are available. This information can be found in the link under appendix 2.

The renewable energy target for the City of Cape Town is 10% renewable and cleaner energy of total energy supply by 2020 (COCT 2012).

5.2 Legislation, Standards and Normative Reference compliance

In addition to the standards mentioned Appendix 1, the generator should comply with regulations mentioned under of City of Cape Town Electricity Department for Electrical Requirements for Embedded Generation. This can be found under link in appendix 2

5.3 Electricity tariffs in 2013

5.3.1 Residential Tariffs

This tariff is available only for approved residential SSEG Connections, where the consumers offset their small scale generation against their purchases from the Municipality, provided that their purchases exceed their generation. An additional meter reading fee may also be applicable (COCT 2013). Although these tariffs currently exist they have not been implemented.

- Service charge (including VAT) = R12.08/day
- Energy charge- consumption = R1.01/kWh
- Energy charge- generation = R0.53/kWh

Residential tariffs without SSEG connection and use more than 450kWh/month are charged:

- Energy charge for those consuming 451-600kWh/month = R1.42/kWh (VAT incl.)
- Energy charge for those consuming 600+kWh/month = R1.73/kWh

5.3.2 Non-residential tariffs

For non-residential SSEG the tariffs are as follows except for the Small Power Users2 (SPU2):

- Energy charge-generation = R0.53/kWh

For small Power Users 1 (>1000kWh/month)

- Service charge = R23.56/day
- Energy charge = R0.13/kWh

For Small Power Users 1 (<1000kWh/month:

- Service charge = R23.56/day
- Energy charge = R1.99/kWh

These tariffs are taken from the City of Cape Town's Electricity Department and may be accessed here: http://www.capetown.gov.za/en/electricity/Pages/ElectricityTariffs.aspx

6. EMBEDDED GENERATION IN ETHEKWINI MUNICIPALITY

6.1 Status

The eThekwini Municipality accepts grid connection applications from renewable energy EPGs. Applicants are required to provide the technical specifications of the mode and energy/fuel source for embedded generation, as well as type of energy conversion, total generation capacity, total export generation capacity, electrical parameters, generator transformer parameters, network connection point, protection details, proposed output levels, etc.

As with all municipalities in the country, eThekwini Municipality is authorised to purchase electricity from embedded generators at the rate at which municipalities are charged to purchase electricity in bulk from Eskom, known as the Mega Flex rate, which is roughly half the price of the consumer price of electricity, or approximately 50-60 cents per kWh. The application form for the connection of embedded generation to the grid can be obtained at from eThekwini's Municipality's website: (http://www.durban.gov.za/Resource_Centre/Current%20Projects%20and%20Programmes/energyoffice/Pages/Embedded-Generation.aspx)

Once approved the generators must sign a Power Purchase Agreement (PPA) with eThekwini Municipality. The PPA may last for a maximum period of three years, after which it can be renewed.

6.2 Renewable energy targets

In 2008 eThekwini Municipality commissioned an Energy Strategy which set targets for carbon emissions reduction for the city. A target of 27% reduction by 2020 was set, which covers various sectors. Renewable energy is seen as a strategy for achieving that target and the city has aimed at promoting renewable energy rollout in the city.

6.3 Electricity Tariffs in 2013

6.3.1 Residential

- Residential Credit tariffs: Energy charge (VAT incl.) = R1.23/kWh
- Residential prepaid tariffs: Energy charge (VAT incl.) = R1.23/kWh
- Free basic electricity = 65kWh/month to customers who use less than 150kWh/month
- Residential time of use tariffs foe customers using greater than 1000kWh electricity per month but manages to shift their load away from peak period towards standard or off-peak periods would benefit from lower energy costs as follows:

Peak (R/kWh)	Std (R/kWh)	Off-peak (R/kWh)	Service charge (R/month)
1.58	0.75	0.59	85.23

6.3.2 Business Tariffs (Commercial and small Industrial customers)

Commercial Time of Use (CTOU)

This tariff is designed for Business and Industrial customers with a Notified Maximum Demand equal to or less than 100 kVA.

