Photovoltaic system

NOMINAL POWER EQUAL TO 5,76 KWP
PROJECT NAME:
RESIDENTIAL HOME IN ADELAIDE

Located in

ADELAIDE
HAYWARD AVE 245

Customer

JOHN SMITH

33 SYMONDS PL
5000 - ADELAIDE (SA)

TECHNICAL REPORT

Designer

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DATE:
ADELAIDE, 12/09/2012

PURPOSE OF THIS DOCUMENT

The document gives the technical report of the photovoltaic system. In the document will be identified the plant, will be provided project data, the characteristics of the materials used (photovoltaic modules, inverters), the criteria for the choice of system solutions and design criteria of major components. In addition, they will be reported to preliminary calculations needed to sizing, bill of quantities and drawings (circuit diagrams and layout of system).

1 - TECHNICAL REPORT

The photovoltaic system of nominal power[1] 5,76 kW will be located at Adelaide (SA) Hayward Ave 245 and will be connected to the electrical distribution grid in Low voltage Single-phase alternating current a 230,00 V the responsibility of the grid operator.

1.1 PROJECT DATA

The project data are reported below and relate to the customer, the installation site, the data on the electricity supply and the presence or absence of objects shading.

Customer	
Name	John
Surname	Smith
Company	
Address	33 Symonds Pl
City	5000 - Adelaide (SA)

Installation site	
Location	Adelaide
Address	Hayward Ave 245
Latitude	-34,93º
Longitude	138,60º
Altitude	56 metri
Maximum temperature	28,27 ºC
Minimum temperature	6,76 ºC
Global irradiation on a horizontal plane	4,64 kWh/m²
Irradiance data	NASA-SSE
Albedo	20%

The photovoltaic system will be connected to a user system served by a electrical supply having the following characteristics:

Electricity supply	
Grid operator	AEMO
Connection type	BT - Mono
Nominal voltage	230,00 V
Available power	6,00 kW

[1] The nominal power of a photovoltaic system is intended as the sum of the nominal power of each module measured at standard test conditions (STC).

Average annual consumption	7.300,00 kWh
Customer code	1234565
Contract number	GF-74834

1.2 DESCRIPTION OF THE PHOTOVOLTAIC SYSTEM

The photovoltaic system with nominal power 5,76 kW will be connected to electrical distribution grid in Low voltage Single-phase in alternating current of type Mono a 230,00 V competence of AEMO.

The characteristics of the system are summarized below, in particular in Figure 1 shows the electrical diagram single-wire of system.
In it are distinguished:
The photovoltaic generator consists of:

- 2 strings of 16 modules connected in series
- The group of conversion formed by 1 inverter Single-phase
- The group of interface
- The systems of measurement of energy

1.2.1 PHOTOVOLTAIC GENERATOR

It will consist of:
- PV modules connected in series for the realization of the strings
- Electric cables for connection between modules and between these to electrical panels

Below are the characteristics of photovoltaic generator and of its main components, namely strings and modules.

Electrical characteristics of the photovoltaic generator	
Nominal power	5,76 kWp
Number of PV modules	32
Intercepting surface	40 m²
Number of strings	2
Maximum voltage @STC (Voc)	716,8 V
Voltage at maximum power @STC (Vmpp)	558,4 V
Short circuit current @STC (Isc)	11,5 A
Current at maximum power @STC (Impp)	10,12 A

In the case of the plant in question, the photovoltaic generator has different exposures (tilt angle and azimuth angle different depending on the photovoltaic field taken into account), namely:
Exposure of the PV generator:

Field 1:
Azimuth : 2,9 °
Tilt : 22,7°

In order to avoid electrical losses for mismatching, the PV fields with different exposures will be connected to inverters distinct or, alternatively, to inverters with independent inputs (independent MPPT).
In the case of the plant in question, the photovoltaic generator presents a single exposure (tilt angle, and azimuth angle equal for all PV modules), namely:
Exposure of the PV generator:

Azimuth : 2,9 °
Tilt : 22,7°

The photovoltaic generator of the nominal power of 5,76 kW uses the series-parallel configuration and will be divided into 2 strings of modules connected in series. The following lists the compositions of the strings of the system.

