Potential for distributed solar photovoltaic systems in the Western Cape Province

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Brief project description	This project quantifies the maximum installation capacity of solar photovoltaic for the Western Cape region and models the impact that this installed capacity will have on balanced electricity supply and demand.		
Key findings	The total amount of PV that can be installed in the Western Cape Province before grid studies are needed, is a very conservative 593 MW_p. Should this amount of PV be installed at least 950 GWh of electricity will be generated per year.		
Keywords	Solar photovoltaic potential, transmission sub stations, generation, Western Cape		

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DNI	Direct Normal Irradiation
EG	Embedded Generation
GHI	Global Horizontal Irradiation
GTI	Global tilt irradiation
GW	Gigawatt
GWh	Gigawatt hour
ha	Hectare
HV	High Voltage
kW	Kilowatt
kWh	Kilowatt hour
kW_p	Kilowatt peak
LV	Low Voltage
MV	Medium Voltage
MW	Megawatt
MWh	Megawatt hour
MW_p	Megawatt peak
NMD	Notified Maximum Demand
NRS	National energy Regulator of South Africa
PV	Photovoltaic
RE	Renewable Energy
REIPPPP	Renewable Energy Independent Power Producers Procurement Programme
WCG	Western Cape Government

Introduction

Following on from an Energy Design Lab held in early 2015, the Department of the Premier of the Western Cape Government (WCG) Identified that there is a need to set a clear, bold action agenda on energy security for the WCG and local municipalities in order to minimise the impact of power shortages on the region's economy in the next 5 years and improve long-term energy security of the region and the country.

Small scale embedded generation, and in particular solar photovoltaic (PV) electricity generation was identified as a key intervention that can be rolled out in the short term. For this reason, it is necessary to quantify the maximum installation capacity of PV for the region and model the impact that this installed PV capacity will have on balanced electricity supply and demand.

The aim of this document is to quantify the maximum amount of PV that can be installed in the Western Cape before grid studies are needed. The electricity generated from this calculated installed PV capacity is then compared with the load profiles at the transmission substations.

1: Solar Resource in the Western Cape

The power production of a PV panel is directly proportional to the solar irradiance (solar energy) incident on the surface of the panel. For any PV plant, the irradiation component of interest in assessing the solar resource is the Global Tilt Irradiation (GTI). Considering the solar resource and the optimally mounted angle for PV panels at each location, which maximises electricity generation, a PV output map is generated for South Africa, Figure 1.1.

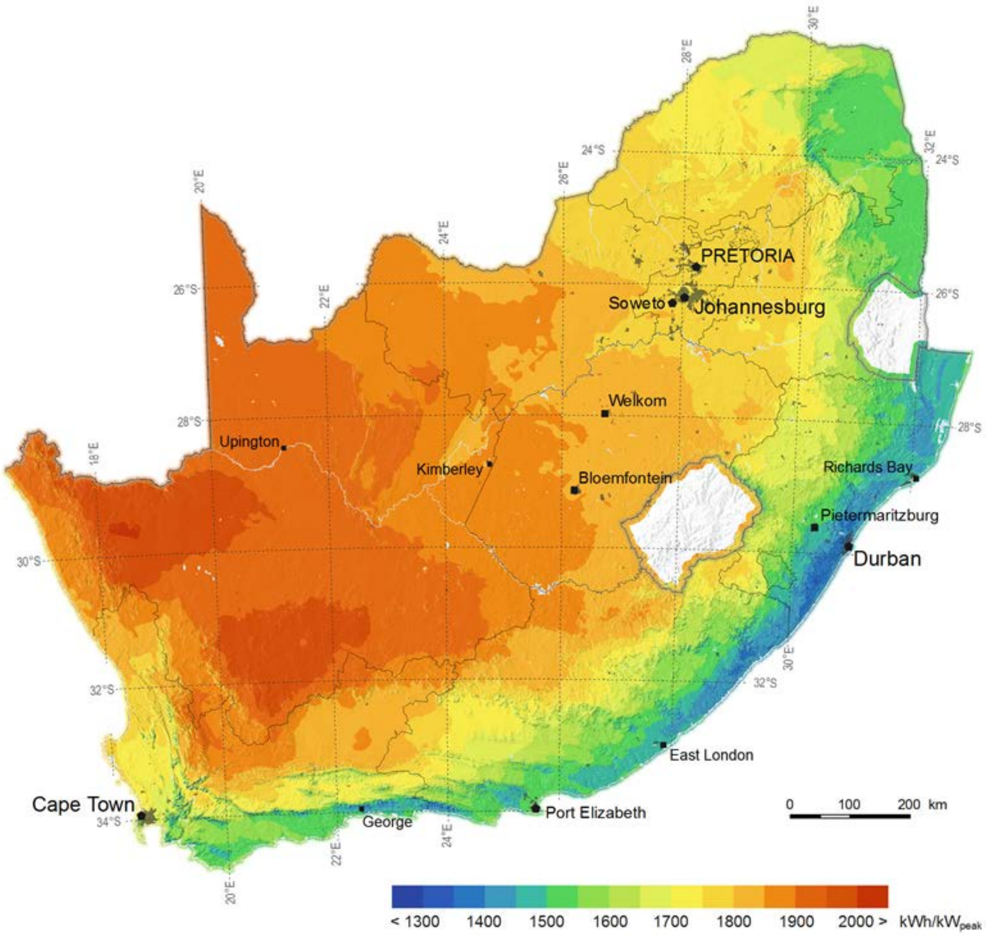


Figure 1.1: PV output map for South Africa, measured in annual kWh production per kW_p installed

PV systems' production potential is measured as the amount of electricity (kWh) that can be produced during a year, for the peak amount of PV power installed (kW_p). The units for PV production potential (specific yield) are kWh/kW_p per year. As an example, the specific yield for

Cape Town is 1 649 kWh/kW_p per year. This means that a 1 kW_p installation in Cape Town will produce 1 649 kWh per year.

The average capacity of a PV panel is about 250 W_p – so four panels will give you about 1 kW_p installation. This 1 kW_p installation will on average cover an area of about 6.5m^2.

Table 1 shows this output for various locations around South Africa, as obtained from PVPlanner software. Note that this is merely an approximation based on monthly average data. In South Africa, a power production potential of 1 600 to 1 800 kWh/kW_p per year is considered to be a feasible range for PV projects, above this is considered to be excellent. However, projects have been completed in ranges below 1 600 kWh/kW_p, but extended payback periods are seen. It should be noted that Germany, the country with the highest penetration of PV in the world, has a PV production (specific yield) of below 1 000 kWh/kW_p per year.

Table 1 shows the specific yield for three locations in the Western Cape compared to that of Pretoria and Kimberley. Vredendal has a high specific yield, which is not much lower than that of Kimberley. George has a significantly lower specific yield when compared to the rest of South Africa, because of a high amount of cloud cover.

Table 1: PV output comparison across South Africa

Location	Annual PV output (optimally inclined)
Cape Town	1 649 kWh/kW_p
George	1 439 kWh/kW_p
Vredendal	1 776 kWh/kW_p
Pretoria	1 731 kWh/kW_p
Kimberley	1 854 kWh/kW_p

Besides the large range of localised climate systems in the Western Cape which affect the specific yield of a system, obstacles on the horizon such as mountain ranges will also impact the specific yield of a system. The horizon of a location can shorten the solar day and hours of yield from the PV panels. An example of such a case would be the town of Paarl. The sun path diagram, Figure 1.2[1], show the shading effects due to the mountains surrounding Paarl. The diagram allows the

[1] Shading diagram produced by PVPlanner software, GeoModel Solar

visual representation of the sun's movement and shading effect on the PV system during different times of the day and different seasons, throughout the year.

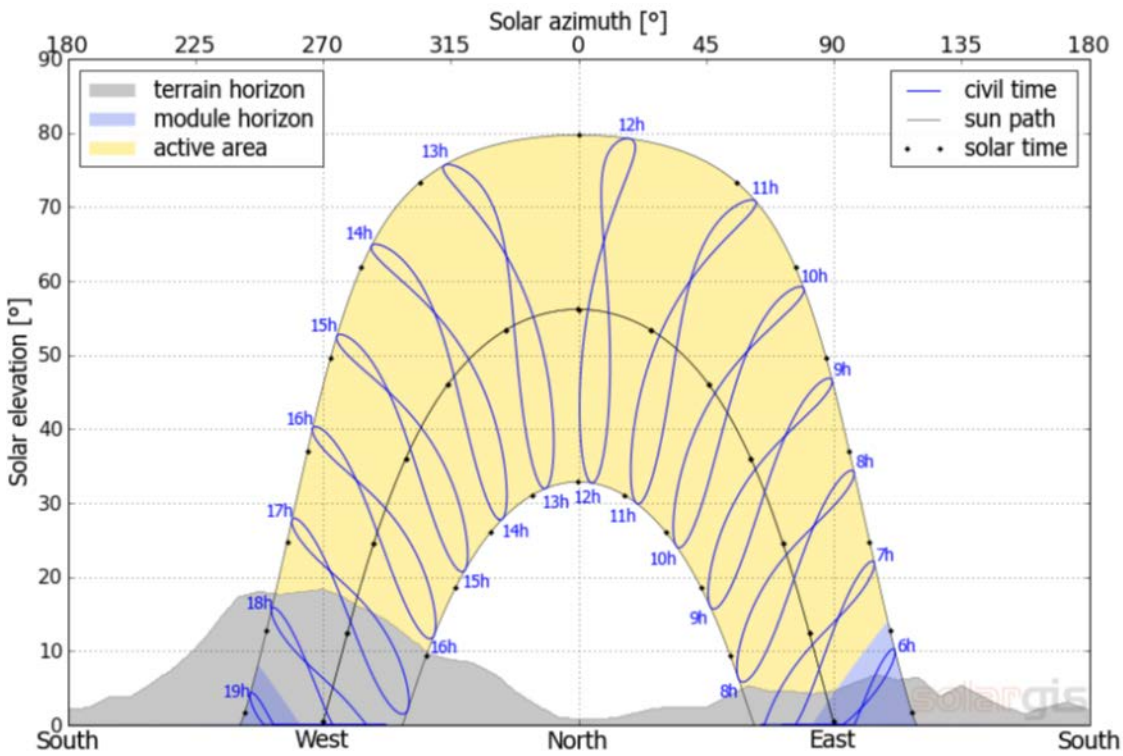


Figure 1.2: Terrain horizon and day length for 1 Market Street, Paarl

The effect of the mountain ranges on either side of Paarl is seen in Figure 1.2, with the predominant loss of generation in the late afternoon due to shading caused by Paarl Mountain. In summer Paarl Mountain will limit PV production from 18:00 (upper curve) and in winter from 16:00 (lower curve). However, it must also be noted that even though these shading effects shorten the PV production day, during the late afternoon PV panels would not have produced electricity at the rated power due to the low incidence angle of the sun on the PV panels. To maximise the PV output of the PV panels they should be installed facing North and at a tilt angle optimised for maximum average yearly production.

2: Existing Solar Photovoltaic installations

Figure 2.1: City of Cape Town mayor, Patricia de Lille, at the signing of the first SSEG contract in the City of Cape Town at Black River Office Park (1 200 kW_p) – 23 September 2014

There is an installed capacity of over 10 MW_p of small scale grid tied PV (up to 1 200 kW_p) in the Western Cape Province[2] that is known of[3]. There are probably many more small "illegal" installations that are unlisted. The Western Cape is also the province in South African estimated to have the most installed PV capacity, with Gauteng, in a close second place. The listed installations per province can be seen in Figure 2.2. A list of known installations in the Western Cape is listed in Appendix 1.

[2] For a list of known PV installations in South Africa, see: http://pqrs.co.za/s-a-solar-pv-list-2/solar-pv-list/
[3] Excluding off grid installations and installations from the REIPPPP

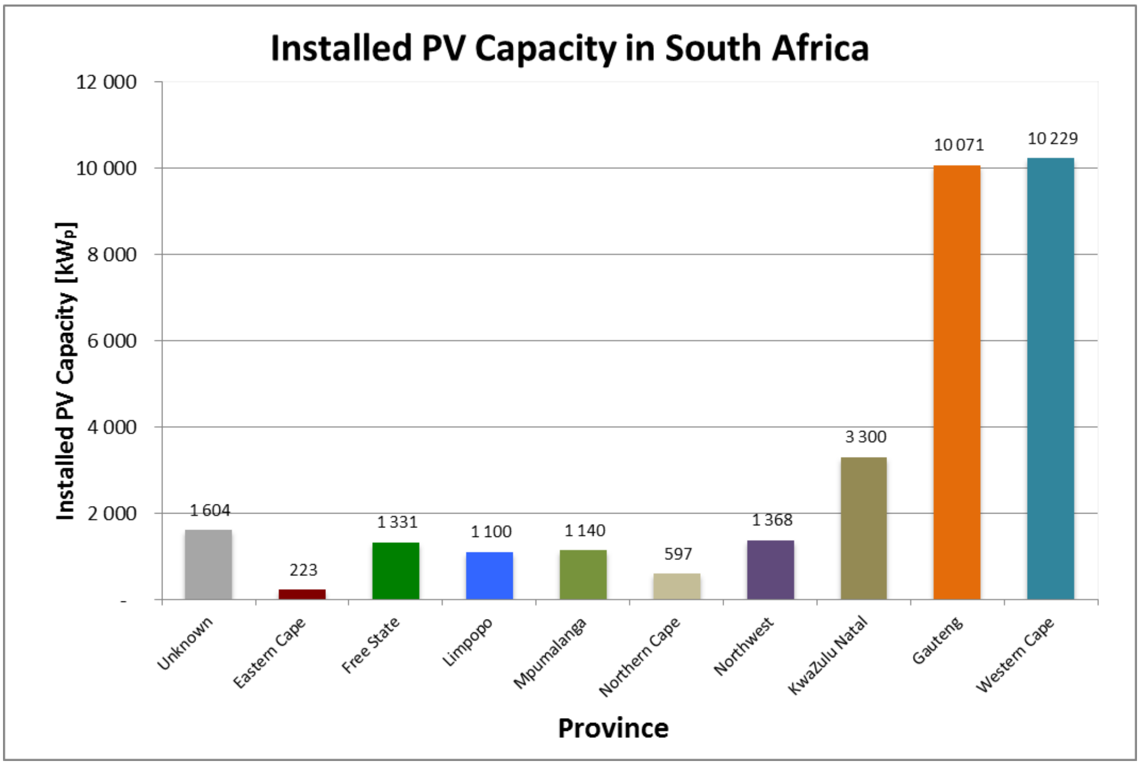


Figure 2.2: Known installations in kW_p per province (excluding off grid and REIPPPP)[4]

Figure 2.3: 500kW_p PV installation at Lourensford Wine Estate, Somerset West

[4] Own analysis from the list at: http://pqrs.co.za/s-a-solar-pv-list-2/solar-pv-list/

3: Assessment Methodology

3.1: Embedded Generation Rules in South Africa

There are no specific standards or regulations currently in place in South Africa for small-scale embedded generation (SSEG), but the National Regulation, NRS 097-2-1:2010, covers the utility interface of grid interconnected embedded generation. In the 2010 edition of the NRS097-2-1 document, the size of an embedded generator is limited to the rating of the supply point on the premises while the NRS097-2-3:2014 specification sets out the technical requirements for the utility interface, the embedded generator and the utility distribution network with respect to embedded generation. The specification applies to embedded generators smaller than 100 kW connected to low-voltage (LV) networks.

