Featured Articles

Global Collaborative Creation with Customers on Energy Solutions

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OVERVIEW: While the current state of energy supply is facing a period of change on a global scale, the immediate issues facing each region of the world are different. This article presents examples of collaborative creation with customers in regions that are taking the initiative in dealing with these various issues, accompanied by an explanation of the global deployment strategies being pursued in each of the areas—regional grids, transmission systems, and retailers—that make up an energy solution. Hitachi intends to contribute to social innovation by utilizing the knowledge it has acquired in these areas to work collaboratively with customers on implementing energy solutions that fit the characteristics and requirements of each region, using a broad range of equipment and system technologies, and IT.

INTRODUCTION

THE electric power and energy supply business has been approaching a major turning point in recent years on a global scale. Prompted by factors such as encouraging greater use of renewable energy generators, like photovoltaics and wind power, to help combat global warming, and changing market conditions for crude oil, natural gas, and other resources, numerous regions are making changes to their power generation mix.

At the same time, energy is playing an increasingly important role in the social infrastructure. The growing sophistication of supply chains has led to demand for security of energy supply from the standpoint of business continuity planning (BCP). There has also been considerable debate about how to ensure energy security.

This has led various parts of the world to seek new energy solutions. In developed economies in particular, despite the aging of the transmission and distribution infrastructure, planned investment based around the large power plants and transmission networks used in the past has become problematic. Along with distributed sources making up an increasing proportion of the power supply, companies are reviewing the form that regional energy networks should take and how to maintain the stability of transmission systems. Also on the increase are new initiatives in energy retailing, including the liberalization of the retail power market. Given the different technical and geopolitical circumstances in different parts of the world, there is a need to engage with customers in these regions so as to understand the underlying issues they face, and to work together to develop solutions to these challenges.

The UK, USA, and Japan are at the forefront of dealing with these issues. This article presents examples of collaborative creation with customers in these three countries in relation to the operation of the regional grids, transmission systems, and electricity retailers that make up an energy solution.

COLLABORATIVE CREATION OF A SOLUTION FOR REGIONAL ENERGY OPERATION IN UK

This section describes an example of the collaborative creation of a solution for regional energy operation in the UK, a country where the horizontal division of energy businesses is well advanced.

UK Market Trends

The Climate Change Act 2008, which targets an 80% reduction in greenhouse gas emissions by 2050, represents a major objective of the UK government. Use of renewable energy sources is growing rapidly with the aim of achieving this target (generation increased by 21% in 2014 from 53.3 TWh to 64.7 TWh)[(1)]. Moreover, demand for electric power is expected to roughly double from current levels due to the switch from gas boilers to electrical devices such as heat pumps for hot water supply and heating energy[(2)].

The challenge this poses is the huge investment in generation and distribution facilities required to deal with demand peaks and fluctuations in the output of renewable energy generators.

Collaborative Creation of Solution for Regional Energy Operations

Hitachi, Ltd. has been working with Daikin Industries, Ltd. and Mizuho Bank, Ltd., under contract to the New Energy and Industrial Technology Development Organization (NEDO), on a smart community demonstration project in Greater Manchester, UK that runs from April 2014 to the end of February 2017[3), 4)]. The aims of the project are to encourage a shift to efficient energy use in the UK by adopting Japanese heat pumps with superior performance, and to trial technologies and systems that use heat pumps as operating reserves using information and communication technologies (ICT).

In addition to using heat pumps to replace gas boilers in public housing, the project also involves using remote control of individual heat pumps to adjust demand for electric power. Adjustments of electric power use by individual consumers will be bundled and the bulk adjustment capacity will be sold on the UK electricity market in the form of an operating reserve. The project will also verify that the use of residential heat storage systems and hot water tanks installed along with the heat pumps will prevent demand adjustments from interfering with consumer comfort.

Challenges for Region-wide Adoption of Heat Pumps

The plan to install heat pumps requires prior agreements with the distribution network operator (DNO) and related parties. While DNOs typically plan for the expansion of distribution infrastructure based on demand forecasts, the increased risks of overloading or voltage instabilities on the distribution grid that can come with the widespread installation of heat pumps create a need for heavy investment in measures to prevent this. This, in turn, creates a need for techniques that can minimize the requirement for additional distribution facilities when large numbers of heat pumps are installed, such as aggregation services that control the overall heat pump load.

