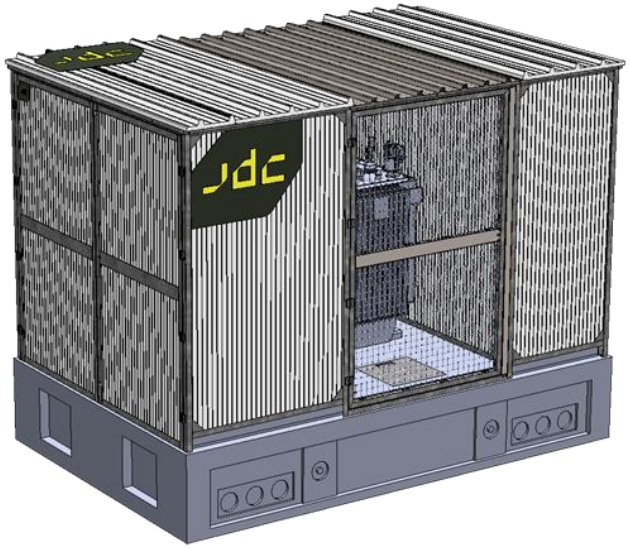
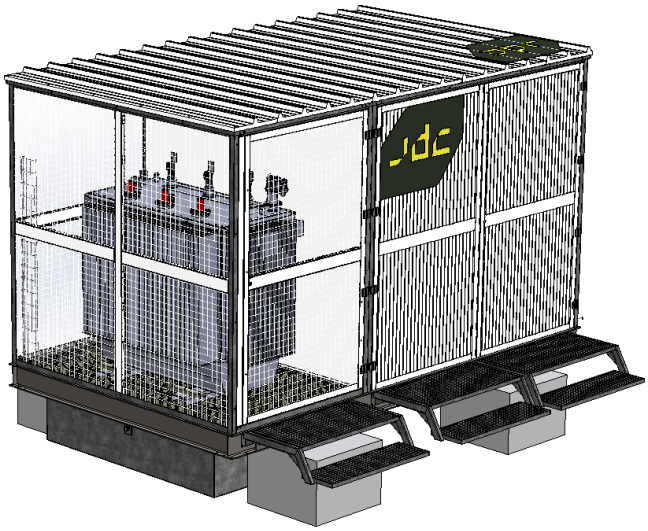




SKID^{UPP}

PRODUCT SPECIFICATION

DOC NUMBER: DAE2200002O01

JAYME DA COSTA

1. INTRODUCTION

This document presents the product specification of Jayme da Costa SKID UPP solutions designed specifically for Photovoltaic Power Plants up to 1 MW (UPP - Unidades Pequena Produção). The product consists of a turnkey transformer station solution designed to interconnect PV string inverters to the MV grid as shown in Figure 1. The energy produced by the solar panels in the Power Plant flows through the inverters, converting the energy from DC to AC, and delivered to the inverters panel on the Low Voltage Compartment. The next step comprises the AC voltage rise to 15/30 kV level, through the power transformer integrated inside the SKID. The interconnection to the public grid is performed through the MV Switchgear installed on MV compartment of the SKID.

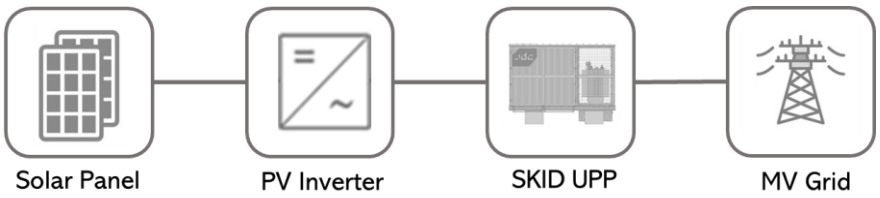


Figure 1 - PV System with SKID UPP

The SKID UPP was specifically intended for PV power plants up to 1MW, compliant with the Portuguese grid-code regulation and fulfilling legal requirements of UPP legislation. The product is composed by the following functional compartmental units:

