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CONSEIL INTERNATIONAL DES GRANDS RESEAUX ELECTRIQUES
INTERNATIONAL COUNCIL ON LARGE ELECTRIC SYSTEMS

STUDY COMMITTEE D2
INFORMATION SYSTEMS AND TELECOMMUNICATION

2013 Colloquium
November 13-15, 2013
Mysore – KARNATAKA - INDIA

D2-03_05

DEVELOPMENT OF PHOTOVOLTAIC POWER GENERATION FACILITY MONITORING SYSTEM FOR DECENTRALIZED POWER PLANT OPERATORS

by

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SUMMARY

The numerous benefits that cloud computing services offer, such as the ability to access a shared pool of configurable computing resources via networks whenever necessary and quickly allocate and provide such resources with minimum need for procedures for use and interaction with service providers, make cloud services invaluable and the age of full-fledged cloud services has now also come in Japan.

Moreover, power generation from renewable energy sources such as photovoltaic power, wind power and small-scale hydroelectric generation is attracting attention to deal with global environmental issues and as a result, large numbers of small-scale decentralized power plants are now under construction. This has given rise to a demand for measures to facilitate tasks including the remote collection of facility-related information such as power generation amount and remote facility monitoring in order to efficiently manage small-scale decentralized power plants.

To realize remote monitoring of multiple facilities from a single location, we have developed a system that makes use of our information transmission equipment to enable centralized collection of information relating to photovoltaic power generation facilities over an Internet connection at the data center and centralized display of such information for each plant. Development of this system that incorporates cloud computing technology using a Web server has made possible the centralized management of decentralized information and efficient operation, monitoring and maintenance of photovoltaic power generation facilities.

In the future, we plan to improve convenience even further by applying SCADA technologies using ICT to enable monitoring of power generation facilities and power generation statuses even for large-scale photovoltaic power generation facilities (mega solar plants) scheduled for construction in the future.

KEYWORDS

Cloud, Power Conditioner, M2M, Data Mining

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1. Background to the Development

1.1. Issues and Needs of Decentralized Power Plant Operators

With the spotlight on renewable energy, decentralized power plant operators are in the process of introducing small to medium size photovoltaic power generation facilities, with the result that the number of photovoltaic power plants is increasing every year.

Photovoltaic power generation facilities owned by decentralized power plant operators are installed at multiple decentralized plants, each of which has its own information.

As a result, decentralized power plant operators find themselves confronted with the problems listed below relating to the operation of the power generation facilities they own, and this has given rise to the need for efficient maintenance and management of their plants to ensure stable supply of electric power.

- Data on photovoltaic power generation facilities is managed individually by each plant and can only be checked on site.
- To ensure the continuous generation of power, faults must be identified quickly and speedy recovery carried out.
- Information from power conditioners for solar panels differs depending on the manufacturer.
- The collection of information from each plant and the production of reports on actual power generation performance are time consuming.