Heat Pump Installation Solution

In response, Hitachi has developed a prototype virtual power plant (VPP) control system for minimizing the effect on distribution facilities of installing heat pumps (see Fig. 1). The system uses predicted heat pump demand to determine the potential for overloading or voltage instabilities on the distribution grid and to optimize the day-ahead operation plan for the heat pumps. In addition to minimizing the additional facilities required to handle the heat pumps by operating in accordance with this plan, the demand predictions also provide a basis for facilities expansion to be undertaken with a high degree of certainty.

Hitachi is using the UK project to assess the benefits of regional energy management.

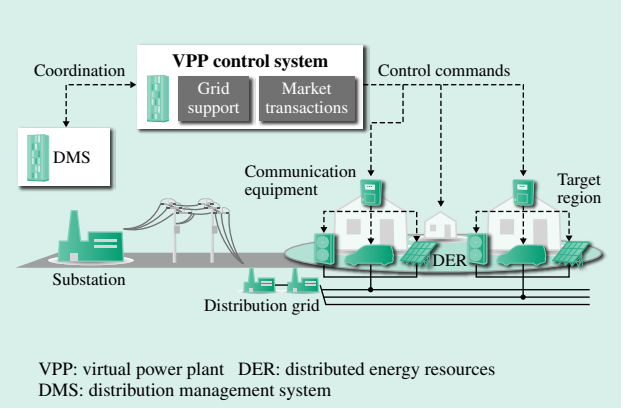


Fig. 1—VPP Control System.
The VPP control system performs integrated management of the distributed energy sources in a target region to enable market transactions and grid support.

COLLABORATIVE CREATION OF A GRID STABILIZATION SOLUTION FOR NORTH AMERICA

This section describes the challenges faced by distribution companies in North America and an initiative based on collaborative creation with customers that is designed to solve these problems.

Challenges for Electric Power Distribution in North America

In North America, factors such as the aging of electric power distribution infrastructure and the rising incidence of outages caused by natural disasters, etc. have created a need for measures to prevent major blackouts. With the 17% increase in the use of renewable energy in 2014[5)], the operation of transmission grids is being complicated by output fluctuations, and investment in grid analysis is rising.

As a response to these challenges, Hitachi is offering a remedial action scheme (RAS) based on an integrated grid stabilization system and a decision support system (DSS) for grid operators.

Overview of RAS and R&D Project with BPA

The RAS is a mechanism for automatically implementing predefined stabilization control measures in response to indications of a grid fault, in accordance with operating practices stipulated by the North American Electric Reliability Corporation (NERC). Offline RAS systems, which rely on control parameters being determined in advance by grid analysis, are used at numerous electric power companies. In contrast, Hitachi has experience in Japan using online RAS, meaning that grid protection measures are calculated in real time. Hitachi has undertaken joint research and development (R&D) with the Bonneville Power Administration (BPA) aimed at deploying the solution in North America. This R&D has involved developing a prototype of the online RAS system to enable the quantitative analysis of system viability, operational cost savings, and other factors based on grid data supplied by BPA. The quantitative analysis considers issues such as increases in the number of calculation parameters due to differences in operating practices and grid configuration between Japan and the USA, and measures for dealing with forms of instability specific to individual grids. Hitachi intends to continue engaging in collaborative creation with customers in North America in the future.

Overview of DSS and Mini-control Room Demonstration

The importance of monitoring and control of widespread instabilities in the electric power grid has been recognized since the major Northeast Blackout of 2003 in North America, and regional grid monitoring and control systems that use phasor measurement units (PMUs) have increasingly been installed, particularly in the USA. PMUs use the global positioning system (GPS) to synchronize measurements over a wide area to provide more accurate monitoring of what is happening on the grid, using voltage, current, and phase data acquired at a rate of 30 Hz or more. According to the North American SynchroPhasor Initiative (NASPI), there were approximately 2,000 PMUs installed in North America as of 2015[6]. While applications for monitoring wide-area power fluctuations have been developed using realtime PMU data, debate is only just getting started on how to use the tens of terabytes of data being collected annually by each electric power company.

The authors have developed a prototype DSS for grid operators through discussions with North American utilities that operate PMUs at forums such as NASPI[7] and the Center for Ultra-Wide-Area Resilient Electric Energy Transmission Networks (CURENT)[8] (see Fig. 2). Based on the concept of using accumulated PMU data and operational knowledge, the system performs high-speed searches of operational logs and similar past cases from the characteristics of grid fluctuations identified using online PMU data. Using an ultrafast database engine*, it takes only a few seconds to present operators with recommended actions gleaned from 18 TB of stored PMU data.