Section 4.5 of the NRS097-2-3:2014 specification gives a summary of the connection criteria as shown in Figure 3.1.

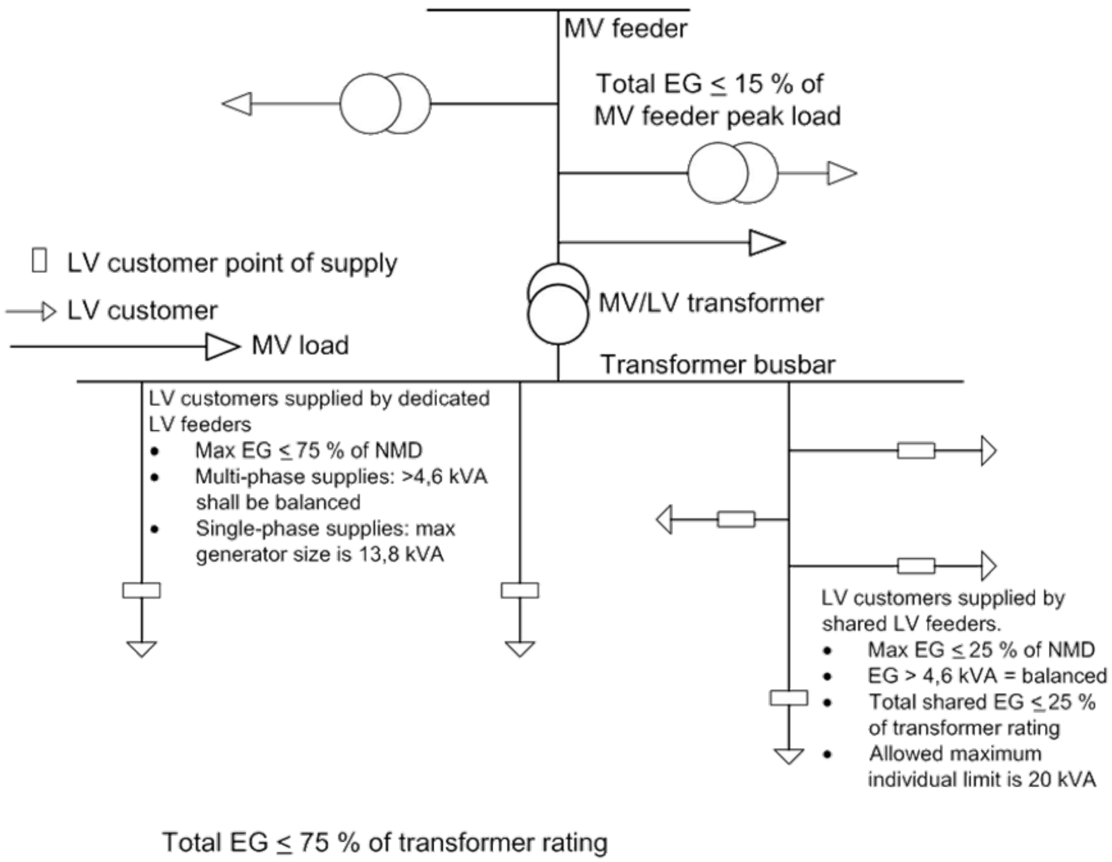


Figure 3.1: Summary of simplified connection criteria

To quantify the maximum installation capacity of PV, at a high level, a conservative approach is taken by using 15% of the installed transformer capacity of High Voltage (HV) substations in the Western Cape Province . This is the amount of embedded generation capacity that can be installed before a grid study is needed. It is possible that detailed grid studies will reveal that the potential is much higher, but this is the potential that can be done in a short time with no grid studies needed.

Looking at Figure 3.1 it is shown that embedded generation should not exceed 25% of the notified maximum demand where customers are supplied by shared low voltage feeders and where dedicated low voltage feeders exist the embedded generation should not exceed 75% of the notified maximum demand. Higher up in the supply chain it is suggested that embedded generation does not exceed 15% of the demand from a medium voltage feeder. Medium voltage feeders are typically supplied through the high voltage substations and therefore when looking at high voltage substation data you see a summary of the medium voltage (MV) load.

This study looks at the maximum capacity of embedded generation that could be installed in the province and therefore it is assumed that the existing electricity network infrastructure would also be able to accommodate the 15% of generation.

3.2: Solar Data

The solar data used in the hind cast model to predict the PV plant production output is sourced from SoDa solar radiation data. The Solar irradiation data that is supplied by SoDa is from the HelioClim database, which combines measurements from ground stations and satellite data, and provides hourly GHI data that is used in the PVsyst software for detailed modelling. The layout of the panels and area covered is determined by the selected equipment and spacing thereof.

PVsyst software is used to model final production estimates. PVsyst software allows for detailed modelling, taking into account the effects of local shading, equipment losses, and panel- and string layouts, among other features. There are standard industry practices used in the report, which will not be described in detail.

In order to model the potential production of a PV array, a specific PV panel and inverter needs to be selected. The choice of reference equipment is based on global statistics on the manufacturers' production volumes, age of the company and the manufacturer having an established presence in South Africa.

The reference PV panel that is used for modelling purposes is the polycrystalline panel available from Yingli Solar, YL250P-29b. Yingli Solar is one of the top global producers of PV panels that has been manufacturing for more than 15 years and fall in the Gigawatt production category. The panels are assumed to be north facing with a tilt angle optimised for maximum annual production. The reference inverter used is a SMA Sunny Boy 2,5 kW inverter. SMA is currently the largest inverter manufacturer globally, with more than 25 years of experience and an established local market. Both of the reference equipment manufacturers are very large globally and in South Africa with proven reliability.

The study and its results are impacted by data inconsistencies, loss assumptions and equipment selection. Owing to the unpredictable nature of the climate and the variety of installation setups, the actual production of the installation can differ from the predicted values. The results of the study is therefore for decision making purposes and should not be used as an accurate prediction of the PV production of the installed system.

Figure 3.2: Rooftop PV installation at a guest house in Somerset West

4: Results

Eskom supplied data for the installed transformer capacities of the known 160 HV substations in the Western Cape and also the feeder line capacities for an additional 56 substations. 28 of these additional substations are traction substations and were not included in the total capacity calculations due to their limited supply and user network. Figure 4.1 shows the transmission substations in the Western Cape. The distribution of the high voltage and the transmission substations in the Western Cape that were considered in this study can be seen in Figure 4.2.

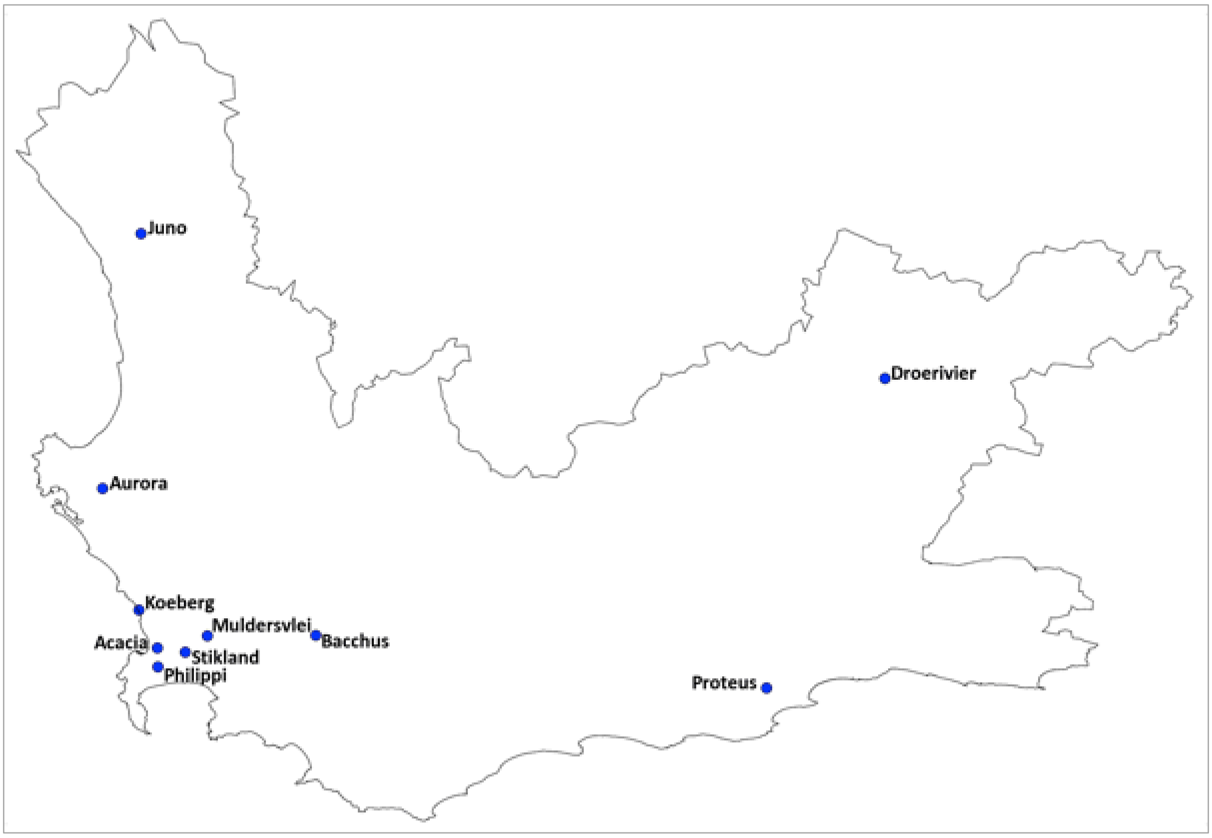


Figure 4.1: Transmission substations in the Western Cape

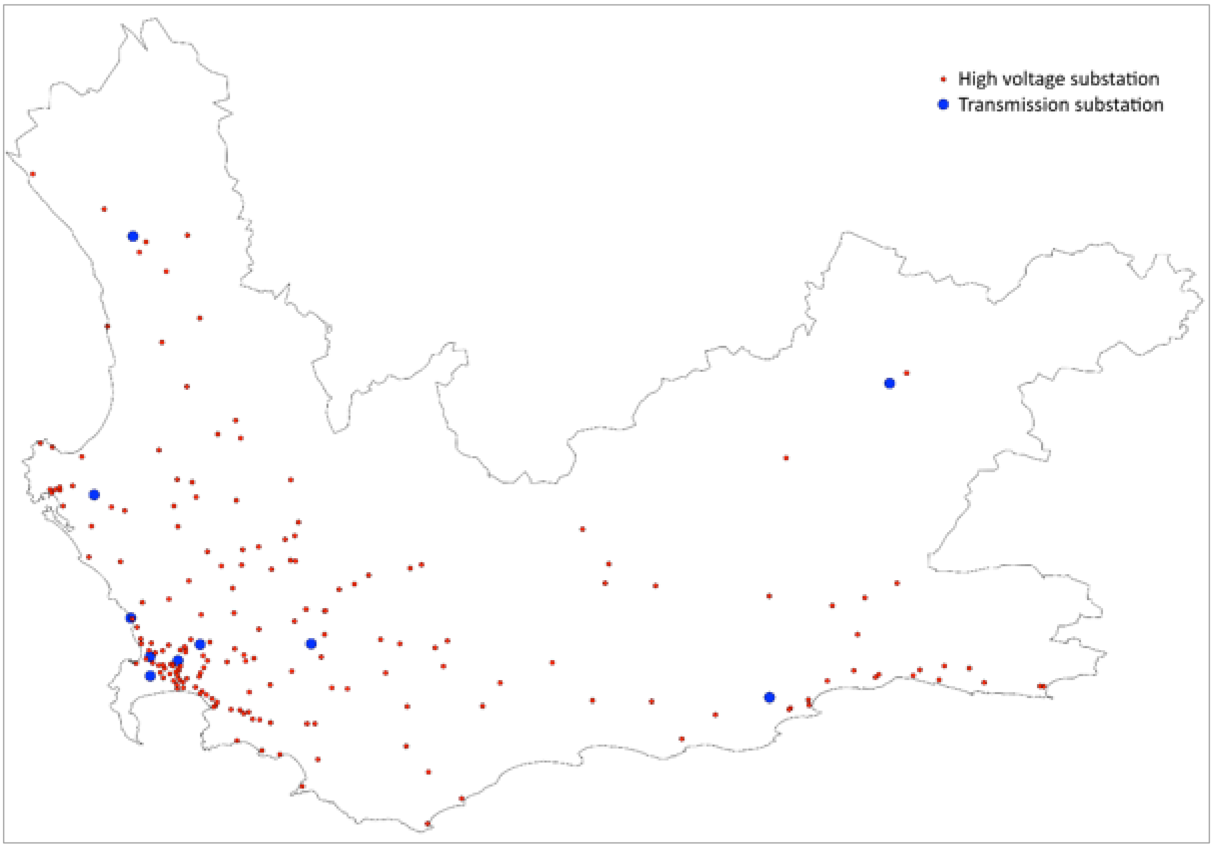


Figure 4.2. Substation distribution in the Western Cape

The installed capacities of the transmission substations that supply these high voltage substations are given in the *Generation Connection Capacity Assessment of the 2016 Transmission Network* document published by Eskom and used as a check for the high voltage substation installed capacity.

