Monitoring Platform for Photovoltaic Plants

SMARTMSYST - A Martifer Solar solution for monitoring and operation of Photovolatic Plants

A Photovoltaic System is a power System designed to supply usable power by means of photovoltaics.
During the Photovoltaic plant equipment life cycle, it is imperative to consider the costs of operation, costs of maintenance and reducing yield due to the performance degradation. It becomes essential to ensure high performance, low downtime and fault detection in a PV plant. On the plant site, data from the equipment like weather stations and inverters need continuous monitoring and performance analysis. A SCADA system provides the proper field equipment integration and communication as well as data integrity.

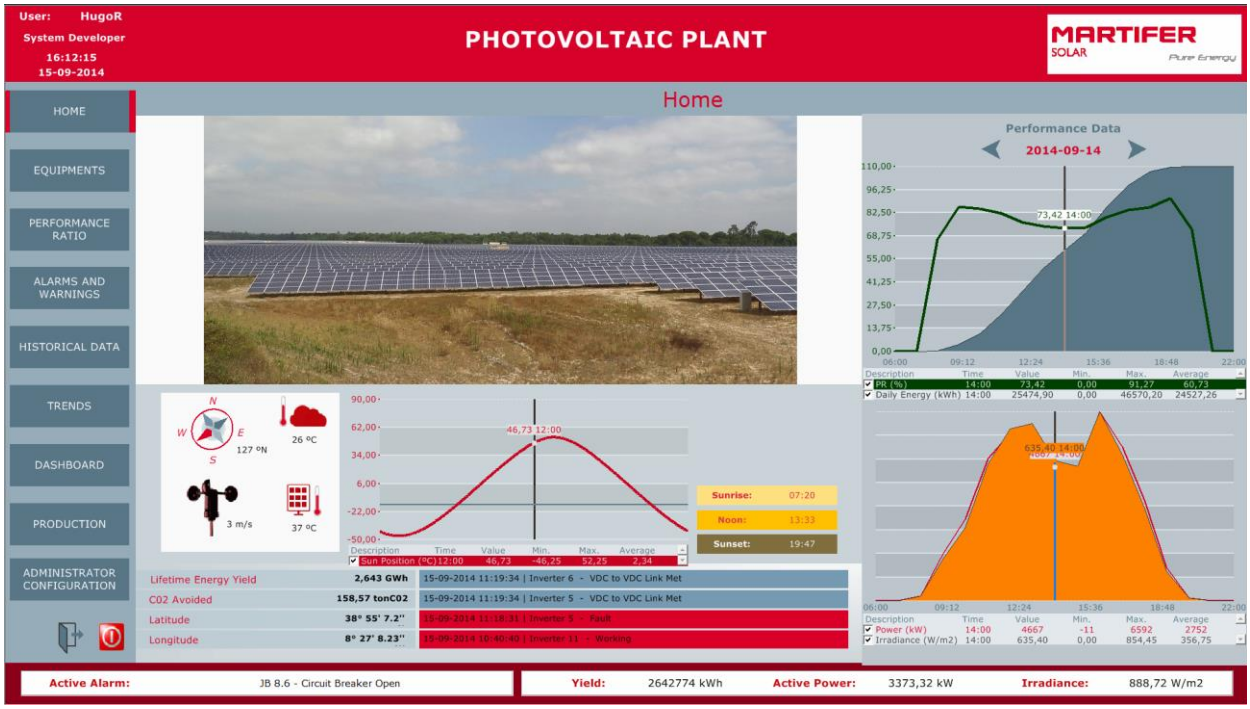
MARTIFER SOLAR is a Portuguese-based company with presence in more than 20 countries over 4 continents and has implemented 560 MW of solar energy all over the world. Founded in 2006, it is supported by a proven track record and true worldwide presence.

Martifer Solar is a leading global player in Development, EPC and O&M Services in the photovoltaic market.