- Building
- MV Switchgear
- Power Transformer
- LV Compartment

UPP – System Architecture

JdC SKID UPP Product

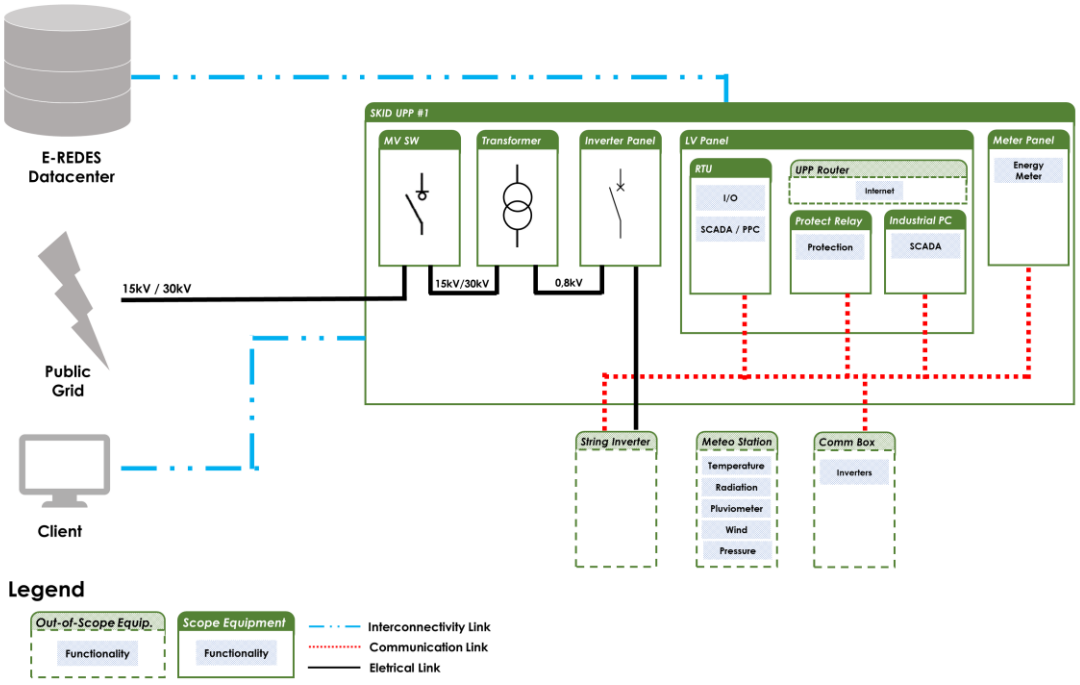


Figure 2 - SKID UPP System - Architecture

2. PRODUCT DESCRIPTION

2.1. BUILDING

The SKID UPP is based on a concept of functional integration and modularity providing high level of robustness and degree of protection which makes it ideal for applications in facilities dedicated to renewable energy generation. The transformer station accepts two different building configurations:

- Metal Base Frame – Complete metallic MV Station with modular structure in hot-dip galvanized steel providing constructive rigidity and portability.
- Concrete Base Frame – Concrete base structure with a metallic upper building enclosure, resulting in a light and cost-effective solution for transformer station unit.

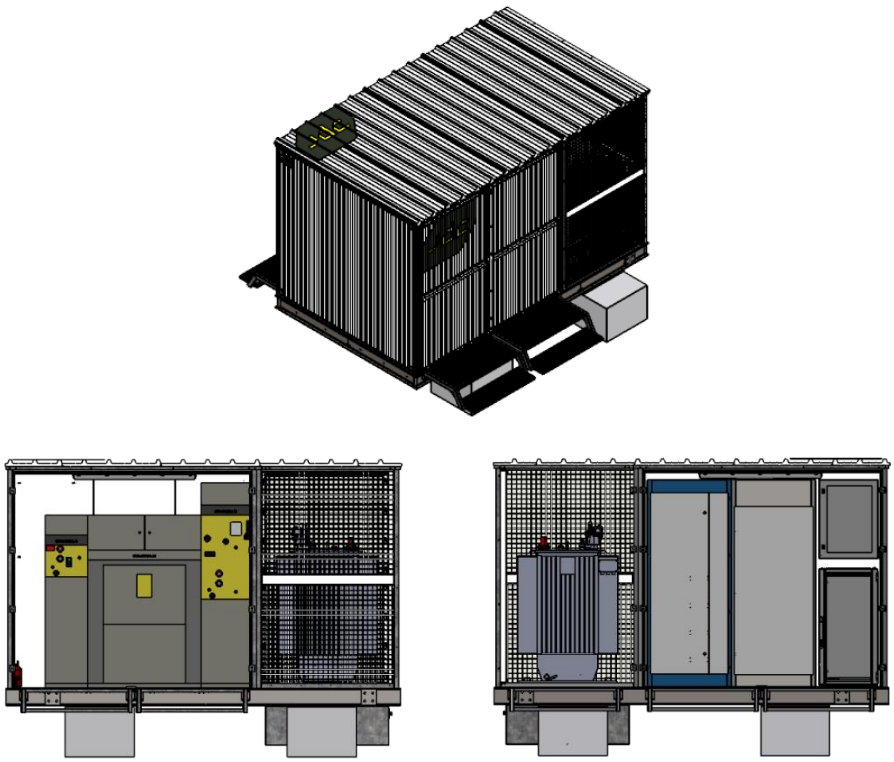


Figure 3 - SKID UPP with Metal Base Frame

Figure 4 - SKID UPP with Concrete Base Frame

2.2. MV COMPARTMENT

2.2.1. MV SWITCHGEAR

The MV Switchgear performs the interconnection to the grid, guaranteeing the fulfillment of the applicable requirements and provides centralized control and protection for the medium-voltage power equipment. The MV Switchgear Compartment, used in the SKID UPP, comprises a 3-RMU configuration set from SFA Electric comprehending of:

- Switch-Disconnector RMU for interconnection with the grid.
- Metering RMU for measuring voltage and current values.
- Circuit Breaker RMU for power transformer protection.

Figure 5 - SKID UPP MV Switchgear

Table 1 - Technical Details Switch-Disconnector RMU – RM 36.S (J1)

Technical Details – RM 36.S		
Type	IEC 62271-200	
Function	Connection to the grid	
Nominal Voltage – kV	24	36
Service Voltage - kV	15	30
Frequency – Hz	50	50
Rated Current – A	630	630
Rated Power frequency withstand voltage - kV	50	70
Rated lighting impulse withstand voltage - kV/peak	125	170
Rated Pike Withstand Current – kA/peak	50	
Rated short circuit withstand voltage - kV/peak	16/1	
Internal arc class (IAC) / A(FL) - kV/peak	16/1	
IP Class (Energized Parts)	IP 54	
IP Class (Switchgear)	IP 3X	

Table 2 - Technical Details Metering RMU – RM 36.M (J2)