When looking at the N-1[5] installed capacity, shown in Table 2, the figures are considerably lower, but because we are not considering security of supply we will not focus on these numbers.

The amount of PV that can be installed per transmission substation before a grid study is needed can either be calculated as 15% of the installed transformer Capacity (maximum penetration) or as 15% of the maximum load of that transmission substation (conservative estimate and more in line with NRS097-2). As the most recent hourly load data per transmission substation available is for 2013, this is the data used.

[5] N-1 refers to Eskom's security of supply. N is the total capacity with all the transformers switched on and N-1 indicates the capacity if one of the transformers would be switched off for maintenance or due to failure.

Table 2 shows the installed capacity as well as the 15% allowable embedded generation that approximates the maximum installation size of embedded solar PV that can be rolled out in the short term without the requirement of any grid studies.

Table 2. Installed Transformer capacity in the Western Cape

	Installed Transformer Capacity [MVA]		Maximum Demand [MWh]	15% Embedded Generation [MW]		15% of Maximum Demand [MW]
	N	N-1		N	N-1	
HV Substations	**8 927**	3 983	**NA**	**1 339**	597	NA
Transmission Substations	**8 860**	4 930	**3 954**	**1 329**	740	593

From this it is clear that it is technically possible to install at least a total of 593 MW_p[6] of PV systems across the Western Cape Province before any grid studies are needed. Interestingly, this correlates well will the figure of 597 MW_p calculated as 15% of the N-1 transformer capacities as can be seen in Table 2. If 15% of the installed transformer capacity at the HV transmission substations are taken as a maximum of PV before grid studies are needed, then the figure rises to 1 329 MW_p[7].

Table 3 shows the installed transformer capacity and the maximum load for 2013 for the nine[8] transmission substation in the Western Cape as well as the 15% embedded generation associated with each substation.

[6] This is equal to 593 000 kW_p
[7] This is equal to 1 329 000 kW_p
[8] The Koeberg generation transmission substation is not considered in this study because it cannot handle any additional generation capacity.

Table 3. Transmission substations' capacity in the Western Cape[9]

Transmission Substation Name	Installed Transformer Capacity [MVA]	Maximum Load [MW]	15% of installed capacity - PV [MW]	15% of Maximum Load – PV [MW]
Acacia	1 500	644	225	97
Aurora	1 000	453	150	68
Bacchus	1 000	437	150	66
Droërivier	240	86	36	13
Juno	320	80	48	12
Muldersvlei	1 640	615	246	92
Philippi	1 000	617	150	93
Proteus	1 160	407	174	61
Stikland	1 000	615	150	92
TOTAL	**8 860**	**3 954**	**1 329**	**593**

To put this in perspective, 593 MW_p of installed PV is almost sixty times more than the known installations in the Western Cape.

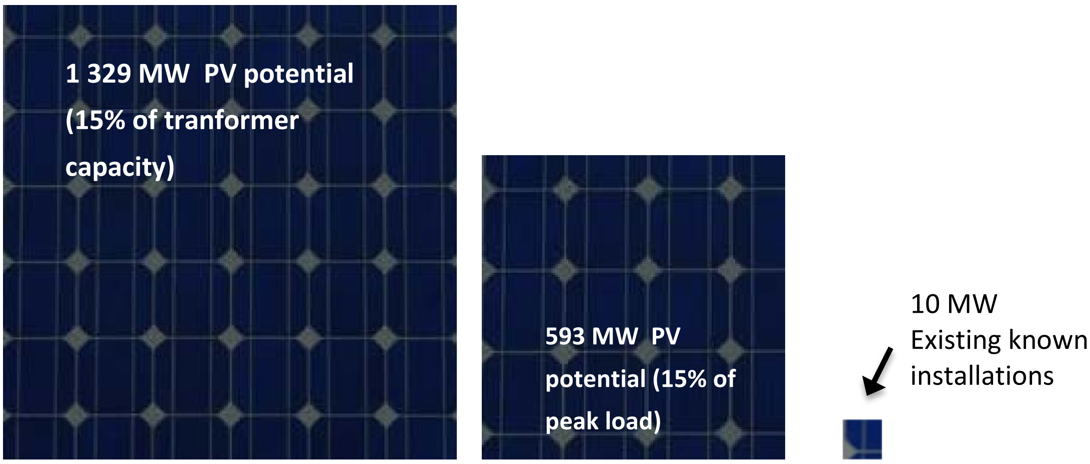


Figure 4.3: Known installed embedded generation in the Western Cape compared to potential

[9] The Koeberg transmission substation is not included because this is a generation substation and no additional generation can be connected to this substation.

Four typical 250 W_p solar PV modules (giving 1 000 W_p or 1 kW_p) will cover an area of about 6.5m^2. If allowance is made for spacing between panels, wiring, brackets etc., it can be conservatively estimated that the area needed to install 1 kW_p of PV is about 10m^2. This means that the area needed to install 1 MW_p of PV is about 1 hectare (ha).

A typical home installation will be about 2-6 kW_p (4 kW_p on average). This means that 148 250 PV installations of 4 kW_p each can be installed all over the Western Cape before grid studies are needed[10].

Figure 4.4: A 4.25 kW_p PV installation at private residence, Paarl

[10] It also means that 494 installations the size of Blackriver Office Park (1 200 kW_p) can be installed in stead of these residential systems before grid studies are needed.

5: Impact of maximum PV generation on the load profile at transmission substation

PVsyst software was used to model final production estimates in hourly intervals for 2013[11]. These production estimates were then plotted against the load profiles per transmission substation to show the impact that solar PV can have. The mounting angles of the PV modules were optimized for annual energy production and is given in the table below.

Table 4: Transmission substations optimal tilt angles as calculated by PVsyst software

	Site (transmission substations)								
	Acacia	Aurora	Bacchus	Droe-rivier	Juno	Mulders-vlei	Philippi	Proteus	Stikland
Azimuth	0° (N)	0° (N)	0° (N)	0° (N)	0° (N)	0° (N)	0° (N)	0° (N)	0° (N)
Optimal Tilt	30°	30°	30°	31°	30°	29°	30°	32°	30°

5.1: Impact of PV on energy demand

The energy demand on the individual substations is shown in Table 5, along with the energy that could have been supplied by solar PV if 1 329 MW_p of PV and 593 MW_p of PV respectively was installed in the Western Cape in 2013. As a comparison, 1 329 MW_p PV would have generated 2 131 GWh of energy, the equivalent to providing more than 389 000 houses with electricity for a full year[12].

[11] 2013 was used, because the hourly load data per transmission substation for 2014 was not yet available from Eskom
[12] This figure is calculated with the assumption that a household consumes 15 kWh per day.

Table 5. Transmission substations energy usage for 2013 and potential PV electricity generation

Transmission Substation Name	Installed Transformer Capacity [MVA]	Energy used during 2013 [GWh]	15% of Transformer Capacity		15 % of Peak load	
			Potential PV installed [MW]	Potential PV Energy for 2013 [GWh]	Potential PV installed [MW]	Potential PV Energy for 2013 [GWh]
Acacia	1 500	3 317.35	225	364.93	96.53	156.57
Aurora	1 000	2 901.55	150	246.03	67.91	111.38
Bacchus	1 000	2 116.20	150	238.65	65.62	104.40
Droërivier	240	320.49	36	64.01	12.91	22.96
Juno	320	454.97	48	82.43	12.05	20.69
Muldersvlei	1 640	3 691.68	246	389.50	92.21	146.00
Philippi	1 000	3 867.71	150	238.79	92.58	147.39
Proteus	1 160	2 371.72	174	268.71	60.98	94.18
Stikland	1 000	3 464.80	150	238.78	92.23	146.82
Total	**8 860**	**22 506.46**	**1 329**	**2 131.83**	**593.04**	**950.39**

5.2: Impact of PV on the load profile for a winter and a summer week

The impact of Solar PV on the combined load profile of the Western Cape Province for a winter and a summer week is shown in Figure 5.1 and Figure 5.2. The energy contributions are shown for the conservative case (yellow on figure) where only 15% of the peak energy demand was used to calculate the PV contribution and the additional solar energy (orange on graph) is shown that could have been generated if 15% of the installed transformer capacity was used to estimate the PV production. Outlined in black on the graph is the total energy demand profile of the Western Cape Province for 10-16 June and 2-8 December 2013, while the grey area would be the resulting load Eskom would have had to supply if these potential solar PV installations were contributing to the network. The impact of solar PV on the individual transmission substations in the Western Cape Province for a winter and a summer week can be seen in Appendix 2.

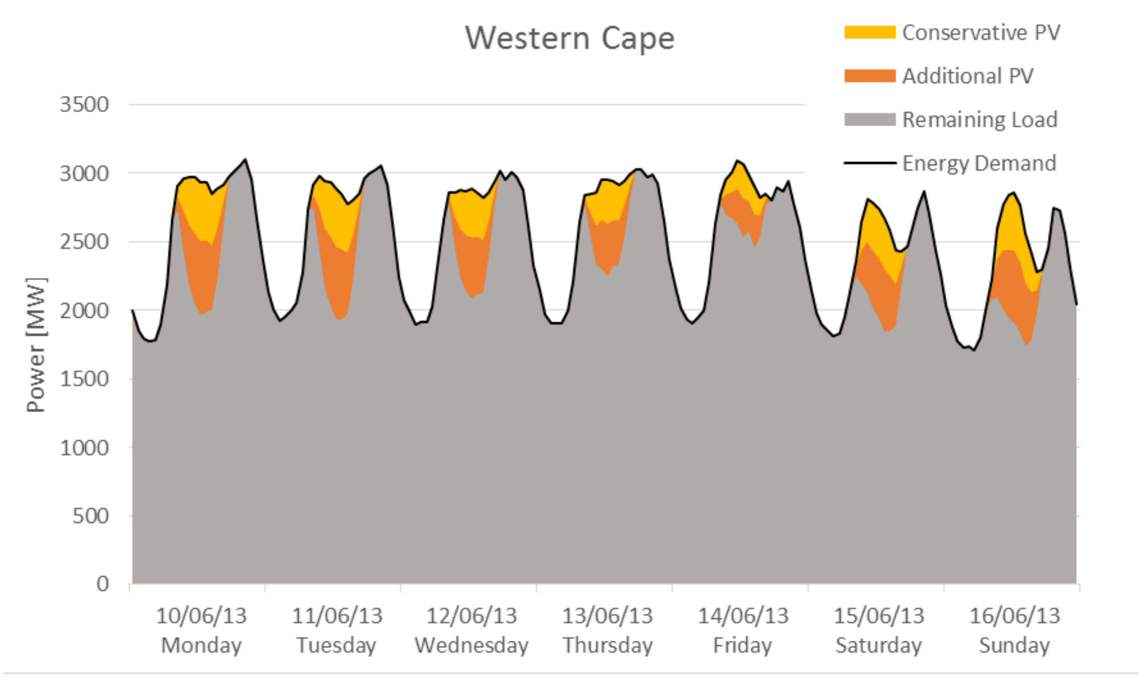


Figure 5.1: Impact of PV generation on the load profile of the Western Cape for a winter week [13]

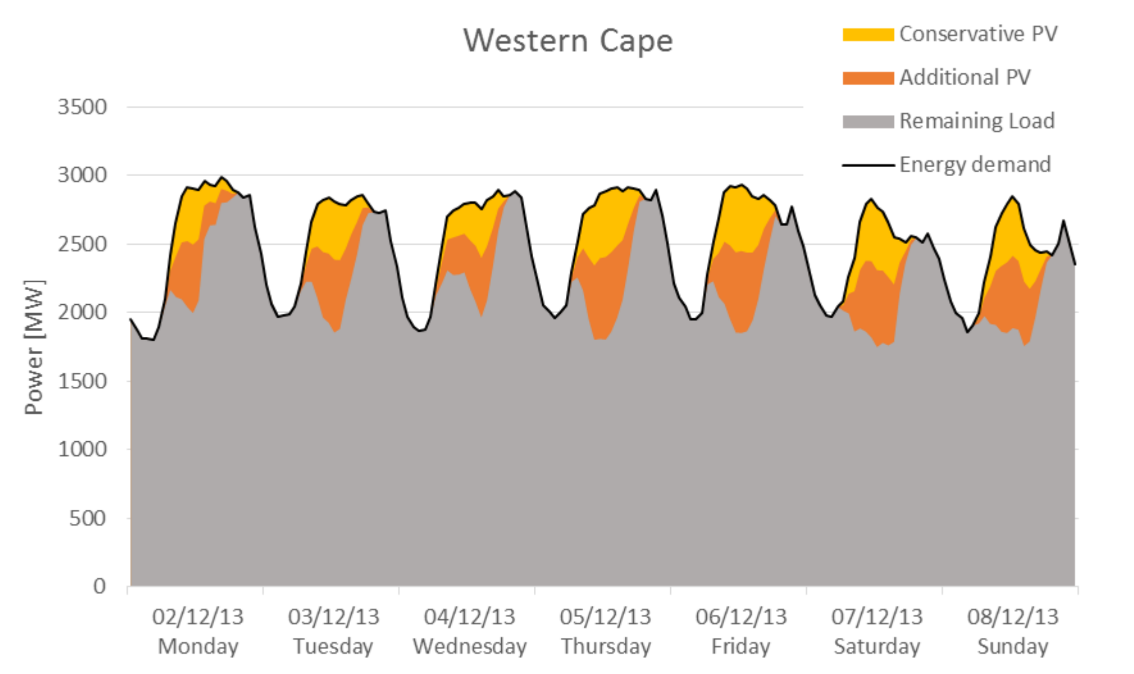


Figure 5.2: Impact of PV generation on the load profile of the Western Cape for a summer week[14]

[13] Instantaneous power values for an hour is averaged over the hour, resulting in the MW value indicated on the y-axis

5.3: Impact of PV on the load profile for a winter and a summer day

The impact of Solar PV on the load profile of the individual transmission substations in the Western Cape Province as well as the combined load profile of the Western Cape Province are shown in the figures below. The energy contributions are shown for the conservative case (yellow on figure) where only 15% of the peak energy demand was used to calculate the PV contribution and the additional solar energy (orange on graph) is shown that could have been generated if 15% of the installed transformer capacity was used to estimate the PV production. Outlined in black on the graph is the total energy demand profile of the Western Cape Province for 10 June and 5 December 2013, while the grey area would be the resulting load Eskom would have had to supply if these potential solar PV installations were contributing to the network.