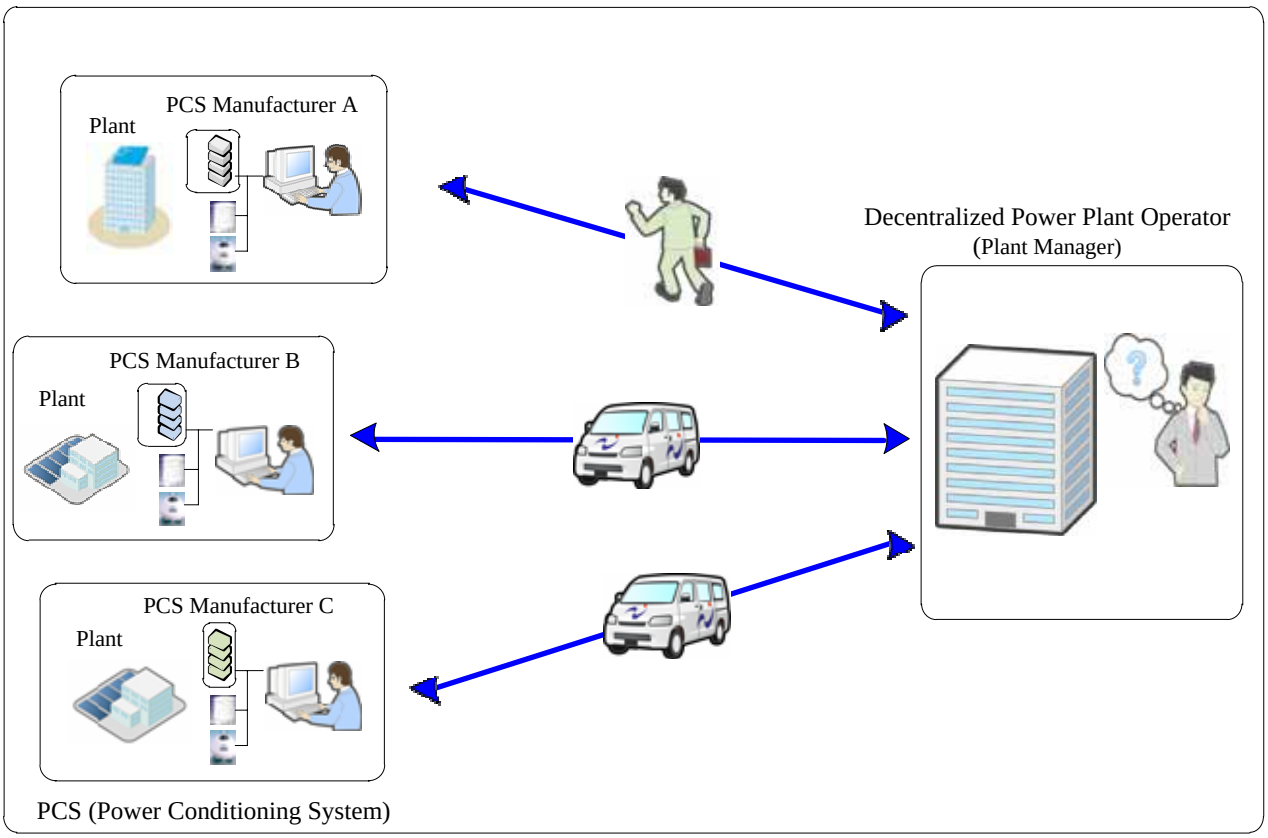

Fig.1: Issues of Decentralized Power Plant Operators

2. Overview of Photovoltaic Power Generation Facility Monitoring System

2.1. System Requirements

To resolve the above issues and needs, we sorted out requirements for decentralized power plant operators and the system as shown below.

- Centralized collection and management of all kinds of data on photovoltaic power generation facilities at the data center
- Capability to support power conditioners of major domestic manufacturers
- Notification by e-mail of fault information to mobile phones and PCs
- Provision of software services using cloud computing technology
- Collection of information using a secure Internet connection
- Viewing of data using a Web application
- Ensuring reliability and expandability allowing for long-term storage of massive amounts of data
- Real-time monitoring
- Low-cost information transmission equipment used at each facility to monitor multiple facilities

Based on the above requirements, “To handle information from the power conditioners of the respective manufacturers, we used the compact IP-based information transmission equipment manufactured and sold by our company to collect information from each plant and load the information into the management server at the data center and applied cloud computing technology, thereby realizing centralized management of information by accumulating measurement and fault data on photovoltaic power generation facilities at multiple decentralized plants on the management server.

In addition, the creation of an environment for the long-term storage of all kinds of data from decentralized plants made it possible to analyze data and realize a design that enabled the effective use of accumulated data.”