Technical Details – RM 36.M		
Type	IEC 62271-200	
Function	Metering	
Nominal Voltage – kV	24	36
Service Voltage - kV	15	30
Frequency – Hz	50	
Rated Current – A	630	
Rated Power frequency withstand voltage - kV	50	70
Rated lighting impulse withstand voltage - kV/peak	125	170
Rated Pike Withstand Current – kA/peak	50	
Rated short circuit withstand voltage - kV/peak	16/1	
Internal arc class (IAC) / A(FL) - kV/peak	16/1	
IP Class (Energized Parts)	IP 54	
IP Class (Switchgear)	IP 3X	
Current Transformer	25 / 1-1-1 A , 36 kV , BLOCK CL: 0.5 - 2.5 VA CL: 0.5 - 15 VA CL: 5P10 - 15 VA	
Voltage Transformer	30:V3 / 0.1:V3-0.1:V3-0.1:3 CL:0.5 , 0.5-3P , 3P 2.5VA , 15VA , 10VA CL: 5P10 – 2.5VA	

Table 3 - Technical Details Circuit Breaker RMU – RM 36.CB (J3)

Technical Details – RM 36.CB		
Type	IEC 62271-200	
Function	Transformer protection	
Nominal Voltage – kV	24	36
Service Voltage - kV	15	30
Frequency – Hz	50	
Rated Current – A	630	
Rated Power frequency withstand voltage - kV	50	70
Rated lighting impulse withstand voltage - kV/peak	125	170
Rated Pike Withstand Current – kA/peak	50	
Rated short circuit withstand voltage - kV/peak	16/1	
Internal arc class (IAC) / A(FL) - kV/peak	16/1	
IP Class (Energized Parts)	IP 54	
IP Class (Switchgear)	IP 3X	
Current Transformer	0.72 Kv, Toroid (taped) 150-50 /1 A CL: 5P10 – 2.5VA	

2.3. POWER TRANSFORMER COMPARTMENT

2.3.1. POWER TRANSFORMER

At the core of the SKID UPP is a 1 MVA power transformer that ensures the right voltage level interconnection to the MV grid, 15 or 30 kV. The electrical and mechanical characteristics shall be in accordance with the international standard IEC 60076, with Eco-Design "ECO-DESIGN Tier2 (EU 2019/1783) Transformer Losses" and with the inverter specification used in the power plant project.

Table 4 - Technical Specification Power Transformer

Technical Details – 1 MVA Power Transformer	
Type	IEC 60076
Winding Material	Aluminum-Aluminum
Rated Power	1000 kVA
Rated Voltage (HV)	15000V / 30000 V
Rated Voltage (LV)	800V
Maximum Ambient Temperature	40ºC
Vector Group	DY11
Cooling Type	ONAN
Frequency	50Hz
Type of Insulating Liquid	Mineral Oil
Type of Oil Preservation System	Sealed Type
Type of Tank Construction	Corrugated Wall
I/O Signals	Defect Gas; Defect Pressure; Temperature Alarm; Defect Temperature:

2.4. LV COMPARTMENT

2.4.1. INVERTERS PANEL

The PV string inverters deployed along the power plant are connected to the inverters LV switchboard on the low voltage compartment. This switchboard comprises of junction switchboard, with circuit breaker protection on the incoming connection from the inverters and on the outgoing connection to the power transformer.

Table 5 - Technical Specification Inverters Panel

Technical Details – Inverters Panel	
Operating Voltage	400V / 800 V
Rated current	Up to 1250A
Short-circuit Current (Icu)	50 kA
Outgoing Protection (Power Transformer)	Circuit Breaker
Incoming Protection (PV String Inverters)	Circuit Breaker
Number of Poles	3 Poles
Surge Protection Device (SPD)	Optional
IP / IK Degree	IP 31 IK07

2.4.2. LV PANEL

The LV panel incorporates the equipment for monitoring the SKID UPP itself and the power plant facility. This comprises controlling and monitoring the MV switchgear and transformer; implementing and assuring the correct functioning of the interconnection between the power plant and the grid; data acquisition and connection to the client's SCADA;

The LV Panel Incorporates a protection relay that is used for protection & control purposes and monitoring & metering of the command control protection panel.

The relay is equipped with advanced communications options and detailed monitoring capabilities making It Ideal to fulfill the requirements of grid-code. The protection relay provides advanced functionality, including high-performance protection (which detects abnormal voltage and current conditions in the power system), extensive control functions (sends signal to circuit breaker to remove faulty part from rest of the power system.) and flexible configuration capabilities:

- Overcurrent Protection;
- Over/Under Voltage Protection;
- Over/Under Frequency Protection;
- Trip Circuit Monitoring;
- Breaker Failure and Control;

2.4.3. Auxiliary Supply

The LV compartment also incorporates in it a switchboard for auxiliary services that ensure the energy supply for all circuitry of SKID UPP and power plant facility, including lighting, outlets, monitoring units of the facilities, etc... The SKID UPP also comes equipped with emergency supply when power failure occurs by means of the battery charger or UPS system, ensuring the operation for additional 12hours in scenarios of power failures.

Table 6 - Technical Details Auxiliary Supply Transformer.

Technical Details – Auxiliary Supply	
Primary Voltage	800VAC
Secondary Voltage	230VAC
Power	5kVA (higher power optional)
Emergency Supply Voltage	48VDC or 230VAC
Battery Capacity	40Ah

2.4.4. Metering Panel

The metering panel is included in the LV compartment of the SKID UPP. The panel comprises a meter device approved for UPP to monitor the production of active and reactive energy of the power plant. The metering panel is qualified to be used for billing purposes and for SCADA integration.

