



*Soleil Energy Harvest Power Station*  
*EH PS660 LV*  
*Technical specification*

*Power station for Energy Storage and Release*

## Soleil EH PS660 LV

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During the whole life time of the equipment

## *TECHNICAL SPECIFICATION*

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## 1 MAIN FEATURES

Soleil EH Power Station is a containerized, 'ready-to-play' platform, for the management of large storage systems, supporting state-of-the-art batteries optimized for storage, suitable for on-grid and off-grid system application.

It exploits the well known and worldwide appreciated power module technology of Soleil family PV inverters, boosted with a newly designed control FW, to interface and enhance the usage of different type of batteries, from the simple lead-acid technology to the most complex, top-spec, Lithium-ions or NaS systems.

When operated in '**On-Grid**' mode, thanks to a sophisticated control and redundant monitoring platform, Soleil EH Station can support a full **four-quadrant** operation (from battery to the grid and the other way around), aimed to provide the grid with following functionalities:

- Services to **Distribution System Operators (DSO)**, such as:
  - **Capacity Support**, by 'shaving' the loads from their peaks to bottom-line values, in normal operating situation (e.g. by providing a grid with an extra-capacity from a 500kW to a few MW at MV-level for few hours).
  - **Local Voltage Control**, through controlled reactive power injection into the grid (where lines are predominantly 'reactive') or active power curtailment or boosting (where lines are mostly 'resistive'), or a mix of both.
  - **Power Quality Enhancement**, by compensating, on-demand, some amount of reactive power introduced on the line by some loads, also at night time.
  - **Emergency grid support**, e.g. when a major component (like a transformer) of the Distribution system fails, by filling-in for the missing feeder altogether with the remaining 'N-1' feeders.
- Services to **Transmission System Operators (TSO)**, such as:
  - **Participation to Primary and Secondary Frequency Control**, by helping the system to keep frequency stable, avoiding load shedding, thanks to a quick time response (less than 1s) in regulating the active power (injected or absorbed) exchanged with the grid.
- Services to **Generation Operators**, such as:
  - **Generation capacity support**, contributing to reduce the stress on central generation facilities, thus saving fuel and dropping emissions.
- Services to **Final Customers**, combined with renewable energies:
  - **Time shifting**, meaning using some renewable energy form to store into batteries, at a zero-cost (almost), the extra-availability of the primary source (wind or sun), in order to use

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it in a delayed fashion, e.g. when the primary source is not present or all along periods of time when taxation is more convenient.

- **Prosuming**, i.e. helping the householders to adopt an energy-saving oriented behavior, aimed to spread and promote the 'Energy Self-sufficiency' concept, according to which, the customer is not only a consumer but also a 'producer' (merging –up these two terms into the concept of 'Prosumer').

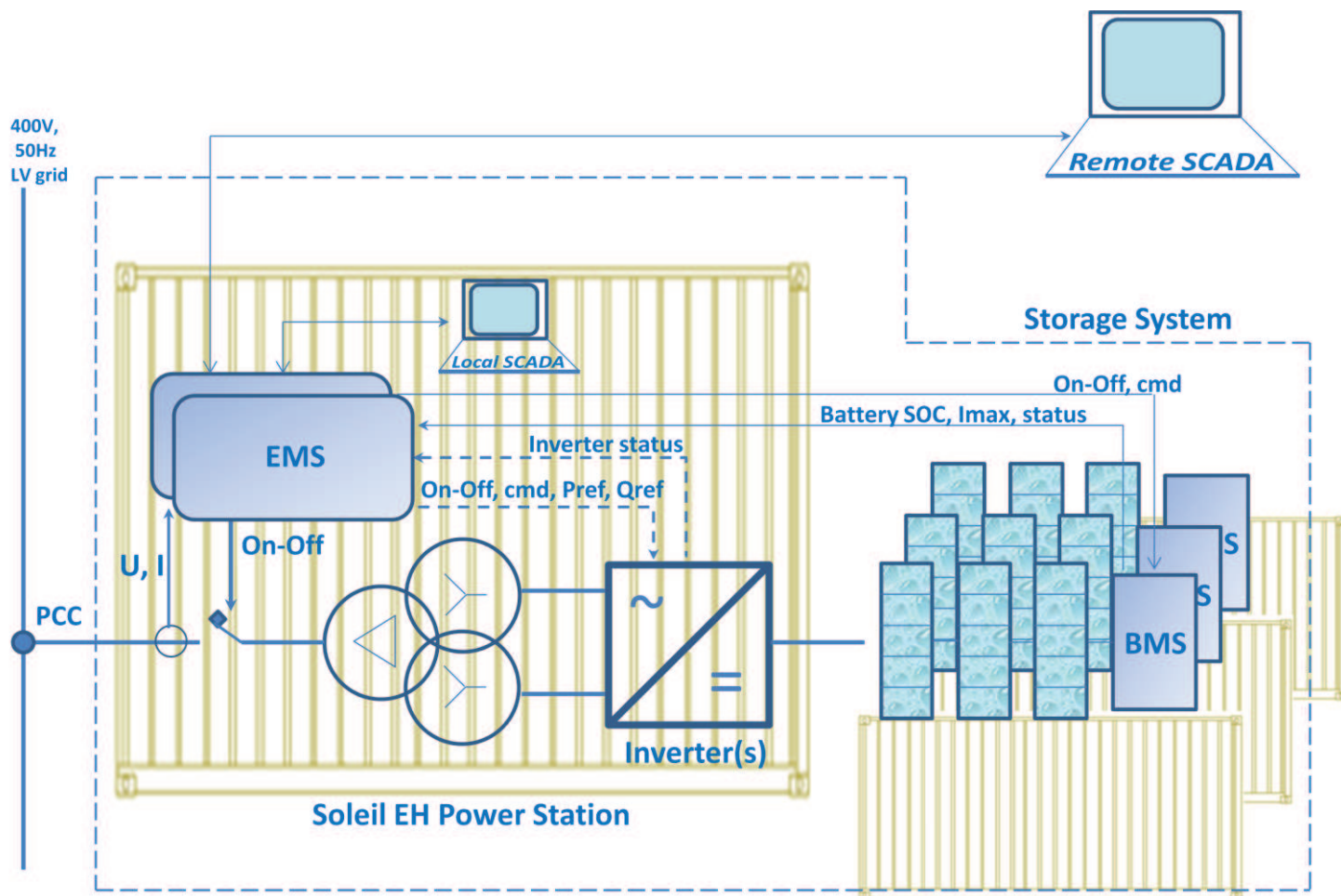
When operating in 'Off-Grid' mode, Soleil EH Power Station behaves like a Voltage Generator, by constituting the main energy source for an islanded grid. In order to recharge the batteries, some form of back-up power must be there available, either in a renewable format (wind or PV), or through a Generator-Set.

It has to be noticed that, also in the 'Off-grid' mode, Soleil EH constitutes not only an essential generator of energy for an islanded grid (e.g. privately bound environment, such as a rural village), but can also be, once again, a cost-effective solution to help those **DSO**, whose Distribution Network encompasses some non-loopable feeder, hence operating some branches of the grid in islanded mode during outages.

In this operating mode, the system benefits of:

- Black-Start capability of the inverters.
- Relatively low short circuit power.

## 2 SYSTEM BLOCK DIAGRAM



### ACRONYMS:

- **EMS:** Energy Management System (two embedded PCs, connected to the system with a 'redundant architecture').
- **PCC:** Point of Common Coupling.
- **BMS:** Battery Management System.
- **GUI:** Graphical User Interface (Desktop PC).
- **Pref, Qref:** Setpoints of Active and Reactive Power.
- **SOC:** Battery State Of Charge.
- **SCADA:** Supervisory Control And Data Acquisition. There may be a 'local SCADA', located into the 'Delivery Station/SCADA Room' and there's a 'Remote SCADA', usually owned by the grid operator and most likely (but not necessarily) located into the nearest primary sub-station.

