Responding to the Various Needs for Energy Usage Electricity Optimization using Demand Prediction

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Large consumers including factories use various utilities such as energy (electricity, heat, fuel, etc.), water and compressed air, and they need to not only reduce energy costs, but to also simultaneously solve many difficult issues including the reduction of CO_2 emissions, the improvement of production efficiency, the stabilization of operations and the shortage of skilled engineers. To solve these issues, prediction technologies for determining how much and when energy will be needed in the future are essential. Mitsubishi Heavy Industries Ltd. (MHI) developed the "power demand prediction system" which predicts factory power demand using its proprietary AI, and this report introduces the system as well as case examples of demonstrations conducted in MHI's plant.

1. Introduction

In recent years, the needs in energy supply and demand have been diversified through the liberalization of energy market, the increase in the use of renewable energy, the shift from centralized energy systems to distributed energy systems, the management of BCP (Business Continuity Plan), environmental conservation through the promotion of carbon-free energy, etc., and these needs have been continuously changing. On the other hand, a stable energy supply is required for factory production activities, and efficient energy operation through energy saving measures, the reduction of CO_2 emissions, the reduction of energy cost and measures against the shortage of skilled engineers, are also required. Therefore, the need for prediction technologies through which factory power demand can be accurately predicted has been increasing.

Digital technologies including AI and IoT (Internet of Things) have made remarkable progress, and various kinds of systems using prediction technologies have been developed. The ENERGY CLOUD™ Service provides an energy solution for the prediction of factory power demand using MHI's proprietary AI. General power demand predictions are made, in many cases, based on the past actual values, weather information, etc. On the other hand, the system introduced in this report provides a highly-accurate prediction of power demand in association with factory operational planning and production planning for the optimization of factory power supply and demand.

This report introduces an overview of this system and the results of the demonstration of its effects conducted at MHI's plants.

2. Explanation of the power demand prediction system

The power demand prediction system employs the ensemble learning method[*1], which is an AI analysis method using MHI's proprietary technology. For highly-accurate prediction[(1)], the system automatically extracts the effective feature quantity from a large number of explanatory

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variables that are factors for prediction and classifies objective variables, i.e., targets to be predicted, into clusters[*2] before prediction. Based on the prediction system incorporating this method, the user interface and the system configuration were standardized. Then, the demonstration was conducted onsite at MHI's plants, and the prediction system for factory power demand was established.

[*1] Method of increasing versatility through the integration of the prediction results of multiple analysis results

[*2] A small group in which similar objects are collected from the population

2.1 Characteristics of the power demand prediction system

2.1.1 Power demand prediction in association with equipment operational planning

The power demand prediction system is constructed in the cloud, and prediction is conducted by analyzing the actual demand data accumulated by the customer and the data measured in real time. The mechanism of the prediction system and the actions taken for the improvement of prediction accuracy are presented in **Figure 1**.

Action (1): Customer inputs the explanatory variables, such as calendar data for factory operation days and the operational plan for specific pieces of equipment which have a correlation with power demand, through a web browser to the system.

Action (2): Power demand prediction is periodically corrected based on the demand data measured in real time on the day and the production equipment operational data.

Action (3): Through continuous system operation, the AI conducts self-learning based on the accumulated data and the analysis capability is improved.

