ATS
Leading of Integration

@DERM™

Distributed Energy Resource Management System

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TAKAOKA TOKO CO., LTD.

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A. Product Overview

@DERM is Distributed Energy Resources Management System which is developed to ensure properly operation of distributed renewable energy resources in accordance to technical requirements of distribution and transmission networks as well as ready to operate as Virtual Power Plant (VPP) for improving the participation and cost-effectiveness of DER sources in the electricity market.

The @DERM along with SCADA/DMS/EMS systems are important monitoring and control facilities for dispatch centers and play key roles in power system operation with high penetration of distributed resources. This is necessary to support dispatching jobs with DER to ensure economical and reliable operation of the power systems.

ADVANTAGES

- Allow dispatching centers to fairly allocate generation output under conditions of system curtailment;
- Allow flexible operation of various DERs to avoid overloading while maintaining power quality for the local grids
- Provide the tool for optimum generation commitment in the market with transparency, safety and national energy security
- Decrease the frequency of generator shut down/start for those units with high start-up cost and long start-up time (coal thermal, gas turbines), enhance system reserves, avoid oil thermal unit commitment for peak load and reduce overall system operation cost.
- Forecasting of power generation output of DERs are more accurate due to the smoothing effect when combining large number of DERs.
- A large number of DERs, storage systems as well as controllable loads can be assembled into a single, adjustable power unit (a Virtual Power Plant) with rated power and performance characteristics equivalent to a traditional power plant.
- Helps DERs flexibly respond to price signals in the electricity market, accurately forecast their own generation schedule, and reduce the imbalance between generating capacity and load demand in the power system.
- Allow participation in the market of providing auxiliary services (such as voltage regulation support, frequency regulation support, power reserves, black start,...).

MAIN FEATURES

- Provide tools for collecting all important data of operation status of renewable equipment, including system data, metered data, status of integrated control devices, alarming,... in real time with standard interconnection protocol as well as for sharing them to SCADA systems at dispatching centers, power companies, and for making necessary control requests.
- The system is not only suitable for roof top solar power management but also ready for integrating other renewable energy sources such as wind turbines, small hydro power plants, etc.
- Manufacturer independence, suitable for controlling power Plant with different Inverter, Turbine,... vendors.
- Ready for future utility interface bus integration.

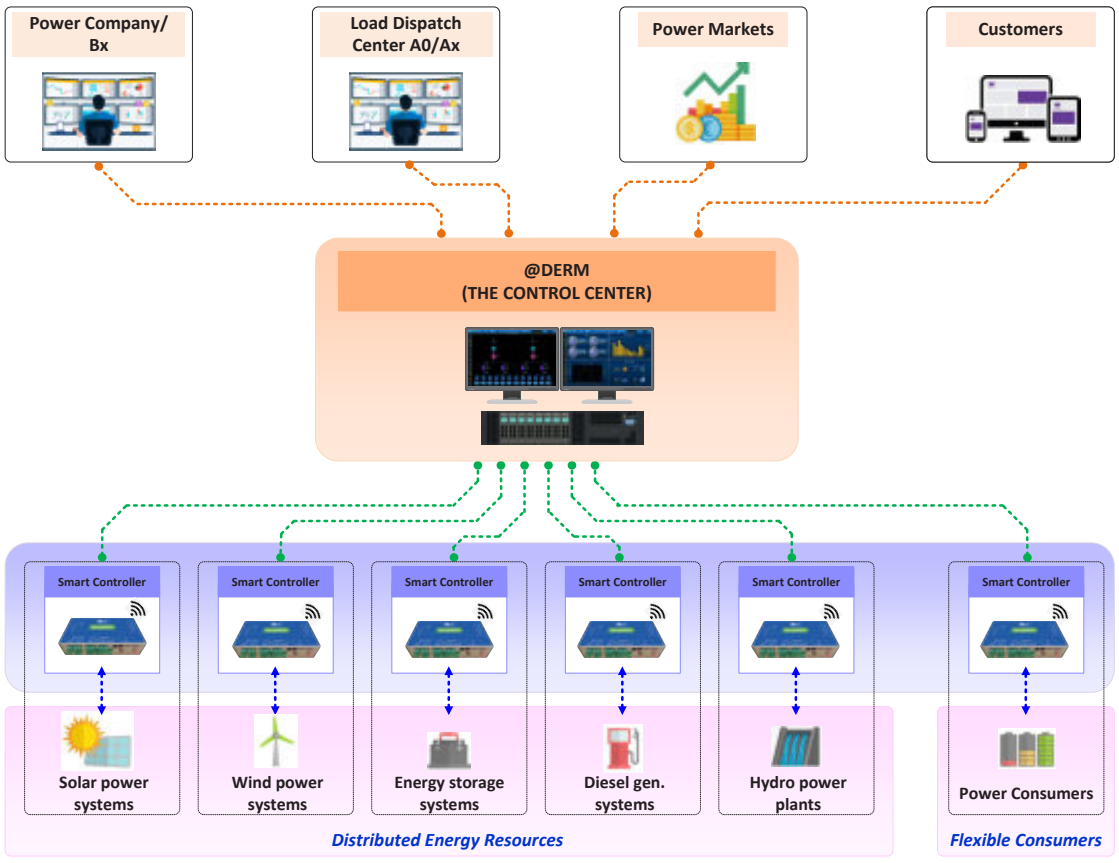


Figure 1. Overview of @DERM system

1. HARDWARE STRUCTURE

Hardware system is consist of:

- **A central system:** include main component:
  - A FEP Server for connection management, processing of monitoring / control data from DER systems, SCADA/DMS systems at Power Company, Load Dispatching Center.
  - Host Servers are served for calculating of dispatched power flows as requested by the operators, configuration of reports, grouping of distributed power sources. These servers are manufactured in accordance to industrial standards and operated with redundancy to ensure system can be operated reliably, stably even when one fails.
  - Operator Workstation with HMI that allows operators to monitor and control distributed sources.
  - HIS Servers for historical data storage which is necessary for operational reporting as well as production forecast of DER.
  - Cloud Server provides monitoring system for DER on Web platform, allows customers to access remotely via internet.
  - @DERM system can be connected with existing SCADA/DMS system to at the Power Company/Load Dispatching Centers for data exchange.
- **On-site system:** ATS SmartDER device is utilized for data aquisition/concentration and local control at distributed energy sources. Connection and data exchange with cnetral system are implemented with encrypted communicatin channel using Internet/3G/4G or leased line, fiber optic,...

