Featured Articles

Hitachi's IT Solution for Creating Value in a Competitive Market of Electricity System Reform/Full Liberalization of Retail Markets

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OVERVIEW: When the Amended Electricity Business Act (2nd Stage) goes into effect in April 2016, Japan will enter an era of full liberalization of the retail electric power market. When added to the recently opened 7.5 trillion-yen low-voltage sector, the revision in the law will create a 16 trillion-yen market into which many providers have announced their intention to enter. Drawing on technology and expertise accumulated over many years of providing solutions for power companies, Hitachi has recently developed a demand cluster analysis technology. It is also providing a supply-demand management solution that will enable electricity retailers to prevail in Japan's new competitive market.

INTRODUCTION

THE full liberalization of Japan's retail electric power market starting in April 2016 will liberalize the entire retail power market, including households and other low-voltage sector users. Many new providers have announced plans to use this opportunity to enter the electric power market, and power companies with previously limited sales areas have announced plans to expand into other areas.

Competition is expected to intensify, with providers also looking into new business strategies never before seen in Japan's power industry, such as sales of power packaged together with other products and services.

In the run-up to liberalization, low-voltage users have been able to apply to change (switch) providers

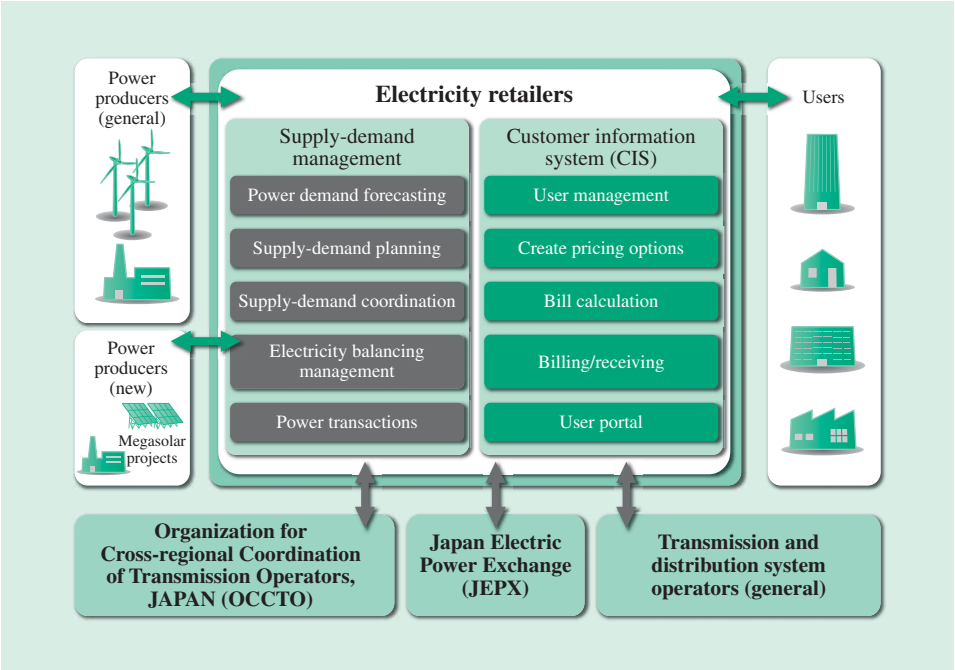

Fig. 1—Positioning of Electricity Retailers in Fully Liberalized Power Market.
In addition to acting as points of user contact for retail power operations, electricity retailers will need to partner with general transmission and distribution system operators and industry bodies such as OCCTO.

since January 2016, creating growing momentum with true competition among providers to expand user bases.

While providers are focusing their energies on sales and marketing activities, they are also being called on by the Japanese government to meet certain standards in order to be recognized as electricity retailers involved selling electric power. The obligations they need to fulfill will include supply-demand management tasks such as power procurement and electricity balancing, and user management tasks such as handling complaints and explaining the provisions of agreements to users.

Implementing more efficient operations will be a key goal for electricity retailers to attain. To meet it, they will need to partner with a large number of other providers such as transmission and distribution system operators, along with industry bodies such as the Organization for Cross-regional Coordination of Transmission Operators, JAPAN (OCCTO) and Japan Electric Power Exchange (JEPX) (see Fig. 1).