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## 2.1 Operation modes

The system is operated under the control of an Energy Management System, basically an application SW running on an embedded industrial PC, supervising all the operation of the inverters by constantly monitoring the status of the batteries. Moreover, the EMS, is the equipment who decides the behavior of the whole storage system, according to the operating mode set through the Graphical User Interface:

- **On-grid mode:** In this operating mode, the Soleil EH PS works connected in parallel to an existing AC grid, acting as a 'current generator' and, as such, may perform following functions:
  - **Active and Reactive power generation according to variable set-points (Pref, Qref) sent from remote:** the system is constantly operated, under the control of some remote intelligence, by trying to regulate the components of the generated power (active P and reactive Q), as much closer as possible to their own set-point values, sent from remote.
  - **Active Power generation as a linear function of the frequency:** the active power P is actuated according to the following linear relation:  $P = Af + C$ . A and C are parameters that can be sent from remote (or locally from the GUI), f is the instantaneous value of the frequency. The relation between the active power P and the frequency is actuated only when the frequency is out of a tolerance band 'B'.
  - **Scheduled variation of set-points (Pref, Qref):** the system is configured (either from remote or local GUI) with the required values for Pref and Qref according to a time-table and actuates those set-points accordingly.
  - **Local 'automatic' Reactive Power generation according to  $Q=f(V)$  or  $\cos\phi = f(P)$ :** the system is configured (either from remote or local GUI) to actuate the reactive power according to an automatic logic of operation, local to the inverter, as stated by regulation CEI016. The values of voltage and active power or power factor ( $\cos\phi$ ) used by the system as 'feedback' for this 'automatic' mode, refer to measurements taken at the PCC. If the PCC is the point the storage system is directly connected to, the system itself uses its own measured values (U and I in the previous figure) to perform Q generation.  
  
Otherwise, in case the PCC is upwards the point of connection of the system to the grid, the measures of the line-to-line voltages (U) and line currents (I), are received from remote (for example from the SCADA of the grid operator), i.e. from where the PCC is actually located.
- **Off-grid mode (V, f control):** In this working mode, the inverter is operated in 'islanded' mode, i.e., disconnected by the public grid (Protection Interface open), by generating a 'local' grid itself, thus working as a 'voltage generator' and, as such, performing the following functionalities:
  - **Voltage and frequency regulation according to variable set-points (Uref, fref) sent from remote:** the system is constantly operated, under the control of some remote intelligence, by regulating the rms (line-to-line) value and frequency of the generated sinusoidal waveform, as much closer as possible to their own set-point values, sent from remote (Uref, fref).

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- **Automatic U and f regulation:** if the automatic regulation function is enabled, in this operating mode, once the rated values of the Voltage and Frequency are set (either from remote or locally through GUI), the Soleil EH PSxxx, can automatically perform a power curtailment (for both active and reactive power), whenever the actual values of voltage and frequency go out of the relevant tolerance bands of their nominal values (**droop control**), in order to keep the generated grid working as close as possible to the set rated values.

#### **2.1.1 ON GRID MODE:**

If no alarm is present (neither from inverters, nor from batteries nor from Soleil EH Power Station), the system has to deliver to the grid exactly the same amount of power (active and reactive) requested by the operator through the set-points (or parameters), having the Power Station work as an 'actuator'. In order to do so, the batteries must deliver to the Soleil EH station enough DC power to fulfill the requested power in a well-specified response time. Therefore, the EMS interrogate the BMS every 50ms, in order to check whether the battery system can deliver to the inverter such amount of instantaneous power, which depends on some different factors (SOC of the batteries as first).

The EMS, which is the heart of the system, has to 'take decisions' on the basis of different types of information, coming from different sources:

- Requests from the Remote SCADA (e.g. generating a certain amount of reactive power at the PCC through a periodically refreshed value of relevant set-point  $Q_{ref}$ , time of refresh being usually variable between 1s and 3s), sent through a standard automation-oriented communication protocol (for example IEC 61850 or IEC104).
- Present status of the batteries, acquired by the BMS of any set of batteries and containing data such as:
  - Status of charge (SOC) of any single battery rack,
  - Current and Voltage from batteries
  - Available current from batteries (for both charging and discharging phase)
  - Maximum and minimum temperature of batteries
  - Current environment temperature
  - Alarm codes of the battery system (if some is active)
  - Status of the DC Battery contactor (present in the battery system)
- Instantaneous status from the HW Soleil EH Power Station, such as:
  - Operation status of the inverter (Ready, Running, Stop).
  - Alarms and protection code of the inverter (if some is active)





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- Status of the DC Main Circuit Breaker at the DC input of the Soleil EH.

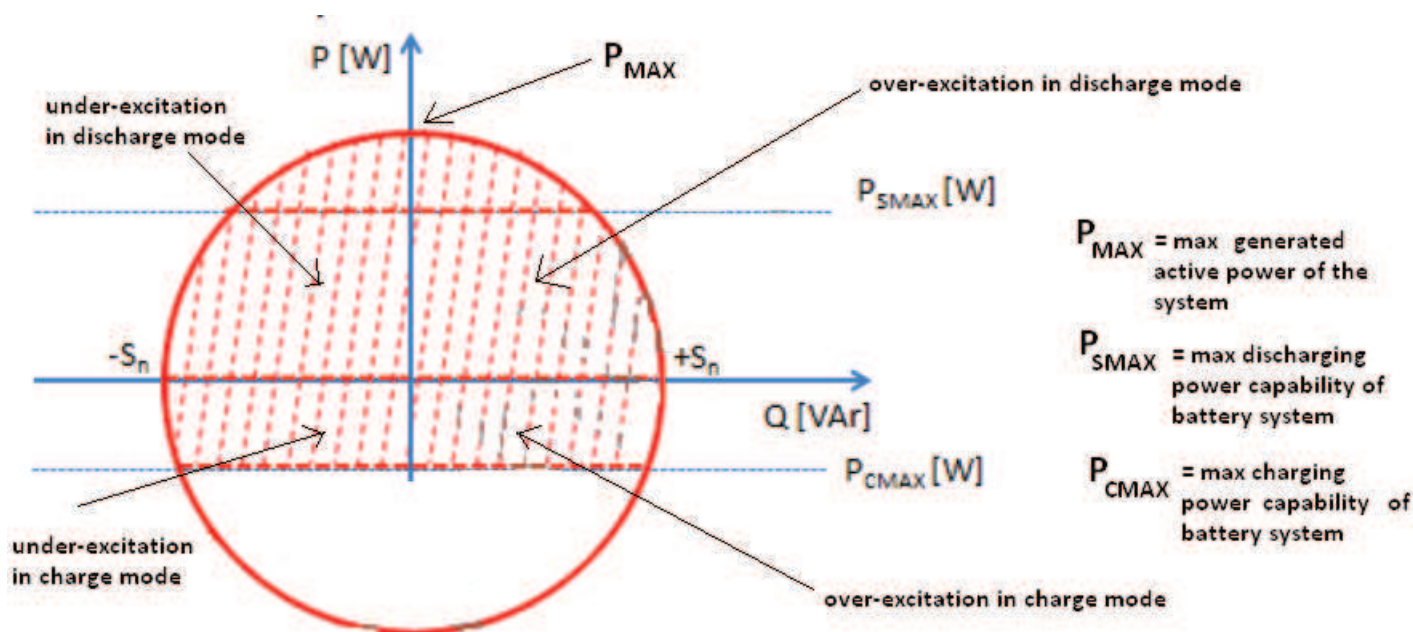
### 3 SYSTEM OPERATION RANGE AND PERFORMANCES

When 'on-grid' mode is set and the Soleil EH Power Station works in parallel to the grid, the operation range is according to following voltage and frequency thresholds:

- **AC Voltage:** from 85%V<sub>n</sub> to 115%V<sub>n</sub>, with no power de-rating.
- **Frequency:** from 47,5Hz to 51,5Hz.
- **DC Voltage:** from 560V up to 930V. Optimized range of operation: 560V up to 820V.