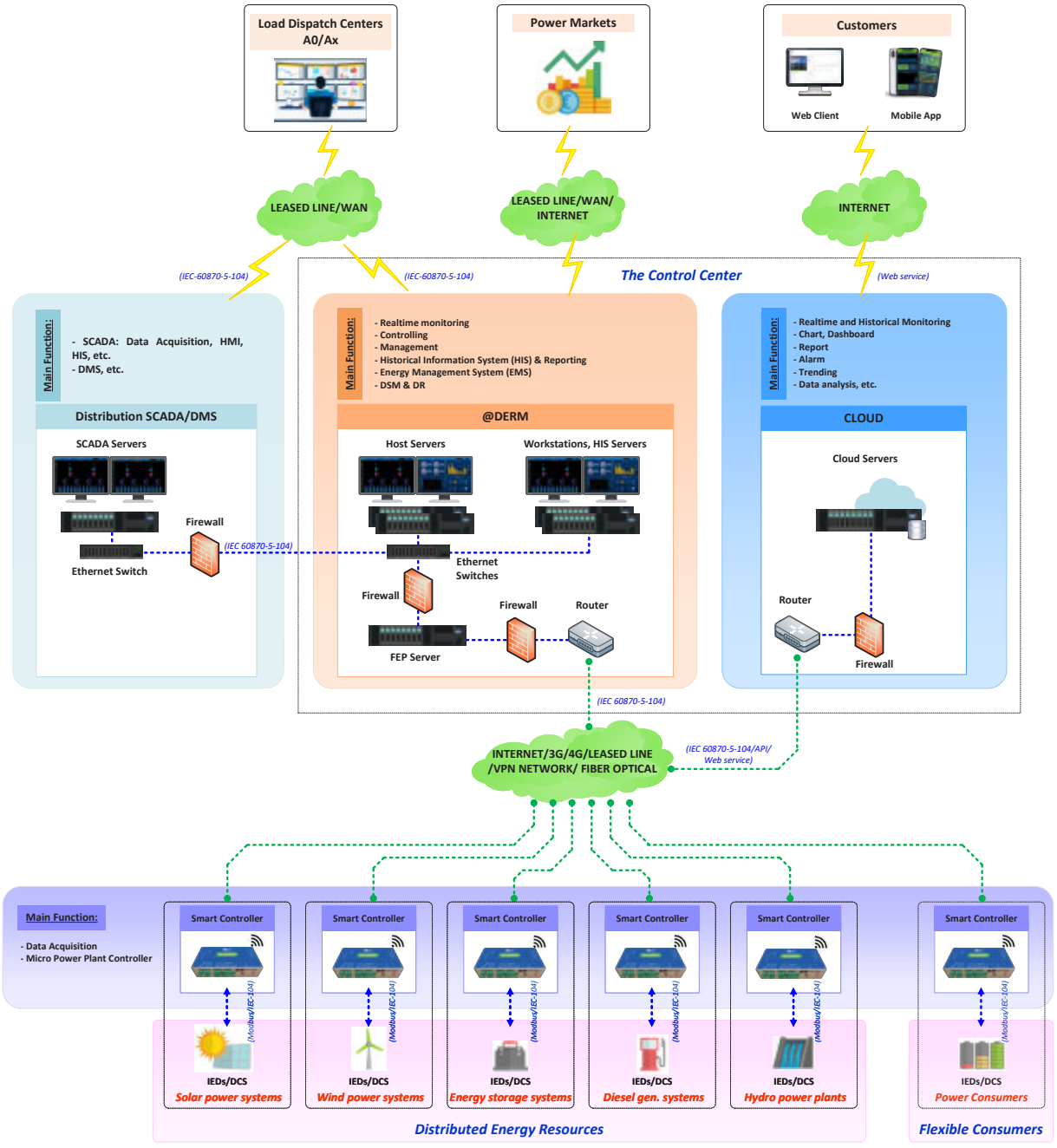


Figure 2. Typical @DERM Hardware System

B. Technical Highlights

2. SOFTWARE DESCRIPTION

2.1. Software Architecture

The @DERM system is designed with software modules for flexibility and simplicity in maintenance, expansion, safety and stability. Main software modules of the @DERM system include:

- **Standard modules:**
  - Data Acquisition (DA)
  - Real-time Database (RTDB)
  - Time-series Historical Information System (HIS)
  - Realtime Setpoint Control
  - Human – Machine Interface (HMI)
- **Advanced modules:**
  - Report
  - Web-based monitoring
  - Information Management System
  - Bill Payment
  - Data Analysis and Warning
  - Asset Management
  - Estimation/Forecasting
  - DSM&DR

2.2. Supported Communication Protocol

Supported communication protocols include:

- OPC UA: internal data exchange among system software modules
- IEC 60870-5-104: data exchange with monitoring / control systems at each of distributed sources and with SCADA/DMS/EMS at power companies, power corporations, dispatching centers.
- Modbus RTU/TCP: data exchange from actuator devices at site such as Inverter, Data Logger, Controller...
- IEC 62056-21/Modbus RTU: data exchange with power meters.
- FTP (.xls, .txt): for transfer of power allocation data file
- API/Web Services: data exchange for weather forecast.
- The system is also ready for integrating with other protocols based on industrial accepted standards.

2.3. System Sizing

The PV SCADA & PPC system can support to control and monitor over **512** distributed power sources, as well as **256.000** data points. This capacity can be extended in the future without having to upgrade any of the system software modules.