2.4.5. Weather Station (Optional)

The weather station (optional equipment comprises a set of sensors to integrate with the SKID system that include:

- Pyranometer
- Ambient Temperature and Humidity Sensor
- PV Module Temperature Sensor
- Atmospheric Pressure Sensor
- Anemometer
- Pluviometer

Table 7 - Technical Details Pyranometer

Technical Details – Pyranometer (Optional)	
Characteristics	Spectrally Flat Class C ISO9060:2018, Secondary Class ISO9060:1990
Measuring Band	0 to 2000W/m2
Spectral response	300 to 2800nm
Time response	95%: <20s
Spectral Error	< ±5 %
Operating Temperature	-40 to 80ºC
Input Voltage	5-30 VDC
Output	4-20mA

Table 8 - Technical Detail Ambient Temperature & Humidity

Technical Details – Ambient Temperature & Humidity Sensor (Optional)	
Temperature Sensor Element	PT100 1/3 DIN
Temperature Measuring Band	-40 to 80ºC
Temperature Resolution	± 0,2 °C ± 0,15 % measurement
Humidity Sensor Element	Capacity
Humidity Measuring Band	0 to 100%
Humidity Resolution	±1,5 % (0…90 %RH) / ±2 % (90…100 %RH)
Operating Temperature	-40 to 80ºC
Input Voltage	5-30 VDC
Output	4-20mA

Table 9 - Technical Detail PV Module Temperature

Technical Details – PV Module Temperature Sensor (Optional)	
Temperature Sensor Element	Pt100 Classe B (0,3°C)
Thermal Constant (τ 63%)	60 s
Temperature Resolution	± 0,2 °C ± 0,15 % measurement
Maximum Operating Temperature	150ºC
Output	4-20mA

Table 10 - Technical Detail Atmospheric Pressure Sensor

Technical Details – Atmospheric Pressure Sensor (Optional)	
Measuring Band	800 a 1100hPa
Accuracy	±0.5hPa @20ºC
Operating Temperature	- 30 a 60ºC
Input Voltage	12 VDC
Output	4-20mA

Table 11 - Technical Detail Anemometer

Technical Details – Anemometer (Optional)	
Measuring Band	0.5 a 60m/s
Resolution	< 0.1m/s
Precision	0.3 m/s ≤ 10 m/s • 0.5 m/s...60 m/s
Input Voltage	20 to 28 VDC
Output	4-20mA

Table 12 - Technical Detail Pluviometer

Technical Details – Pluviometer (Optional)	
Opening area	200 cm2
Resolution	0,5 mm
Maximum Precipitation Rate	600 mm/h
Input Voltage	12 VDC

3. Power Plant Monitoring and Control

3.1. Power Plant Monitoring Equipment

The RTU is installed within the LV compartment for controlling all types of equipment installed in the SKID UPP and power plant. This comprises digital input and output modules and customizable modules for monitoring client's equipment Installed on the power plant field (weather station, analog equipment apparatus, digital sensors).

Table 13 - RTU Technical Specs

Technical Details – RTU	
Communication protocols	Modbus TCP Modbus RTU, IEC60870-5-104
Digital Input	28 Digital Input
Digital Output	5 Digital Output
PPC	Power Plant Control
Analog Input	Optional (8 Analog Input)

3.2. Power Plant Control

The Power Plant Controller (PPC) is used to regulate and control the inverters, devices and equipment at the PV Plant in order to meet the specified setpoints and grid parameters at the point of interconnection. Site operators, can communicate these setpoints and parameters to the PPC either directly or throughout the SCADA system. Globally, the PPC is a tool that allows to control the plant behavior in terms of production levels, compliance and grid stability.

The PPC supplied by JdC is designed to achieve compliance with the Portuguese Grid Code (Portaria n.º 73/2020) for a Plant Type A or B according to the classification of Regulation (UE) 2016/631. Depending on the model of inverter used, this compliance can be automatically demonstrated. Please consult JdC for details on inverter models that are certified for that compliance. The power plant controller can regulate the following parameters:

- Voltage;
- Frequency;
- Reactive Power;
- Active Power:
- Power Factor;
- Ramp Control.

4. SCADA

The SCADA Monitoring System is based on a distributed architecture supported by a real time network and multiple different units.

This solution is based on a web application, allowing remote and local management of the solar plant providing to the users an overview of the performance of their power stations as well as details about the different equipment that are part of the PV Plant

This SCADA platform is used to monitor the following data:

- Current plant status;
- Output between specific dates;
- Daily, monthly and annual summaries;
- Comparison and details of the different variables of each element in the PV Plant such as strings, inverters, meters, weather stations, etc.).

Each section of the system includes tools for printing and exporting data in standard XML format, which is fully compatible with spreadsheets such as Excel and Open Office.

In the chapters below is presented the information that can be monitored in the SCADA platform.

4.1.1. Home screen Current Status

After successful login in the platform, an home screen is presented for the current and daily status of the PV Plant. Other details such as daily PR (performance ratio), energy production, ambient temperature, wind speed, alarms, etc., are also displayed.

The presents the Home Screen Current Status that is displayed after the login in the platform.