#### 3.1 Power Capability

The power capability of the system, on the AC side, is the shaded area of the (P,Q) circular diagram as depicted in the following figure:



It has to be noticed that, in the example of the figure, the discharging and charging capabilities of the battery system are the limiting factors of the System Capability (see dotted horizontal lines  $P_{smax}$  and  $P_{cmax}$ ). The actual capability of the system, therefore, depends on how the battery system is sized in terms of power, respect to the rated power of the inverter, the inverter capability being the whole area of the depicted circle.

For example, a 660kVA inverters, can deliver a 660kVA, at whichever power factor. If the desired power factor is 1 (in generation), the inverter can deliver (or absorb from the grid) up to 660kW (if the battery system can support this amount of instantaneous power).

It is therefore up to the System Designer, to choose a battery system properly sized and such to be compatible (in terms of operating conditions) with the Soleil HE Power Station.

### 3.2 Dynamic response to a step-varying setpoint and accuracy

The max response time of the system to a step change of the set-point (Pref, Qref), measured from the time at which the variation of set-point is received by the EMS, to the time at which the required set-point is actuated (P and Q both settling in a 1% tolerance band), is **200ms**.

The power (P and Q) are actuated within a maximum **1%** error of the relevant set-point (Pref or Qref), when the operating mode is 'on-grid'.

For the 'off-grid' mode, the voltage is actuated within a maximum **0.5%** error of the relevant set-point (or rated value, in 'automatic mode') and the frequency is controlled within a **1%** of the relevant set-point (or rated value, in 'automatic mode').

## 4 BASIC WIRING DIAGRAM

The main power components of the system are:

- **EH PS660 LV:**
  - MV transformer with **2 secondary windings** on the low-voltage side.
  - 1 x DSPX 660 TLH inverter (2 x 330kW power modules), with dual DC input and dual DC output.
  - 1 x General LV incoming AC line switchboard, containing the main automatic switch with Thermal, Magnetic and differential protection (and voltage surge arresters). Line interface protection electronic relais is included (ANSI protections codes 27, 59, 81>, 81<).
  - 1 x incoming DC line switchboard, containing two automatic-motor driven circuit breakers and voltage surge arresters).

Low-voltage side of the transformer is always operated with **isolated neutral**.

Every power module of the inverter, is connected to **its own battery system** and protected, on the DC side, by a motorized automatic circuit breaker, located in a dedicated DC cabinet.

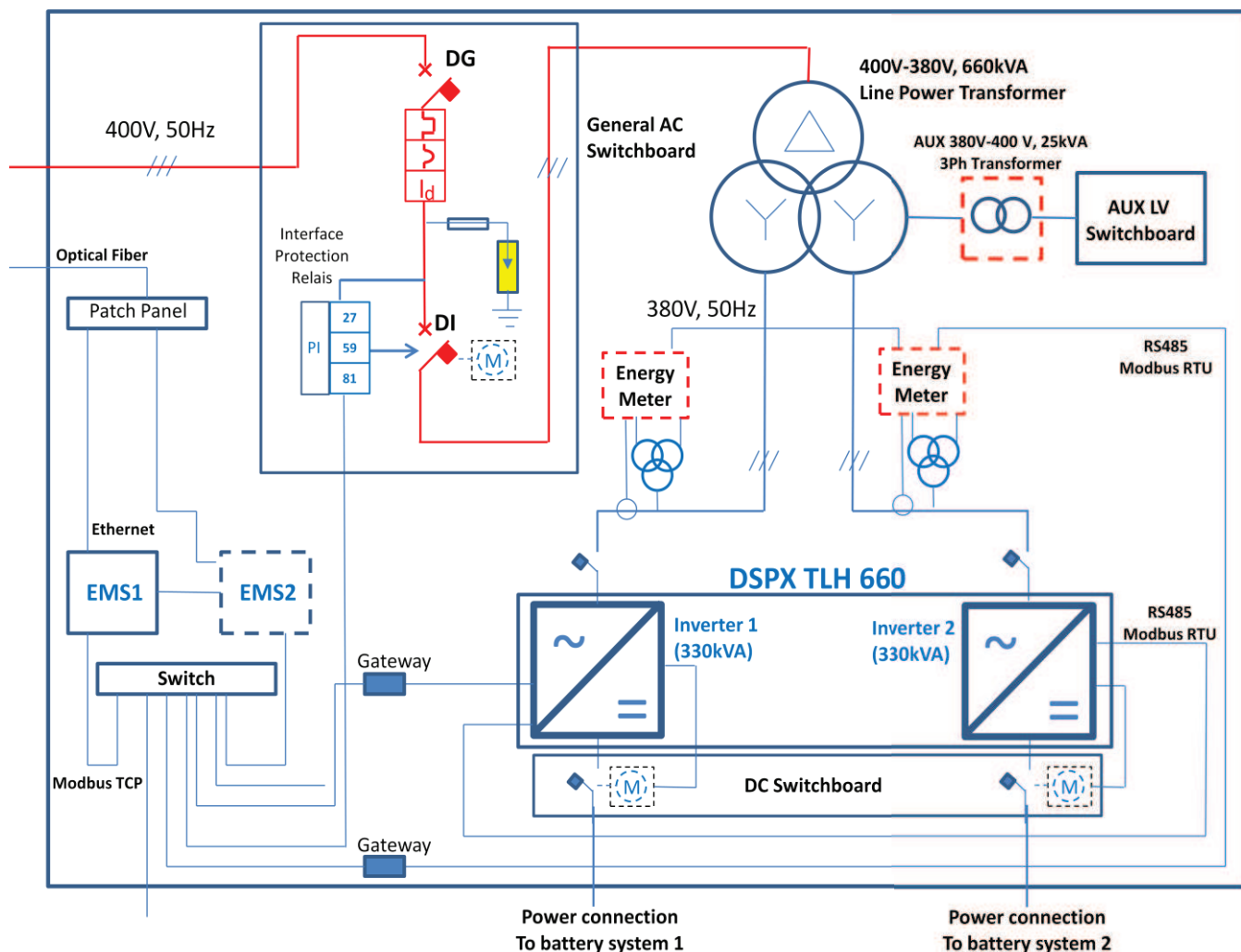
Energy Metering system (optional) is composed by two energy counters, same as the number of secondary windings of the transformer.

Please notice that, the General Switch (DG, according to CEI021 naming rules ), is coincident with the Interface protection device (DDI, according to CEI021 naming)

Following illustration depicts the basic layouts of the Soleil EH PS660 LV (two secondary windings of the MV-LV transformer).

Dotted lines denote components that are considered '**optional**'.

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## 5 SYSTEM COMPOSITION

### 5.1 Container

Soleil EH PSxxx LV system is based on metal frame container with following features:

- Base frame in UNP240 beams with welded corners; corner blocks in accordance with ISO1161.
- External walls and roof made of corrugated steel sheet.
- Liner in "sandwich" panels constructed from two sheets of galvanized steel Sendzimir that includes the insulating rigid polyurethane foam (60mm thickness).
- Raised floor room formed by slats in galvanized steel

The interior is divided into two main sections:

- **LinePower transformer room, equipped with:**

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- LV to LV isolation, 660kVA rated, with a double secondary winding (330kVa each) and suitable transform ratio for connections to a 400, 3Ph (delta configuration) grid, with isolation shield (grounded) between primary and secondary windings.
- Air exhaust system based on wall axial fans, temperature-driven.
- Double grate door for direct room access and ventilation air intake.
- **Technical room and entry line, equipped with:**
  - General Low voltage switchboard for incoming line, containing:
    - General Disconnection circuit breaker device (DG) with thermal, magnetic and differential protection.
    - Interface protection automatic circuit breaker, controlled by its own electronic protection relais (CEI021 compliant, featuring ANSI protection codes 27, 59, 81>, 81<). This device can optionally be equipped with motor for remote-driven reclosure.
  - Insulation monitors on AC connection to Line Power transformer and on DC connections to Battery System (the system is operated in 'Isolated Neutral' regime).
  - Soleil DSPX TLH series 660kVA inverter, made by 2 single 330kVA inverters, dual input from DC line and dual output to AC.
  - DC cabinet, with automatic circuit breakers, for connection to the battery system. These circuit breakers are equipped with motor for forced disconnection (by the inverter).
  - Low Voltage cabinet for auxiliary services, integrating I/O collection module, energy metering system (with current and voltage transducers).
  - Low-voltage transformer feeding auxiliary services (optional), available in different power ratings (from 15 to 50kVA), protected by automatic circuit breaker.
  - Forced air system, based on axial fans, wall mounted.
  - UPS for continuous power supply of supervision system, available in different power ratings (from 3kVA to 6kVA) and backup time.
  - Dual grill doors providing direct access to the space and ventilation.
  - Lighting system and power supply.
  - Safety Accessories for cabins and warning signs.