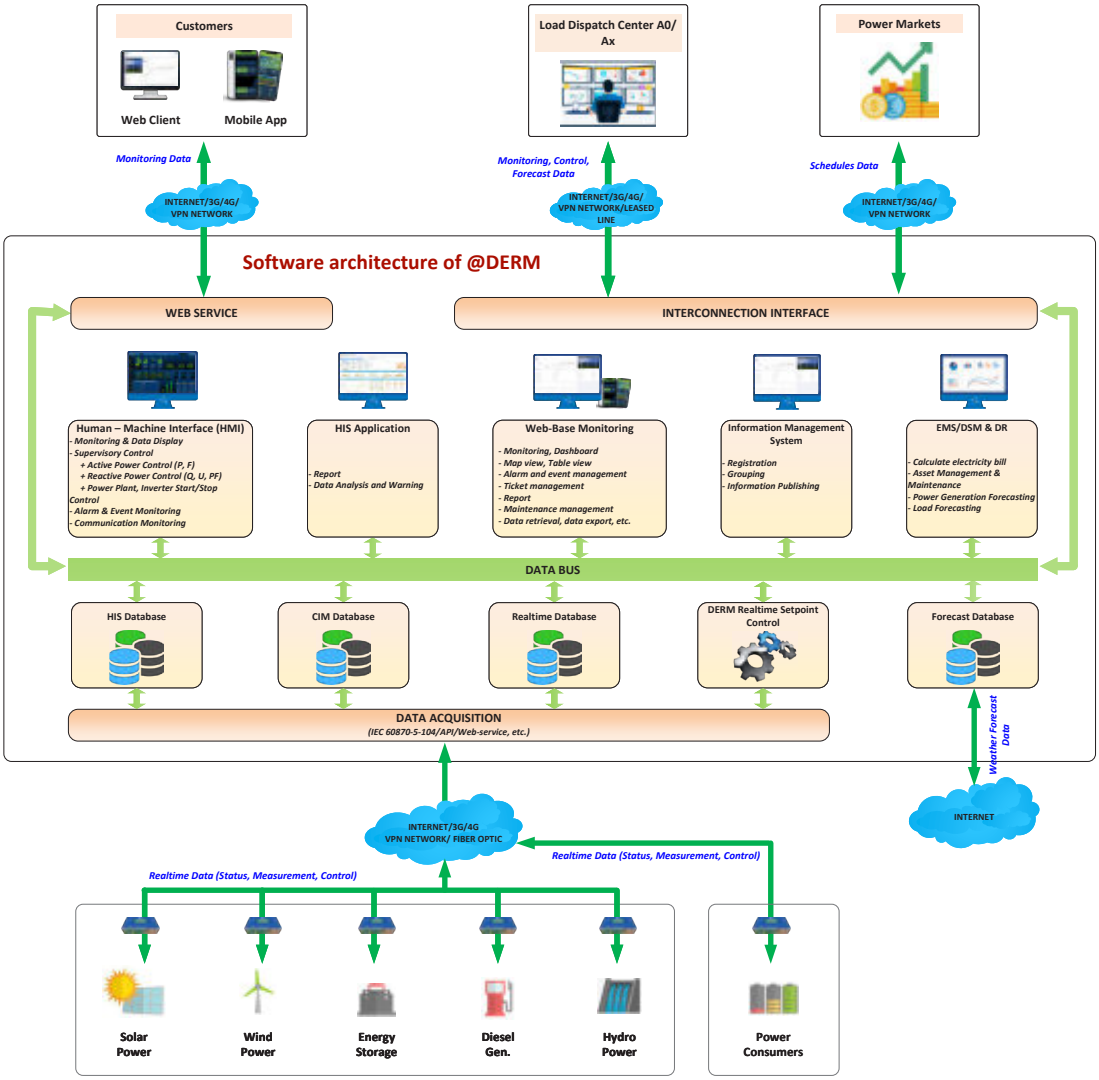


Figure 3. Typical @DERM Software System

2.4. Standard Software Modules

2.4.1. Data Acquisition (DA)

DA module is utilized for definition and management of real time data channels and data exchange with other devices or systems. DA module acts as a direct connection between central system and on-site monitoring and control module and also is used for gateway connectin purpose to exchange data with other SCADA/DMS/EMS based on IEC 60870-5-104 protocol.

Data collected from DER are:

- Real time monitored data:
  - Device status: Inverter, Logger, ACB...
  - Metered value: current, voltage, output power, etc...
  - Accumulated data: output / input energy...
  - Alarms
- Control command:
  - Plant Start/Stop, Inverter Start/Stop
  - Power Setpoint control, power factor of each inverter/turbine/the whole plant

2.4.2 Realtime data processing (RTDB)

The real time database is able to process unlimited amount of data points at both operation level and processing level including data from Logger, Inverter, POI.

This module is a central part of system which connects DA and other application modules, to manage and process all system real time data. Collected data will be processed and converted to archive format or other types in accordance to user request.

The real time database will describe power system status at a specified time instance and all system status change to new status at the next instance. This database support real time data access for applications

2.4.3. Time-series Historical Information System (HIS)

The central @DERM system is integrated with HIS data module. The module utilizes non-SQL data structure for long time storage of all operational time-series data of power system at various conditions (normal or faulty operation).

All operational data is integrated and stored in HIS Server to make unique storage and consistent data retrieval for reporting, network analysis.

The HIS is a database for all historical operational information time series data. The HIS is developed with client-server concept.

Initially the data is stored with initially defined resolution in 5 years.

The HIS is operated with non-SQL, data is generated continuously with processing industry. Such a concept allows to enhance storage capacity and ad-hoc querry while save the memory and CPU workload. The whole database is utilized for other applications via standard protocol (Web Service, ODBC, SQL...).

2.4.4. Realtime Setpoint Control

The central control software will send control commands to Smart Controllers at site to adjust generation parameters smoothly and stably in accordance to operator and dispatching center request.

Function to control distributed power sources:

- **Support for distributed source group control:**
  - Controls for entire sites, or for groups of sites
  - Control the total capacity of the sites, each group of sites, each site separately according to the preset schedule.
  - Controls for each site.
- **Support for control methods:**
  - *AGC control mode* as requested by SCADA/EMS: control is handed over to dispatching centers.
  - *Schedule mode:* setpoint can be assigned for all sites, group of sited, or individual site as scheduled.
  - *Manual mode:* control individual site according to the set value manually
  - *Calculation mode:* calculate and redeploy distributed sources in case of capacity limitation of transformers and lines to avoid overload.
- **Control functions:**
  - *Active power control:* to maintain plant output power at a setpoint defined value or to reduce power with reservation in accordance to operatore request / dispatching order so that the output power is not exceeded required level.
  - *Ramp Rate Control*
  - *Reactive power control:* to maintain voltage at plant connection point at predefined controlled setpoint.
  - *Power factor control:* to maintain plant power factor at required level. This status is usually achieved with automatic reactive power control based on system acitve power profile.
  - *Voltage control:* to maintain voltage at plant connection point at predefined controlled setpoint.
  - Control modes according to grid operation requirements (*Grid support*): limit active power and power reserve, voltage profile monitoring and control, adjust reactive power to maintain grid voltage at connection point, grid frequency support, fault-right through support.
  - *Start-up and shutdown* of the entire plant.