It is important to note that generation by municipalities are not shown in the figures and this can be noted in the winter evening load profile of the Acacia sub station, where it is presumed that the City of Cape Town utilises the Steenbras pump storage facility during evening peak hours when the price of electricity from Eskom is at its highest.

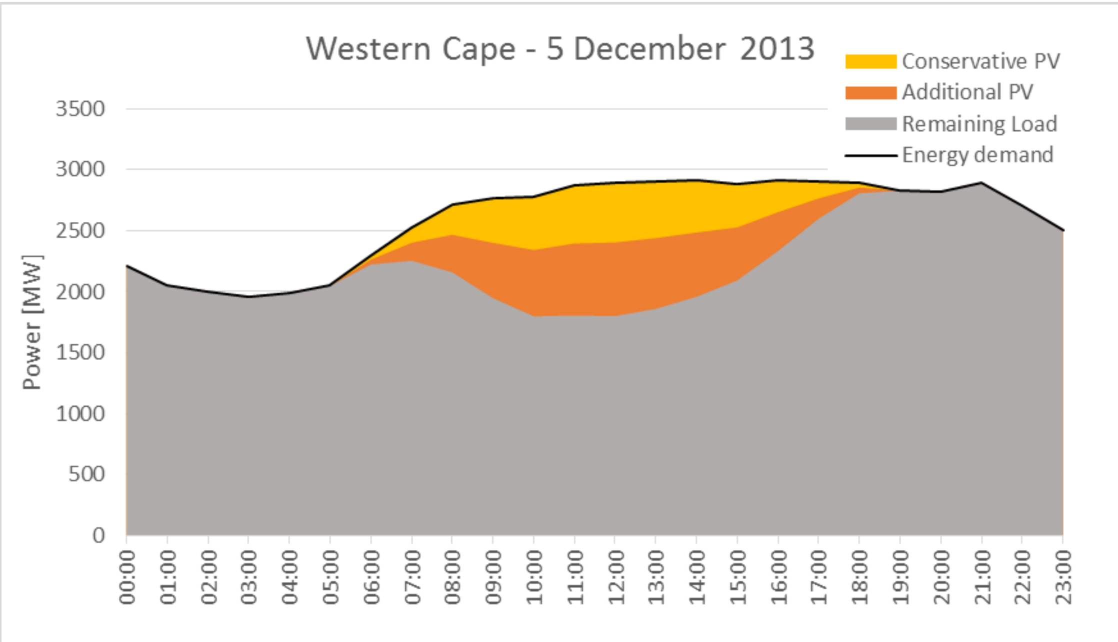


Figure 5.3: Impact of PV generation on the load profile of the Western Cape for a summer day 5 December 2013[14]

[14] Instantaneous power values for an hour is averaged over the hour, resulting in the MW value indicated on the y-axis

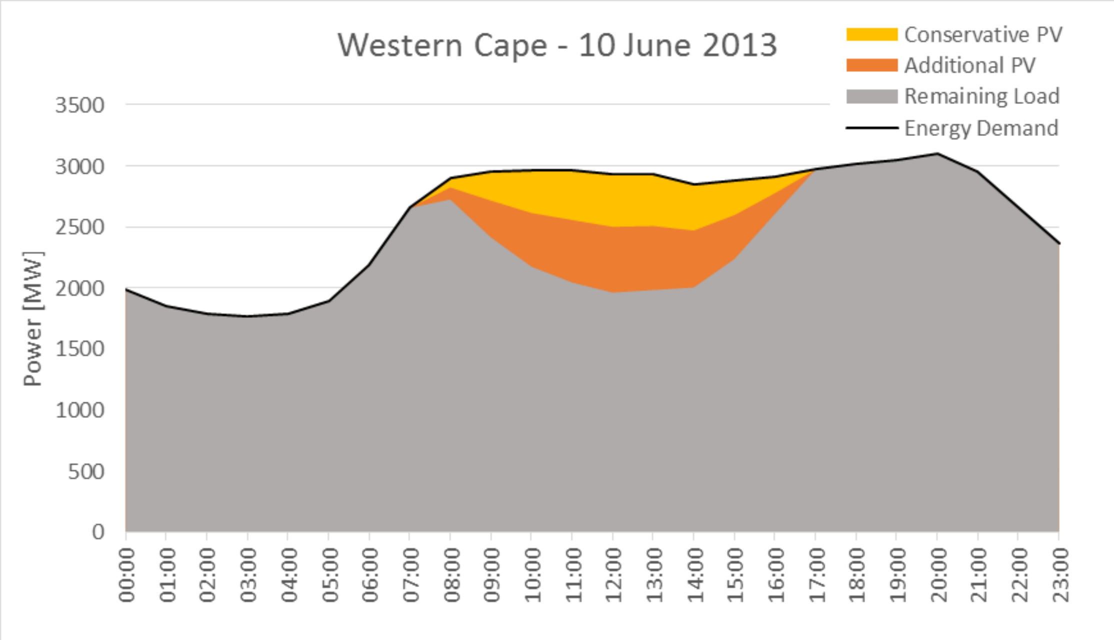
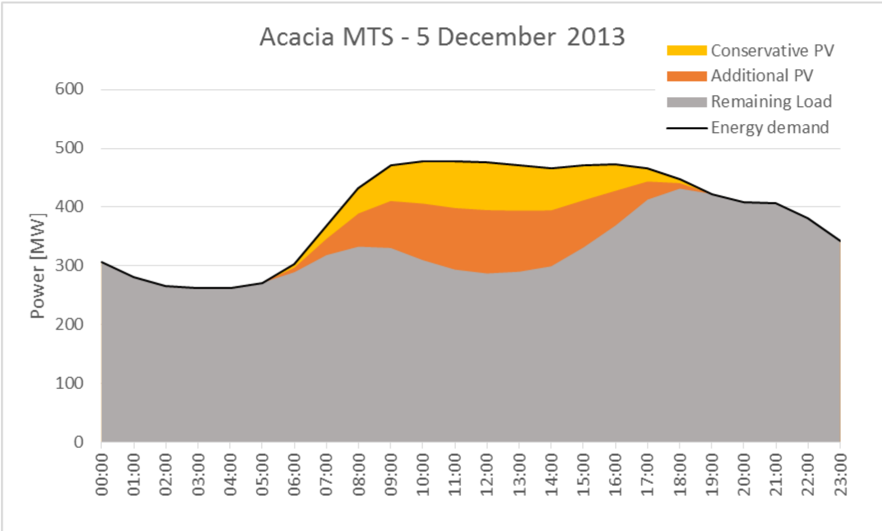
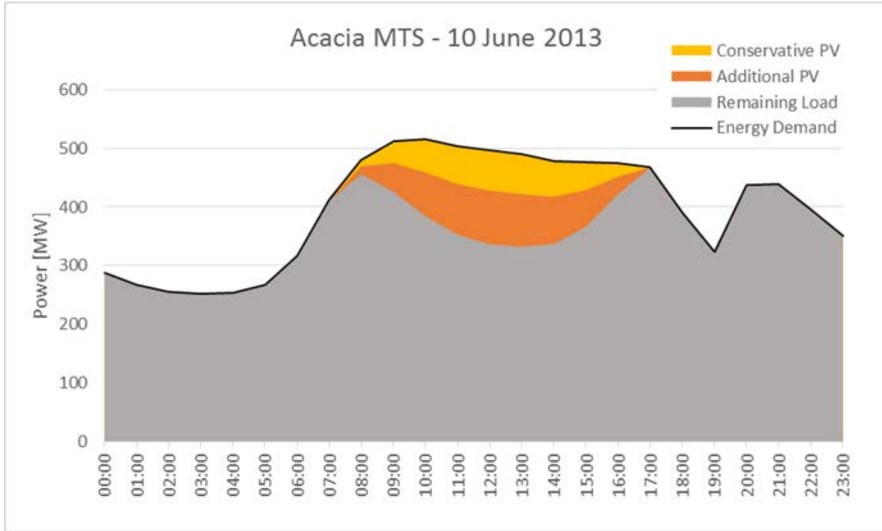
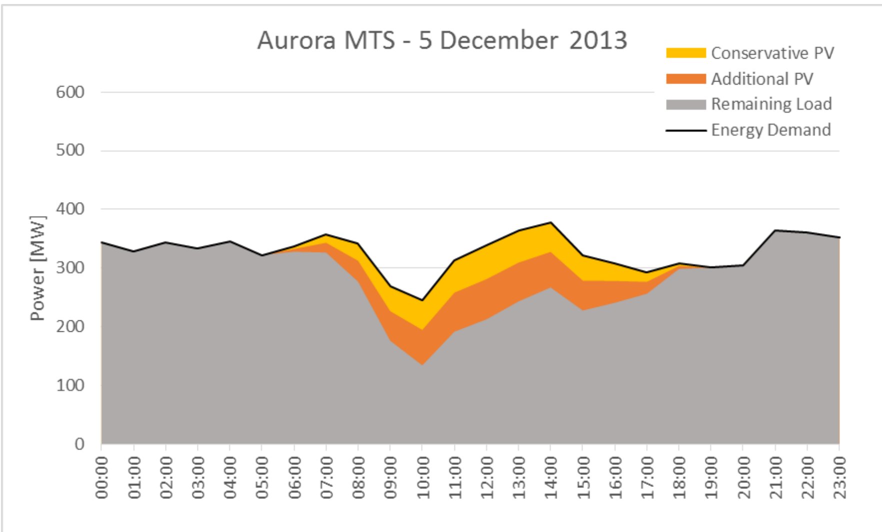
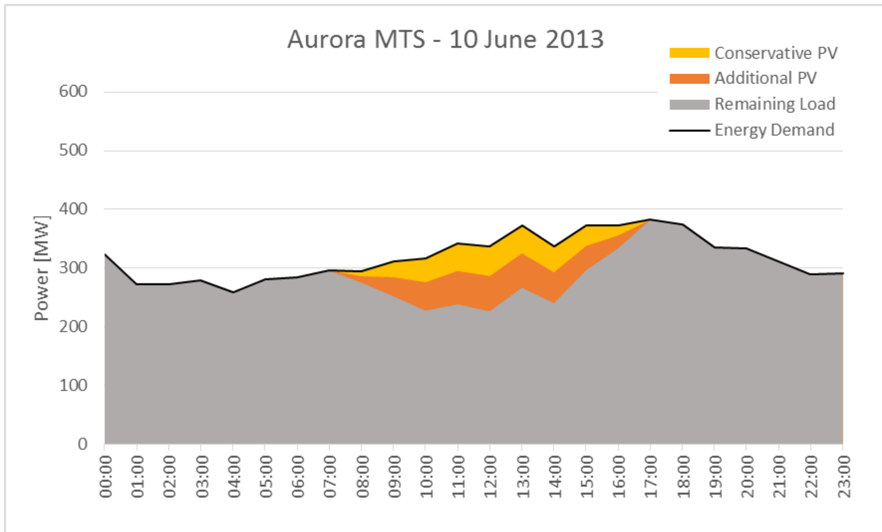
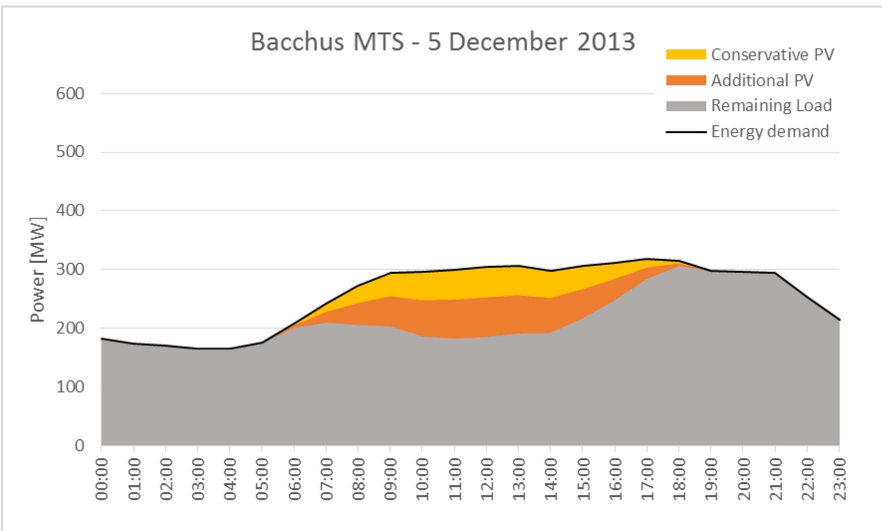
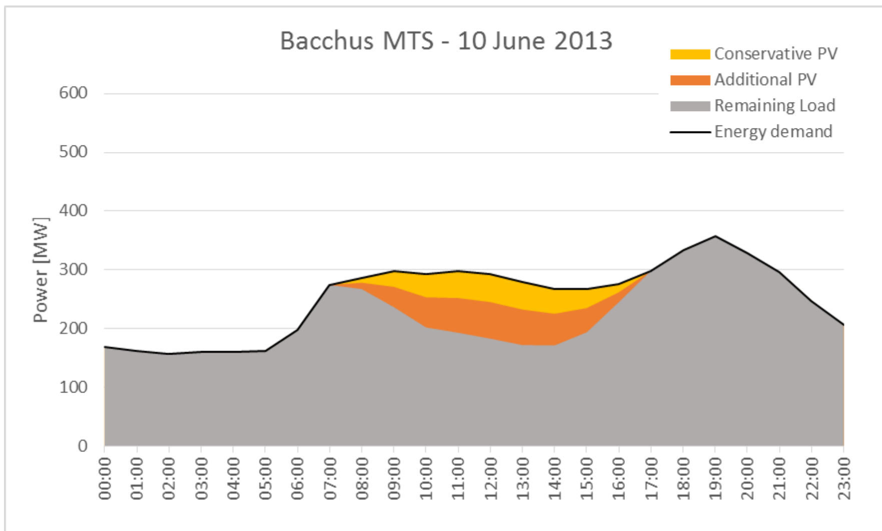
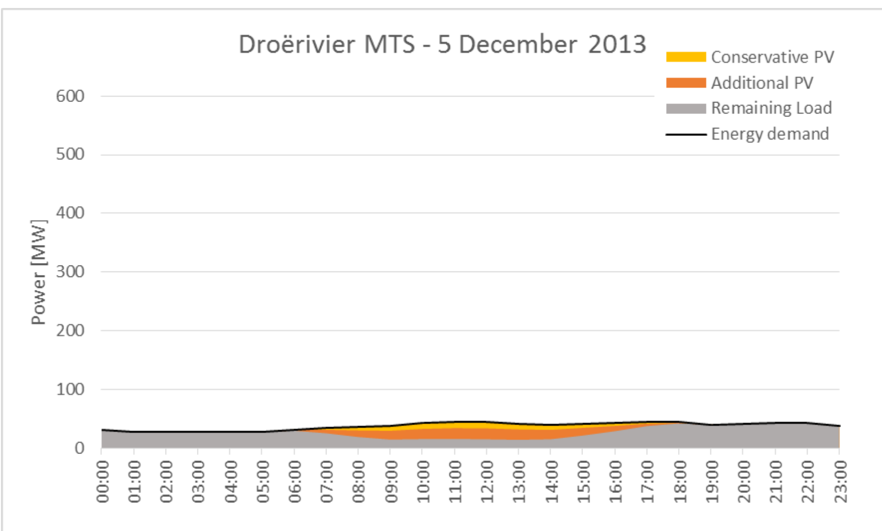
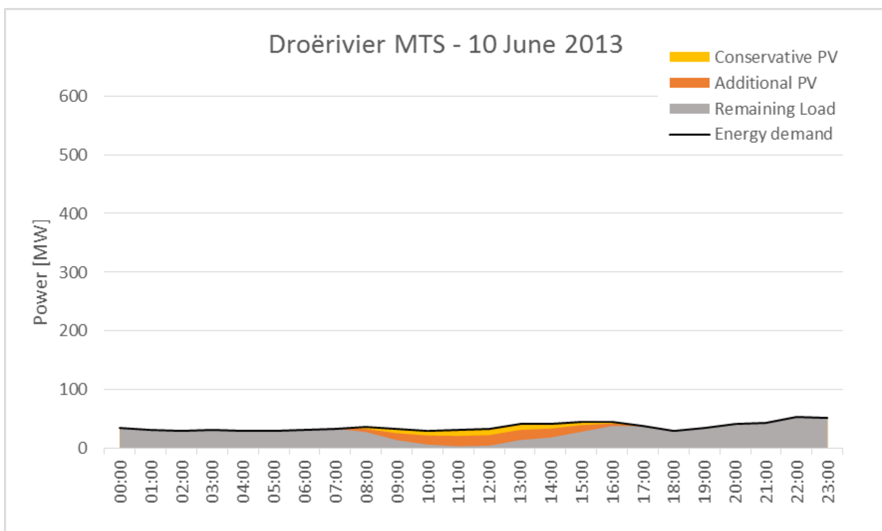


