SolarPeak®

SolarPeak® 5.0 kW PV-Generator

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www.SolarPeak.com

SolarPeak Head Office | ops@SolarPeak.com | (03) 547 58 19| Nelson

1 What is this?

This document details the SolarPeak 5,0 kW PV-Generator. This is a grid connected photovoltaic (PV) generator of 5,0 kW_{peak}. This report is divided in following sections:

- ✓ Description of the system
- ✓ Expected savings
- ✓ Technical details

2 The system

The SolarPeak 5,0 kW PV-Generator is a grid tied photovoltaic system of 5,0 kW peak power. This means that it has a power of 5,0 kilo-Watts when the sun is shining strongly, or equivalently, that **it will deliver 5,0 kWh for every peak sun hour**. An average New Zealand city has more than 1.400 peak sun hours a year. Hence 1.400h · 5,0 kW = 7000 kWh/year could be delivered under these average condition, if there were no losses (see next section to find out more).

Grid tied means that every unit of generated energy will be injected to the electricity grid, causing your meter to spin backwards. This lowers your electricity bill. If your produce more energy than you consume, the electricity company buys the surplus from you –usually at the same price you pay-.

Box 1: PV grid tied advantages

- ✓ It does not require batteries; therefore investment costs are considerably lower than off-grid systems.
- ✓ Maintenance is near zero (occasional cleaning of modules required).
- ✓ There is no waste energy. Every unit of energy that is produced can be delivered to the grid.
- ✓ You will never be short of energy: you are still connected to the grid, so even in winter you can consume all the energy you need (excluding blackouts).
- ✓ The system helps reducing greenhouse emission. During its operation there is zero pollution.
- ✓ It improves that national electricity grid's efficiency. During daytime more cost-inefficient and polluting power plants operate to satisfy the daytime peak. PV grid-tied systems reduce the amount of those inefficient systems.

The system is composed of the **PV modules**, which transform the solar energy into electricity; the **inverter**, which transforms the direct current to alternating current and allows the connection to the grid; the **cables** to connect the components; and the **safety devices** to ensure the endurance and safety of the system. Other devices are included such as connectors and junction box. The SolarPeak 5,0 kW PV-Generator is available in mono-crystalline and thin-film PV technology. The basic difference is that thin film is cheaper, but requires more space than mono-crystalline. No matter the implemented technology, the SolarPeak 5,0 kW PV-Generator will generate the same amount of energy. The main specifications for both technologies are shown Table 1 to Table 3.

The expected lifetime of the inverter is around 10 years. The PV-modules are TÜV certified and a 90% of their original efficiency is ensured after 10 years and 80% after 25 years

Table 1: PV array specification

	Mono-crystalline	Thin-film
Total Power [kW]	5,0	5,0
PV modules	27	98
Array (Strings x Modules)	3x9	14x7*
Required space [m^2]	41	87

The generator can be mounted on the roof, a field or any other area where the sun reaches. The installation place should have as less shadows possible, since they could reduce the performance considerably.

Table 2: Inverter specification

	Mono-crystalline	Thin-film
Make	SMA	SMA
Model	SB5000TL-20	SB5000TL-20*

***Transformerless inverters have been proven compatible with our thin-film modules**

Table 3: Cable specification for DC (PV) and AC (after inverter) circuits

	Mono-crystalline		Thin-film	
	DC*	AC	DC*	AC
Cable length [m]	16	10	10	10
Cable section [mm^2]	1,5	6	1,5	6
Breaker	10	30	10	30

***Cable section refers to each string, i.e. if there are 4 strings each one will have 1,5mm^2. Hence total is 6mm^2.**

Box 2: Monitoring device: Sunnybeam

Optionally we can provide remote monitoring. Sunnybeam allows you to supervise the performance of your PV generator on a little sun-powered screen.

Online monitoring is possible as well. So you will be able to check the system's status and your solar savings no matter where you are.

3 Expected savings

This section shows the energy and monetary savings you can expect to achieve with the SolarPeak 5,0 kW PV-Generator.

Before analyzing the savings we would like to show how to estimate the electricity demand of a standard household. This way you can replicate the method for your own family and understand how much a "kWh" is. Please see Box 3 for more details.

Box 3: Energy demand of a household

The energy consumption of every household is different. It depends on their way of life, habits and what they use electricity for. As a general recommendation you should use PV-electricity only for appliances. For water and house heating there are more efficient (and also clean) technologies available, such as passive solar, solar thermal, heat pumps and biomass heaters.

Every appliance demands a certain amount of power (that is the instantaneous energy consumption). It can be found usually next to power plug or transformer and is measured in Watts (W). For example a notebook consumes 50 W approximately. Now, if we use this notebook during one hour, we would have consumed 50W·1h= 50Wh. Since Wh is a small unit of energy, the electricity bill usually shows the consumption in kWh, equivalent to 1000 Wh.