Electrical characteristics of the strings	
Number of PV modules in series	16
Nominal power	2,88 kW
Open circuit voltage (Voc)	716,8 V
Short circuit current (Isc)	5,75 A
Current at maximum power (Impp)	5,06 A

Construction data of the modules:

Construction data of the modules	
Manufacturer	Sun Tech Solar Co. Ltd.
Model	XTP 180-34
Tecnology	Si-Mono
Nominal power	180,00 W
Tollerance	5,00%
Open circuit voltage (Voc)	44,80 V
Voltage at maximum power (Vmpp)	34,90 V
Short circuit current (Isc)	5,75 A
Current at maximum power (Impp)	5,06 A
Area	1,25 m²
Efficiency	14,4%

1.2.2 GROUP OF CONVERSION DC/AC

The conversion group of the photovoltaic system will consist of 1 inverter Single-phase for a total output of about 5,76 kW.

The main technical characteristics of the inverter are summarized below.

Construction details of the inverter	
Manufacturer	ABB Automation Products GmbH

Model	PVS300-TL-6000W-2
Nominal power	6,10 kW
Maximum power	6,70 kW
Maximum efficiency	97,10%
European efficiency	96,60%
Maximum voltage from PV	900,00 V
Minimum voltage MPPT	335,00 V
Maximum voltage MPPT	800,00 V
Maximum input current	19,00 A
Number of MPPT	1
AC output voltage	230,00 V
Output	Single-phase
Isolation transformer	True
Frequency	50/60 Hz

1.2.3 ELECTRICAL DC PANELS

The photovoltaic system consists of 1 panels DC, as follows are listed the different compositions of the electrical panels in the system:

Electrical DC panel	
Number of inputs	2
Max current for each input	5,75 A
Max input voltage	792,06 V
Max output current	11,50 A
Input device	ABB OT16F8
Nominal current of the input device	16,00 A
Protection	None
Nominal current protection	0,00 A
Blocking diode	None
Nominal current of the blocking diode	0,00 A
Output device	ABB OT16F8
Nominal current of the output device	16,00 A
Discharger	ABB OVR PV 40 1000 P
Category of discharger	II
Discharger voltage	1.000,00 V