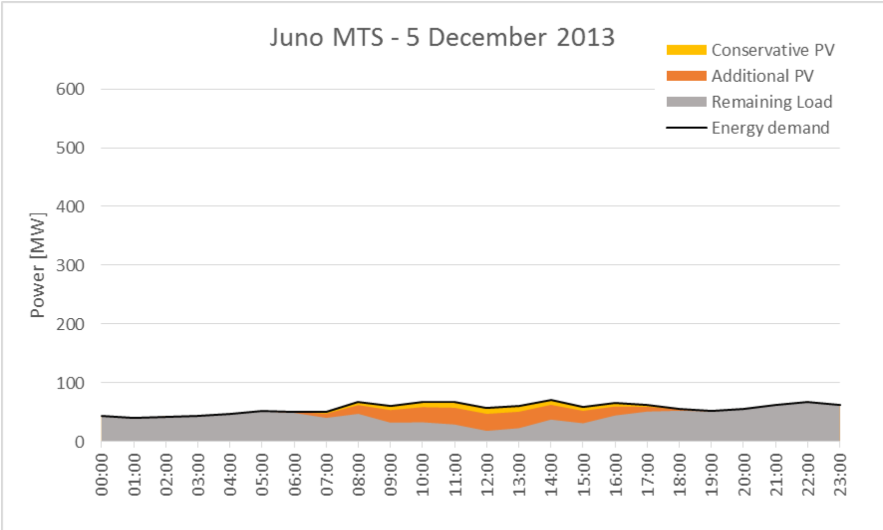
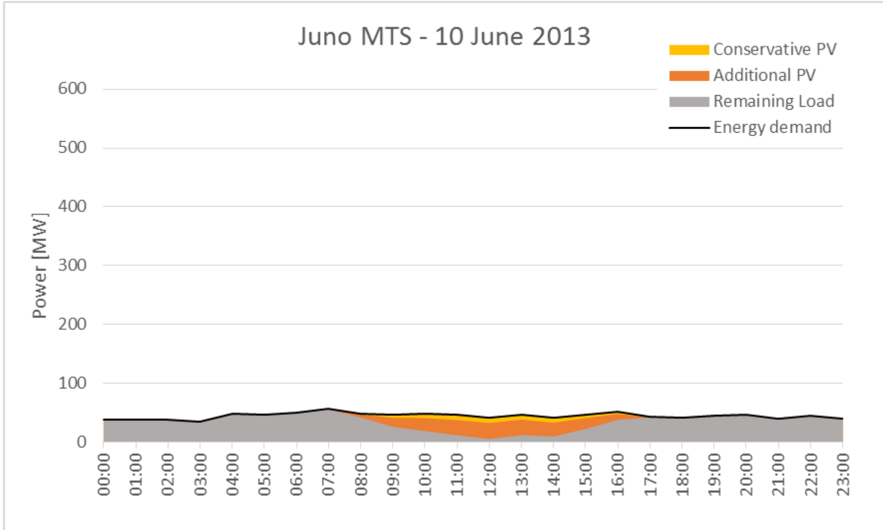
Figure 5.4: Impact of PV generation on the load profile of the Western Cape for a winter day 10 June 2013[15]

[15] Instantaneous power values for an hour is averaged over the hour, resulting in the MW value indicated on the y-axis

Figure 5.5: The impact of Solar PV on the load profile of the individual transmission substations in the Western Cape for a sunny winter and a sunny summer day[16]

	Summer Day 5 December 2013	Winter day 10 June 2013
Acacia MTS (225 MW Solar)		
Aurora MTS (150 MW Solar)		
Bacchus MTS (150 MW Solar)		
Droerrivier MTS (36 MW Solar)		

[16] Instantaneous power values for an hour is averaged over the hour, resulting in the MW value indicated on the y-axis

<table>
<tr><th></th><th>Summer Day 5 December 2013</th><th>Winter day 10 June 2013</th></tr>
<tr><td>Juno MTS (48 MW Solar)</td><td>
</td><td>
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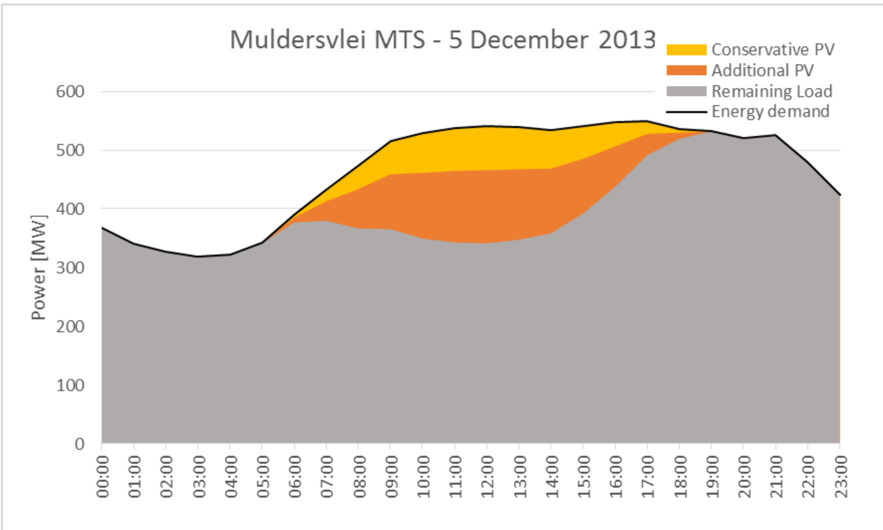
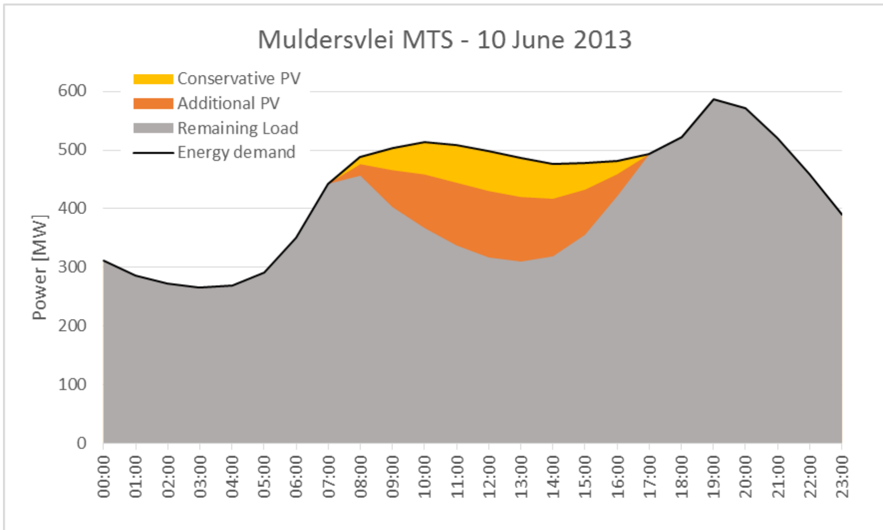
<tr><td>Muldersvlei MTS (246 MW Solar)</td><td>
</td><td>
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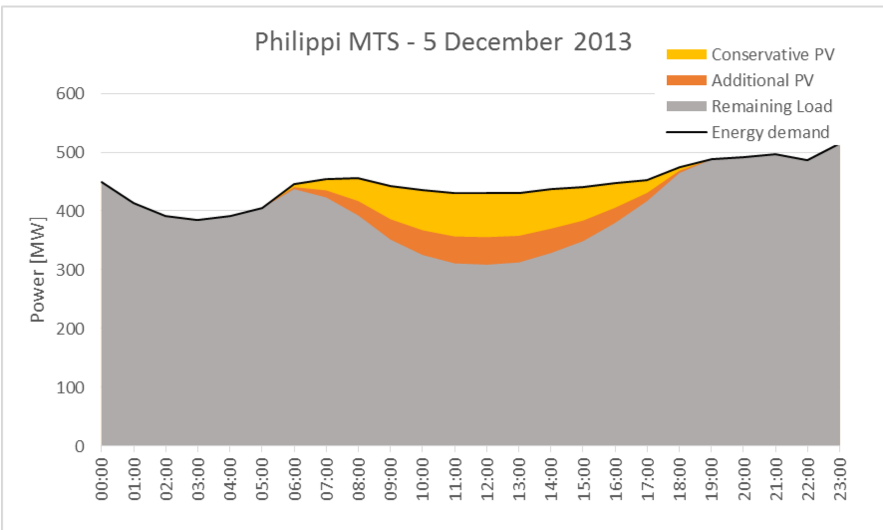
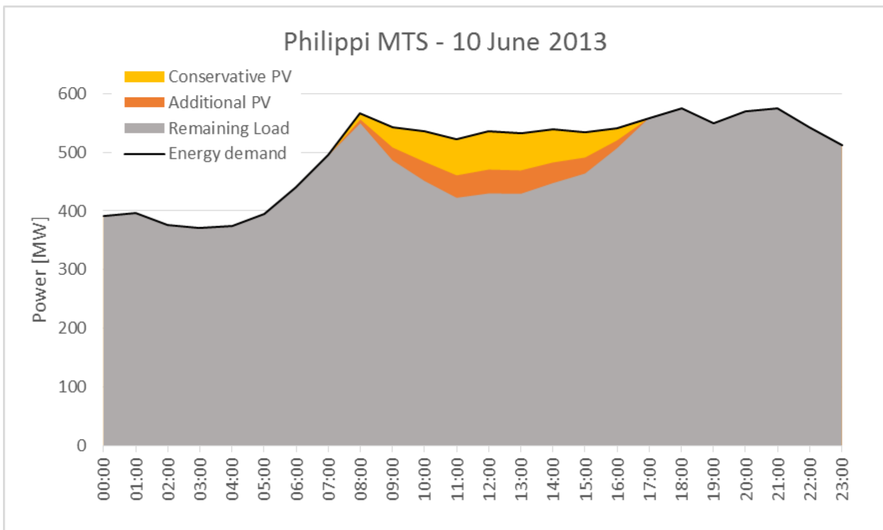
<tr><td>Philippi MTS (150 MW Solar)</td><td>
</td><td>
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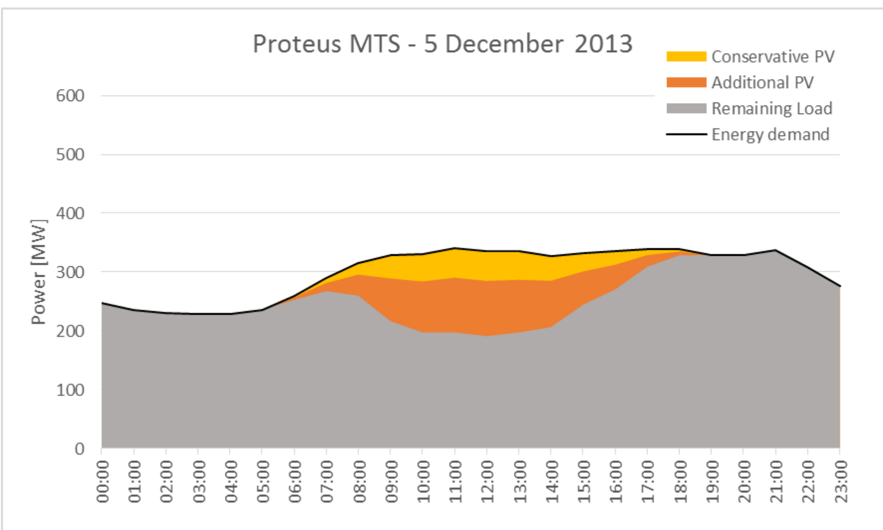
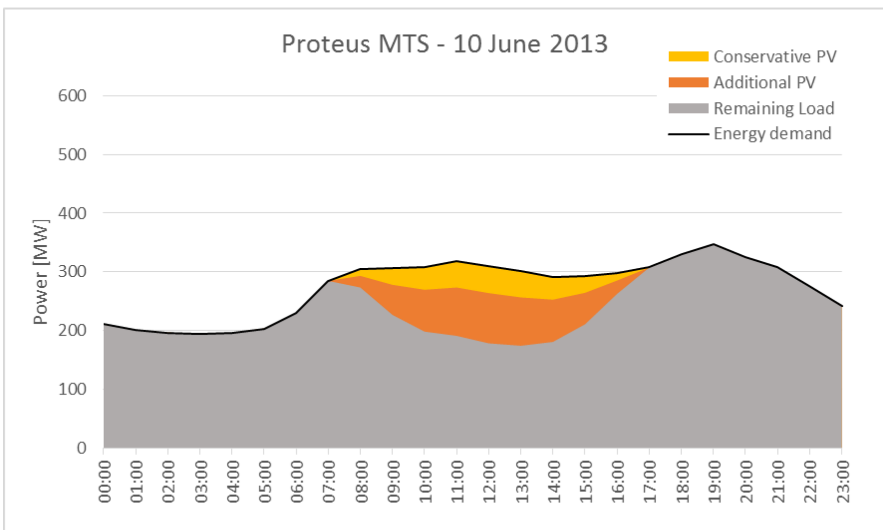
<tr><td>Proteus MTS (174 MW Solar)</td><td>
</td><td>
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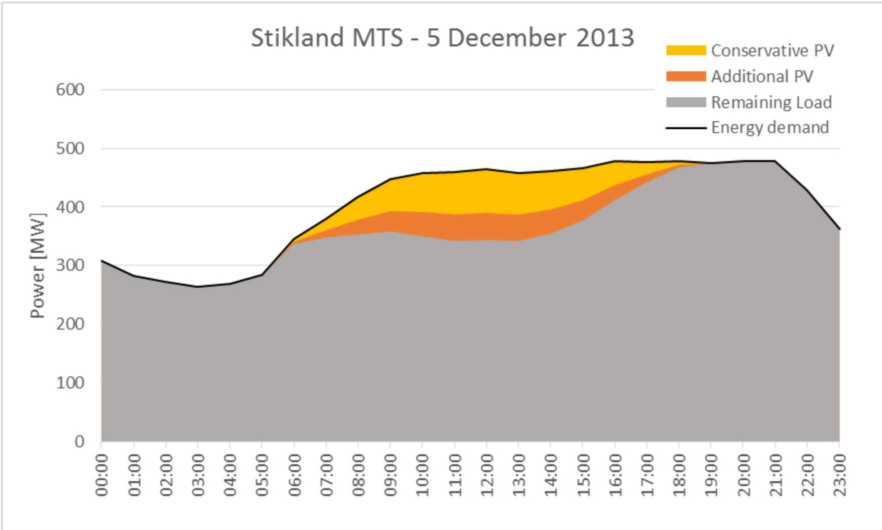
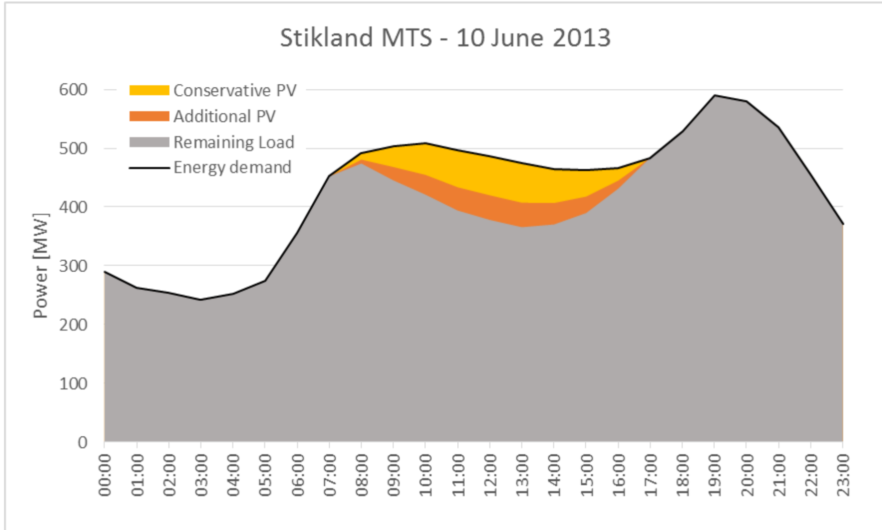
<tr><td>Stikland MTS (150 MW Solar)</td><td>
</td><td>
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5.4: Other Limiting Factors