The company provides 360º turnkey solutions adapted to each customer's individual needs. Martifer Solar achievements place the company among the world's largest solar companies in the sector, acknowledged by renowned research companies.

Recognized capabilities across the entire value chain enable the company to manage all phases of the solar development cycle, from market and site identification to the grid connection and subsequent plant operation.

MARTIFER SOLAR covers all market segments:
- Ground mounted systems;
- Rooftop systems;
- Small generations;
- Offgrid system;
- Build Integrated photovoltaic systems.



SMARTMSYST is able to monitor PV plants from 3000 to 8000 variables.
The interfaces can be accessed on local station at the plant site or remotely

SMARTMSYST – Monitoring Platform for Photovoltaic Plants

General SCADA developers usually create industrial nature applications.
Premises generally taken from granted to build industrial applications do not usually fit photovoltaic monitoring systems.
To develop a monitoring system of this nature, specific knowledge about electricity production from photovoltaic resources is required.

Martifer Solar is a global player in EPC (Engineering, Procurement and Construction) for photovoltaic solutions.

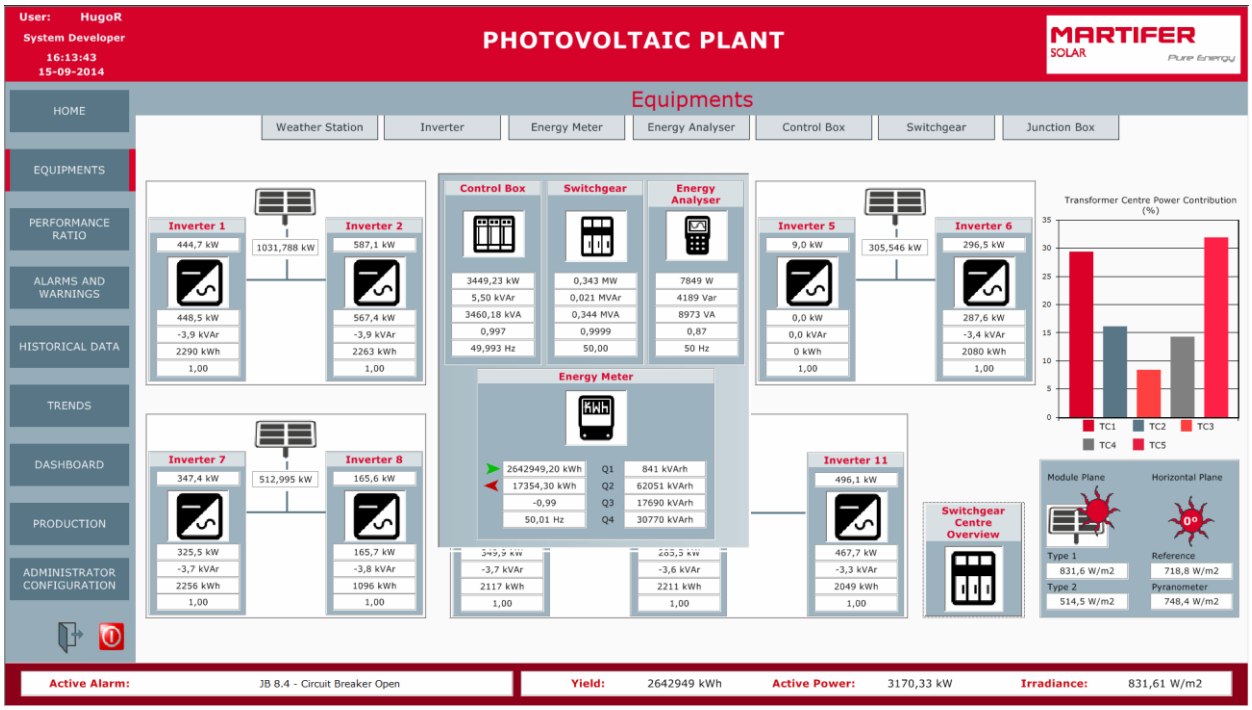
A monitoring system is an EPC subsystem. The need and specificity of these systems often lead to the hiring of an external company to develop the monitoring software. Resort to external companies to develop software, implies the transmission of know-how.