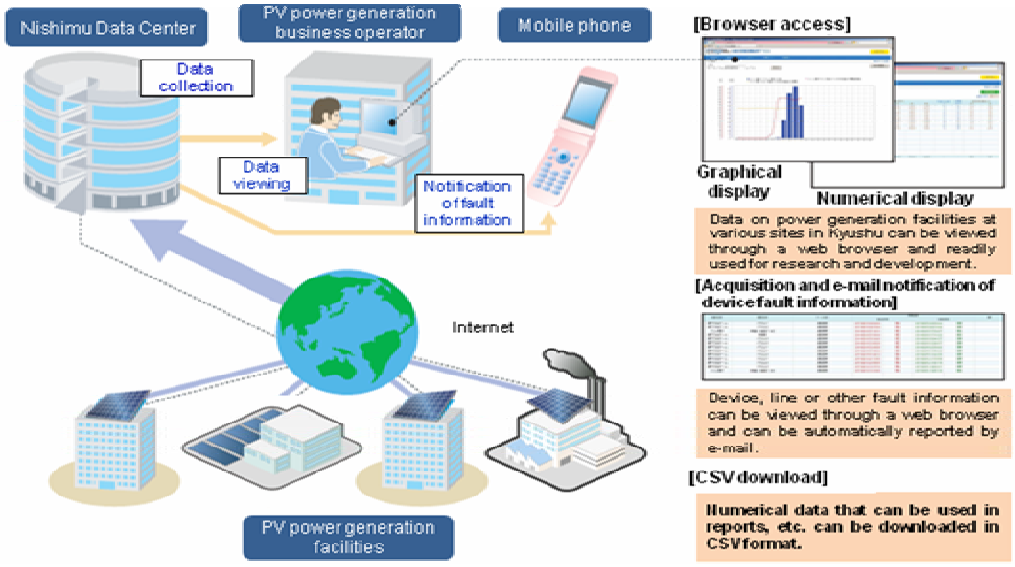

Fig. 2: System Overview

2.2. System Configuration

The photovoltaic power generation facility monitoring system is configured with low-cost, compact IP-based information transmission equipment installed at multiple decentralized plants and a management server in the cloud that collects information on and monitors photovoltaic power generation facilities, linked to each other over an Internet connection.

Since information on power generation from solar panels is sent to power conditioners, measurement and fault data from photovoltaic power generation facilities is collected via power conditioners by the information transmission equipment and the collected information is loaded together with information on meteorological conditions and peripheral equipment at plants into the management server at the data center over an Internet connection.

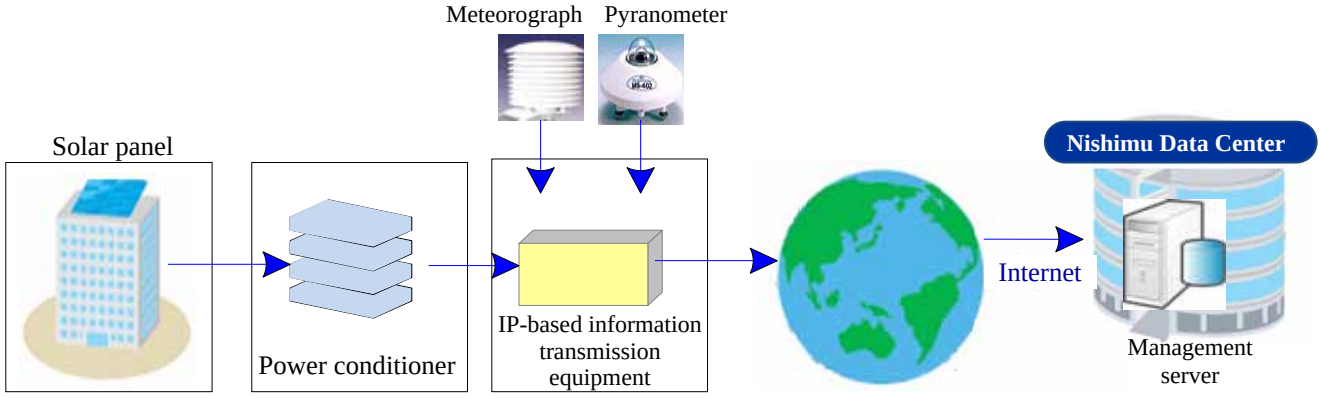

Fig. 3: Information Collection

Decentralized power plant operators can view and display information accumulated on the management server at the data center over an Internet connection. In addition, notification of fault information is sent by e-mail to mobile phones and PCs.