According to NRS 097-3, the amount of embedded generation that could be installed at the different levels of the electrical supply grid. There are other factors that also need to be considered when larger installations are planned e.g. the size of an installation based on the rated capacity of that network instead of the demand of that network segment. Other factors that should be considered because they influence grid stability are;

- A weak network at distribution level will influence the penetration level even though the grid is stable at transmission level[17].
- Adding to the point above, if the distribution of PV installations are too concentrated geographically, this will influence grid stability – in the penetration levels given in this report, an aggregate distribution of installations were supposed.
- Intermittency of use as is common for individual residential electricity users
- Cloud cover and associated rapid voltage change[18]

In cases where the network capacity is available to have larger installations than dictated by the use of that network, it is critical to engage with the utility provider and it is important to note that additional network studies will need to be carried out to determine how such a PV installation will affect that network.

[17] This is especially relevant to the "15% of installed capacity" scenarios.
[18] See more here: Cloud cover impact on photovoltaic power production in South Africa. Available online: http://geomodelsolar.eu/_docs/papers/2014/Suri-et-al--SASEC2014--Cloud-cover-impact-on-PV-power-production-in-South-Africa.pdf

6: Areas not covered in this research and suggestions for further studies

- Investigate the electricity load for each town in the Western Cape and compare to the results in this report
- Do a GIS analysis to determine the available roof space for PV installations in the Western Cape
- Investigate the appetite for PV uptake per area with existing tariff structures in place
- Investigate incentives / tariff structures that will encourage PV uptake
- Examine the intermittency/irregular usage profiles of individual residential users and the impact that has on non-aggregated bi-directional metering and concerns about tariff structures
- Modelling off-grid battery solutions for electricity users seeking grid independence
- Modelling battery solutions for electricity users for electricity load peak shaving
- Researching grid scale battery solutions to support grid stability - specifically in existing weak grids
- Identify sectors with a high potential for PV installations and investigate barriers

Conclusion

This document quantifies the maximum amount of PV that can be installed in the Western Cape before grid studies are needed. The electricity generated from this calculated installed PV capacity was then compared with the load profiles at the transmission substations to evaluate the impact.

This is a high level technical study that should lead to more detailed investigations on local level in technical- and socio-economic spheres.

A conservative approach based on the electricity load profiles at transmission substation level, indicates that 593 MW of distributed solar PV could easily be installed in the Western Cape. This is almost sixty times more than what is already installed. These results show a large scope for rooftop PV installations within the Western Cape and that the Western Cape Provincial Government can encourage these installations.

Furthermore, if this PV potential is installed across the Western Cape, the electricity generation from these installations will complement the load profiles well at transmission substation level.

The installed transformer capacity, at high voltage level, could allow installations up to 1 329 MW_p, but the stability of the grid might be influenced and a detailed investigation and grid studies will be required on a case by case basis.

This research confirms that distributed solar PV is a viable option to supplement the Western Cape's electricity requirements.

Appendix 1: List of installed PV in the WC (excluding off grid and REIPPPP)[19]

Description / Location	Application	Size (kW_p)
Somerset College	Commercial	2
Zootee Studios		2
Hi Temp Johan	Residential	3
Clan William		3.2
Hout bay		3.3
Constantia		3.3
Constantia		3.7
Llandudno		4.5
Constantia		4.5
Hout bay		4.5
Tokai		4.5
Durbanville		4.5
Durbanville		4.5
Two Oceans Aquarium		5
Claremont		5
Hout bay		5.5
Durbanville		5.8
Christian brothers centre	Commercial	7
Somerset west	Residential	7
Cape Town		8
Wolwedans	Commercial	9
Hout bay		10
Wellington		10
Stellekaya Wine Farm	Agricultural	10
House Whitaker	Commercial	12
Cavendish Square	Commercial	15
Khayalitsha Environmental Health Offices		17
Cybersmart	Commercial	20
Vineyard Hotel spa		20
Chaloner	Commercial	21
Solar irrigation system Montague	Agricultural	24
Khayalitsha Distric Hospital	Commercial	25
Koppie Alleen	Commercial	25
Kleinood	Agricultural	28

[19] From: http://pqrs.co.za/s-a-solar-pv-list-2/solar-pv-list/

Impahla Clothing	Industrial/Manufacturing	30
Store-age Pinehurst	Commercial	30
Imperial Logistics	Commercial	30
Hessequa Municipality	Commercial	33
Beaufort West Municipality	Commercial	33
Rectron Cape Town	Commercial	34
Lelienfontein	Agricultural	35
Oldenburg Vineyards	Agricultural	45
Boland bottling plant	Commercial	48
Bosman Family vineyards	Agricultural	53
Cavalli Wine and Stud Farm	Agricultural	58
La Motte Winery	Agricultural	60
Klein Constantia	Agricultural	60
Eric Miles	Commercial	62
Cape Town Mitchells plain hospital	Commercial / Industrial	62
BP Offices	Commercial	67
Glenelly Wine Estate	commercial	70
Cornerstone	Commercial	81
Historic wine	Commercial	84
J.C.Bosman & Groenfontein	Agricultural	88
Bloemhof	Commercial	100
Quoin Rock Winery	Agricultural	102
HQ Foods Cape Town	Commercial	103
Woolworths		108
Blue jay fruit	Agricultural	127
Villiera Wine Estate	Agricultural	132
Glaxo Smith Kline	Industrial	143
Bo-Radyn Farm	Agricultural	162
De Grendel Winery	Agricultural	210
Cape Quarter		212
Vrede & Lust		218
Bowler Plastics Phillipi		280
Apple warehouse	Agricultural	288
Pick n Pay Distribution	Commercial	300
Stellenpak Fruit packers		420
Arbeidsvreugd	Agricultural	450
Villiersdorp Cold storage	Commercial	450
Lourensford	Agricultural	500
Bayside Mall	Commercial	500
Vodacom Century City		542
Wembley square		576

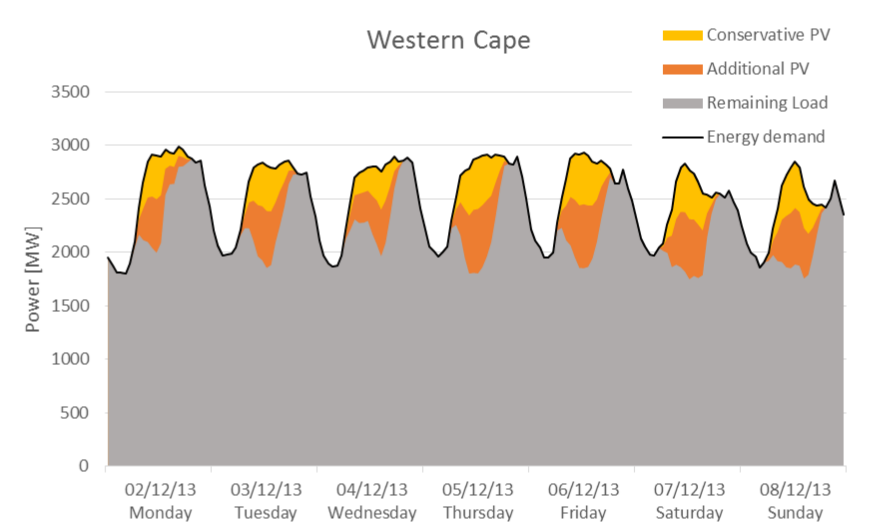
Silver stream business Park		691
Ceres Coldrooms	Commercial	1015
Black River Park	Industrial	1200
TOTAL		**10 229**

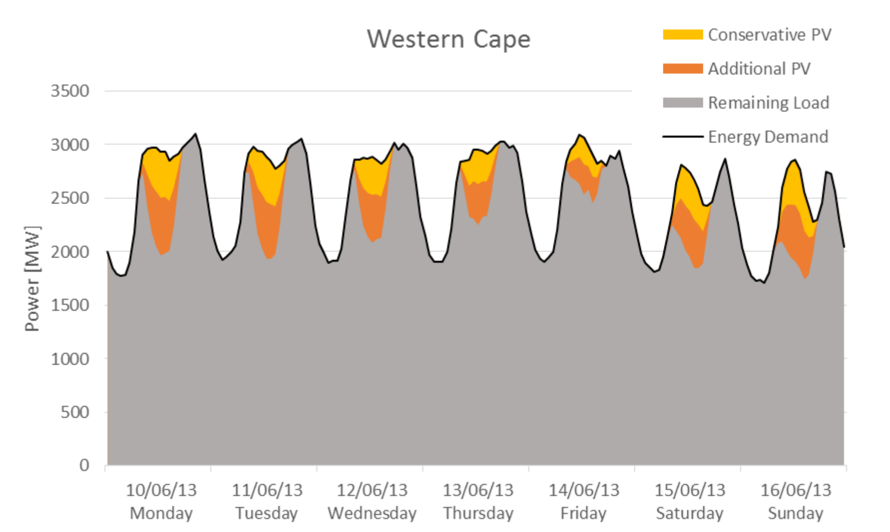
A 33 kW_p PV municipal installation in Riversdale

Appendix 2: Impact of potential PV generation for a typical winter a and a typical summer week