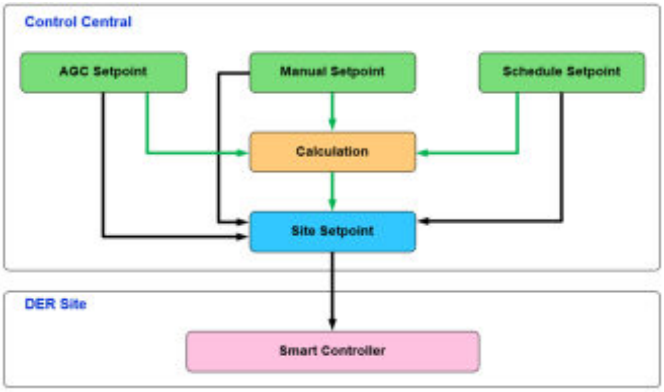


Figure 4. Block diagram for central control commands

B. Technical Highlights

2.4.5. Human-Machine Interface (HMI)

HMI provides interaction between users and system monitoring, control applications as well as other functionalities. HMI provides system control and monitoring, accessing to stored data tin the database simply and smoothly. HMI allows users to perform basic actions with just a few annunciations, users do not have to switch between displays during working.

(1). Control Functions

Control functions for distributed energy resources are implemented with operator's actions on control panels of graphical display interfaces. These control commands will be processed with Smart Controller after successful verification. Unsuccessful control commands will be prevented with alarms. These alarms or results of operator's actions are displayed as events without fault-type warnings.

Control sequence is conducted with Select and check before operate (SBO) to enhance safe operations.

The control sequence is described below:

- Display the diagram
- Select the system or devices to be controlled on the display. Control request will be ignored upon any of the followings:
  - The selected system / devices are not assigned for control.
  - The system / devices are tagged with control prohibition.
  - The system / devices are faulted or not ready.
  - Control request does not meet interlocking prerequisites.
  - Control timer is collapsed (this can be preset)
- Message warnings are issued for operators if control commands are unsuccessful to ensure rapid checking for incidences

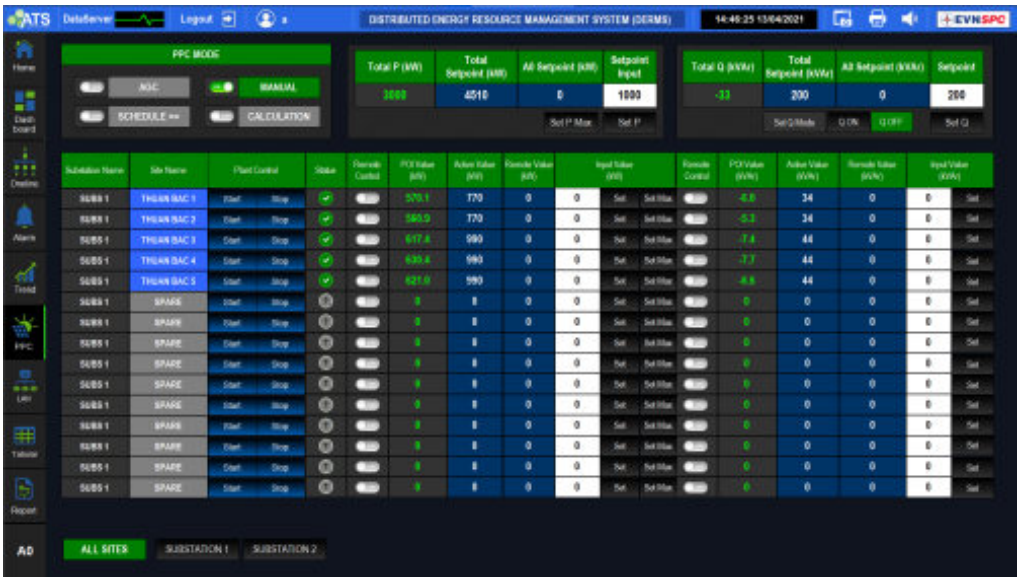


Figure 5. Setpoint setting screen for all sites

Control functions for all sites / groups of sites can be defined with control options, setpoint setting for all sites or groups of sites.

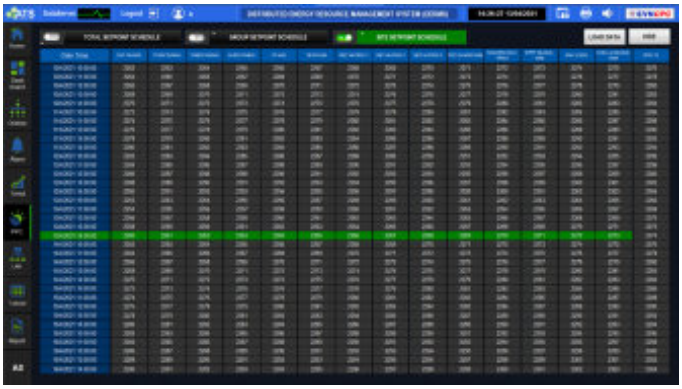


Figure 6. Scheduled setpoint setting screen. Control functions for total power of sites, groups of sites, each site with predefined schedule.

Figure 7. Plant control screen. Control functions for each site: options for various setpoints (P, Q, U, I).

(2). System Access Management

The HMI is designed with system access management with user accounts. That allows simple operator account management, enhance security and optimize system operation.

(3). Monitoring Functions

The HMI is designed with layers with more details are assigned to the inner layer.

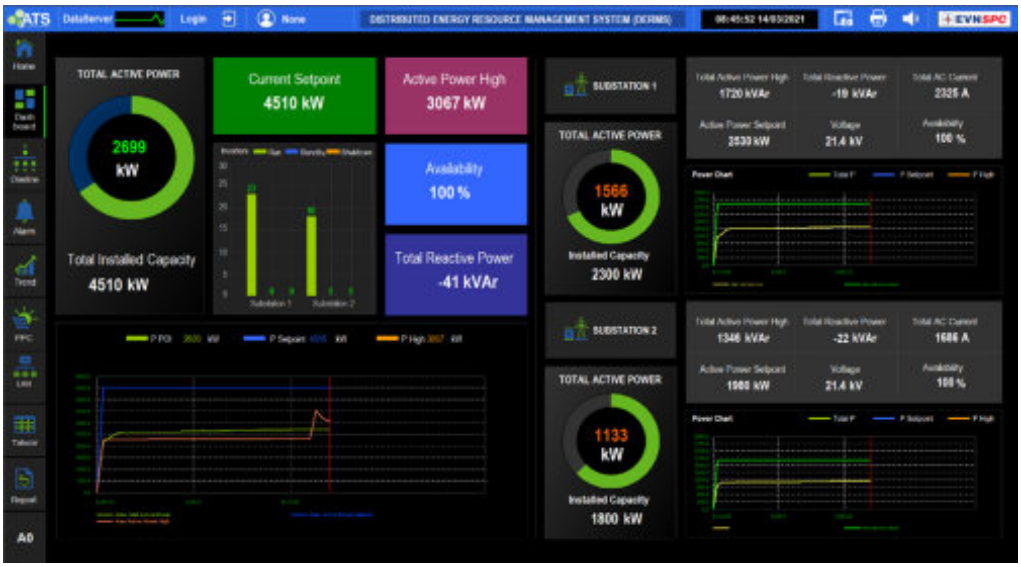


Figure 8. Display plant general information

Dashboard for general operation information monitoring: total active power, reactive power, frequency, voltage, with instant values for sites or group of sites, trending graphic for generated power, setpoint.