CHALLENGES FOR RETAILERS IN A COMPETITIVE MARKET

To outdo the competition, electricity retailers will need to meet their government-mandated obligations while implementing effective measures to grow profits. In the radically altered business environment to come, retailers will need to deal with the following two major challenges.

(1) Identifying user characteristics

Low-voltage customers can currently obtain a low-voltage power agreement just by providing basic information such as their name, address, and payment method. And, except in cases of delinquent accounts or similar problems, more detailed user information has not been of particular importance to retailers up to now. But the new providers will be starting out with small user bases, making it much more important for them to be able to identify types of users and power consumption figures than it is for existing power companies. An inability to identify these

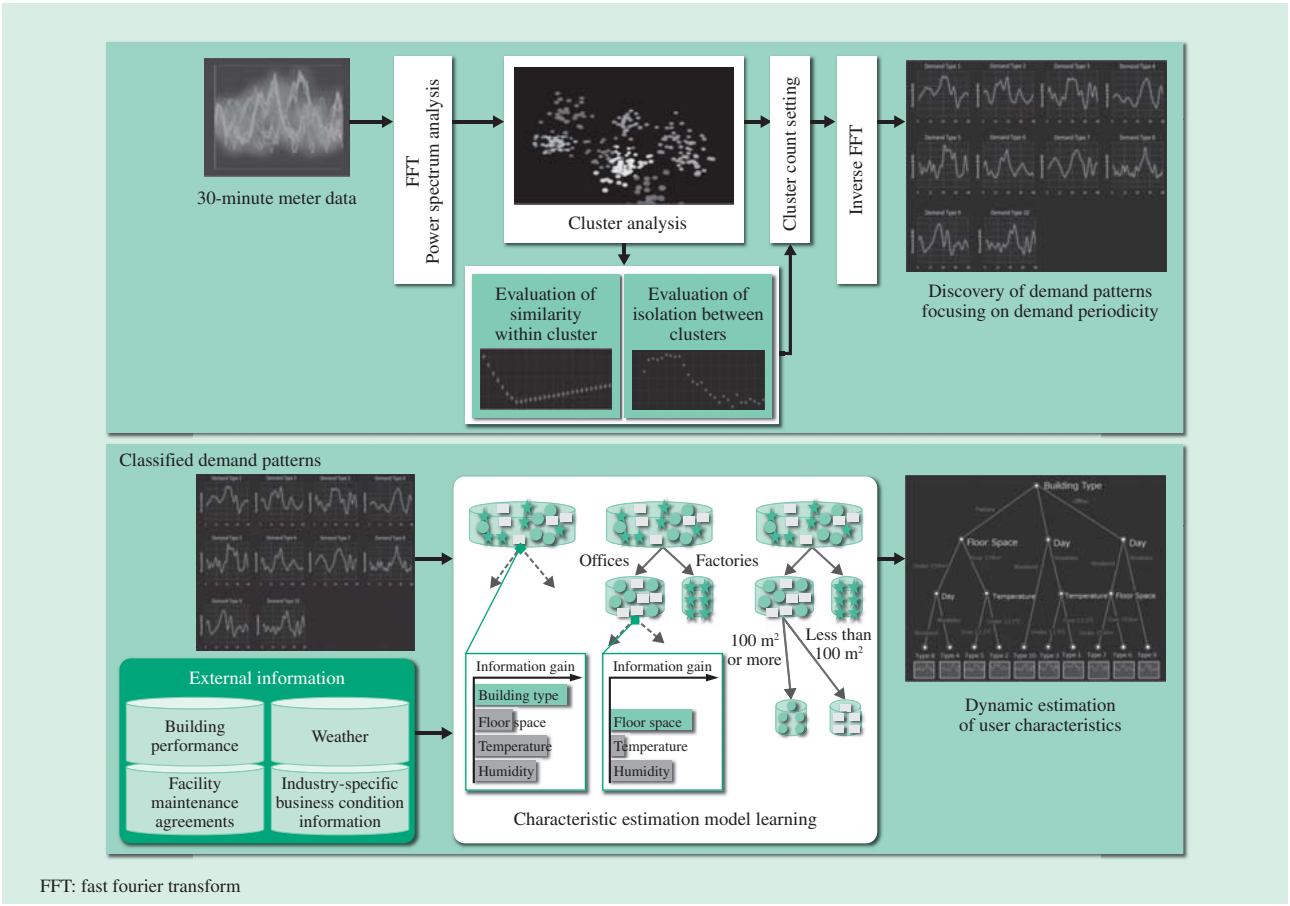

Fig. 2—Demand Cluster Analysis Technology.
The technology analyzes the power consumption (load curve) of large users in 30-minute increments, generates similar clusters from demand patterns, and performs profiling.

user characteristics will result in less precise power demand forecasting, making proper supply-demand management difficult, and sales and marketing activities such as creating pricing options tailored to user characteristics ineffective.