2. Drawings

2.1 - Single-line circuit diagram

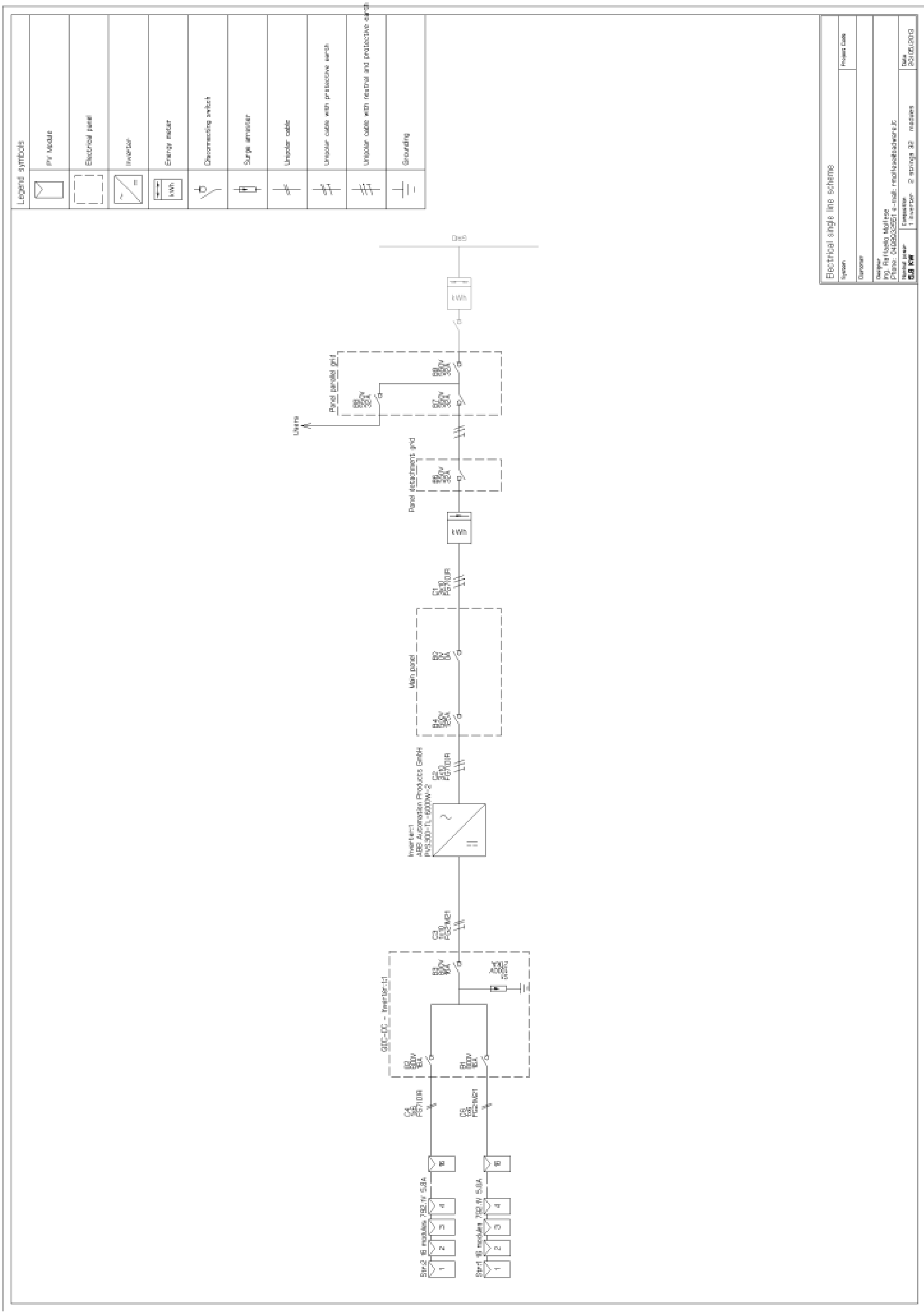


Figure 1: single-line circuit diagram

2.2 - General layout of system

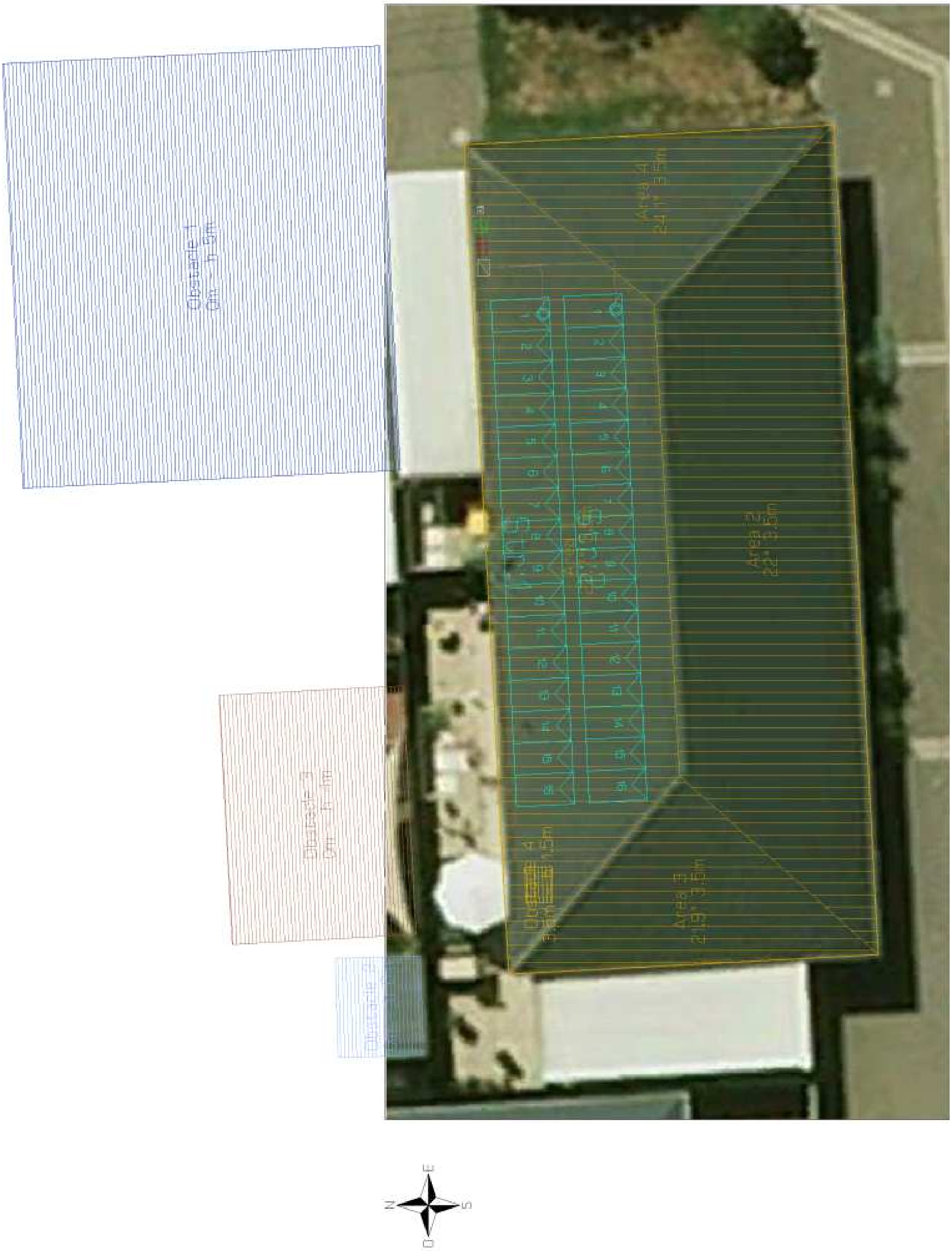


Figure 2: Placement of the PV generator and group conversion

3. Preliminary calculations

3.1 - Annual producibility

Site installation
The plant will be installed in locations Adelaide (SA) Hayward Ave 245.
The table below shows the main geographical data of the installation site.

Geographic data of the site	
Location	Adelaide
Latitude	-34,93º
Longitude	138,60º
Altitude	56 metri
Maximum temperature	28,27 ºC
Minimum temperature	6,76 ºC
Irradiance data	NASA-SSE

At this location we have the following daily irradiation on a horizontal surface obtained according to the source NASA-SSE.

Month	Diffuse daily [kWh/m²]	Direct daily [kWh/m²]	Global daily [kWh/m²]
January	2,37	4,48	6,85
February	2,05	4,16	6,21
March	1,67	3,32	4,99
April	1,24	2,54	3,78
May	0,94	1,82	2,76
June	0,80	1,51	2,31
July	0,85	1,71	2,56
August	1,11	2,20	3,31
September	1,51	2,86	4,37
October	1,96	3,51	5,47
November	2,34	3,98	6,32
December	2,52	4,20	6,72
Yearly	**1,61**	**3,03**	**4,64**

Considering the monthly average daily irradiation and the number of days which make up the twelve months of the year, you can determine the value of the annual global irradiation on a horizontal surface for the location of Adelaide (SA). This value is equal to 4,64 [kWh/m²]..

Far shadings
Normally in a photovoltaic system the shading should be avoided because they cause loss of power and therefore of energy produced. However, limited phenomena are be permitted where they adequately assessed.
In case of the plant in question not exist shadowing.

Calculation of producibility
The producibility of the system was calculated on the basis of data, derivates from source of climate data NASA-SSE, of the installation site relative to the average monthly global of solar radiation incident on horizontal surface.

The procedure for the calculation of the energy produced by the system takes into account the nominal power (5,76 kW), the angle of tilt and azimuth (22,7° , 2,9°) of the PV generator, the losses on the PV generator (resistive losses, losses due to difference in temperature of the modules, for reflection and for mismatching between strings), the efficiency of the inverter as well as the coefficient reflectance of the ground in front of the modules (20%) (albedo).