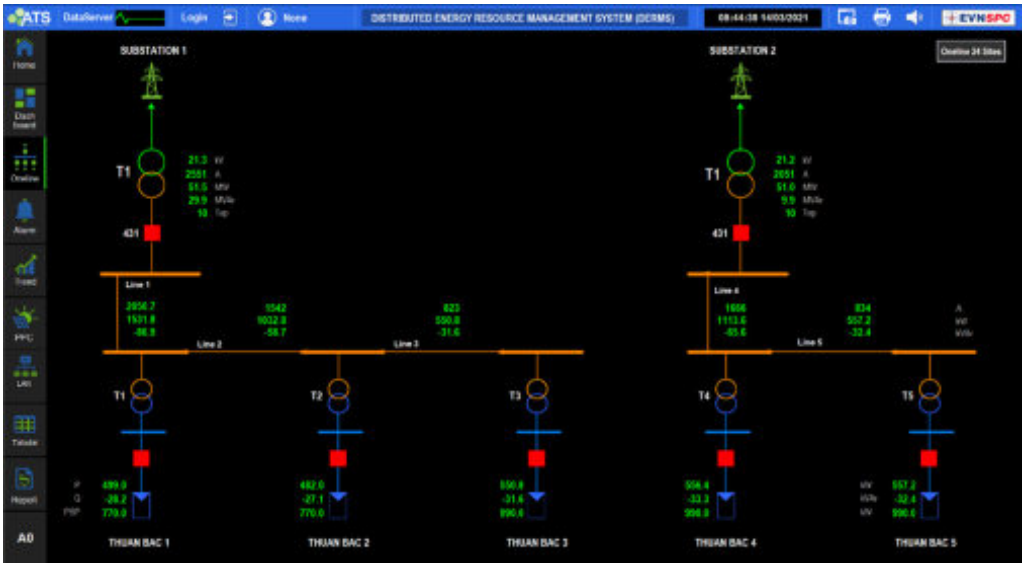


Figure 9. Display single line diagram

The screen can show single line diagram on the network map with operational parameters.

Figure 10. Display site information

Monitor main parameters of sites: power, daily generation output, date, voltage, frequency, power factor, number of online inverters.

B. Technical Highlights

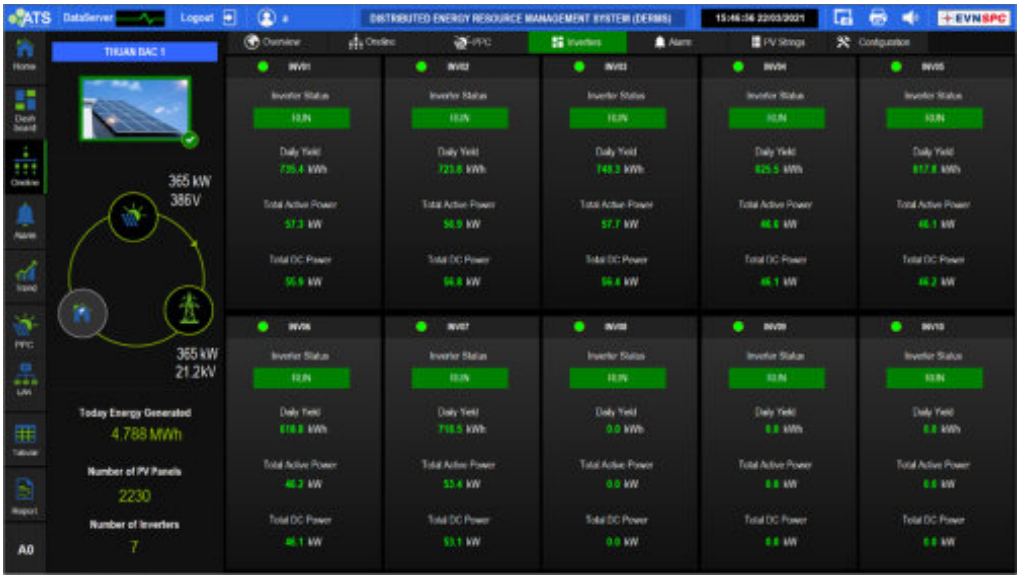


Figure 11. Inverter monitoring

Monitor metered values including current, voltage, active and reactive power, power factor, frequency, operating time, output, status of each inverters

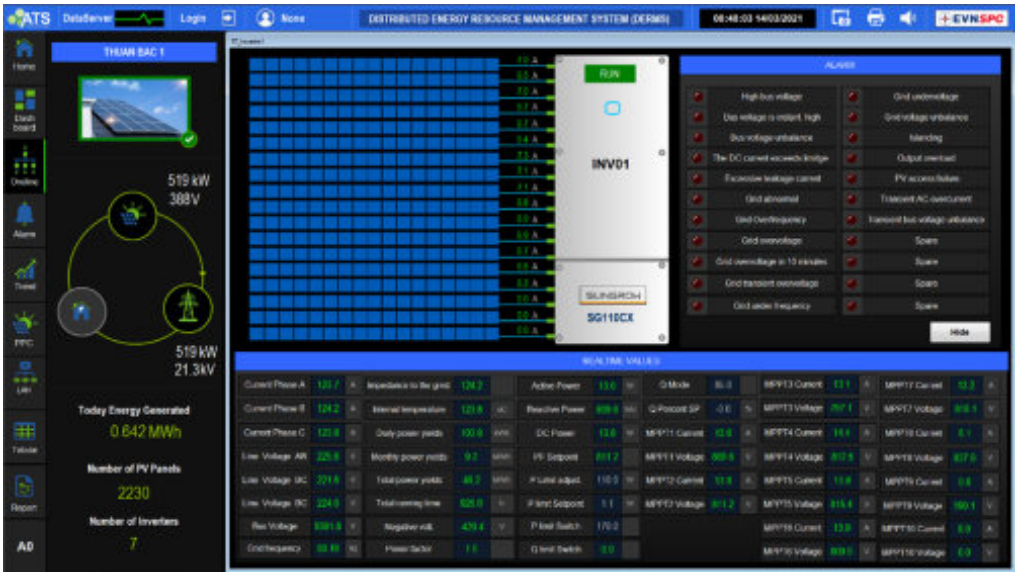


Figure 12. Inverter detailed parameter monitoring

Figure 13. Weather condition monitoring

Monitor current weather conditions: radiation, air temperature, panel temperature, wind speed, wind direction.