(2) Lack of smart meter data

Providers are installing 'smart meters' for low-voltage customers at a rapid pace throughout Japan. Smart meters can gather power consumption data in 30-minute increments, enabling past power consumption data to be used in supply-and-demand plans that require a 30-minute resolution, for more precise planning. But it will take several years before smart meters have been installed nationwide under the current schedule, and even when fully installed, a certain amount of missing data is expected from glitches such as communication problems. Technical challenges therefore remain. Without a sufficient store of past data, smart meters will not be a sufficiently effective tool for improving power demand forecasting precision in 30-minute increments or creating pricing options for different times of day.

TECHNOLOGY AND SOLUTION FOR OVERCOMING CHALLENGES

Demand analysis is a key tool for enabling providers to deal with the challenges currently facing them and to outdo their competitors. Hitachi has therefore developed demand cluster analysis technology and a supply-demand management solution that uses it. This technology is based on the idea that analysis that groups demand and models its characteristics is a more effective approach than using limited data to analyze radically varying demand as discrete data points.

Demand Cluster Analysis Technology

Demand cluster analysis technology is used to analyze demand trends to enable precise power demand forecasting, optimum power procurement, and more effective sales and marketing activities (see Fig. 2).

By transforming past demand data into data in a feature space, features can be found from demand data samples without limiting the time scale to a particular scale such as minutes or months, and clusters can be generated from data with similar features. Using multiple information criteria to set the number of dimensions and number of clusters in the feature space enables the acquisition of good-quality demand patterns with ample ability to express demand features. Information criteria are used to evaluate the isolation between clusters, the similarity of the data within a cluster, and frequential features. Demand features are extracted from generated clusters to identify demand patterns. By tagging demand patterns with attributes of samples belonging to clusters as external information, the major factors generated by demand patterns can be analyzed, and demand patterns can be identified for users outside the gathered sample data using simple analysis from external information.

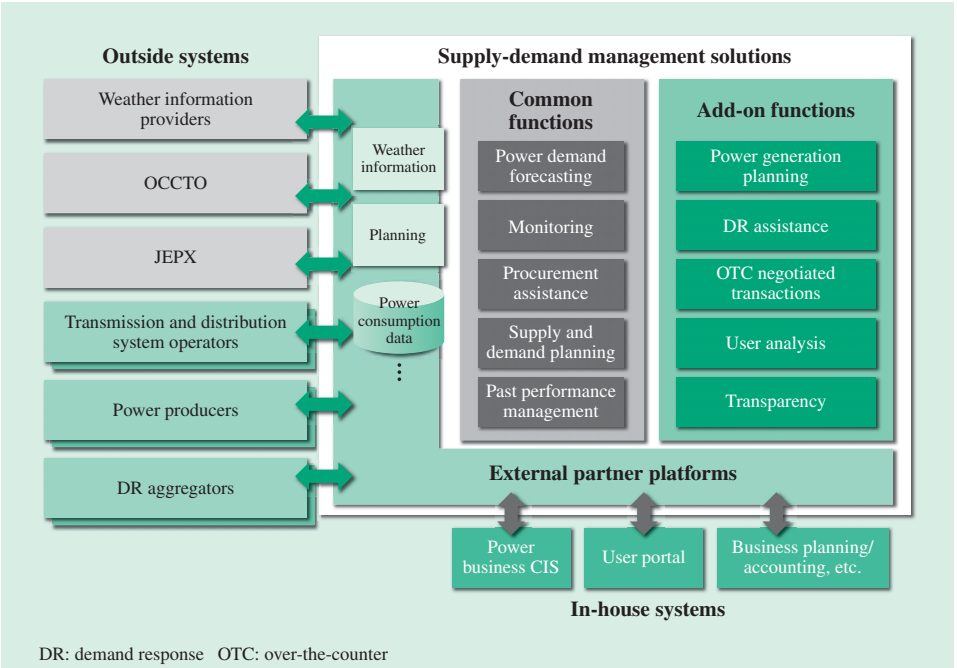

Fig. 3—Hitachi's Supply-demand Management Solution. The solution provides the functions electricity retailers will need to start business in April 2016, and assists in the startup process. By adding functions needed for future system reforms and partnering with existing systems it ensures flexible expandability.