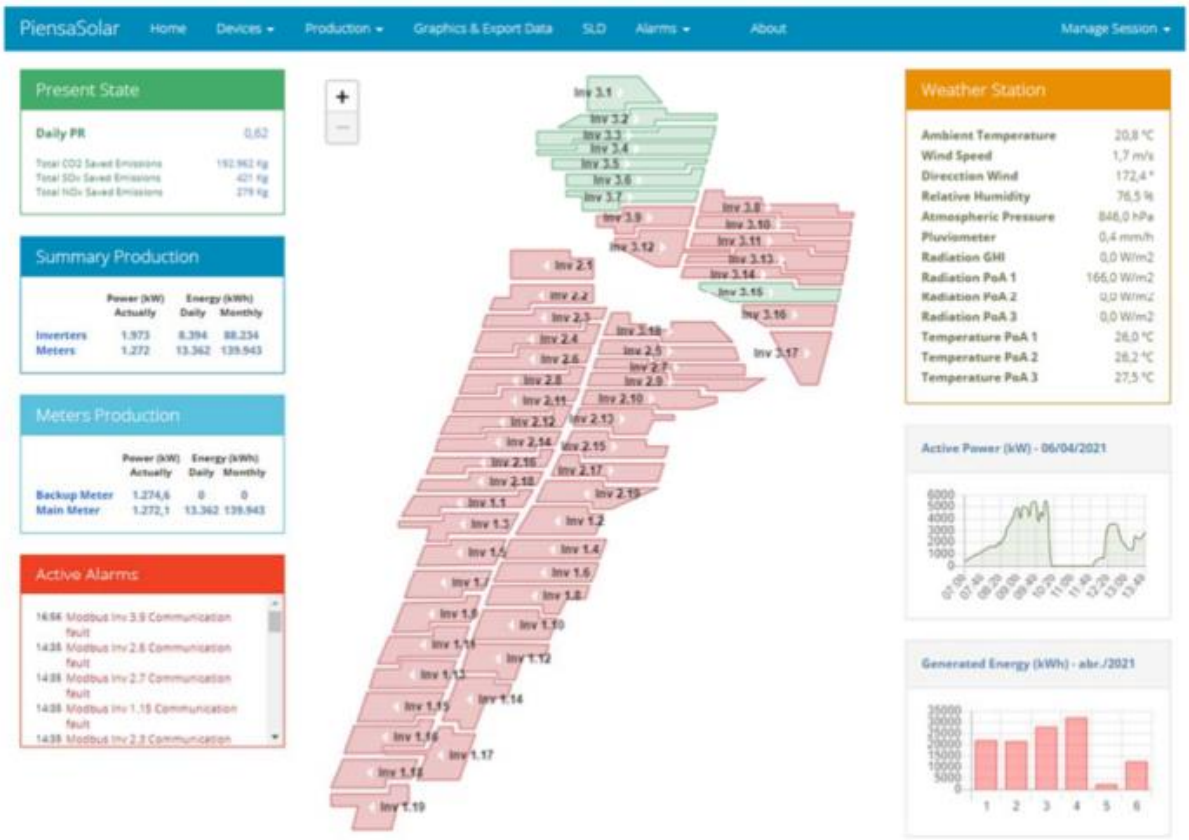


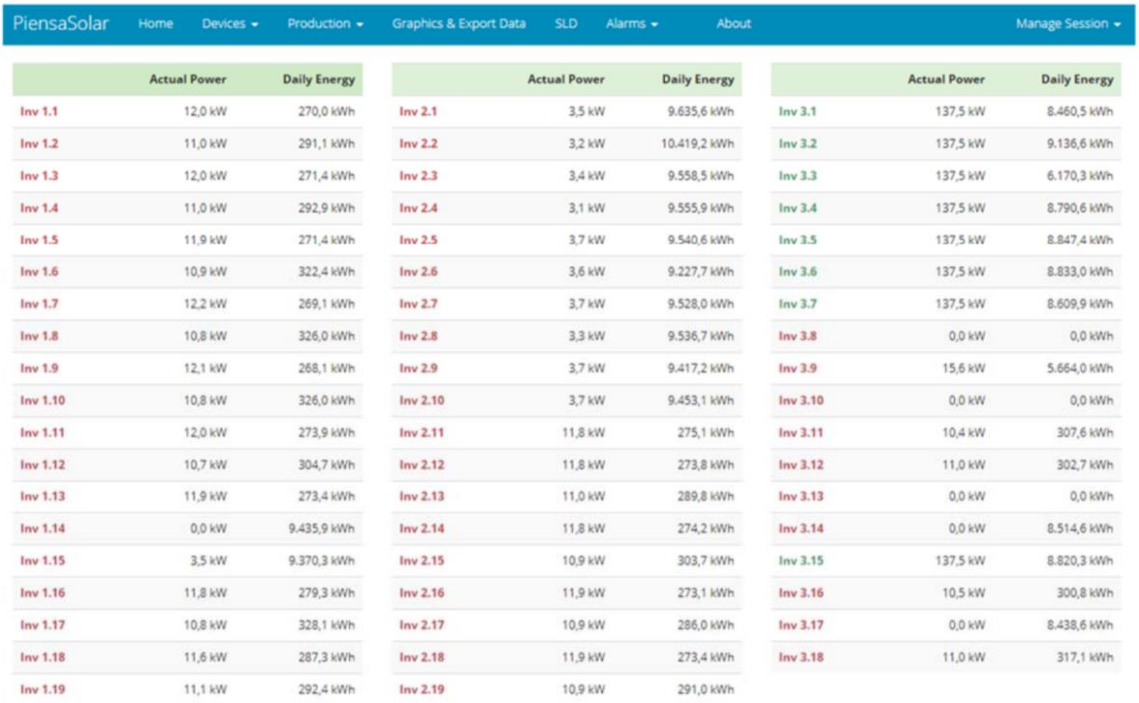
Figure 6 – Home Screen Current Status

4.1.2. DEVICES

Clicking in the menu “Devices”, are displayed the equipment that are being monitored such as inverters, meters, PPC, protection relays, etc.