A SCADA system is capable to collect data from one or more distant equipment and make it available to one or more users.
Equipment monitoring and control intends to maximise the produced energy, reduce the down time and consequently prevent equipment failure due to wearying.
On this way, equipment malfunction and failure can be earlier detected.

Particularly requisitions for supervision systems to monitor photovoltaic plants usually lead companies to subcontract its development. This situation flows into know-how transmission. Moreover, monitoring systems bought to external companies often lack correct data conditioning or reliable equipment information. Due to the complexity of a supervision system, sometimes these anomalies are detected after the SCADA installation and its corrections result into extra-cost due to extra-works.

It is clear the importance of an own SCADA application software, developed internally at Martifer Solar.
After a Survey of SCADA development, Martifer solar chose Movicon 11.3 SCADA/HMI platform which besides fulfilling all the hardware requirements, proved to be very reliable and easy to use.

With the purpose of developing an optimized and efficient supervision system it is necessary to be aware of the equipment to be monitored as well as the PV plant infrastructures where this equipment will be installed. PV plant architecture is arranged in a simple and logic manner, aiming to present an organisation which can be seen often in real photovoltaic plants.



Realtime Equipment Synoptic intend to depict the PV plants as well as the system main realtime variable values.

A PV Plant is organized in facilities: there are 3 main facilities: transformer centre, switchgear center and the control center.
The monitored PV equipment is usually associated with a facility. For instance, the PV modules are grouped by strings; these strings usually connect to other strings by means of a junction box and then connect to an inverter placed on the transformer center. Inside the transformer center is placed a monitoring cabinet with all the necessary equipment to monitor the PV Plant equipment, namely: protocol converters, PLCs, dataloggers, gateways and Optical Fiber Switches. An optical fiber ring connects all the facilities: the transformer center, the switchgear center (which hosts equipment such as the energy meter and the medium voltage switchgear) and the control center. The control center is the "brain" of the PV Plant. All information flows into the server located in the control center's rack. The SCADA system gathers and stores and this information and make available to the "external world".

The final application intends to collect and store data from the PV Plant. It makes the data available to the plant operator by means of intuitive synoptic. The final application also manages the data in order to make it available for the Martifer Solar's Operation Management System – a platform that integrates data from all PV Plants in Martifer Solar's operation and maintenance portfolio.

SMARTMSYST

SMARTMSYST is a tool developed with the purpose of equipment monitoring, data storage and visualisation. It provides graphical display for monitoring plant production and equipment status. The developed monitoring platform includes screens with data tables, trend graphics and alarm management.
SMARTMSYST monitors PV plants from 3000 to 8000 variables.
This interface can be accessed on a local station at the plant site. This interface can also be accessed remotely by authorised users through a web client interface.
The developed application (SMARTMSYST), approximately one year after its first installation, monitors eight PV plants which correspond to around 37 MW. Among those is a PV cluster of 17.4MW. The PV cluster, which was inaugurated on 31st October 2013, consists of six PV plants constructed in Loures, Montijo and Montemor-o-Novo regions. Martifer Solar is the operations and maintenance contractor to ensure the optimal generation levels of these six PV plants.