One of the obligations of electricity retailers is to ensure that the amount of power they have available for sale is equal to the total amount consumed by their users. Under the new system, providers will be required to avoid imbalances between demand and supply by precisely forecasting the amount of demand up to one hour in advance. Forecasting precision can be improved by creating a forecasting model from demand clusters with different demand patterns.

Supply-demand Management Solution

Hitachi has used demand cluster analysis technology to develop a supply-demand management solution (see Fig. 3). Power demand forecasting is the most difficult task among the supply-demand management tasks, and a task that greatly affects business. Hitachi's supply-demand management solution supports multiple power demand forecasting methods, which can be combined to enable power demand forecasting that is tailored to the characteristics of a provider's users.

For example, the demand cluster analysis technology described in the section above can be used to classify users and to apply a combination of suitable forecasting methods such as multiple regression analysis and time-series analysis to each demand cluster, achieving more finely tuned power demand forecasting.

The power demand forecasting method used is determined by the timing of the forecast (such as one year or one hour beforehand), and by factors in the business environment such as the electricity retailer's number of users or rate of smart meter installation. The approach to power supply and demand forecasting must therefore be varied to fit the situation. Table 1 lists the forecasting methods used by Hitachi's solution. Fig. 4 shows example applications of power demand forecasting methods.

Multiple regression analysis is a method of power demand forecasting that uses empirically set explanatory variables to perform analysis, and is widely used for estimating daily maximum temperatures and maximum demand quantities. It will be used when the full liberalization of the retail power market starts in April 2016, at which time the rate of smart meter installation will be low and there will be little numerical data in 30-minute increments. As more smart meters are subsequently installed and user data accumulates, it will become possible to use the demand cluster analysis described in the section above to make forecasts by extracting and classifying data from similar days.

Once the infrastructure has reached the point where it is possible to gather a large quantity of fresh 30-minute increment data, it will then be possible to use time-series data observed in the previous hour in short-term daily or hourly forecasts, enabling forecasts to account for demand fluctuation processes such as classified demand patterns and attribute information.

Table 1. Power Demand Forecasting Methods Available with Hitachi's Solution

Hitachi's solution provides the following power demand forecasting methods, each using its own past performance data or prior investigation approach.

No.	Method	Features
1	Multiple regression analysis	Forecasts using multiple regression model with explanatory variables such as temperature
2	Similar day analysis	Performs cluster analysis of representative days/users from measured demand quantities (meter data), and forecasts in combination with various forecasting methods
3	Time-series analysis	Forecasts future demand (such as demand one hour in the future) from time-series data created from observations of demand quantities over time

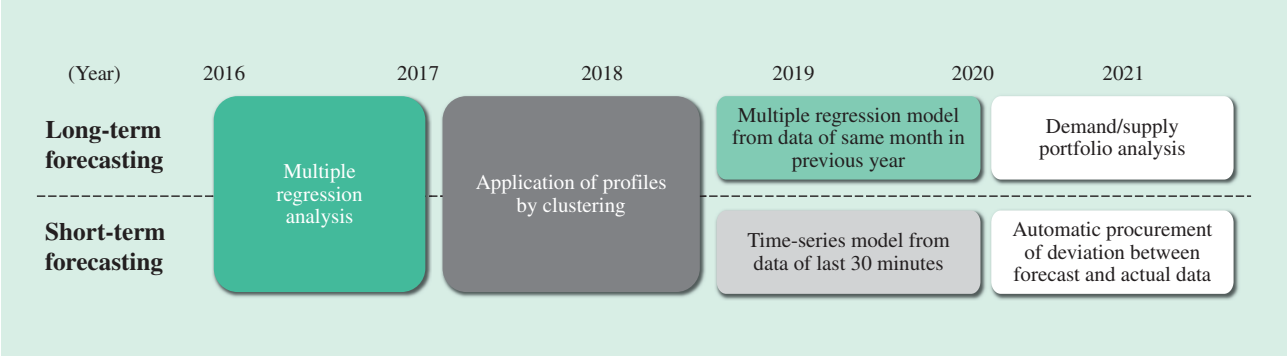

Fig. 4—Example Applications of Power Demand Forecasting Methods.
As the smart meter installation rate and number of users increase in the future, providers will need to use optimal combinations of multiple forecasting methods.