The system is classified according to two different categories of temperature tolerance range:

- **'Standard' temperature range, suited for installation with ambient temperature between -10°C and +45°C.**
- **'Extended' temperature range, suited for installation with ambient temperature between -50°C and +45°C.**

**'Standard'** version of Soleil EH PSxxx features a ventilation scheme with a **Forced air Open architecture**, for both the inverter room and the transformer room. In these models, the 'cold' air is sucked-in from the outside through 'intake' grills (with anti-dust filters) and it is expelled through 'output' grid. The transformer room is equipped with axial fans, temperature-driven, to help the air evacuation when needed.

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**‘Extended’** temperature version of Soleil EH PSxxx PSxxx, is particularly suited for very low temperature environments and its ventilation scheme is a ‘controlled’ open architecture . This basically means that the container has air intake openings from the outside to inside and air exhaust openings. Both of them are controlled through a PLC and motorized roll-up blinds.

Depending on the internal and external temperature, the logic opens and closes the roll-up blinds.

If the internal temperature is low but in the operating range of the equipments, the windows are closed and the equipments (inverters and MV transformer) work in a ‘closed’ architecture fashion (no air flow exchange with the exterior).

This happens until the internal temperature gets high enough to need some fresh air to be brought in. In this case, the control, lets the windows to open-up (proportionally to the temperature difference between the internal ambient and the external), in order to appropriately refresh the internal ambient. In this case, the ventilation architecture gets fully ‘open’. In order to handle long no-run periods, at a very low external temperature, a warm-up phase of the container will take place. Every container will be supplied with a appropriate heating resistor bank, in order to raise the ambient temperature when it is too low (e.g. when it is less than -20°C), for instance because the container has not been operated for a long time on winter.

| Model              | L (mm)<br>(feet) | W (mm) | H (mm) | Weight (kg ) |
|--------------------|------------------|--------|--------|--------------|
| Soleil EH PS660 lv | 6.057mm<br>(20') | 2.438  | 2.896  | 9.000        |

## 5.2 AC General LV Switchboard

The LV AC Main Switchboard is classified ‘form 2’ according to the CEI EN 60439-1 regulation, i.e. with the only segregation of the bus bars.

### 5.2.1 General Disconnecting Device and

The general disconnecting device of the system, is supposed to be connected downstream of a Medium Voltage to Low Voltage transformer. It is based on a ‘A’ category type circuit breaker, box-shielded.

It is equipped with thermal, magnetic and differential current sensors

|                    |                                   |
|--------------------|-----------------------------------|
| Type               | ABB SACE Tmax T series or similar |
| Insulation voltage | Up to 1150Vac                     |
| Rated current      | 1000A                             |
| Rated Voltage      | 690V                              |
| Icu (up to 415V)   | 50kA                              |
| Icw                | 50kA                              |
| Number of poles    | 3                                 |

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##### 5.2.2 Protection Interface Device (DDI)

The general disconnecting device of the system, is supposed to be connected downstream of a Medium Voltage to Low Voltage transformer. It is based on a 'A' category type circuit breaker, box-shielded, with the same characteristics of the general disconnecting device. It is coupled with an electronic interface protection relays (Thytronic NV10P or similar), featuring necessary protection functionalities, as required by regulation CEI021:

- Undervoltage (27)
- Positive seq. undervoltage (27V1)
- Overvoltage (59)
- Residual overvoltage (59N)
- Average overvoltage (59Uavg)
- Negative seq. overvoltage (59V2)
- Frequency rate of change (81R)
- Underfrequency & overfrequency (81U 81O)
- Breaker failure (BF)

Furthermore, its status can be acquired through Modbus TCP for monitoring.

## 5.3 DC Switchboard

### 5.3.1 Disconnecting devices

The DC switchboard is equipped with two motor driven circuit breakers, whose technical spec are reported in the table below.

|   |   |
|---|---|
| <b>Type</b>   | Open type, such as ABB Emax series E2N/E MS, or similar |
| <b>Location</b>   | 1 circuit breaker per DC input, totally 2               |
| <b>Insulation voltage</b>   | Up to 1000Vdc   |
| <b>Rated current</b>  | 2000A   |
| <b>Withstand current capability for short duration <i>I<sub>cw</sub></i> (1s)</b> | 25kA  |
| <b><i>I<sub>cm</sub></i> (@ 1000V)</b>  | 52.5kA  |

The opening of each circuit breaker is automatic. The reclosure can be remotely operated (by the inverter), in order to disconnect the battery system if needed.

For instance, at night time, if a great amount of reactive power has to be generated by the inverter (operation in quadrant 1 or 2), but no active power is requested, the DC bus of the inverter can be shifted-up to a value which is not compatible with the status of the battery system. The inverter, can work connected in parallel with the AC grid (in order to generate the requested reactive power) and must be isolated from the battery system on the DC side. The EMU, therefore, will send a signal to open the DC switch and will send another one to reconnect the battery system to the inverters when an appropriate operating condition will take place.

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**5.3.2 Isolation Monitoring unit and CPU**

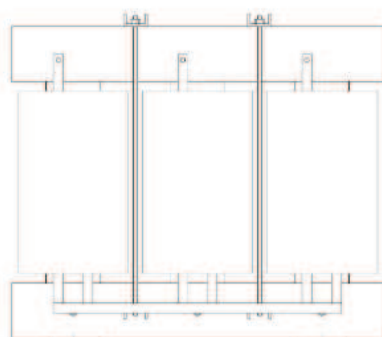
It is essential for the system to operate properly and for safety reasons, to quickly detect any condition of 'low isolation' to ground on the DC connection from the battery system.

For this reason, the DC main switchboard hosts a couple of (optional) isolation monitoring units (such as ABB CN-IWM).



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## 5.4 Line Power Transformer

|                               |             |              |            |   |
|-------------------------------|-------------|--------------|------------|---|
| DATASHEET N°<br>Progetto N°   | 001         | DATE<br>Data | 15/10/2014 |  |
| TRANSFORMER TYPE<br>Tipo      | DRY TYPE    |              |            |   |
| N° PHASES<br>N° fasi          | 3           |              |            |   |
| COOLING<br>Raffreddamento     | NATURAL AIR |              |            |   |
| INSTALLATION<br>Installazione | INDOOR      |              |            |   |
| CLIENT NAME<br>Cliente        | SIEL S.p.A. |              |            |   |