With an installed capacity between 2.2 and 6.7 MWp each, these plants are built with more than 74,000 Hanwha SolarOne modules installed in

ground-mounted structures. The “green” energy that will be produced by the entire cluster is estimated to sufficiently power over 24 800 inhabitants and to avoid the annual emission of 19 300 tons of greenhouse gases

Operational Graphic User Interface

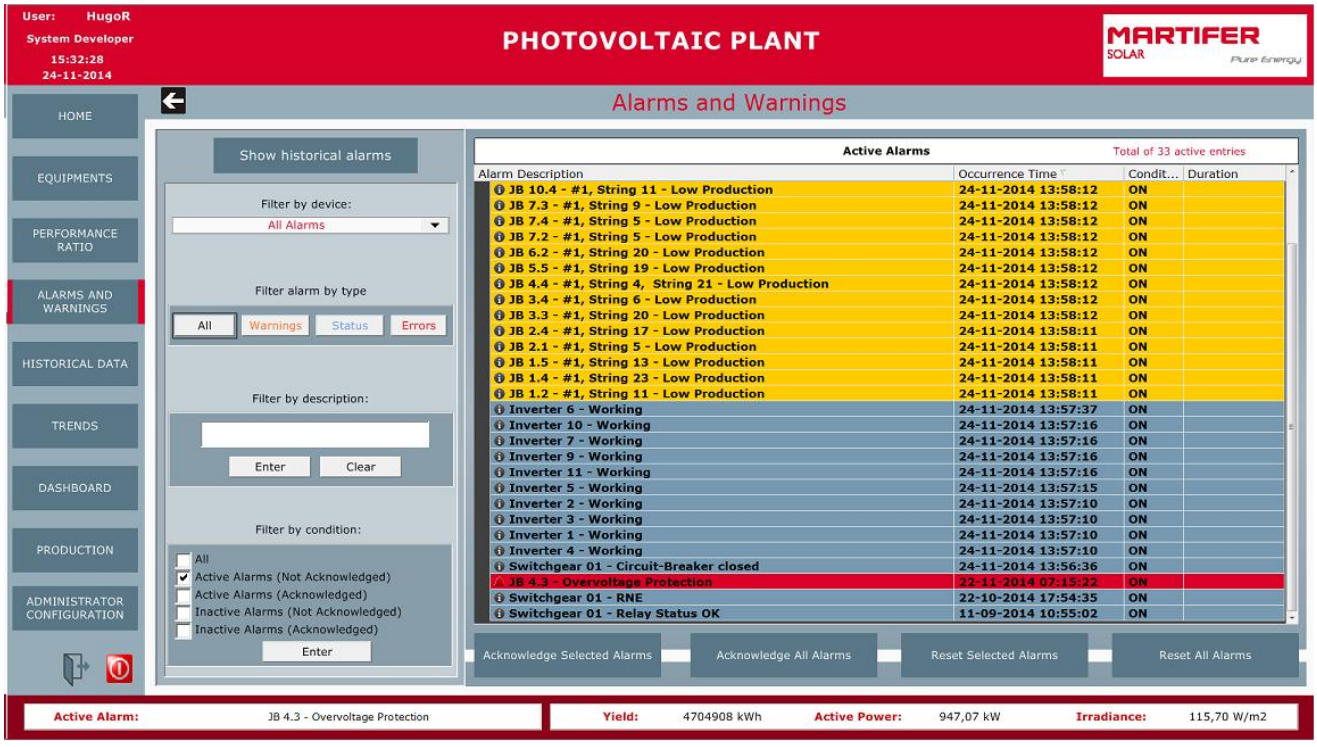
The application interface is very user friendly. The home synoptic depicts the most relevant data such as trends depicting the daily produced energy, grid supplied power, solar irradiance, performance ratio and the power supplied by the inverters. Embedded screens depict relevant information and give the operator navigation options throughout the application.

Realtime equipment synoptics are available to depict the PV plant layout as well as the system main realtime variable values. Each equipment data can be consulted individually or, when no such level of requirement is needed, consulted in a broader screen.

which the solar modules should be able to deliver under certain meteorological conditions. This KPI can be check in a screen by means of numerical representation and by horizontal gauges. All this to ease the operator’s comparison between the actual performance and the expected one.