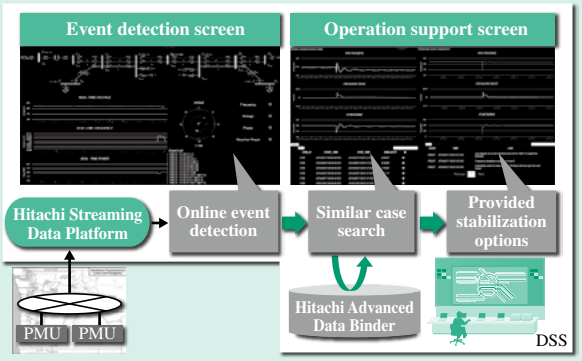


Fig. 2—DSS Overview.
The system uses instances of instability detected from online PMU data to search for similar cases in the historical data stored in Hitachi Advanced Data Binder, and provides operators with options for stabilization.

To expedite the deployment of solutions that use this new technology, Hitachi has provided a space for collaborative creation with customers at the Santa Clara office of Hitachi America, Ltd. and has set up a "mini-control room" demonstration of the DSS solution that combines online grid monitoring, event detection, high-speed similar case searches, and grid simulations (see Fig. 3).

The demonstration is used to show customers a DSS solution that combines Hitachi's information and operational technologies, including grid analysis and a high-speed database. In the future, Hitachi plans to use it for R&D that is better-tailored to customer needs, while also obtaining feedback on its use on actual grids by marketing it to North American power companies.

* Utilizes the results of "Development of the Fastest Database Engine for the Era of Very Large Database and Experiment and Evaluation of Strategic Social Services Enabled by the Database Engine" (Principal Investigator: Prof. Masaru Kitsuregawa, The University of Tokyo/ Director General, National Institute of Informatics), which was supported by the Japanese Cabinet Office's FIRST Program (Funding Program for World-Leading Innovative R&D on Science and Technology).

Fig. 3—Mini-control Room Demonstration.
The mini-control room is used to demonstrate a DSS solution that combines online grid monitoring, event detection, high-speed similar case searches, and grid simulations.

EFFORTS INVOLVING ELECTRICITY REFORMS IN JAPAN

This section explains the challenges facing businesses involved in selling electric power to consumers in Japan where market reforms are ongoing, and it also describes efforts being made through collaborative creation with customers to overcome these challenges.

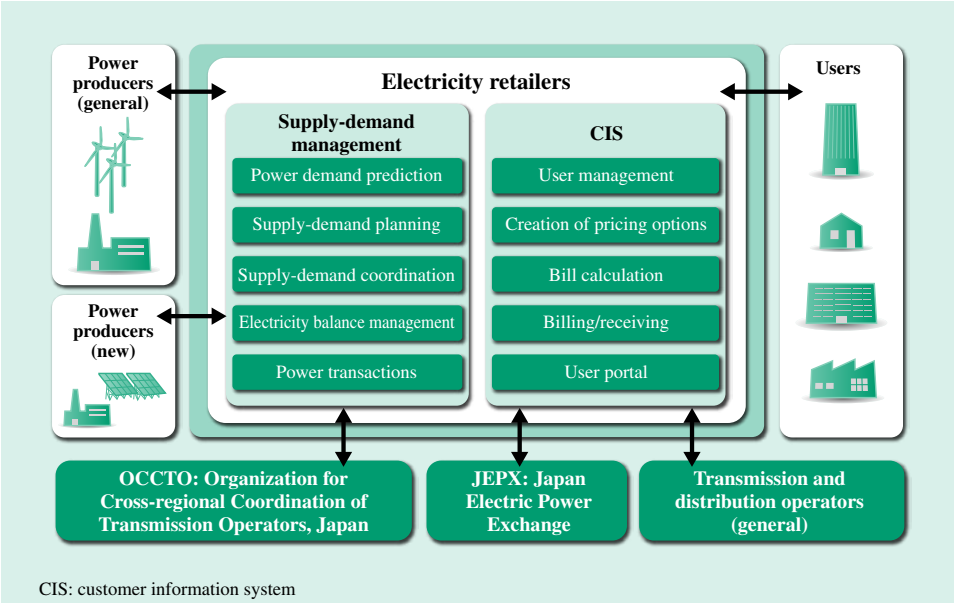
Challenges for Electricity Retailers in Japan

The April 2016 full liberalization of the electricity market in Japan extends to all markets, including households and other low-voltage consumers. This liberalization will be followed in 2020 by the unbundling of generation and distribution, meaning that retailers and generators will be prohibited from also operating a transmission business. These changes have led to a large number of participants announcing plans to enter the retail market to sell electric power to consumers. An issue for retailers that are independent from transmission operators is managing supply and demand in a way that allows them to procure generation capacity in accordance with the new planned electricity balancing rules on electric supply utilization, and to operate commercially by setting prices that are competitive with those of other suppliers (see Fig. 4).