4.1.2.1. INVERTERS

In the inverters menu can be verified the active power being injected by the inverters at the moment.
The Figure 7 presents the inverter menu where the actual power and daily production are displayed. More detailed data such as strings voltage, current and power can also be checked and displayed.



	Actual Power	Daily Energy
Inv 1.1	12,0 kW	270,0 kWh
Inv 1.2	11,0 kW	291,1 kWh
Inv 1.3	12,0 kW	271,4 kWh
Inv 1.4	11,0 kW	292,9 kWh
Inv 1.5	11,9 kW	271,4 kWh
Inv 1.6	10,9 kW	322,4 kWh
Inv 1.7	12,2 kW	269,1 kWh
Inv 1.8	10,8 kW	326,0 kWh
Inv 1.9	12,1 kW	268,1 kWh
Inv 1.10	10,8 kW	326,0 kWh
Inv 1.11	12,0 kW	273,9 kWh
Inv 1.12	10,7 kW	304,7 kWh
Inv 1.13	11,9 kW	273,4 kWh
Inv 1.14	0,0 kW	9.435,9 kWh
Inv 1.15	3,5 kW	9.370,3 kWh
Inv 1.16	11,8 kW	279,3 kWh
Inv 1.17	10,8 kW	328,1 kWh
Inv 1.18	11,6 kW	287,3 kWh
Inv 1.19	11,1 kW	292,4 kWh

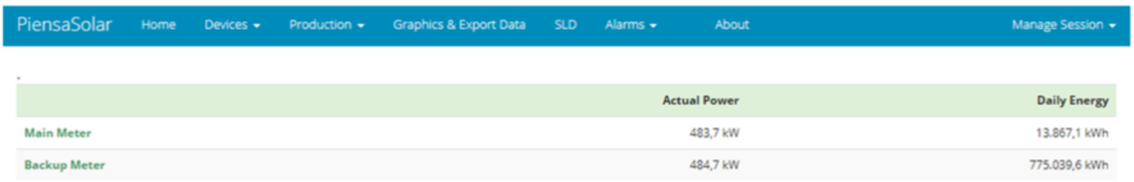
	Actual Power	Daily Energy
Inv 2.1	3,5 kW	9.635,6 kWh
Inv 2.2	3,2 kW	10.419,2 kWh
Inv 2.3	3,4 kW	9.558,5 kWh
Inv 2.4	3,1 kW	9.555,9 kWh
Inv 2.5	3,7 kW	9.540,6 kWh
Inv 2.6	3,6 kW	9.227,7 kWh
Inv 2.7	3,7 kW	9.528,0 kWh
Inv 2.8	3,3 kW	9.536,7 kWh
Inv 2.9	3,7 kW	9.417,2 kWh
Inv 2.10	3,7 kW	9.453,1 kWh
Inv 2.11	11,8 kW	275,1 kWh
Inv 2.12	11,8 kW	273,8 kWh
Inv 2.13	11,0 kW	289,8 kWh
Inv 2.14	11,8 kW	274,2 kWh
Inv 2.15	10,9 kW	303,7 kWh
Inv 2.16	11,9 kW	273,1 kWh
Inv 2.17	10,9 kW	286,0 kWh
Inv 2.18	11,9 kW	273,4 kWh
Inv 2.19	10,9 kW	291,0 kWh

	Actual Power	Daily Energy
Inv 3.1	137,5 kW	8.460,5 kWh
Inv 3.2	137,5 kW	9.136,6 kWh
Inv 3.3	137,5 kW	6.170,3 kWh
Inv 3.4	137,5 kW	8.790,6 kWh
Inv 3.5	137,5 kW	8.847,4 kWh
Inv 3.6	137,5 kW	8.833,0 kWh
Inv 3.7	137,5 kW	8.609,9 kWh
Inv 3.8	0,0 kW	0,0 kWh
Inv 3.9	15,6 kW	5.664,0 kWh
Inv 3.10	0,0 kW	0,0 kWh
Inv 3.11	10,4 kW	307,6 kWh
Inv 3.12	11,0 kW	302,7 kWh
Inv 3.13	0,0 kW	0,0 kWh
Inv 3.14	0,0 kW	8.514,6 kWh
Inv 3.15	137,5 kW	8.820,3 kWh
Inv 3.16	10,5 kW	300,8 kWh
Inv 3.17	0,0 kW	8.438,6 kWh
Inv 3.18	11,0 kW	317,1 kWh