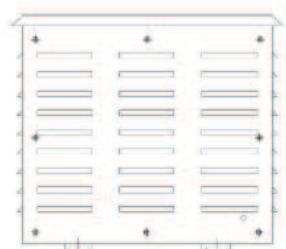
| MAIN DATA /dati di targa  |     |                                   |   |     |                         |
|---|-----|-----------------------------------|---|-----|-------------------------|
| RATED POWER<br>Potenza  | kVA | 660                               | FREQUENCY<br>Frequenza                                    | Hz  | 50 / 60                 |
| PRIMARY VOLTAGE<br>Tensione primaria                              | V   | 400                               | CONNECTION<br>Collegamento                                | -/- | DELTA / STAR+N – STAR+N |
| PRIMARY VOLTAGE REGULATION<br>Regolazione della tensione primaria | %   | ± 2 X 2,5                         | GROUP<br>Gruppo   | /   | Dyn11yn11               |
| SECONDARY VOLTAGE 1<br>Tensione secondaria 1                      | V   | 380 at no load<br>(330KVA STAR+N) | ISOLATION MATERIAL CLASS<br>Classe d'isolamento materiali | /   | H                       |
| SECONDARY VOLTAGE 2<br>Tensione secondaria 2                      | V   | 380 at no load<br>(330KVA STAR+N) | OVERTEMPERATURE CLASS<br>Classe di sovratemperatura       | /   | H                       |

| ELECTRIC DATA /dati elettrici                        |    |      |   |     |                     |
|--|----|------|---|-----|---------------------|
| NO LOAD LOSSES<br>Perdite a vuoto                    | W  | 1750 | TEST VOLTAGE<br>Tensione di prova                           | kV  | 3                   |
| IMPEDANCE LOSSES (115°C)<br>Perdite a carico (115°C) | W  | 8850 | INDUCED OVER VOLTAGE TEST<br>Tensione indotta               | /   | 2 VOLTE LA NOMINALE |
| IMPEDANCE VOLTAGE<br>Tensione di corto circuito      | %  | 6 ~  | OVER TEMPERATURE<br>Sovratemperatura                        | °C  | 100                 |
| MAX INRUSH CURRENT<br>Massima corrente d'inserzione  | In | 5    | AMBIENT MAX/MIN TEMPERATURE<br>Temperature ambiente max/min | °C  | + 50 / - 20         |
| ELECTROSTATIC SHIELD<br>Schermo elettrostatico       | /  | SI   | WINDINGS MATERIAL (PRI/SEC)<br>Materiale avvolgimenti       | -/- | AL/AL               |

|   |    |
|---|----|
| OUTPUT ON OPPOSITE SIDES<br>Uscite sui lati opposti | SI |
|---|----|

|  |                          |
|--|--------------------------|
| STANDARD RULES<br>Norme di riferimento | CEI EN 60076-11, IEC 726 |
|--|--------------------------|

| WEIGHT AND DIMENSIONS /peso e dimensioni |    |      |
|--|----|------|
| TRANSFORMER<br>Trasformatore             |    |      |
| LENGTH<br>Lunghezza                      | mm | 960  |
| WIDTH<br>Larghezza                       | mm | 850  |
| HEIGHT<br>Altezza                        | mm | 1050 |
| WEIGHT<br>Peso                           | Kg | 1550 |

| BOX WEIGHT AND DIMENSIONS /peso e dimensioni   |                     |      |
|--|---------------------|------|
|  | /                   |      |
|  | LENGTH<br>Lunghezza | mm / |
|  | WIDTH<br>Larghezza  | mm / |
|  | HEIGHT<br>Altezza   | mm / |
|  | WEIGHT<br>Peso      | Kg / |

| NOTES / Note                          |
|---------------------------------------|
| RENDIMENTO A PIENO CARICO 98,4 %      |
| RENDIMENTO AL 50 % DEL CARICO: 98,7 % |
| RENDIMENTO AL 25 % DEL CARICO: 98,5 % |

## Soleil Energy Harvest Power Station

### EH PS660 LV

#### Technical specification

The transformer room is equipped with axial fans, controlled in their operation by a thermal monitoring unit, acquiring both the environment temperatures and the PT100 sensors from the transformer.

### 5.5 Inverter Soleil DSPX



Soleil DSPX 500 TLH 'M' - 833TLH 'M'



Soleil DSPX 500TLH-833TLH

#### 5.5.1 System composition

| EH PSxxxx LV<br>model | Inverter type and quantity   |
|-----------------------|--|
| <b>EH PS660</b>       | 1 x Soleil DSPX 660 TLH (dual DC input and dual AC output configuration) |

All Soleil inverters are three-phase inverters connecting to a 3Ph, 4 wires (R,S,T, Protection line) grid, without neutral, 380V line-to-line, 50Hz.

Their connection with a different voltage amplitude grid, is done through a step-up transformer.

Soleil DSPX from 500TLH to DSPX 833TLH are composed of an IGBT double power module, dual control, with two independent MPPT, PWM (Pulse Width Modulation) technology.

Soleil DSPX from DSPX 660TLHM to DSPX 833TLHM are composed of an IGBT double power module with single control, single MPPT, PWM (Pulse Width Modulation) technology.

The system transfers a current to the mains with an identical waveform to that of the voltage, power factor is adjustable from 0.9 (leading or lagging) to 1. Default is 1.

Soleil inverters feature all the state-of-the art requirements in terms of grid support functions, such as:

- Reactive power generation (depending on a setpoint communicated through 'RS485 Modbus RTU protocol').

## Soleil Energy Harvest Power Station

### EH PS660 LV

#### Technical specification

- Active power limitation (according to a setpoint communicated through 'RS485 Modbus RTU protocol').
- Voltage regulation support through automatic reactive power injection (as a function of actual voltage, either read at the output of then inverter or passed through RS485 Modbus RTU).
- Frequency regulation support through automatic active power derating (as a function of frequency, either read at the output of then inverter or passed through RS485 Modbus RTU).
- Low Voltage Failure Ride Through.
- High Voltage Failure Ride Through.

The commands and instructions for the Soleil DSPX 500TLH - Soleil DSPX 833 TLH are entered through a 'touch screen panel enabling visual access to all the operating parameters of the system (electrical measurements, states and alarms).

Please refer to the documents IV346 "Instruction Manual Soleil DSPX" and IV347 "Soleil DSPX Installation Guide" for further and more detailed information on the subject.

| SOLEIL DSPX TLH 380V                                   | 330                   | 500M | 660  | 833M  |
|--|-----------------------|------|------|-------|
| <b>DC input side– Recommended power of the modules</b> |                       |      |      |       |
| Rated [kWp]  | 330                   | 500  | 660  | 833   |
| Maximum [kWp]  | 400                   | 608  | 800  | 1006  |
| <b>DC input side– Electrical specifications</b>        |                       |      |      |       |
| Max Operating voltage range [V]                        | 560 - 930             |      |      |       |
| Optimal operating voltage[V]                           | 560 - 820             |      |      |       |
| Max. voltage [V]                                       | 1000                  |      |      |       |
| Min. voltage [V]                                       | 560                   |      |      |       |
| Number of input connections to battery system          | 1                     | 1    | 1    | 1     |
| Max Isc per input connection [A]                       | 598                   | 910  | 1197 | 1506  |
| <b>AC output side</b>                                  |                       |      |      |       |
| Pmax rated power [kW] <sup>1</sup>                     | 330                   | 500  | 660  | 833   |
| Maximum power Smax [kVA] <sup>1</sup>                  | 330                   | 500  | 660  | 833   |
| Connection   | 3Ph                   |      |      |       |
| Nominal voltage (line-to-line)V]                       | 380                   |      |      |       |
| Rated current [A] <sup>2</sup>                         | 501                   | 760  | 1003 | 1266  |
| Maximum current [A] <sup>3</sup>                       | 557                   | 844  | 1114 | 1406  |
| Min Smax operating voltage [V] <sup>4</sup>            | 90% Vn                |      |      |       |
| Minimum operating voltage [V] <sup>4</sup>             | 85% Vn                |      |      |       |
| Maximum operating voltage [V] <sup>4</sup>             | 115% Vn               |      |      |       |
| Nominal frequency [Hz]                                 | 50                    |      |      |       |
| Frequency operating range [Hz] <sup>5</sup>            | 47,5 - 51,5           |      |      |       |
| Max. efficiency[%] <sup>6</sup>                        | 98,5                  | 98,1 | 98,5 | 98,8  |
| Euro efficiency [%] <sup>6</sup>                       | 98,1                  | 97,3 | 98,1 | 98,35 |
| THD% I @Pnom   | 3                     |      |      |       |
| Power factor <sup>1</sup>                              | 0.... 1.0, adjustable |      |      |       |
| Short circuit current contribution [A]                 | 752                   | 1140 | 1504 | 1899  |
| <b>Other data</b>                                      |                       |      |      |       |
| Ventilation system                                     | Forced air            |      |      |       |
| Dissipated power without load [W]                      | 64                    | 128  | 128  | 128   |
| Control  | Digital DSP           |      |      |       |
| Output wave form                                       | Sinusoidal            |      |      |       |