SMARTMSYST provides Alarm messages to present to information about equipment status. The main objective is to detect abnormal situations as soon as possible. The application has two alarm management screens: one to check actual alarms and other to check the historical alarms. All filter options are given to the operator. The operator can easily distinguish the alarm severity by means of a previous established colour code.

The Historical data screen allows user to select variables from all the different PV plant devices with the purpose to populate a sheet with data from variables previously selected by the user



Alarm messages present information about equipment status in order to detect abnormal situation as soon as possible. SMARTMSYST has two alarm management screen: one to check actual alarms and other to check the historical alarms.

The SCADA application calculates several key performance indicators in order to evaluate the PV plant health. One of them is the Performance Ratio that is obtained by the output AC Energy delivered as a proportion of the total DC Energy

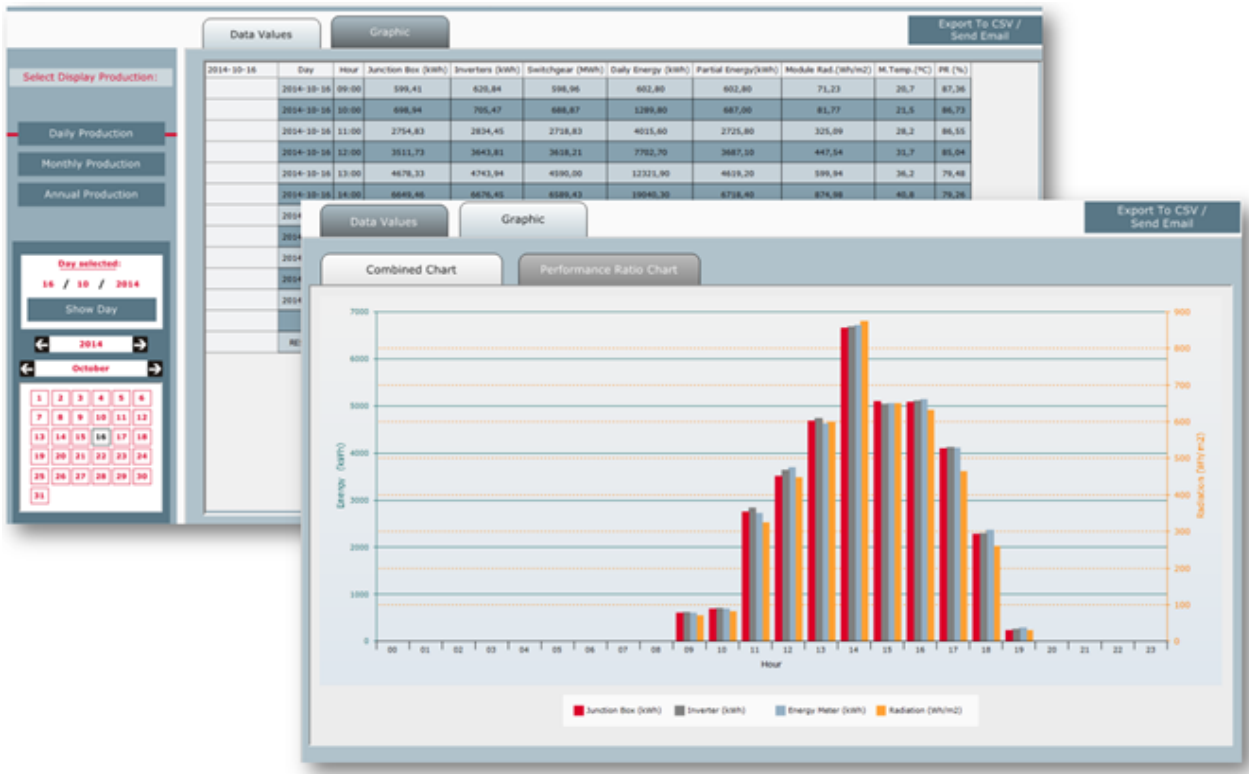
allowing the operator to compare data between all device variables. The data is present in a grid.

The grid content can be sent by email as a third party software compatible file.