Figure 7 – Inverters Menu

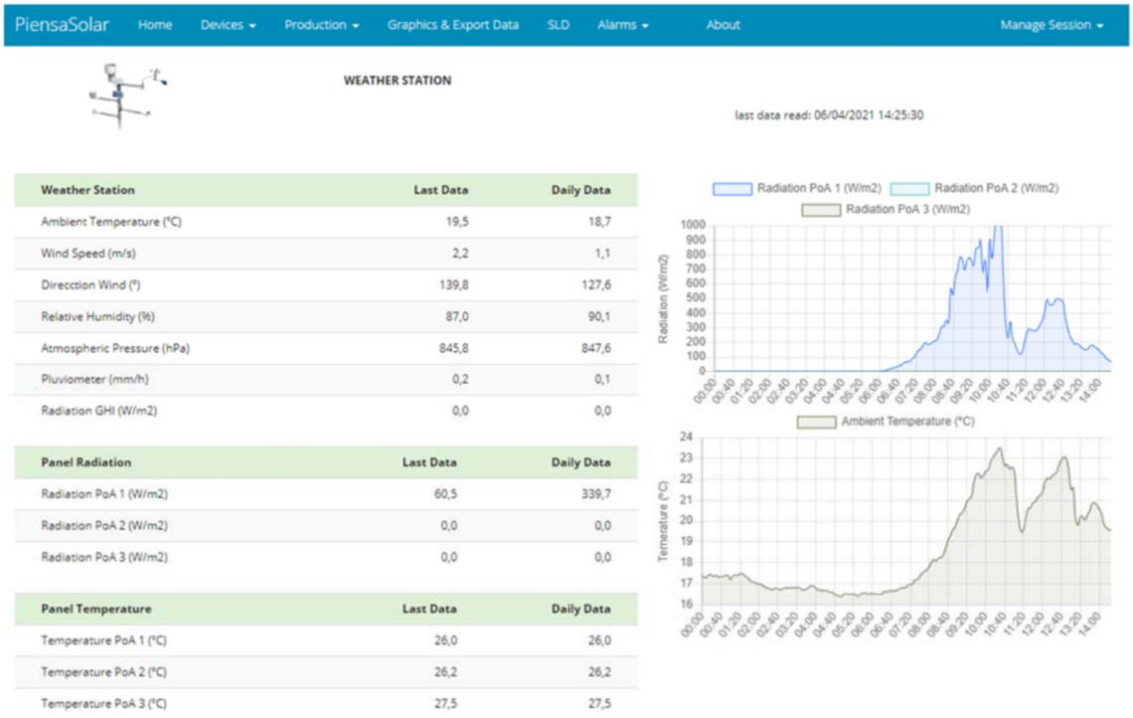
4.1.2.2. OTHER DEVICES

The status of other devices such as energy meters and weather stations can also be monitored.
The Figure 8 and Figure 9 presents the energy meter and weather stations menu.



	Actual Power	Daily Energy
Main Meter	483,7 kW	13.867,1 kWh
Backup Meter	484,7 kW	775.039,6 kWh

Figure 8 – Energy Meter Menu



Weather Station	Last Data	Daily Data
Ambient Temperature (°C)	19,5	18,7
Wind Speed (m/s)	2,2	1,1
Direccion Wind (°)	139,8	127,6
Relative Humidity (%)	87,0	90,1
Atmospheric Pressure (hPa)	845,8	847,6
Pluviometer (mm/h)	0,2	0,1
Radiation GHI (W/m2)	0,0	0,0

Panel Radiation	Last Data	Daily Data
Radiation PoA 1 (W/m2)	60,5	339,7
Radiation PoA 2 (W/m2)	0,0	0,0
Radiation PoA 3 (W/m2)	0,0	0,0

Panel Temperature	Last Data	Daily Data
Temperature PoA 1 (°C)	26,0	26,0
Temperature PoA 2 (°C)	26,2	26,2
Temperature PoA 3 (°C)	27,5	27,5

Figure 9 – Weather Stations Menu

4.1.2.3. MEDIUM VOLTAGE EQUIPMENT STATUS

The monitoring platform allows also to check the MV equipment status. A single line diagram of the installation is displayed and equipment such as circuit breakers, switch breakers and MV transformers status is displayed.

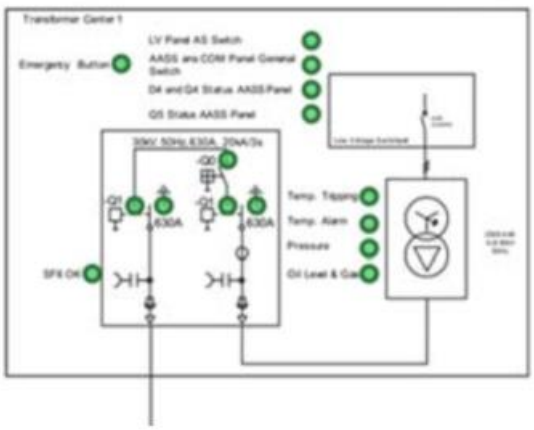


Figure 10 – Medium Voltage Equipment Status

4.1.3. ALARMS

The alarms generated by the different elements can be checked in the SCADA platform. An alarm list with the type of alarm is generated. The Figure 11 presents the alarm list menu.

PiensaSolar Home Devices Production Graphics & Export Data SLD Alarms About Manage Session