*Soleil Energy Harvest Power Station*  
*EH PS660 LV*  
*Technical specification*

| SOLEIL DSPX TLH 380V                   | 330                         | 500M | 660  | 833M |
|--|-----------------------------|------|------|------|
| Operating temperature (full power)[°C] | -20°C / +50°C               |      |      |      |
| Operating temperature range [°C]       | -20°C / +50°C               |      |      |      |
| Storage temperature range [°C]         | -25°C / +70°C               |      |      |      |
| Operating humidity range               | 5% / 95% without condensing |      |      |      |
| Maximum altitude                       | 1000m (s.l.m.)              |      |      |      |
| Environment category                   | Indoor not conditioned      |      |      |      |
| Pollution Degree                       | PD3                         |      |      |      |
| Overvoltage class (input DC)           | Class II                    |      |      |      |
| Overvoltage class (output AC)          | Class III                   |      |      |      |
| Mechanical characteristics             |                             |      |      |      |
| dBA                                    | 68                          | 68   | 68   | 68   |
| Class of protection                    | IP20                        |      |      |      |
| Dimensions LxDxH [mm]                  | 1500x1000x2000              |      |      |      |
| Weight [kg]                            | 850                         | 1520 | 1600 | 1600 |

(\*)Note: the maximum efficiency is measured at the input voltage of 600V dc.  
 For full details of all inverters see the document "IV346E"

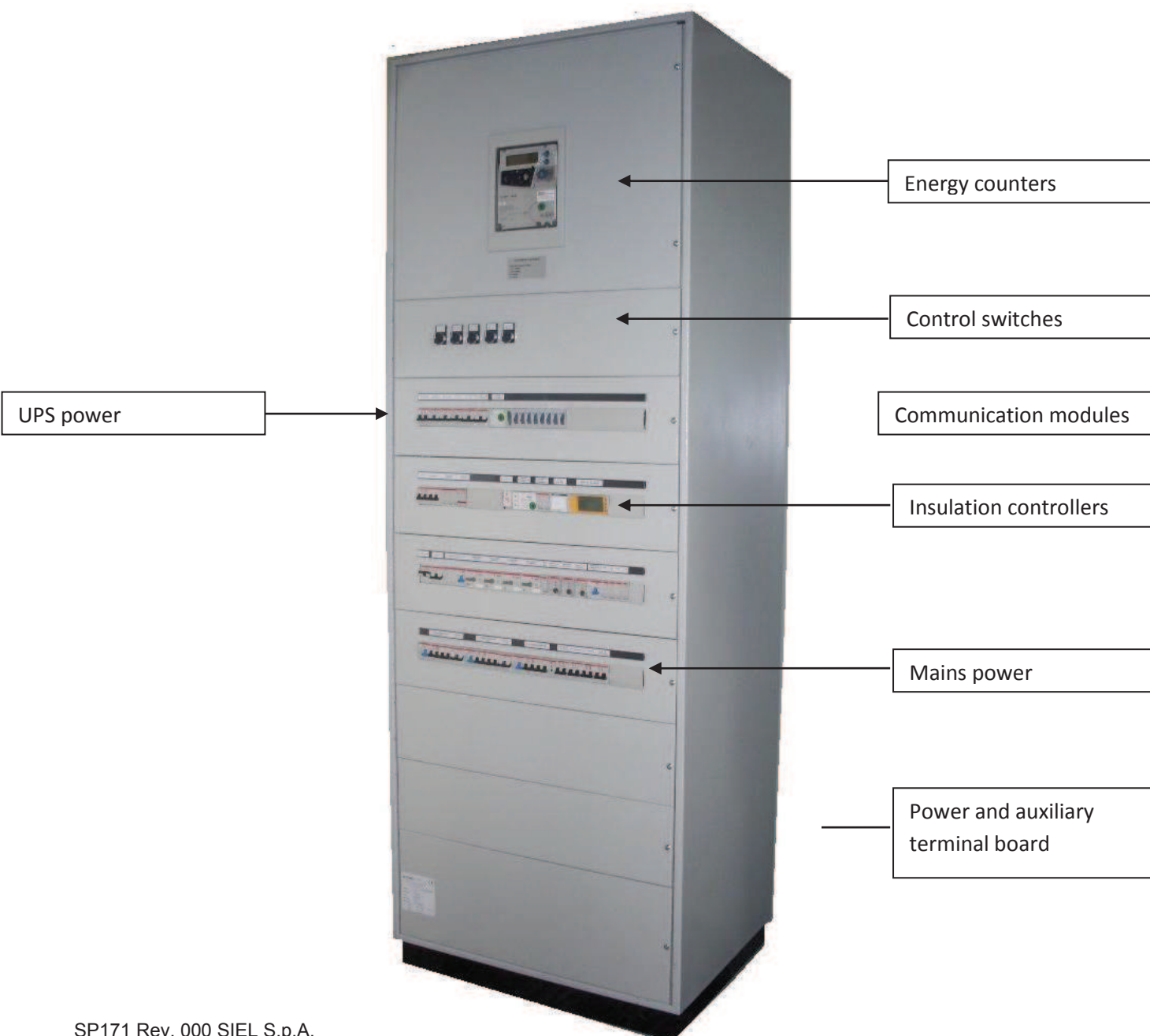
## 5.6 DC Switchgear for inverter connection to the Battery System (TBC)

## 5.7 AC Low Voltage Distribution Switchgear and auxiliary protection

The switchgear contains all the relevant switches for the protection and distribution of the ancillary circuits of the system and, as standard, it is powered by an external electricity line provided by the client.

The electric switchgear is enclosed in a metal cabinet, with the following characteristics:

- Protection grade: IP30
- Operating voltage: 400V
- Rated current: 50A
- Short circuit current: 6 kA





*Soleil Energy Harvest Power Station*  
*EH PS660 LV*  
*Technical specification*

The switchgear also includes the isolation meters for operating the plant in IT (recommended)  
The switchgear also houses the communication devices with acquisition modules (I/O and GPRS modem), as described in Chapter 5.

### 5.7.1 Options

Optionally, the switchgear can be powered by a dedicated transformer from 15 kVA 280 (380)/400V connected directly from the secondary of the MV transformer, housed in the switchgear itself and complete with switch protection on the primary side and of the necessary power connections, performed with FG7/ conductors or 0.6 / 1kV calculated section . Other ratings are available for this transformer.

### 5.8 Energy Meters (optional)

On request, 1, 2,3 or 4 counters for UTF use can be supplied: type ITRON SL761B071-2012 (or similar).

The counters are complete with appropriate measurement TA, in addition to output signals for the measurement of energy, plus predisposed terminals for connection to a supervision system.

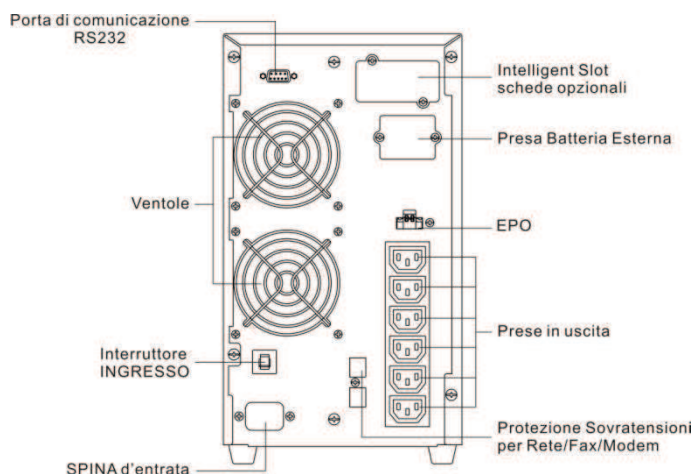
### 5.9 Air conditioning system (optional)

The Power Station is equipped with a forced ventilation system in the “open” architecture version.