To obtain to household's total consumption we need to make a list of all the appliances with their power and the amount of time they are used. This was done as an example for a 2-person household in the next table. The daily energy use [kWh] is the product between the power, quantity and daily use (and divided by 1000 to transform Wh to kWh). The monthly energy use [kWh] is the daily use multiplied by 30; the yearly energy use [kWh] is the monthly multiplied by 12. Please note that some devices don't run all the time at full power and it is easier to consider the daily or monthly energy consumption only (this cannot be read directly from the device, unless it has some kind of energy label or you use an energy meter), e.g. fridge.

Table 4: Example of daily, monthly and yearly energy consumption of a two-person household.

Appliance	Power [W]	Quantity	Daily use [hh:mm]	Daily e. [kWh]	Monthly e. [kWh]	Yearly e. [kWh]
Notebook	50	2	04:00	0,40	12	148
40"LCD TV	150	1	02:00	0,30	9	108
Fridge	-	-	00:00	-	40	480
Washing machine	500	1	00:17	0,14	4	51
Light	20	6	06:00	0,72	22	259
Microwave	1000	1	00:10	0,17	5	60
Cooker/Oven	1000	1	00:30	0,50	15	180
Other devices	2000	1	00:10	0,33	10	120
Chargers/Standby	8	2	24:00	0,38	12	138
Total	-	-	-	**3**	**129**	**1545**

The daily consumption is 3 kWh and the yearly demand is around 1500 kWh. This equals to an average of 65 kWh per month per person. If this household liked to become energy neutral, they would need a 1,2kW system in order to inject about the energy they consume every year.

An average city of New Zeeland has an annual incoming solar radiation of 1400 kWh/m^2 (1400 sun peak hours). If the PV system had no losses it would be able to generate 5,0 kWh of electricity during every sun peak hour. Naturally there are some minor losses due to operating conditions of the cells (when they get hot, they become less efficient), the inverter and the transmission of the electricity (cables). These losses are shown in the next table.

Table 5: Efficiency of PV system

Efficiency	Value
PV array	87%
Inverter	96%
Cables DC	99,5%
Cables AC	99,0%
System efficiency	**82%**

Box 4: PV efficiency

It is common to hear about the low efficiency of **PV cells**. This is true. Usually the efficiency is around 12-18% for monocrystalline technology. This means if 1000W fall on a module of 1m^2, then 120-180 Watt of electricity will be produced. The only advantage of a more efficient cell is that it will use less space (but it will be more expensive). What usually is more important at the moment of purchasing a module, is the cost per Watt of power, no matter the area (when space is no issue).

The system efficiency of Table 5 already considers this (Our system has a net area of 31,7 m^2 and produces 5,0 kW. Hence the efficiency is 5,0/31,7 = 16% for our mono-crystalline modules), since we only consider the output power of the whole system no matter the area it uses.

Once we have the system's efficiency we can calculate the electricity it will generate per year:

$$Generated\ energy = Nominal\ power_{PV} \cdot Efficiency_{system} \cdot Sun\ peak\ hours_{year}$$

For the standard location we have:

$$Generated\ energy = 5{,}0\ kW \cdot 82\% \cdot 1400\ h/year = 5764\ kWh/year$$

We just obtained a yearly solar saving of 5764 kWh for an average radiation in New Zealand. Now, if we want to get a more precise result for the city of this project, we can multiply the 5764 with the factor for the city we obtain from Table 6. For more details see example of Box 5.

Table 6: Correction factors for different cities (if optimum tilt is used)

City	Correction factor
Auckland	105%
Taupo	107%
Hastings	113%
Rotorua	107%
Palmerston	92%
Wellington	100%
Nelson	119%
Christchurch	107%
Dunedin	90%
Queenstown	105%