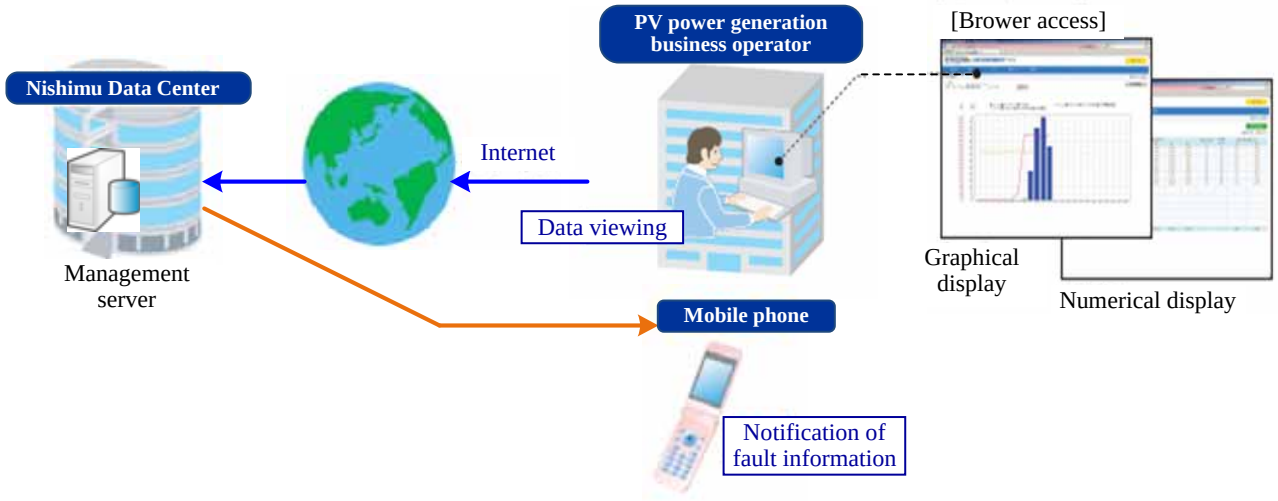

Fig. 4: Information Display and Notification

2.3. Information Transmission Line

2.3.1. Advantages of Using the Internet

Since constructing a dedicated network for use as an information transmission line involves considerable cost and time, an Internet connection is used because of its advantages such as reduced initial costs, availability for use in a short timeframe and lower management costs.

In addition, recent Internet connections enable inexpensive, good quality and readily available high-speed network access, giving the added benefit of being able to use 3G and other mobile connections.

2.3.2. Security

Connection over the Internet requires that Internet security be assured. To realize this, the following security measures have been implemented:

- IP-VPN (IP-Virtual Private Network) is used as the network for collection of information from monitoring equipment to prevent information leakage.
- To ensure security on the network used by users to view information, user ID, password authentication and SSL (Secure Socket Layer) encryption techniques are combined.

3. System Development

To develop the system, we decided to run the system in a cloud environment set up at our data center to satisfy the requirements detailed earlier in this paper. Operation of the system in the cloud environment at our data center facilitated realization of the monitoring system, storage, line redundancy and scalability, and enabled the provision of a stable system that satisfied the requirements.

3.1. Identification of Information Collection and Monitoring Requirements relating to Photovoltaic Power Generation Facilities

Items of information to be collected and monitoring requirements relating to photovoltaic power generation facilities were identified with reference to “Guidelines for PV Power Generation Field Test Project (Facility Management and Data Management)” and “Guidelines for PV Power Generation Field Test Project (System Measurement)” of New Energy and Industrial Technology Development Organization (NEDO).