Another way to check the historical data is by means of trends. In order to allow any variable comparison, SMARTMSYST was created in such a way that even variables from different Movicon dataloggers can be plotted in the same chart.

The PV plant energy production related data can be depicted in screen specifically build for that. This data can be arranged in a daily, monthly or annually basis.

Another developed screen is the dashboard. It is an interface where the user can have access to the most relevant information of plant equipment. The monitoring platform dashboard consists in a number of objects where significant equipment data is shown and it is possible to check every single equipment main measure as well as its status.



PV plant energy production data can be depicted in screen specifically built for that. This data can be arranged in a daily, monthly, or annual basis

Administrator Graphic User Interface

According to its privileges, a user can be able to access the monitoring platform administrator configurations and special features. Entering the administrator menu, the user is provided with the following options:

1) **Equipment configuration and communication status** - configure and check communication status of each PV plant equipment;

2) **System configurations** - general PV plant parameters. Plant name, system file paths, site coordinates, conversion factors or system power can be defined;

3) **System diagnostics** - give an overview of the server and the monitoring system;

4) **Alarm recipients** - allow the operator to select a group of alarms from that he wants to receive notifications when active;

5) **Runtime users** - create, modify or delete users or user group;

6) **Export data** - export database tables content to csv file;

7) **File management** - manage remotely the files stored on the SCADA serve;

8) **Backup databases** - create a backup for all system databases;

9) **Database index fragmentation report** - create a report informing about the table index fragmentation, According to the result,

maintenance operations shall be made to the analyzed table database;

10) **Network devices** - allow the user to ping any IP address inside the SCADA network as well as check a pre-configured group of IPs;

11) **FTP Push configuration** - configure a FTP Push feature that shall be responsible for sending equipment historical data in csv format to the configured FTP server address;

12) **Weather Station Data back fill** - employed to configure the database data back filling feature using the weather station datalogger files.

These options are depicted as buttons. Some of them take the user to another synoptic while others represent action buttons.

Background Features

Several background functionalities are implemented in the developed monitoring platform. The objective is to optimize the system performance as well as give the user more information and possibilities.

address specifying the date from which he wants to receive the production data;

2) **Export Data With High Acquisition Frequencies:** some equipment need high acquisition frequencies due to reasons such as warranties. This data will not necessarily be useful for the SCADA and, therefore, once a day, the SCADA exports this data to a csv file. This process frees space in the application database;

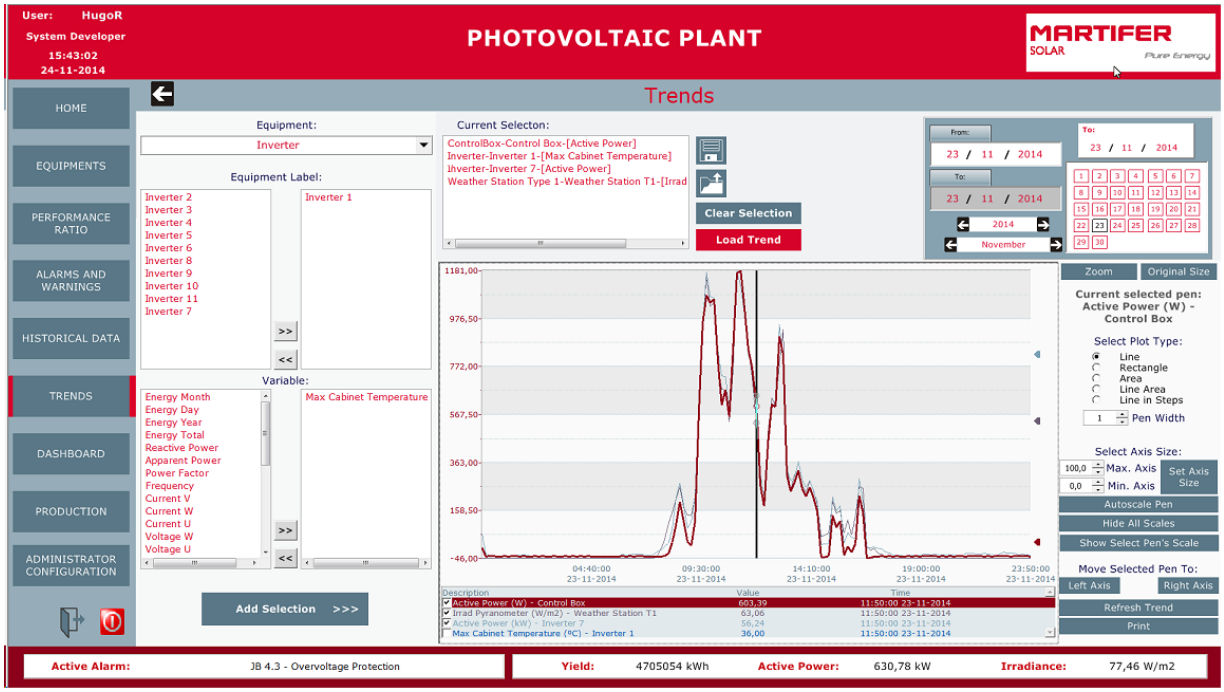
3) **Data Calculations:** statistic calculations on the PV plant acquired data;