The “closed” architecture version includes a precision air conditioning unit, based on Stulz CVS-A2 (or equivalent unit), double (Master-Slave optional operations) for PS990, PS1320, PS1650 , PS1980, PS2500 or PS3320, single for PS500, PS660 and PS833, also operating in “free-cooling” mode.

### 5.10 UPS

All of the Power Stations are equipped with 3KVA (as a standard, high rating models available) continuity groups for the power supply of the supervision platform (chapter 5).



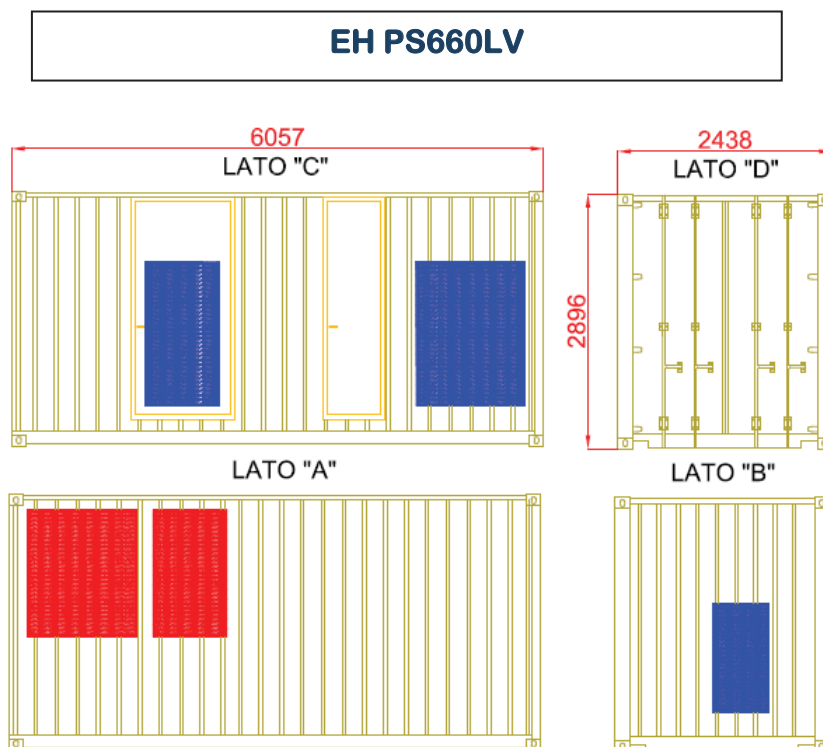
*Soleil Energy Harvest Power Station*  
*EH PS660 LV*  
*Technical specification*

The following information refers to the characteristics of the UPS:

| <b>INPUT</b>   |   |
|--|---|
| <b>Phases</b>  | Single-phase                              |
| <b>Voltage(Vac)</b>  | 175-285                                   |
| <b>Frequency (Hz)</b>  | (45~55)/(54~66)                           |
| <b>Current (A)</b>   | 26  |
| <b>OUTPUT</b>  |   |
| <b>Power</b>   | 3KVA/2.4KW                                |
| <b>Voltage(Vac)</b>  | 208/220/230/240 (±2%)                     |
| <b>Frequency (Hz)</b>  | 50/60 ±0.2Hz (battery Mode)               |
| <b>Waveform</b>  | Sinusoidal                                |
| <b>Typical autonomy<br/>(internal batteries<br/>8x12V, 7.2Ah )</b> | 100% Charge: 5 min<br>50% Charge: 15 min. |

## 6 MECHANICAL DRAWINGS

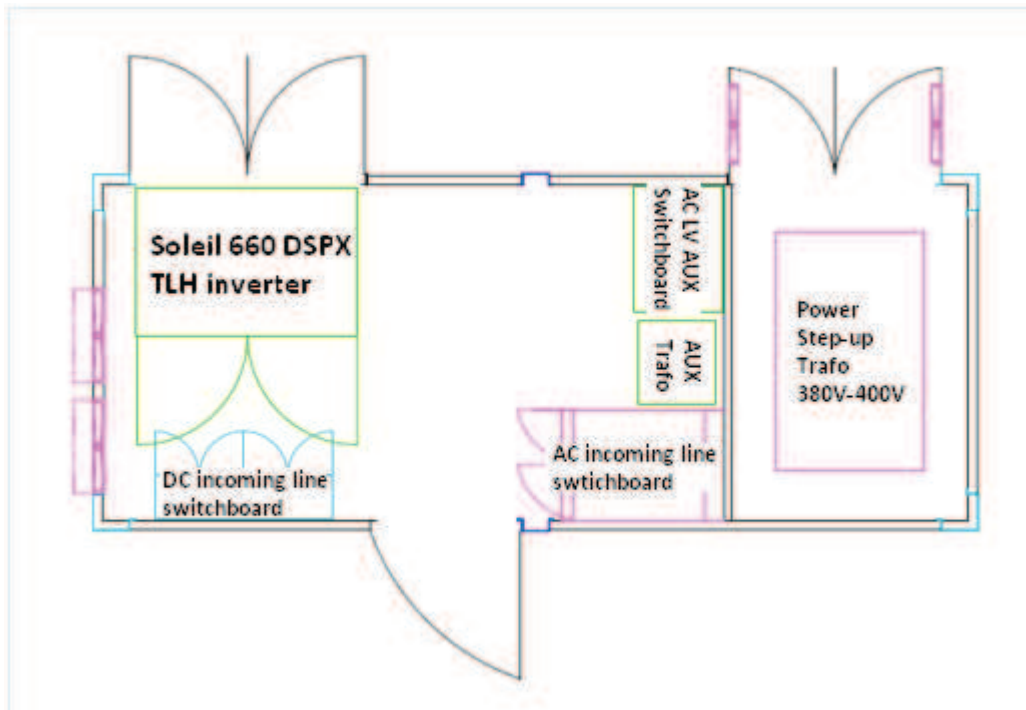
### 6.1 Exterior view and dimensions





## 6.2 Layout and internal top view

### EH PS660 (20' CONTAINER)



Some appropriate clearance must be kept around the container to guarantee correct ventilation and access for maintenance.

## **7 SYSTEM CONTROL AND CONNECTIVITY PLATFORM**

The Energy Management System (EMS) performs all the necessary control of the system (battery + conversion), through a, proprietary application SW, running on an embedded PC, deploying several tasks such as:

### **EMS BATTERY SYSTEM INTERFACE AND OPERATION**

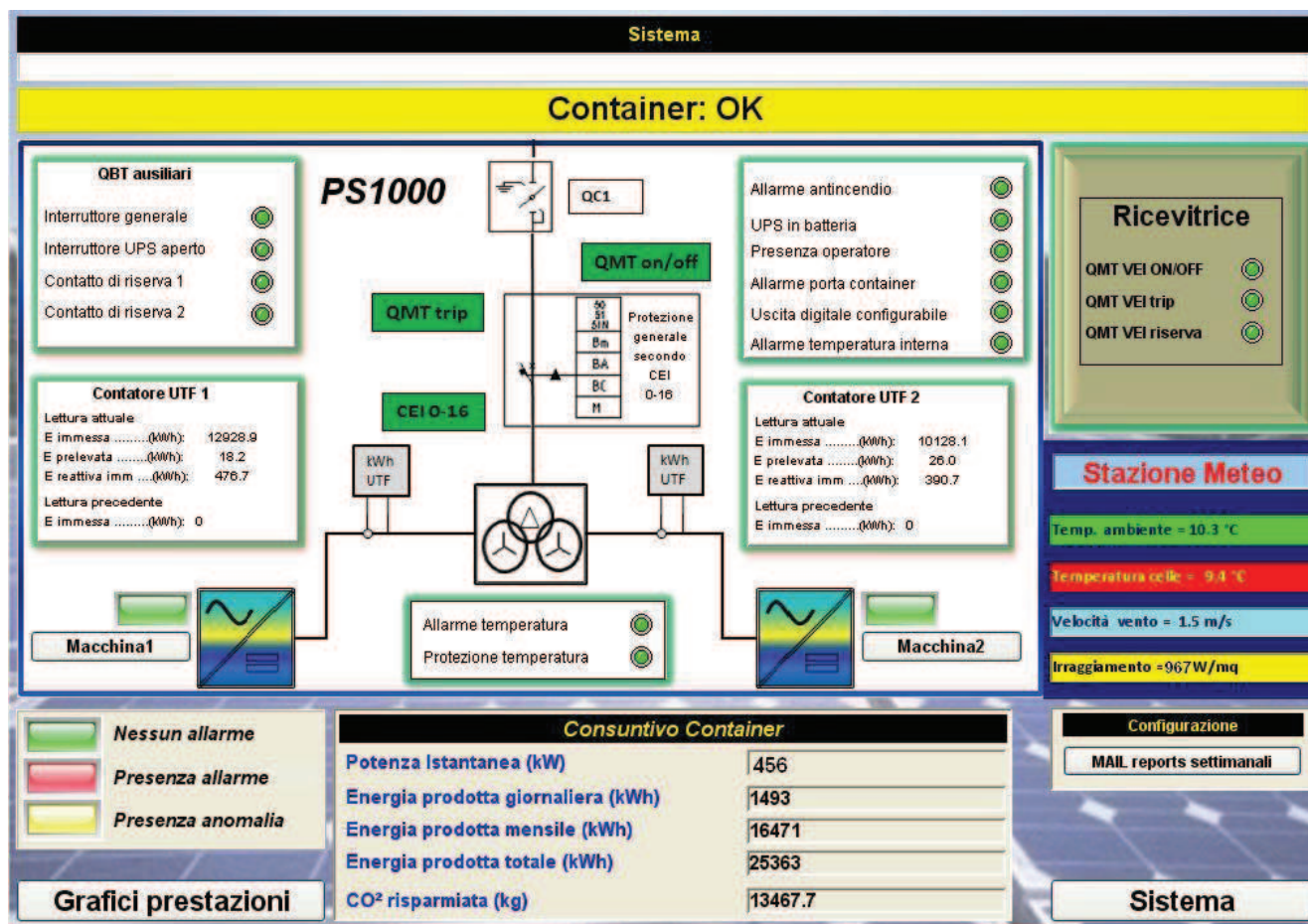
- Battery System Start/Stop, Initialization handling and Autotest.
- Charge and Discharge Management of the Battery system.
- Alarm and trap handling from Battery System and relevant management logic of the Soleil EH Psxxx operations.
- Monitoring and diagnostics of the Battery System and alarm/event data collection.

### **ENERGY CONVERSION SYSTEM INTERFACE:**

- Monitoring and diagnostics of the whole Soleil WH Power Station and alarm/event data collection, such as:
  - Inverter status and alarms.
  - Status of the motorized AC switch (open/closed), if present;
  - Status of the protection interface electronic relays (trip code).
  - State of protection of maximum current;
  - Maximum temperature alarm (first threshold) of the Step-up line power transformer;
  - Maximum temperature protection (second threshold) of the Step-up line power transformer;
  - Fire alarm;
  - Internal temperature alarm;
  - QBT open switch alarm;
  - UPS battery operation;
  - UPS switch open;
  - Container door opening alarm.
- Implementation of the logic of operation depending on the preset mode (on-grid/off-grid) and relevant parameters of configuration.
- Remote Command handling and dispatch to the inverters (setpoint update), according to the logic of operation.

## 7.1 Main features of the EMS

All the information acquired by the EMS, is constantly stored in its database and can be accessed in any moment from the GUI of the system and (if present), or on a local plant SCADA system (in a format similar to the following figure):



A pre-settable portion of the database, can be transmitted, to a Remote Control Station (for example the SCADA of the grid Operator) with a pre-determined scheduling or in real time (for highly critical events), through fiber optic, on a standard automation protocol (such as IEC 104 or IEC 61850).

The operation of the EMS, can optionally be **redundant**, if the optional backup Embedded PC unit is present.

Alarms and events are real-time notified to final customer or to the O&M team through email and SMS.

Reports with statistics of operation can be configured to be sent periodically to O&M and final customer.

## **7.2 Hardware**

The EMS, is composed by:

- N.1 (or two redundant, optionally) PC embedded CPU (such as MXE 3100 dual core series), running the EMS application SW.
- N.1 RS-485 serial local bus, with Modbus RTU protocol, connecting the inverters and relevant gateway (adapter) for Modbus RTU to Modbus TCP conversion.
- N.1 RS-485 serial local bus, with Modbus RTU protocol, connecting the Energy Meters and all the I/O collected from the container, plus the relevant gateway (adapter) for Modbus RTU to Modbus TCP conversion.
- N. 1 Switch Ethernet (delivery point to the customer).
- N. 1 GUI, based on Monitor and Keyboard for local access to the data of the system
- N.1 (optional) patch panel for optical fiber connection (delivery point to the customer).
- Optionally, the system can also be equipped with a GPRS modem, for data transmission to SIEL Operation & Maintenance team.

All the system is powered by the UPS of the station.

## 8 TECHNICAL SPECIFICATIONS

| MODEL   |  | SOLEIL EH PS660 LV                                    |
|---|--|---|
| <b>INPUT DC PARAMETERS</b>                          |  |   |
| Maximum input power                                 |  |   |
| Input short Circuit current                         |  |   |
| Max/min voltage operating range(V)                  |  | 560 - 930   |
| Optimal voltage operating range (V)                 |  | 560 - 820   |
| Number of input connections to the battery system   |  | 1 + 1   |
| Number of inverters                                 |  | 1 x Soleil DSPX 660TLH                                |
| Number of power conversion modules per inverter     |  | 2   |
| <b>OUPTUT AC PARAMETERS</b>                         |  |   |
| Nominal Power Pn (kW)                               |  | 600kW   |
| Maximum Power Smax [kVA]                            |  | 660kVA  |
| Number of phases                                    |  | 3Ph   |
| Rated AC voltage(s)                                 |  | 6kV, 10kV, 15kV, 20kV, 30kV, 36kV (others on request) |
| Harmonic Distortion of current at Nominal power (%) |  | <3%   |
| Inverter Max efficiency (%)                         |  | up to 98.8  |
| Inverter Euro efficiency (%)                        |  | up to 98.35   |
| Power Factor (cos phi)                              |  | 0 to 1, adjustable                                    |
| <b>GENERAL CHARACTERISTICS</b>                      |  |   |
| Operating temperature (°C)                          |  | 5°C/+50°C (1)   |
| Communication system                                |  | Ethernet, optical fiber                               |
| Installation  |  | Outdoor   |
| MV Switchboard                                      |  | Internal, for all models                              |
| LV/MV Transformer                                   |  | Internal, for all models                              |

Note 1: Also available in the “closed “ architecture version with operating temperature -40°C/+60°C

## **9 REFERENCE REGULATIONS**

### **9.1 LV Interface and grid code**

- A70, A68 - CEI 021 compliant

### **9.2 LV Switchboards**

- EN 60439

### **9.3 LV Transformers**

- CEI EN 60076
- IEC 726

### **9.4 UPS**

- CEI EN 62040-1
- CEI EN 62040-2
- CEI EN 62040-3

### **9.5 Inverter**

- EMC Directive 2004 /108/EC
- Directive 2006 /95/EC
- EN 61000-6-1 (immunity)
- EN 61000-6-3 (emissions)
- EN 50178, EN62109-1, IEC 62109-2 (safety)
- EN 61000-3-12 (harmonics)
- EN 61000-3-11 (voltage flicker)
- Guide to connection to the network of Enel Distribution.
- CEI 0-16, CEI 0-21, Annexes A70 (MV connection) and A68 (HV connection) of Terna