Collaborative Creation with Customers on Supply-Demand Management Using Demand Cluster Analysis

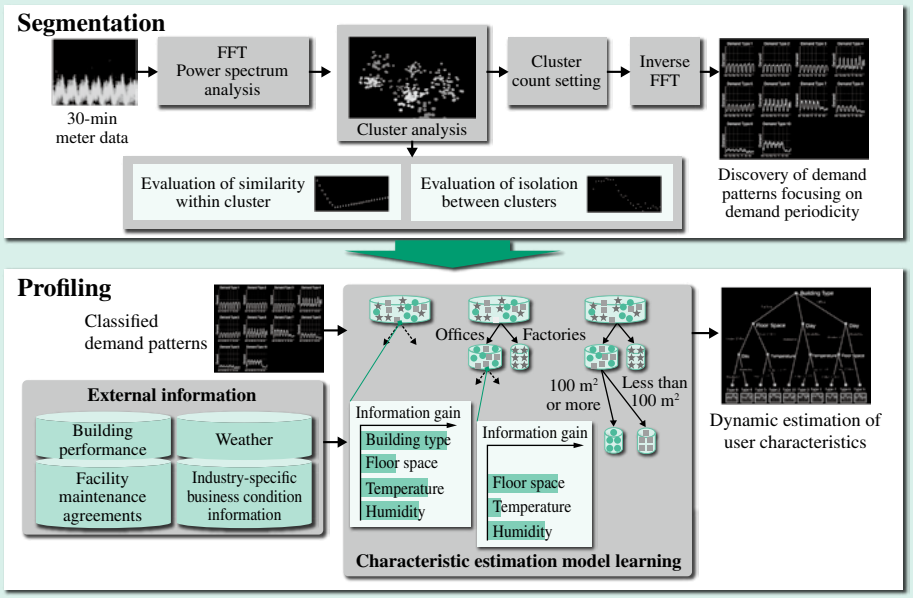
The accurate assessment of demand trends is important for overcoming challenges and succeeding against the competition. Hitachi has developed its own demand cluster analysis technique that uses data on actual demand to reliably identify its characteristic patterns (see Fig. 5). A supply-demand management solution is provided to support a variety of business activities by predicting demand based on these demand patterns. Hitachi's efforts involved in providing this solution include building a test system for engaging in collaborative creation conducting technical trials with customers.

The new demand cluster analysis technique analyzes demand trends to enable more effective sales and marketing along with accurate demand prediction and optimization of electric power procurement.



CIS: customer information system

Fig. 4—Role and Positioning of Electricity Retailers in Japan's Fully Liberalized Power Market.
In addition to acting as points of user contact for retail power operations, electricity retailers will need to partner with general transmission and distribution system companies and industry bodies such as OCCTO, as well as to predict demand, procure power, and set retail prices as they see fit.



FFT: fast Fourier transform

Fig. 5—Demand Cluster Analysis Technology.
The technology analyzes 30-min power data values (load curve) of a large number of users, generates similar clusters from demand patterns, and performs profiling.

Converting data on actual demand into data in feature space enables features to be identified that are independent of the time scale of the actual demand samples, whether they be in minutes or months, and the generation of clusters of data with similar features. Reliable demand patterns that adequately represent the demand features can be obtained by determining the number of feature space dimensions and number of clusters from multiple information quantity bases. The information quantity bases deal with inter-cluster separation, intra-cluster data similarity, and frequency features. The demand patterns are obtained by extracting demand features from the resulting clusters. By tagging attributes as external data in the demand patterns for samples that belong to a cluster and analyzing the main factors formed by the demand patterns, it is possible to use simple analysis to determine demand patterns from external data of consumers other than those whose sample data were collected.

Collaborative creation with customers involves using the test system for Hitachi's supply-demand management solution to identify demand clusters in the supplied test data, verify the accuracy of demand prediction using various different time periods and other factors as conditions, identify issues with procurement plans, or sales and marketing, and assess the effectiveness of solutions.

CONCLUSIONS

This article has presented examples of collaborative creation with customers in regions that are taking the initiative in dealing with the issues surrounding the three areas—regional grids, transmission systems, and retailers—that make up an energy solution. Hitachi intends to contribute to social innovation by utilizing the knowledge it has acquired in these areas to work collaboratively with customers on implementing energy solutions that fit the characteristics and requirements of each region, using a broad range of equipment and system technologies, and IT.

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