Therefore, the energy produced by the system on an annual basis (Ep, y) is calculated as follows:

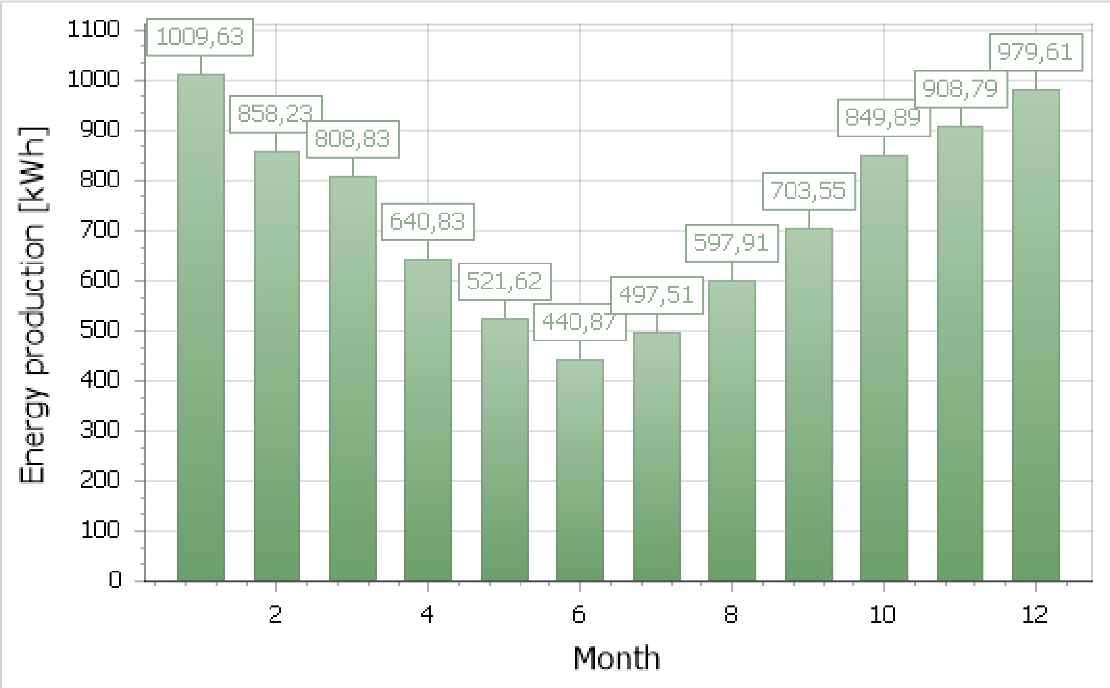
$$Ep,y = Pnom * Irr * (1\text{-}Losses) = 8.817,29 \text{ kWh}$$

Where:
- Pnom = Nominal power of system: 5,76 kW
- Irr = Annual irradiation on the surface of the modules: 1866,34 kWh/m²
- Losses = Power losses: 17,98 %

The power losses are due to various factors. The table below lists these loss factors and their values assumed by the procedure for the calculation of system producibility.

Losses	
Temperature losses	5,00 %
Mismatching losses	5,00 %
Resistive losses	4,00 %
Losses for DC/AC conversion	3,40 %
Other losses	2,00 %
Shading losses	0,00 %
Total losses	**17,98 %**

The graph below shows the trend of monthly production of energy expected during the year.



3.2 - Verification of proper electrical connections between the photovoltaic generator and the group of conversion DC AC.

In order to choose an inverter is normally necessary to verify the compatibility between the inverters used and the PV fields.
The verifications on inverters refer to the section in DC current of the photovoltaic system and concern:

- The verification of the DC voltage
- The verification of the DC current
- The verification of the power

Verification of DC voltage
The verification of the DC voltage is to check that the set of voltages supplied by the photovoltaic field is compatible with the range of variation of the input voltage of the inverter.
In other words, it is necessary to calculate the minimum and maximum voltage of the photovoltaic field and verify that the first is greater than the minimum input voltage acceptable for the inverter, and the second is less than the maximum input voltage allowed by the inverter.

Verification of DC current
The verification of the DC current is to check that the short circuit current of the PV field @ STC is less than the maximum permissible input current of the inverter.