Summer week 2 - 8 December 2013 | **Winter week 10 - 16 June 2013**

Western Cape





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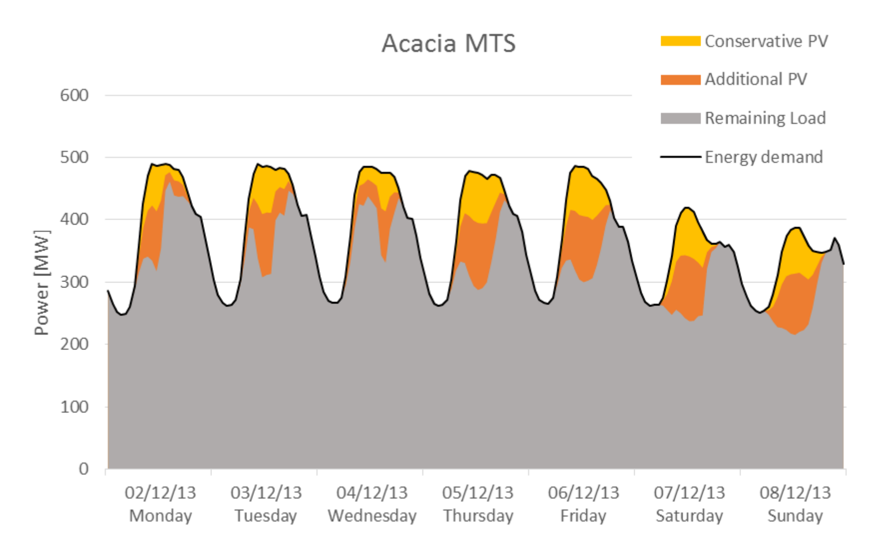
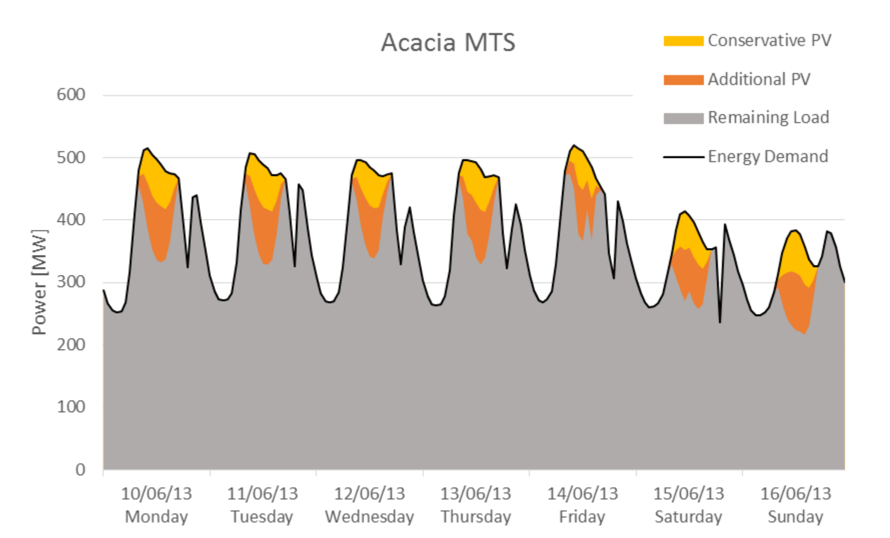
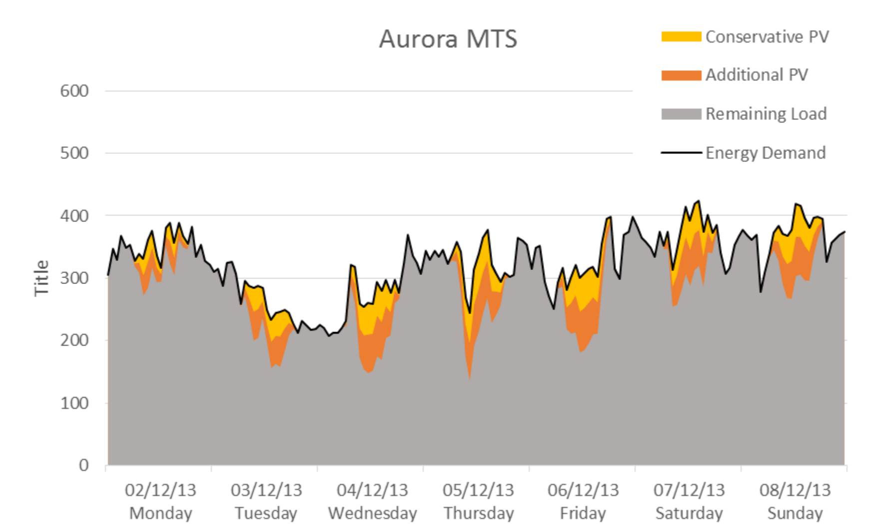
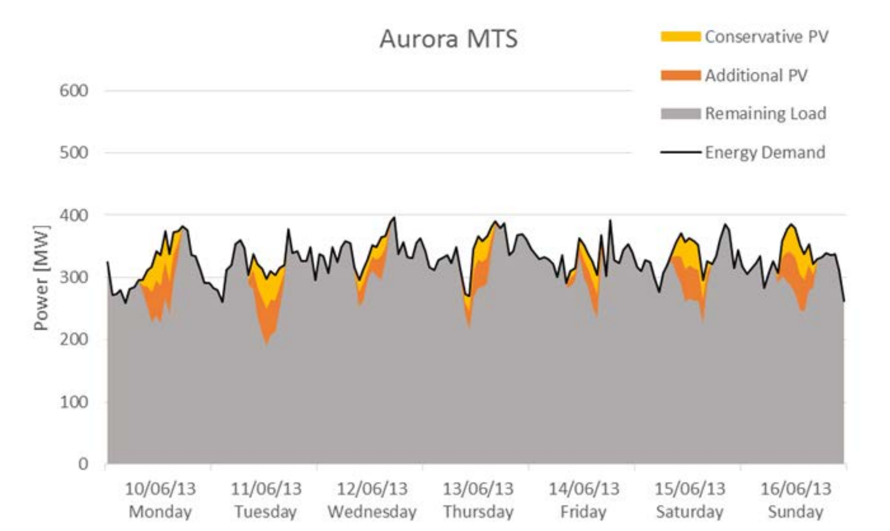