Box 5: Example of customizing location

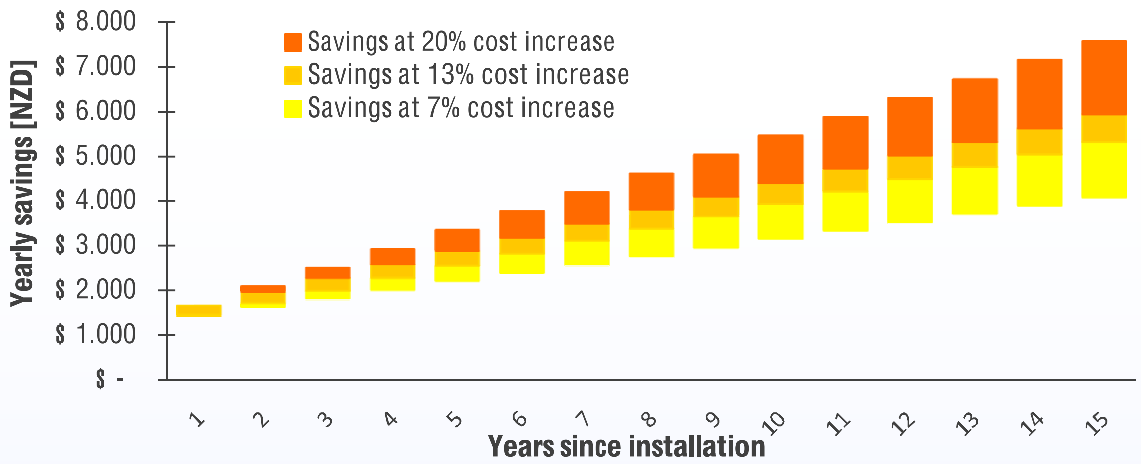
For example in Nelson we would save: 5764·119%= 6859 kWh/year, where "119%" was looked up in Table 6.

To obtain the monetary savings we just need to multiply the yearly saved energy by the energy price. For zones were electricity costs 0,27 NZD/kWh we will have a saving of 0,27·5764 ~ 1560 NZD in the first year. Since energy prices rise continuously, the second year the system will save a bit more; even more the third year; and so on. This is shown in the next chart. There is no certainty of the amount energy prices will raise; therefore we created different scenarios for the cost analysis and let it up to the client which one to choose.

These scenarios are:

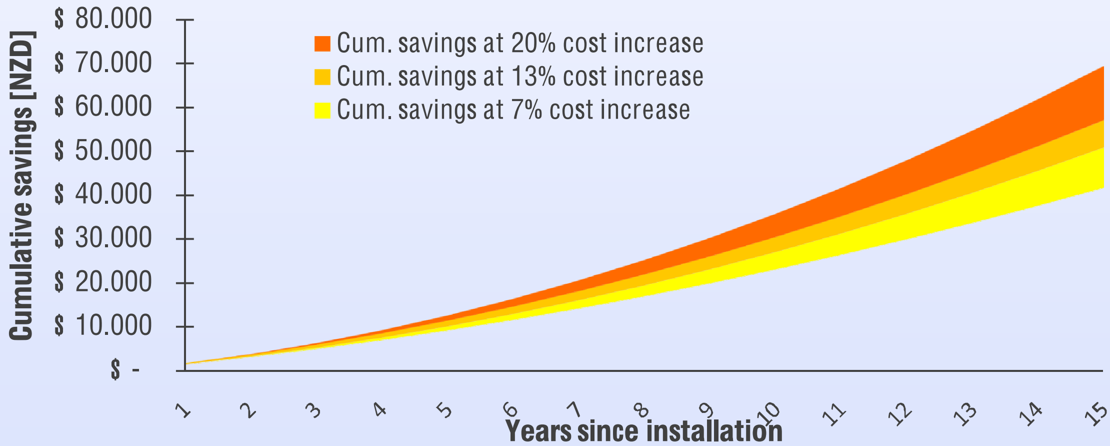
- Conservative scenario (yellow): energy prices increase by only 7% a year.
- Statistic scenario (gold): energy prices increase by 13% a year. This rise is a bit higher than the average increase of electricity over the last 10 years, since is considers the faster growing oil price.
- Accelerated –resource depletion- scenario (orange): energy prices increase 20% a year.

Chart 1: Yearly savings projections for next years at different scenarios



If we sum up the yearly savings we get the next chart. It shows how much we will have saved after a given number of years. For example 8 years after the installation, the system will have save $ 15.732 NZD under the statistic scenario (orange). This is very helpful to determine the payback of the system and the total savings of the system.

Chart 2: Cumulative savings projections for next years at different scenarios



4 Technical characteristics

The PV module's electric characteristics are shown in the next table.

Table 7: Electrical characteristics of one PV module

Characteristic	Mono-crystalline	Thin-film
Normal power [W]	180	50
Voltage at P_{max} [V]	36,2	43
Current at P_{max} [A]	4,97	1,17
Open circuit voltage [V]	44,2	62
Short circuit current [A]	5,36	1,42
Current temperature coeff. [%/K]	0,08	0,09
Voltage temperature coeff. [%/K]	-0,36	-0,33
Power temperature coeff. [%/K]	-0,51	-0,22

The module's physical characteristics are shown in the next table.

Table 8: Physical characteristics of PV module

Characteristic	Mono-crystalline	Thin-film
Dimension [mm x mm x mm]	1580x808x35	1245x635x8
Weight [kg]	17	14,4
Working temperature of modules	-40°C,+90°C	-40°C,+90°C

The technical characteristics of this system are specified in the attached files to this report. Please look at the "System Overview" and "Checklist" file.

5 Attachment

Please see attached files.