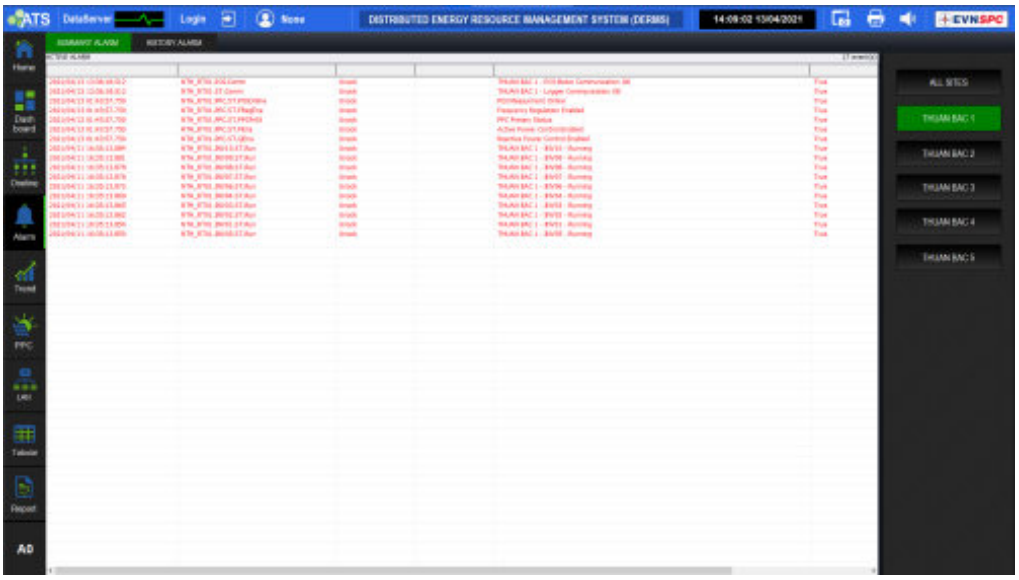


Figure 14. Alarming and alarm management

The system generates 2 types of alarm (critical and non-critical alarms). The operator can assign these types to input signals or devices. Alarms and sequence of events are display chronographically.

Alarms are generated with definition, reason so that the user can rapidly take necessary actions.

Figure 15. Trending graphic

The graphics can be created with HIS data (past trend) or real time data (online trend) on HMI.
Following trending graphics are provided:

* Operational trend with U, I, P, Q, Hz, PF...
* Other supplement parameter trends
* Graphic parameters are selectable

Figure 16. Communication network monitoring

Communication network monitoring:

* Can access to the parameter of connected devices
* Can modify parameters (IP address, Switch configuration, computers,...)
* Track connection errors and restore
* Display graphically the working status of the network and connected devices

B. Technical Highlights

2.5. Advanced Software Modules

2.5.1. Report

- Reports can be built using ATS Data Link tool (an add-in for MS Excel). This add-in can allow data to be retrieved directly from within the spreadsheet program. You can create complex reports and graphs using current or historical data from the HIS (Figure 17).
- Data Link includes a tag search dialog, a dialog for viewing point configuration, a dialog for managing connections to multiple HIS, and support for login security to the HIS.

2.5.2. Web-based Monitoring

The system is equipped with web-based monitoring of data and allows multiple access. The data is acquired, stored and maintained for operational purposes, including planning, maintenance. The system is designed to provide fast access to database with secured connections. Data access is authorized for users based on account privilege.

Main functions are:

- Access management and user authorization
- Monitoring and displaying
- Customer information management
- Alarm/Event configuration and management
- Notice, email
- Ticket management
- Data retrieval