Codigo	Type Of Element	Description	Priority	Temporize (s.)	Send to Telegram	Send e-mail	Send SMS
1	Inverter	DC over voltage	Alarm	300	☑	☐	☐
2	Inverter	AC disconnect open	Alarm	300	☑	☐	☐
3	Inverter	DC disconnect open	Alarm	300	☑	☐	☐
4	Inverter	Grid shutdown	Alarm	300	☑	☐	☐
5	Inverter	Cabinet open	Alarm	300	☑	☐	☐
6	Inverter	Manual shutdown	Alarm	300	☑	☐	☐
7	Inverter	Over temperature	Alarm	300	☑	☐	☐
8	Inverter	Frequency above limit	Alarm	300	☑	☐	☐
9	Inverter	Frequency under limit	Alarm	300	☑	☐	☐
10	Inverter	AC Voltage above limit	Alarm	300	☑	☐	☐
11	Inverter	AC Voltage under limit	Alarm	300	☑	☐	☐
12	Inverter	Blown String fuse on input	Alarm	300	☑	☐	☐
13	Inverter	Under temperature	Alarm	300	☑	☐	☐
14	Inverter	Generic Memory or Communication error (internal)	Alarm	300	☑	☐	☐
15	Inverter	Hardware test failure	Alarm	300	☑	☐	☐
100	Inverter	Ground fault	Alarm	300	☑	☐	☐
100000	Inverter	Communication fault	Alarm	300	☑	☐	☐
100001	Inverter	Modbus Mapping Error	Alarm	300	☑	☐	☐
100000	Meter	Communication fault	Alarm	300	☑	☐	☐
100001	Meter	Modbus Mapping Error	Alarm	300	☑	☐	☐
100000	Network Analyzer	Communication fault	Alarm	300	☑	☐	☐
100001	Network Analyzer	Modbus Mapping Error	Alarm	300	☑	☐	☐
100000	No Element Defined	Communication fault	Alarm	300	☑	☐	☐
100000	Power Plant Controller	Communication fault	Alarm	300	☑	☐	☐

Figure 11 – Alarm List

4.1.4. REPORTS

Summary reports and summary of the production of the different devices can be also analyzed. Data can be exported to XML format making it easily legible by all types of spreadsheet.

5. COMMUNICATIONS ARCHITECTURE

The communication network of the PV Plant is made to guarantee the communication between the several equipment of the PV Plant where the SKID UPP plays a critical role. This communication is ensured through the SCADA communication network switch and communication box. The LAN switch and the communication box are installed at the SKID-UPP. Figure 12 summarizes the architecture and communications diagram of a UPP project.

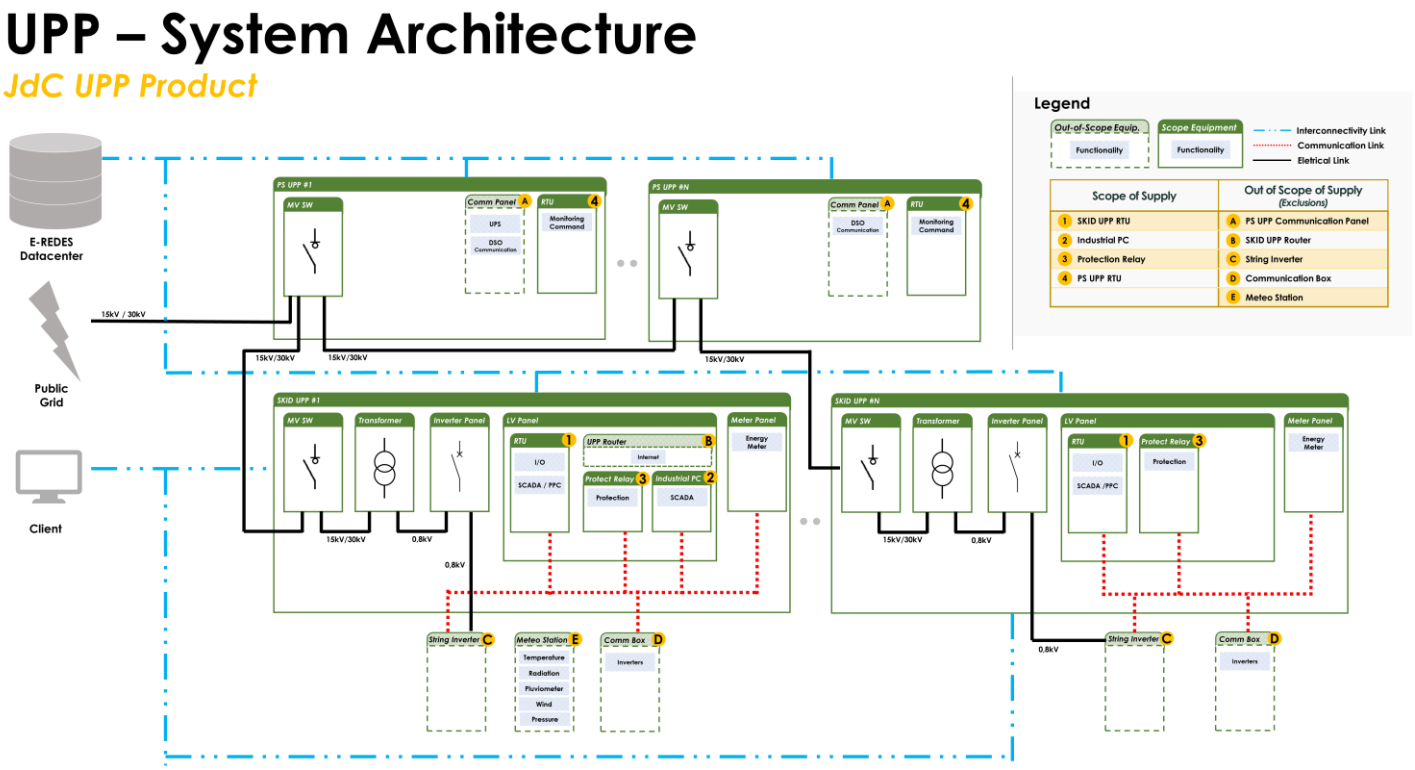


Figure 12 - SKID UPP Communication Architecture

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