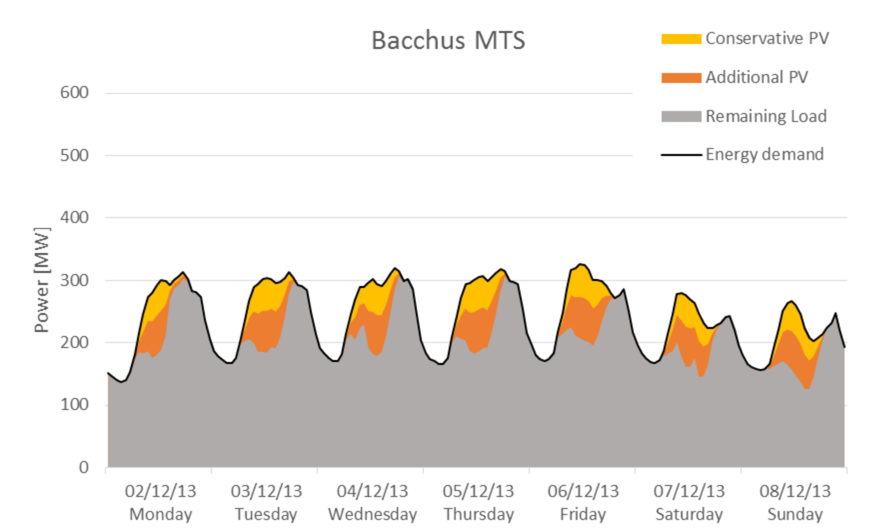


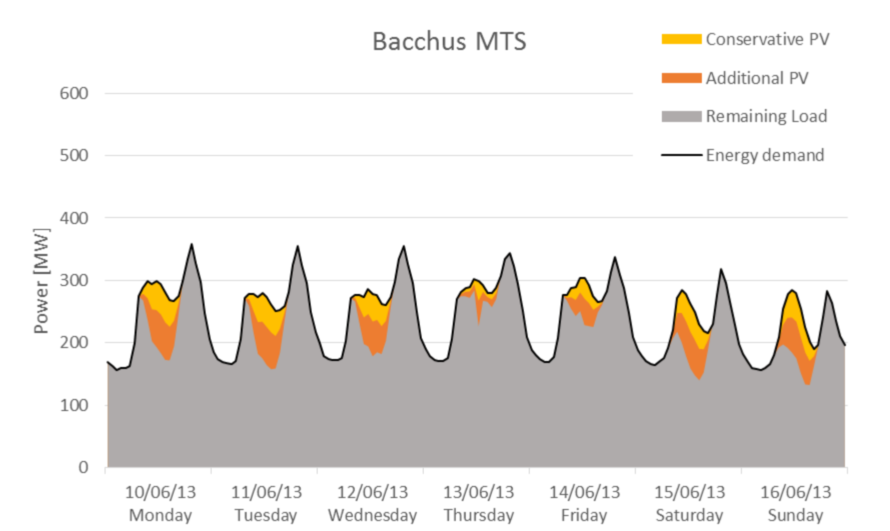
Aurora MTS

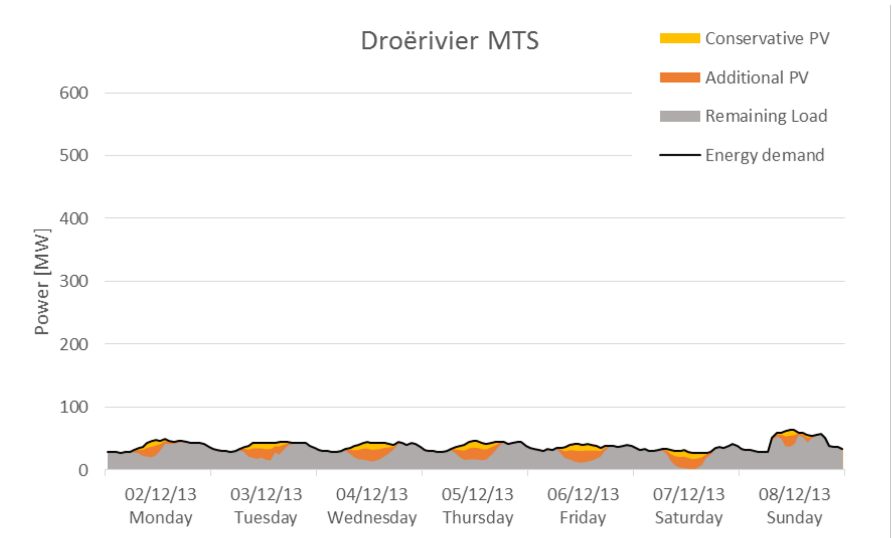
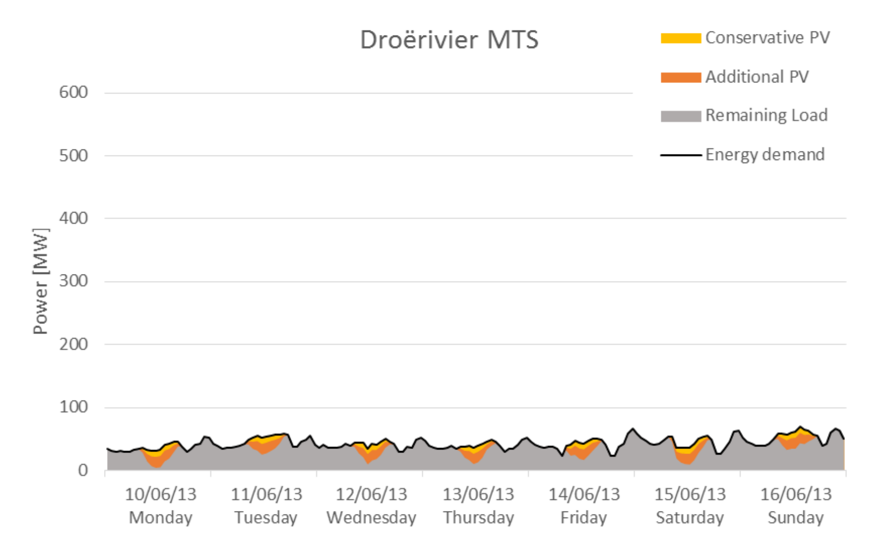
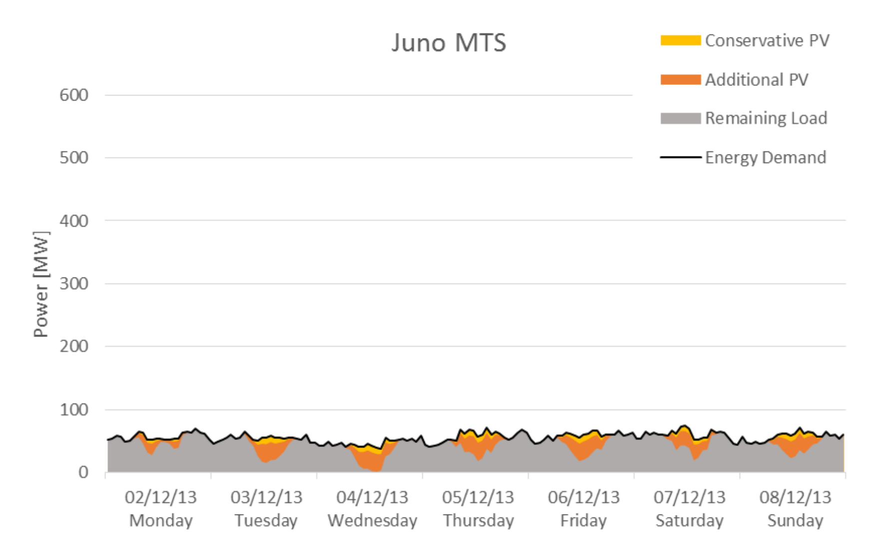
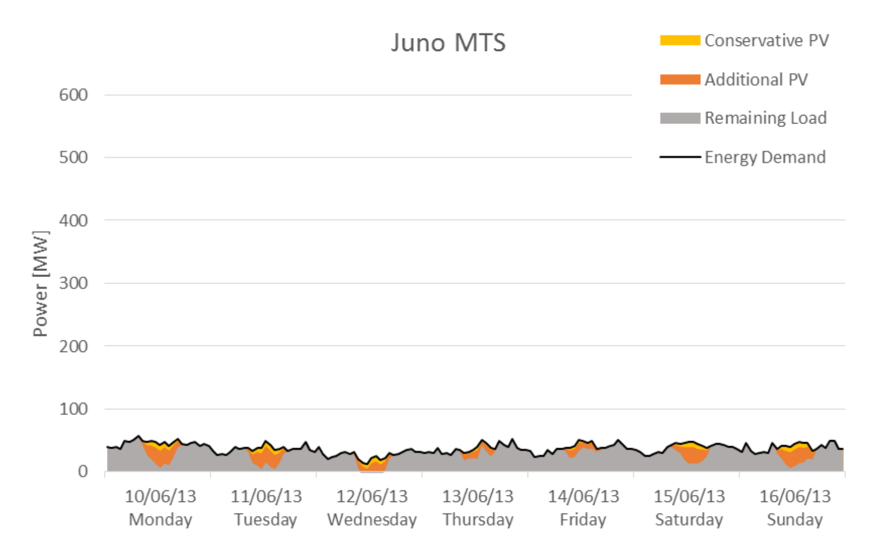
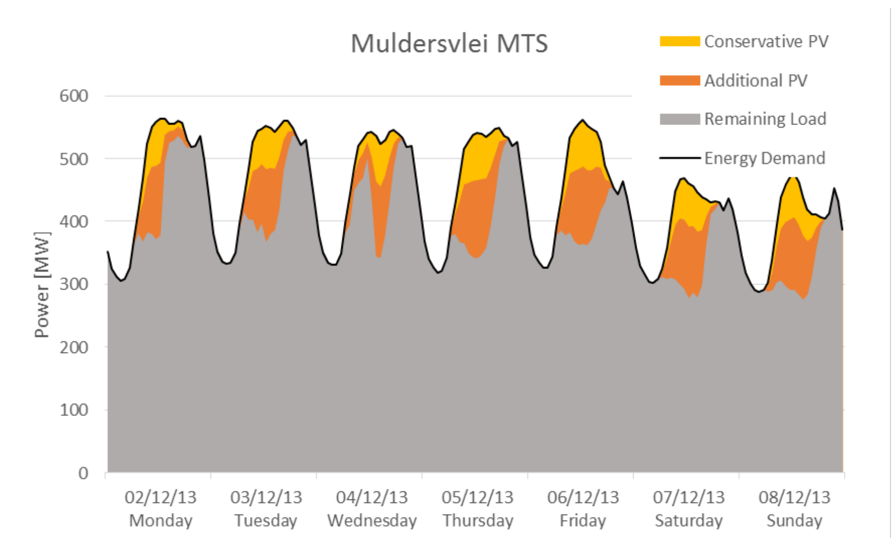
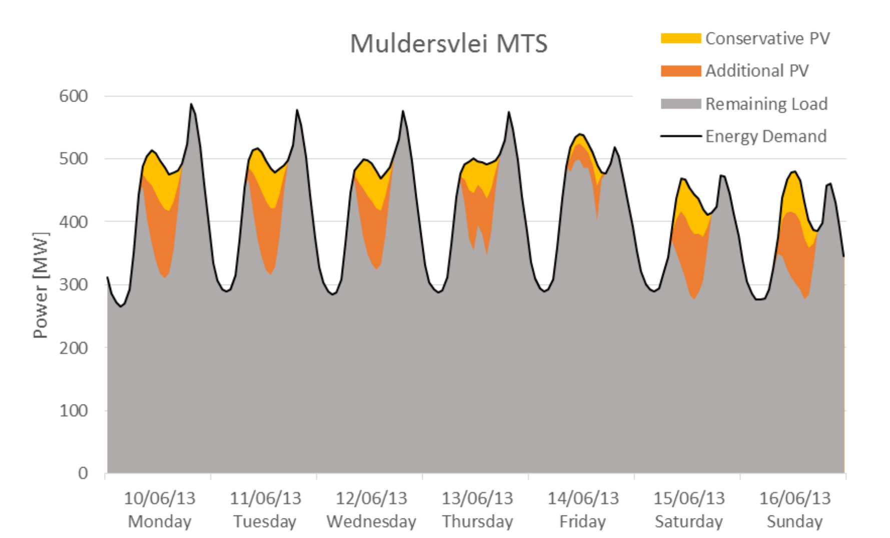
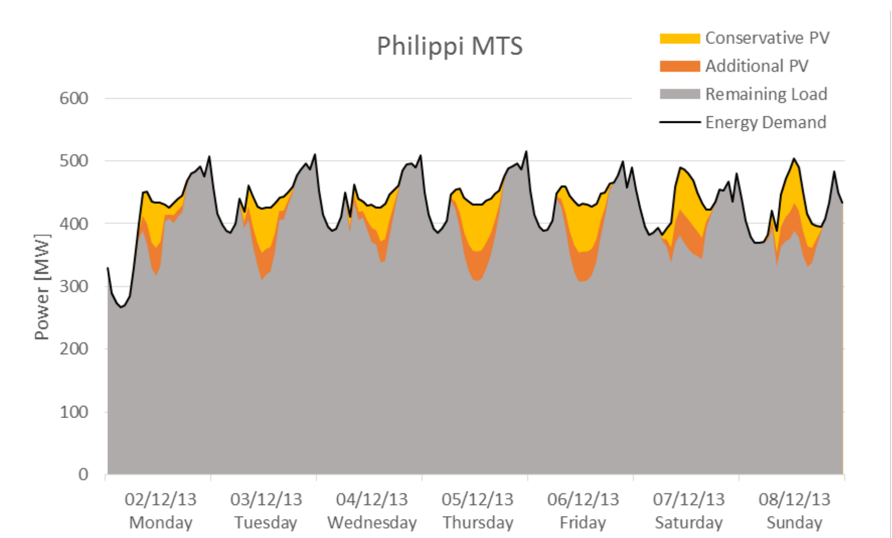
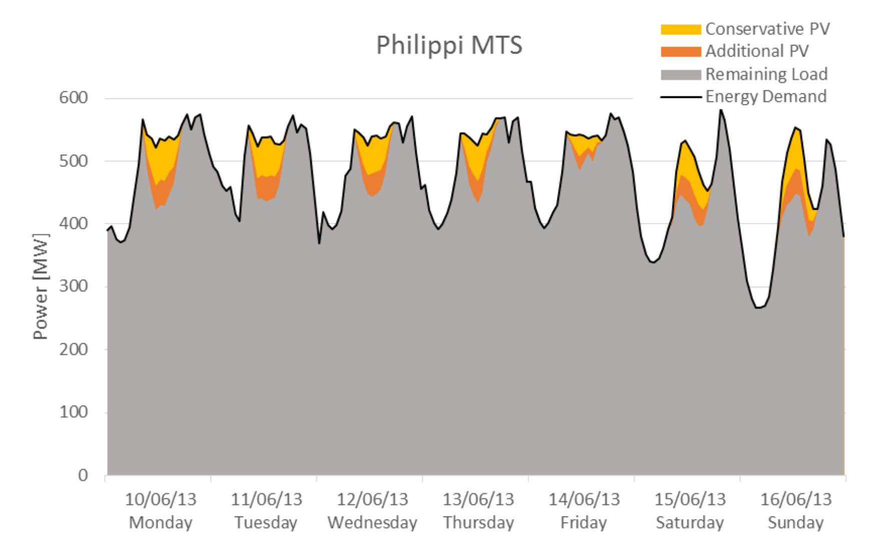




Bacchus MTS





	Summer week 2 - 8 December 2013	Winter week 10 - 16 June 2013
Droerrivier MTS		
Juno MTS[20]		
Muldersvlei MTS		
Philippi MTS		

[20] Negative energy values indicate net generation and power will flow upstream. To avoid this situation the NRS097-3 recommends to use 15% of the maximum load at MV feeders which is more conservative than using 15% of the installed capacity and therefore net generation should not occur as can be seen from the yellow part in the graph.

<table>
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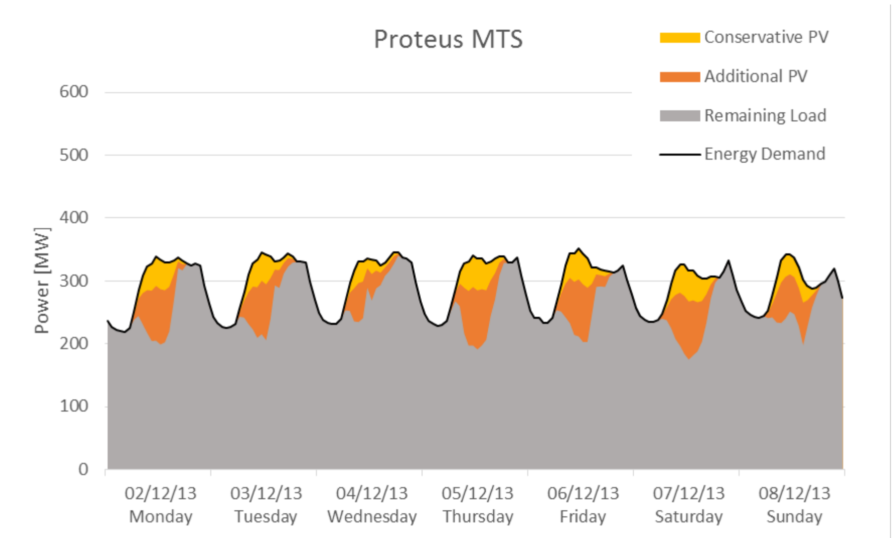
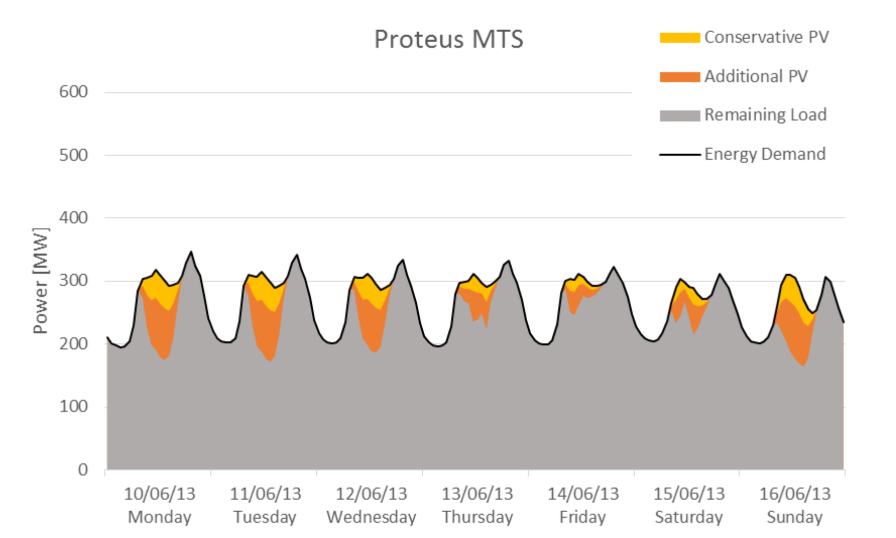
<tr><td>Proteus MTS</td><td>
</td><td>
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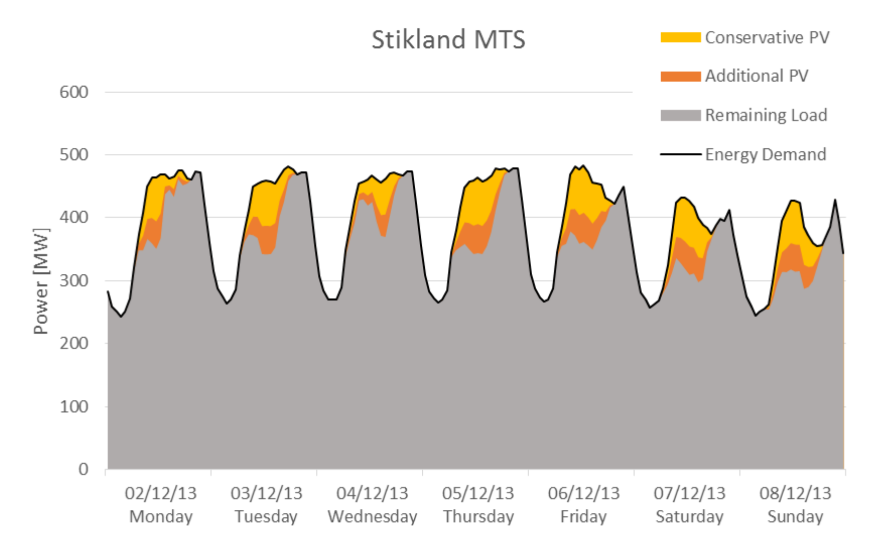
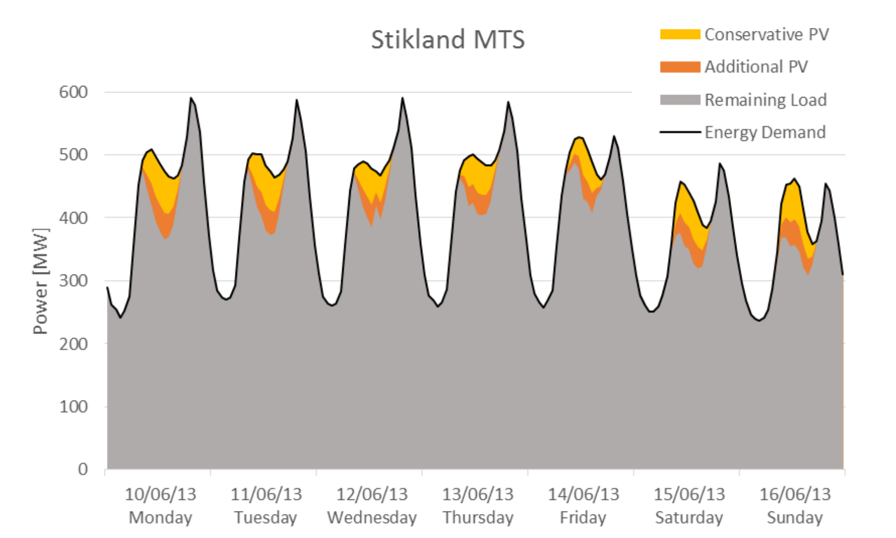
<tr><td>Stikland MTS</td><td>
</td><td>
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