Figure 17. 24-hour operation report

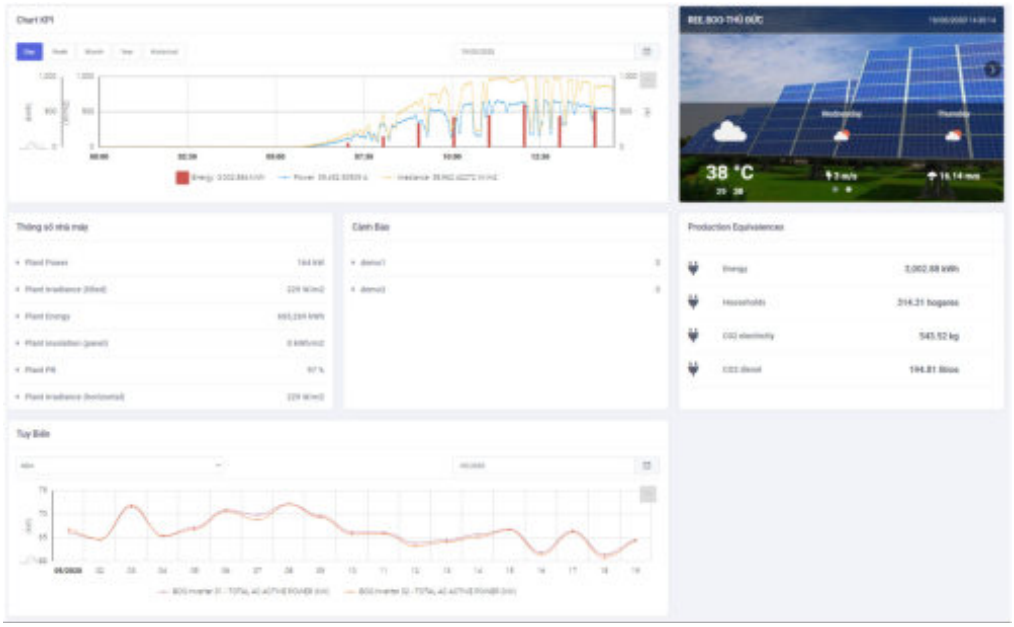


Figure 18. Dashboard for monitoring & dissplaying

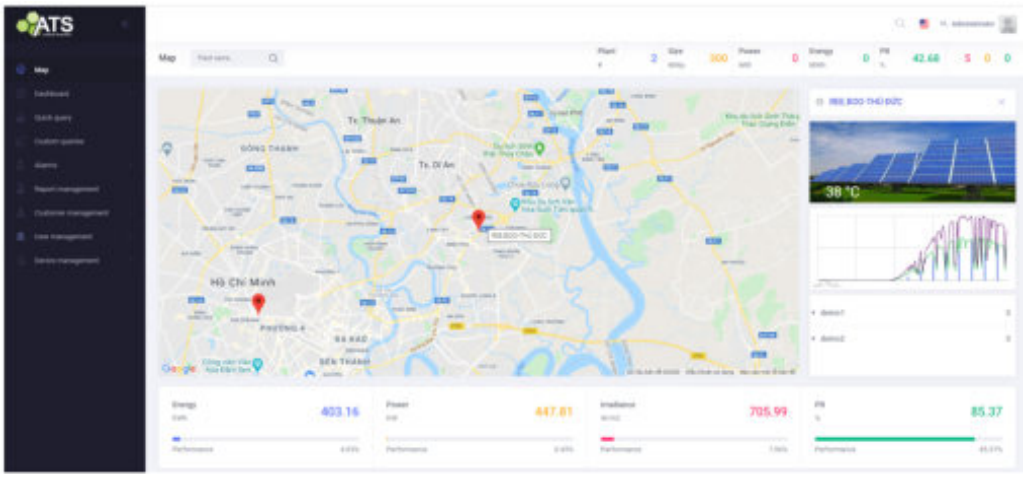


Figure 19. Customer information management

Display location, information of distributed energy sources on geographical map

Figure 20. Operational report on Web

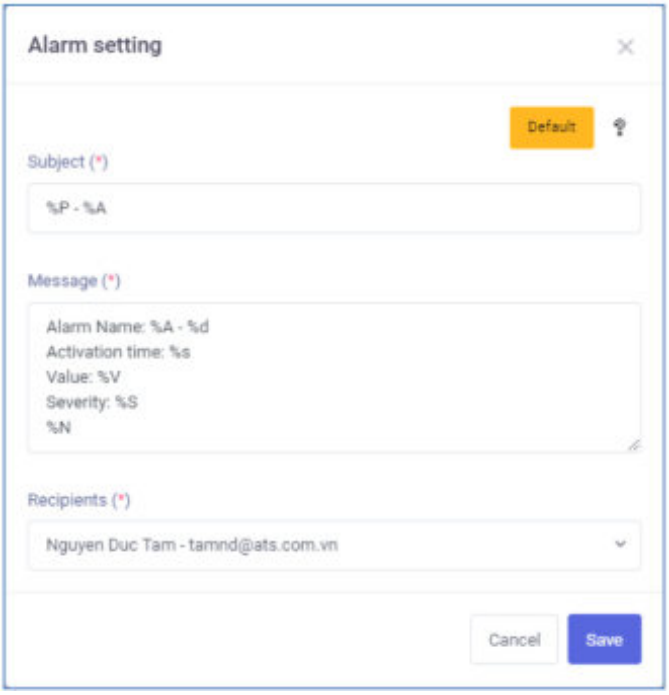


Figure 21. Configuration for notification

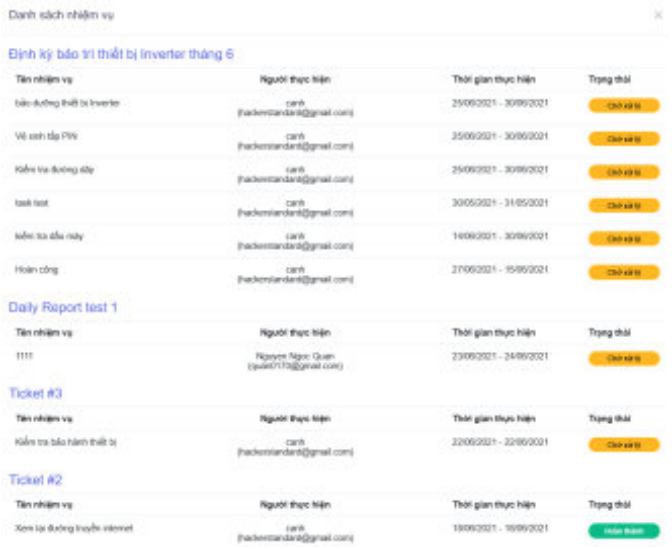


Figure 22. Ticket management

Figure 23. Graphs of retrieved data

B. Technical Highlights

2.5.3. Information Management System

Main functions are:

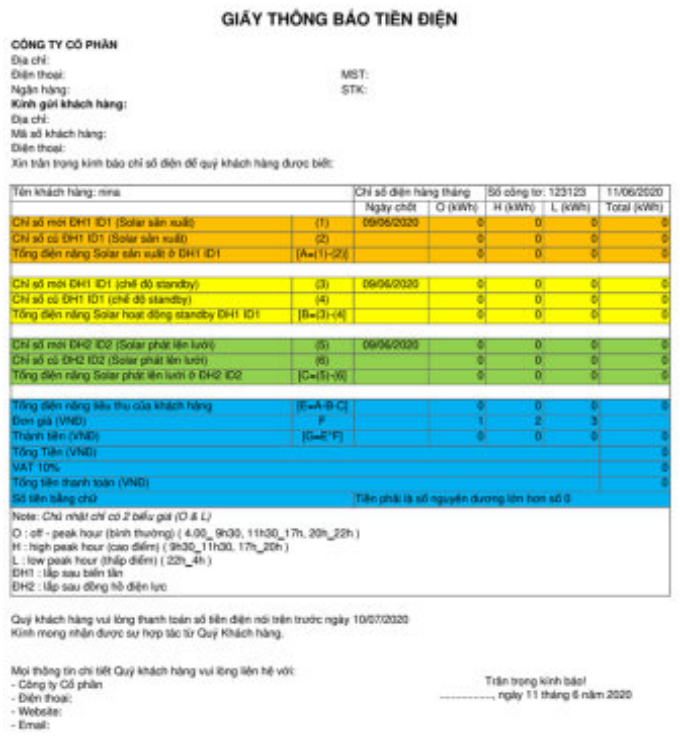
- Registration: DERs which have enought legal and meet requirements for connecting to distribution grid will be registered and updated in the system.
- Grouping: Registered DERs which are ready to operate can be grouped for power allocation. Groups are created depending on physical connection and management structure.
- Information Publishing: operating data will be continuously recorded, stored and published openly to all Owners.