Verification of the power
The verification on the power of is to check the nominal power of conversion group DC / AC (sum of nominal power of the inverter) is more than 80,00% and less than 120,00% of the nominal power of the photovoltaic system (sum of nominal power modules photovoltaic).

The following tables show the result of these verifications.

Inverter:1

Voltage limits	Minimum voltage at module temperature of 65,77°C (470,73 V) > Minimum MPPT voltage (335 V)
Voltage limits	Maximum voltage at module temperature of -10°C (633,66 V) < Maximum voltage of MPPT (800 V)
Voltage limits	Open circuit voltage at module temperature of -10°C (792,06 V) < Maximum inverter voltage (900 V)
Limits on current	Short circuit current (11,5 A) < Maximum inverter current (19 A)
Power limits	Sizing factor on power (80 %) < (94%) < (120 %)

3.3 - Electrical pipes

The sizing of the electric cables involves the following calculations:

- Calculation of the voltage drop

Calculation of the voltage drop
Known the length of the pipeline, type of cable and the maximum current on it, the calculation of the percentage voltage drop for a cable in DC current it obtained with the relation:

$$\Delta V_{\%} = 2 \cdot \frac{R}{V_{nom}} \cdot I_{nom} \cdot \frac{L}{1000}$$

where:
L is the length of the pipeline in meters
I_{nom} is the current in the cable @STC
V_{nom} is the voltage on the cable @STC
R is the resistance per km of cable at a temperature of 80 °C

Note la lunghezza della conduttura, il tipo di cavo e la corrente massima che vi scorre, il calcolo della caduta di tensione percentuale per una conduttura in corrente alternata è ottenibile con la relazioni:

For a single-phase line:

$$\Delta V_{\%} = 2 \cdot \frac{\sqrt{R^2 + X^2}}{V_{AC}} \cdot I_{nom} \cdot \frac{L}{1000}$$

For a three-phase line:

$$\Delta V_{\%} = 1{,}73 \cdot \frac{\sqrt{R^2 + X^2}}{V_{AC}} \cdot I_{nom} \cdot \frac{L}{1000}$$

where:
L is the length of the pipeline in meters
I_{nom} is the current in the cable @STC
V_{AC} is the voltage of Grid
R, X are the resistance and reactance of the line per km, at a temperature of 80 °C

The following tables show the list of cables used in the system.
For more details, please refer to the document "Bill of cables"

Table of cables					
Label	**Code**	**Description**	**Formation**	**Voltage drop**	**Length**

C1	PRYG7P3X010	From: Main panel To: Electricity grid	3x10	0,18%	3,41 m
C2	PRYG7P3X010	From: Inverter:1 To: Main panel	3x10	0,18%	3,52 m
C3	PRYPSUN010	From: QDC-DC - Inverter:1:1 To: Inverter:1	1x10	0,03%	3,53 m
C4	PRYG7P1X006	From: Str:2 To: QDC-DC - Inverter:1:1	1x6	0,06%	8,7 m
C5	PRYPSUN004	String cable: Str:2	1x4	0,13%	12,74 m
C6	PRYPSUN006	From: Str:1 To: QDC-DC - Inverter:1:1	1x6	0,05%	6,87 m
C7	PRYPSUN004	String cable: Str:1	1x4	0,13%	12,74 m

Summary of the cables used in the system					
Code	**Manufacturer**	**Description**	**Formation**	**Section**	**Length**
PRYG7P3X010	Prysmian	FG7(O)R G-SETTE+ 0.6/1 kV 3x10	3x10	10,00 mm²	6,93 m
PRYPSUN010	Prysmian	FG21M21 P-Sun 1.2 kV 1x10	1x10	10,00 mm²	7,06 m
PRYG7P1X006	Prysmian	FG7(O)R G-SETTE+ 0.6/1 kV 1x6	1x6	6,00 mm²	17,4 m
PRYPSUN004	Prysmian	FG21M21 P-Sun 1.2 kV 1x4	1x4	4,00 mm²	25,48 m
PRYPSUN006	Prysmian	FG21M21 P-Sun 1.2 kV 1x6	1x6	6,00 mm²	13,74 m