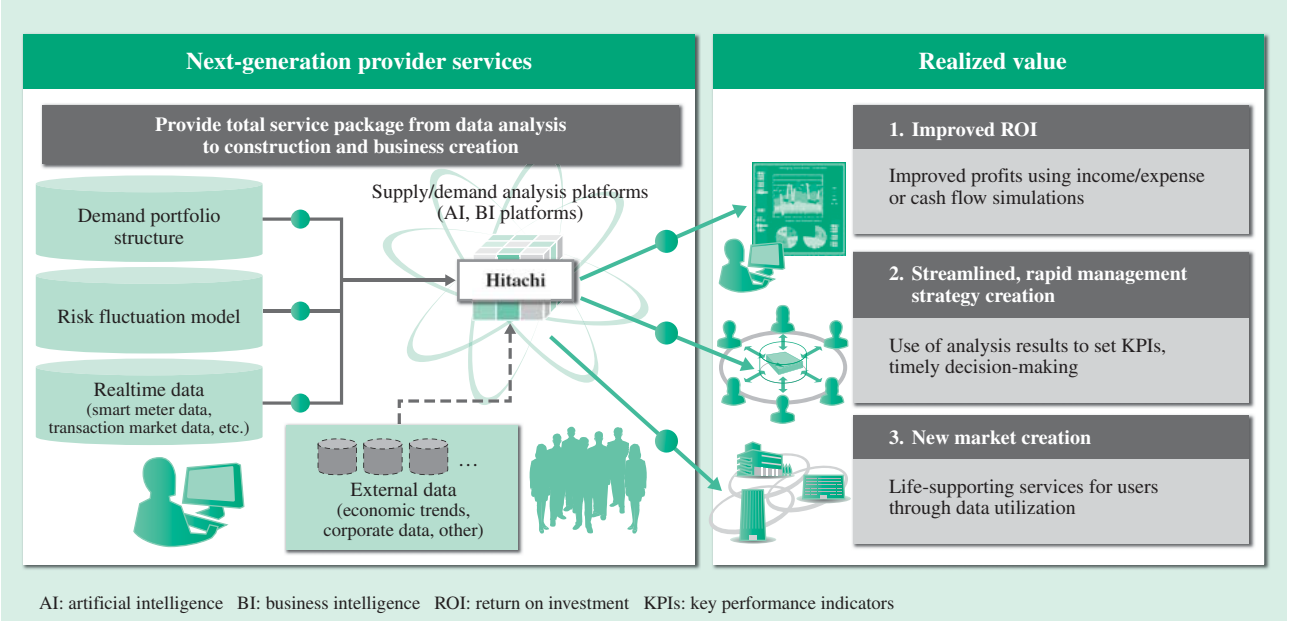

Fig. 5—Next-generation Provider Services Enabled by Large Data Volumes, and Their Value.
In addition to improving ROI, next-generation provider services also pave the way for new user services and innovative management methods by using a variety of connected information to examine complex relationships among stakeholders, and complex correlations.

Effective sales and marketing activities such as pricing options optimized to the characteristics of individual users will be another important challenge in the future, along with improving power demand forecasting precision. Since the demand cluster analysis technology Hitachi has developed will make it possible to identify user characteristics, its use in supply-demand management solutions make it a useful tool for sales and marketing activities.

CONCLUSIONS

This article has described Hitachi's demand cluster analysis technology and its applications. The technology has been designed to promote business success among electricity retailers. As the data-gathering infrastructure becomes more highly developed in the future, this technology should not only help improve forecasting precision, but also boost the effectiveness of marketing activities.

Hitachi plans to analyze massive quantities of data in a wide range of fields in the future to help find ways of improving corporate return on investment (ROI), possibly by drawing on the use of next-generation technologies such as artificial intelligence (AI). It is also looking for ways to assist management strategy proposals in a streamlined and rapid manner, and to help create new markets that cross traditional power market boundaries (see Fig. 5). More than just a provider of individual technologies and solutions, Hitachi is a provider of total service packages for maximizing technology-created value and a leader in Social Innovation.

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