June to August – High season (R/kWh)		
Peak	Std	Off-peak
2.09	1.04	0.51

September to May – low season (R/kWh)		
Peak	Std	Off-peak
1.03	0.83	0.48

- Net demand charge all seasons = R44.48/kVA
- Service charge = R220/month
- Network surcharge for network demand ≥ R110kVA

Business and general credit tariffs

- Service charge (VAT incl.) = R180.71/month
- Energy charge (VAT incl.) = R137.85/month

For prepaid customers, energy charges = R1.53/kWh

7. EKURHULENI MUNICIPALITY

7.1 Status

Currently there is no clear policy in Ekurhuleni municipality that promotes the EG except the diversify energy supply in the municipality which includes renewable energy supply (Thenga 2012). This include solar street lighting which is off-grid that is in Germiston head office and civic centre. These lights provide 12 hours night lighting and 48 hours of standby time in case of bad light. There is also a promotion and implementation of low carbon demonstration projects at the OR Tambo Centre in Benoni (Thenga 2012). This includes the 3 X 200kWp PV solar farm which would power the facilities at the centre and the surrounding low cost housing area.

The Ekurhuleni municipality is targeting 10% of energy supply to come from renewable and clean energy technologies by 2020 (Thenga 2012).

7.2 Electricity tariffs in 2013

7.2.1 Tariff A for small businesses

This tariff is available for single-phase 230 V connections or multi-phase 400/230 V connections with a capacity up to 80 A per phase. It is suitable for low consumption micro business customers.

Fixed service charge (excluding prepaid customers) =R27.63/month

Energy charge (Excl VAT) = R1.45/kWh

7.2.2 Residential Tariff A (IBT)

A1 Block (1-600kWh) = R0.79/kWh (VAT excl.)

A.2 Block (>600 to <=700 kWh) = R1.32/kWh

A.3 Block (>700 kWh) = R2.20/kWh

The rest of electricity tariffs at Ekurhuleni Municipality can be found in: www.**ekurhuleni**.gov.za/residents/customer-information/**tariffs**

8. APPENDIX 1

1(a) **Electricity Regulation Act 4 of 2006 Second Amendment Bill**. Published in government gazette of 19 December 2011 vol. 558 no.34870
1(b)
NRS 097-2-1: Grid Interconnection of Embedded Generation
NRS 029: Current transformers for rated ac voltages from 3,6kV up to and including 420kV
NRS 030: Electricity distribution – Inductive voltage transformers for rated ac voltages from 3,6kV up to and including 145kV for indoor and outdoor applications
NRS 031: Alternating current disconnectors and earthing switches (above 1000V)
NRS 037 -1: Tele-control Protocol for stand-alone remote terminal units
NRS 048: Electricity Supply: Quality of Supply
NRS 054: Rationalized User Specification - Power Transformers
SANS 1019: Standard voltages, currents and insulation levels for electricity supply
SANS 61936-1: Common rules of power installations exceeding 1 kV a.c
South African Distribution Code: The distribution code (section 8.4.1.1 (1)) requires that all embedded generators of nominal capacity of 10MVA shall in addition to the requirements of the distribution code; also comply with Section 3.1 of the South African Grid Code: Network Code
South African Grid Code: Section 3.1 specifies the minimum technical and design requirements for embedded generators.

For safe installations of power systems on buildings or other property, EPGs must where appropriate conform to the national standards for (this list is not exhaustive):
SANS 10142 – 1: 'Wiring Code'
NRS 052-3: Off-grid Solar Homes
NRS 057 -4: Electricity metering Part 4: Code of practice
Structural use of steel: SANS 10162-2

9. APPENDIX 2

Electrical requirements for embedded generation under City of Cape Town Electricity Services http://www.sapvia.co.za/wp-content/uploads/2011/10/ElectricalRrequirements-for-Embedded-Generation-29-07-11.pdf

10. APPENDIX 3

Power Purchase Agreement between embedded generator and eThekwini Municipality: http://www.cityenergy.org.za/files/resources/generation_workshop/PPA%20for%20embedded%20generation%20(eThekwini%20Metro%20council%20March%202012).pdf