3.1.1. List of Items of Information to be collected (Excerpt)

- Amount of electricity generated, including the power output of solar cells and inverters and charge/discharge power of storage batteries
- Amount of solar radiation
- Temperature

3.1.2. Monitoring Requirements

(1) Real-time Monitoring

- Display of items including facility abnormalities, facility faults, operating status and communication failures
- E-mail notification function

(2) Monitoring of Amount of Electricity Generated relative to the Amount of Solar Radiation
- By monitoring the amount of electricity generated input from each power conditioner and the amount of solar radiation, a fault is assumed and an alert issued in the event that the amount of electricity generated is significantly low relative to the amount of solar radiation.

(3) Collection Cycle
- Measurement cycle: 6 seconds
- Calculation cycle: 1 minute and 1 hour (1-minute data and 1-hour data are stored.)

3.2. Information Display

The system displays the items of information collected from the information transmission equipment on the following screens:

(1) Map display screens: Wide area map screen, detailed area screen
(2) Equipment information (e.g. amount of electricity generated) display screens: Power generation status screen, time series screen
(3) Aggregation and analysis screens: Graphical display (comparative display of amounts of electricity generated at multiple plants), data output (CSV)
(4) Alert monitoring screen: Fault information display, operating status display
(5) Management function screen: Registration of e-mail address for notification

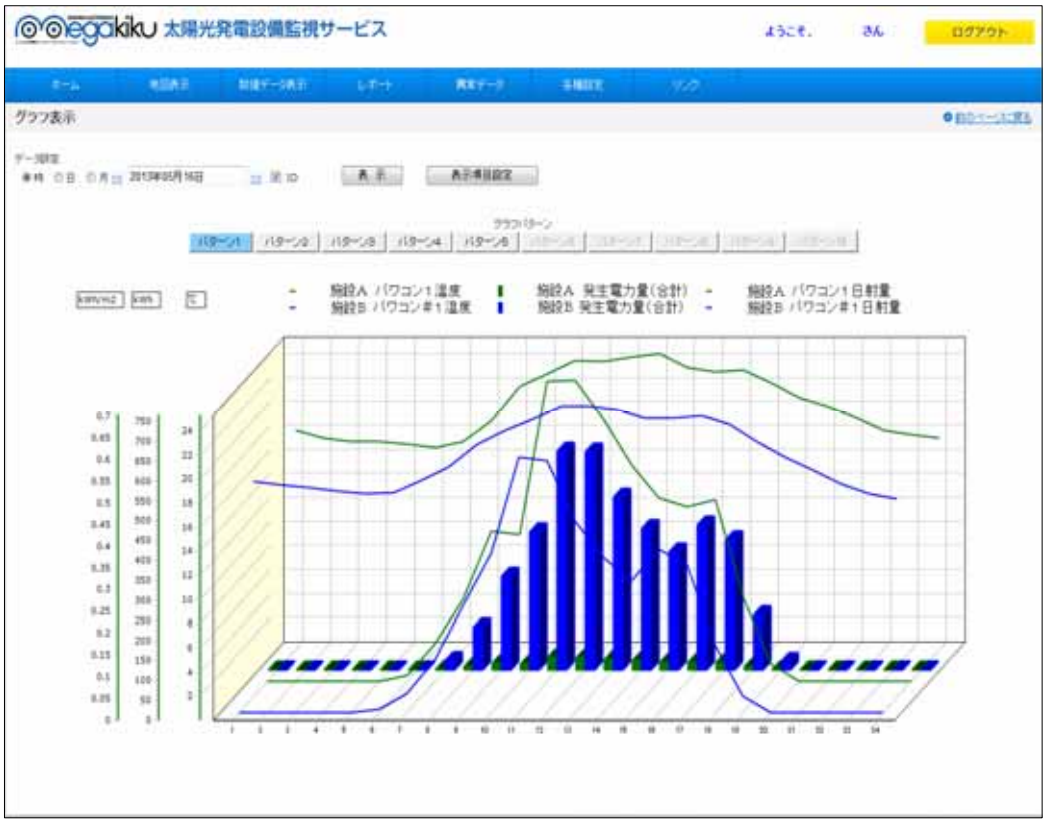

Fig. 5: Screen Display of Graph showing Comparison of Amounts of Power Generated at Multiple Plants

3.3. Information Collection and Accumulation

(1) Centralized Management of Information

A database that allows management of information from the information collection device for each plant has been built to realize an environment to enable centralized management of information.