2.5.4. Bill Payment

Billing is an important function for distributed energy sources. The billing application must comply with power purchase agreement, power tariff, and the process has to be transparent without possible financial conflict.

Main functions are:

- Connection and data acquisition from tariff power meters with standard protocols (IEC 62056-21, Modbus) to collect real time metered data, total output energy with related tariff.
- Generation of invoices with flexible billing process that meets the owner request, customers and power companies with varied number of connecting points. Billing time is configured in accordance to power purchase agreement.
- The billing process is developed in web services. Only authorized users can access and export the bill. The users can preview bills on webpage or download to their computers in pdf format or send to predefined email addresses.
- Invoices can be generated at current time or at past moments.



GIẤY THÔNG BÁO TIỀN ĐIỆN

CÔNG TY CỔ PHẦN
Địa chỉ:
Điện thoại: MST:
Ngân hàng: STK:
Kính gửi khách hàng:
Địa chỉ:
Mã số khách hàng:
Điện thoại:
Xin trân trọng kính báo chỉ số điện để quý khách hàng được biết:

Tên khách hàng: nma		Chỉ số điện hàng tháng		Số công tơ: 123123		11/06/2020
		Ngày chốt	O (kWh)	H (kWh)	L (kWh)	Total (kWh)
Chỉ số mới ĐH1 ID1 (Solar sản xuất)	(1)	09/06/2020	0	0	0	0
Chỉ số cũ ĐH1 ID1 (Solar sản xuất)	(2)		0	0	0	0
Tổng điện năng Solar sản xuất ở ĐH1 ID1	[A=(1)-(2)]		0	0	0	0
Chỉ số mới ĐH1 ID1 (chế độ standby)	(3)	09/06/2020	0	0	0	0
Chỉ số cũ ĐH1 ID1 (chế độ standby)	(4)		0	0	0	0
Tổng điện năng Solar hoạt động standby ĐH1 ID1	[B=(3)-(4)]		0	0	0	0
Chỉ số mới ĐH2 ID2 (Solar phát lên lưới)	(5)	09/06/2020	0	0	0	0
Chỉ số cũ ĐH2 ID2 (Solar phát lên lưới)	(6)		0	0	0	0
Tổng điện năng Solar phát lên lưới ở ĐH2 ID2	[C=(5)-(6)]		0	0	0	0
Tổng điện năng tiêu thụ của khách hàng	[E=A-B-C]		0	0	0	0
Đơn giá (VND)	F		1	2	3	
Thành tiền (VND)	[G=E*F]		0	0	0	0
Tổng Tiền (VND)						0
VAT 10%						0
Tổng tiền thanh toán (VND)						0
Số tiền bằng chữ		Tiền phải là số nguyên dương lớn hơn số 0				

Note: Chú nhật chỉ có 2 biểu giá (O & L)
O : off - peak hour (bình thường) (4.00_ 9h30, 11h30_17h, 20h_22h)
H : high peak hour (cao điểm) (9h30_11h30, 17h_20h)
L : low peak hour (thấp điểm) (22h_4h)
ĐH1 : lắp sau biến tần
ĐH2 : lắp sau đồng hồ điện lực

Quý khách hàng vui lòng thanh toán số tiền điện nói trên trước ngày 10/07/2020
Kính mong nhận được sự hợp tác từ Quý Khách hàng.

Mọi thông tin chi tiết Quý khách hàng vui lòng liên hệ với:
- Công ty Cổ phần
- Điện thoại:
- Website:
- Email:

Trân trọng kính báo!
....., ngày 11 tháng 6 năm 2020

Figure 24. Example of invoice

2.5.5. Data analysis and Warning

The system can provide list of incidences that supports operators to evaluate devices status, prevent damages in advance. Thus the operators can make maintenance plans effectively to reduce cost while enhance plant reliability.

Incidence analysis and warning functions include:

- Transformer analysis & warning
- Inverter analysis & warning
- PV panels analysis & warning

2.5.6. Asset Management

The system provides ability of asset management and maintenance based on CIM data model (IEC 61968/61970).

2.5.7. Estimation/Forecasting

The system can precisely estimate generated power of solar power plants including roof top solar sources to make correct operational plans.

For virtual power plants (VPP), load forecasting plays a particularly important role, together with generation forecasting of DERs to aggregate into a single generation characteristic representing the combined capacity of all DERs in the VPP. This is the basis for bidding in the power market.

2.5.8. DSM & DR

Demand Side Management and Demand Respond (DSM&DR) functions help monitor and manage load data, manage power outages, and adjust controlable loads which are connected to VPP to appropriate response with different price signals.

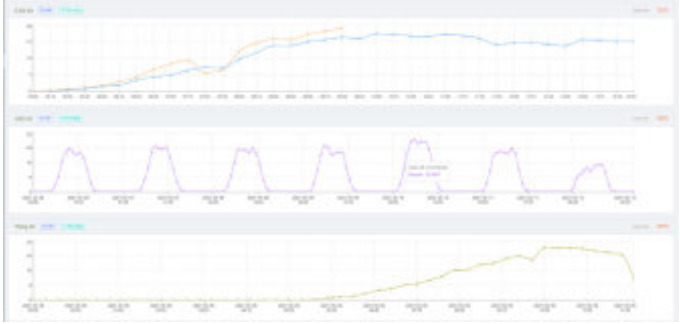


Figure 25. Generation forecasting outcome

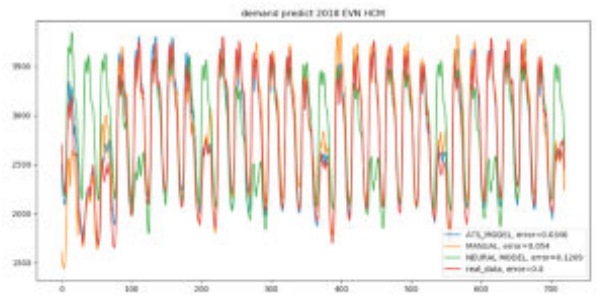


Figure 26. Load forecasting outcome

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