4) **Solar Calculations:** calculations based on astronomical algorithms to obtain the solar elevation angle as well as the sunrise, sunset and noon time;

5) **Access Control and Logging:** In order to keep track of all entities that access the monitoring platform;

Database Maintenance Tasks:

a) **Automatic backup routines**: The system databases are set to automatically backup every



Dashboard interface where user can access to the most relevant information plant equipment. It is possible to check every single equipment main measure as well as its status.

1) **Request Data by Email:** This functionality allows the user to receive PV plant production data without accessing the system. The user needs to send an email to the system email

month;

b) **Intelligent table index rebuilding/reorganization**: The SCADA system monthly evaluates the index fragmentation of the

database tables. If necessary, the system executes the index rebuilt or reorganization;

c) **Database size monitoring:** Every 5 minutes the databases size is checked. If the current size represents 80% of the maximum stipulated size, an alarm is triggered in order to inform the system operator/administrator.

The created SCADA application provides monitoring capabilities for all the devices included in the photovoltaic Plant. It provides local and remote (via internet) client access, showing data from the physical installations, energy production, weather data conditions among others, converting this system into a powerful tool to take preventive and corrective measures.

Conclusions

PV plant monitoring differs from general industrial SCADA applications. Unlike industrial application, these kind of monitoring systems are not based on actuating valves, actuating other outputs based on system inputs or just managing alarms. Photovoltaic plant monitoring requires several data processing, data analysis, key performance indicators calculation as well as intelligent alarm management. For example, there are monitored equipment that are fed from PV production and, since that power is unavailable during night, the system shall ignore communication alarms from that equipment during that period. This management must be done dynamically. Sunset and sunrise time are not the same during the year and irradiance cannot be taken as the only input to distinguish day from night, because there can be a weather station sensor malfunction. Data statistic calculations are another key element in photovoltaic plant monitoring. There are indicators that need to be presented in a time period higher than the acquisition ones, e.g, average irradiance for a specific day, maximum module temperature for a specific month, energy produced in a specific month, daily performance ratio or even the maximum auxiliary services power consumption for a day or month.
For all reasons, Movicon SCADA/HMI proved to be a powerful tool for the SMARTMSYST developement. Any challenge could be overcome due to Movicon flexibility. VBA scripts were used to implement functions from filling a simple box with text to create dynamic complex SQL queries. Dynamic FTP batch files, ODBC connections, user management, KPI calculations, alarm dispactching, filling trends/grids, etc.

Hugo Ribeiro
Automation Engineer
Martifer Group