Common and manufacturer-specific items were identified from differences between the management items provided by individual manufacturers and all items comprising common and manufacturer-specific items were integrated into a database to handle information from products of all the manufacturers.

Differences between items of information acquired from the power conditioners of individual manufacturers are normalized by application of procedures such as conversion of combinations using our IP-based information transmission equipment to standardize information loaded into the management server.

(2) Accumulation of Information

Information on photovoltaic power generation facilities is divided into categories including facility information, measurement information and fault information, recorded and stored over a long period of time. The database has been built based on calculation of the envisaged amount of information in long-term storage as the amount of information collected from 100 plants over a period of approximately 10 years.

(3) Ensuring Database Reliability

Factoring in security issues relating to long-term storage, the database is deployed in a physically separated internal network designed to block unauthorized access from the outside.

In addition, redundancy is provided for the database to improve reliability.

4. Benefits of System Development

The system developed as described in this paper has enabled improvements in work efficiency and speed as well as enhanced convenience in a number of areas and centralized data management in the operation and maintenance of photovoltaic power generation facilities by decentralized power plant operators.

(1) Improved Facility Maintenance Speed

- Information on decentralized plants can be referenced centrally.
- Data on photovoltaic power generation facilities can be checked not only in offices, but anywhere and at any time.
- Notification of faults sent by e-mail enables personnel to check the situation wherever they are.
- Early discovery of faults and speedy maintenance response enable stable power supply.
- The system enables reduction in operation and maintenance personnel and improved efficiency.

(2) Labor-saving and Improved Efficiency in Management
- Use of the information transmission equipment manufactured by our company enables realization of compatibility with power conditioners of major manufacturers in Japan.
- Centralization of data enables unified monitoring and management of all plants.
- The system enables monitoring without the need to travel to multiple plants in remote locations.

(3) Effective Use of Accumulated Data
- Basic data required for analysis can be accumulated and electric power output predicted based on weather conditions.
- Use of actual performance data such as meteorological information and facility utilization rates enables improvement in accuracy of planning for the introduction of new facilities.
- Use of data on faults enables prediction of facility degradation.
- Analysis of fault information improves the accuracy of maintenance planning decisions.

5. Summary and Future Undertakings

As well as centralized management of data collection, aggregation and display, introduction of this system has enabled realization of early-stage maintenance of facilities through the distribution of fault information. Real-time centralized management from a remote location of information on decentralized photovoltaic power generation facilities and the effective use of various collected and accumulated data enable realization of increased efficiency and labor-saving in the maintenance and management of power generation facilities, resulting in stable supply of electric power.

At the present time, as well as more than twenty locations in Kyushu, the “Feed-in Tariffs System for Renewable Energy” inaugurated in July last year has spurred the spread of construction of mega solar power plants nationwide in Japan.

To cope with this situation, we will adopt a flexible approach toward the introduction of this system to meet increasing needs for the monitoring and collection of facility information from such photovoltaic power generation facilities (mega solar plants).

On the system functionality front, we will apply our technologies for monitoring and control of facilities such as hydro power stations and substations to enable implementation of functions such as a control function and power generation efficiency data analysis function in this photovoltaic power generation facility monitoring system, thereby providing even greater convenience in the future.

With regard to future developments, we are considering the following undertakings:
- A M2M (Machine-to-Machine)-based system using remote control technologies to enable control (e.g. operating and stopping power conditioners) of decentralized power supply systems
- Use of smart devices to realize even greater mobility
- Data mining technology for accumulated information to enable the performance of tasks such as power generation forecasts and facility degradation diagnosis

BIBLIOGRAPHY

- NEDO, “Guidelines for PV Power Generation Field Test Project (Facility Management and Data Management)”
- NEDO, “Guidelines for PV Power Generation Field Test Project (System Measurement)”

*NEDO: New Energy and Industrial Technology Development Organization