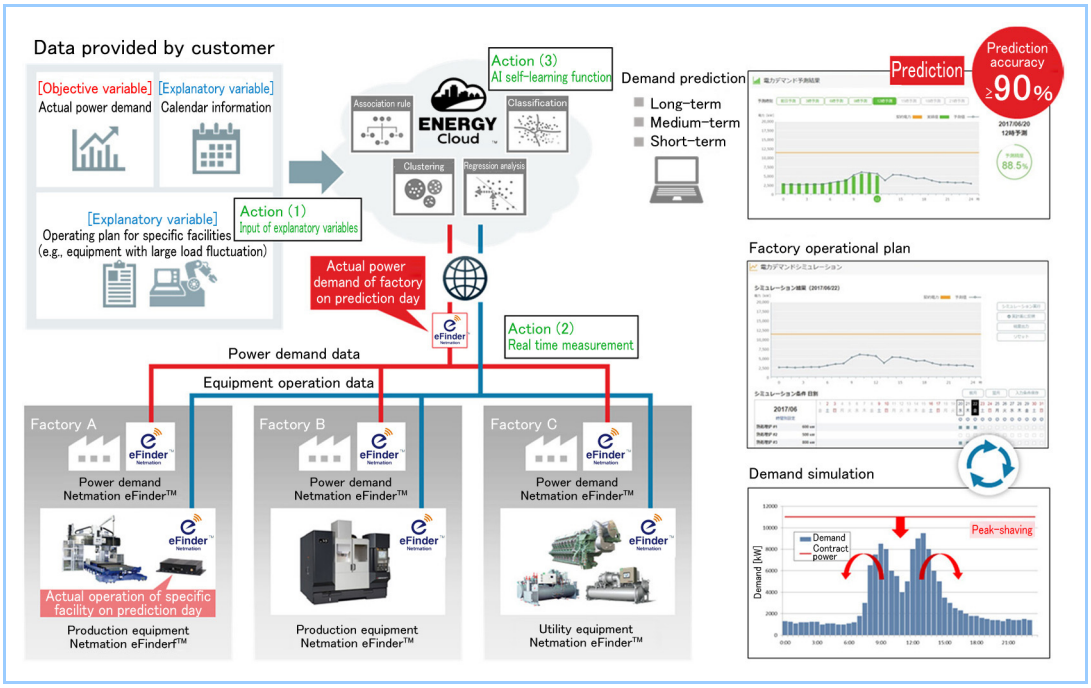

Figure 1 Mechanism of the power demand prediction system

2.1.2 Service provision start in a short period

The system can be used with MHI Group's proprietary Netmation eFinder™ as a standard IoT tool for data acquisition which can be easily installed on the equipment. Therefor the existing data and the measured data by Netmation eFinder™ allow the start of the power demand prediction service in about two weeks.Even if no existing data is available in the case of the start-up of a new factory, etc., the prediction service can be provided because the system conducts analysis while conducting self-learning from the start of data measurement, and the prediction accuracy is improved with the passage of two or three months.

2.1.3 Prediction result display interface with consideration given to usability

The customer can check the prediction results anywhere by accessing the prediction system from a web browser. In addition, two or more concerned parties can view the same screen and results and share information, and quick and precise demand management, etc., can

be realized. The power demand display pattern is illustrated in **Figure 2**.

When a date on the user interface is selected, the predicted value and the actual value are displayed on a graph, and the power demand value (average power usage per unit time) and the power demand pattern can be visualized.

In the power demand prediction system, long-term, medium-term and short-term predictions are conducted, and each prediction is properly used according to the purpose as follows:

- Long-term prediction: Prediction of annual demand tendency and maximum demand value based on factory operation days
- Medium-term prediction: Prediction of monthly or weekly demand tendency based on operational plan
- Short-term prediction: Prediction of day's demand based on real-time data

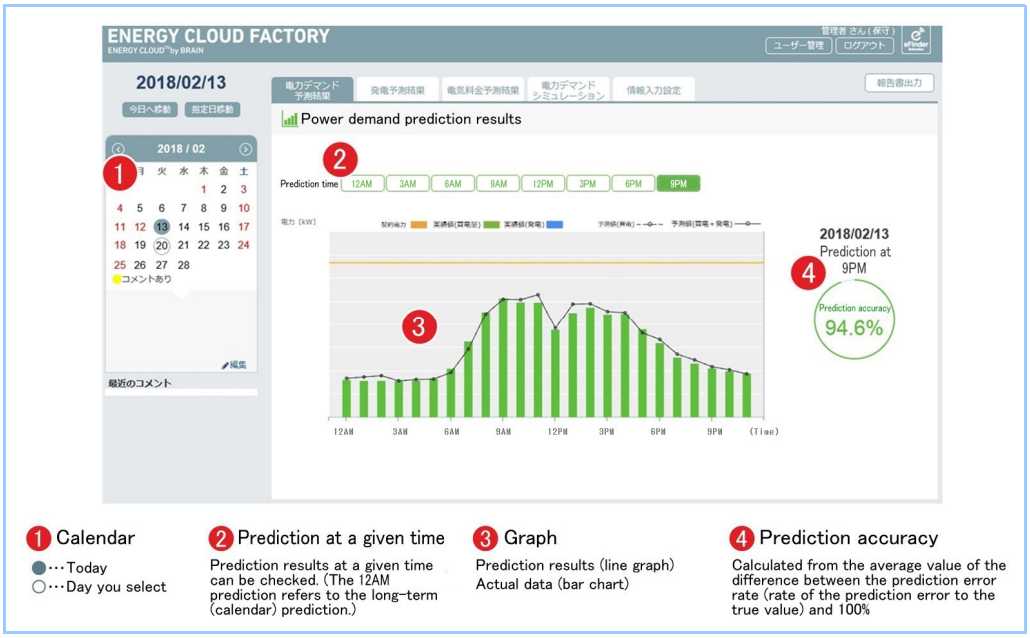

Figure 2 Results of prediction by the power demand prediction system

2.1.4 Demand peak reduction through power demand simulation

The power demand prediction system has a power demand simulation function using explanatory variables as parameters and allows a series of studies toward the optimization of factory power demand. When the prediction shows that the demand peak is getting close to the contract demand, measures can be taken beforehand by implementing a power demand simulation using the equipment operational plan as a parameter and studying the operational plan so that the peak is lowered. The demand simulation display pattern is given in **Figure 3**.

2.2 Effects of the power demand prediction system

By using this prediction system to manage factory power demand, the following effects can be expected:

- Power demand peak prediction was often conducted depending on experience and intuition. This prediction system visualizes and simulates the demand peak, thereby allowing the operational plan to be specifically changed toward a peak shift or peak-shaving and resulting in the improvement of operations and labor saving.
- By accumulating the demand data throughout the year, the annual peak value can be determined, and a study can be made toward the optimization of the contract demand for the next year. In addition, the demand data can be used in planning for the introduction of new utility supply facilities such as self-power generators, resulting in the reduction of power cost.
- The same prediction system is used by the production department and the power management department, so that the latest actual demand, production planning, etc., can be shared, resulting in the implementation of factory-wide energy saving activities and increased energy saving awareness.

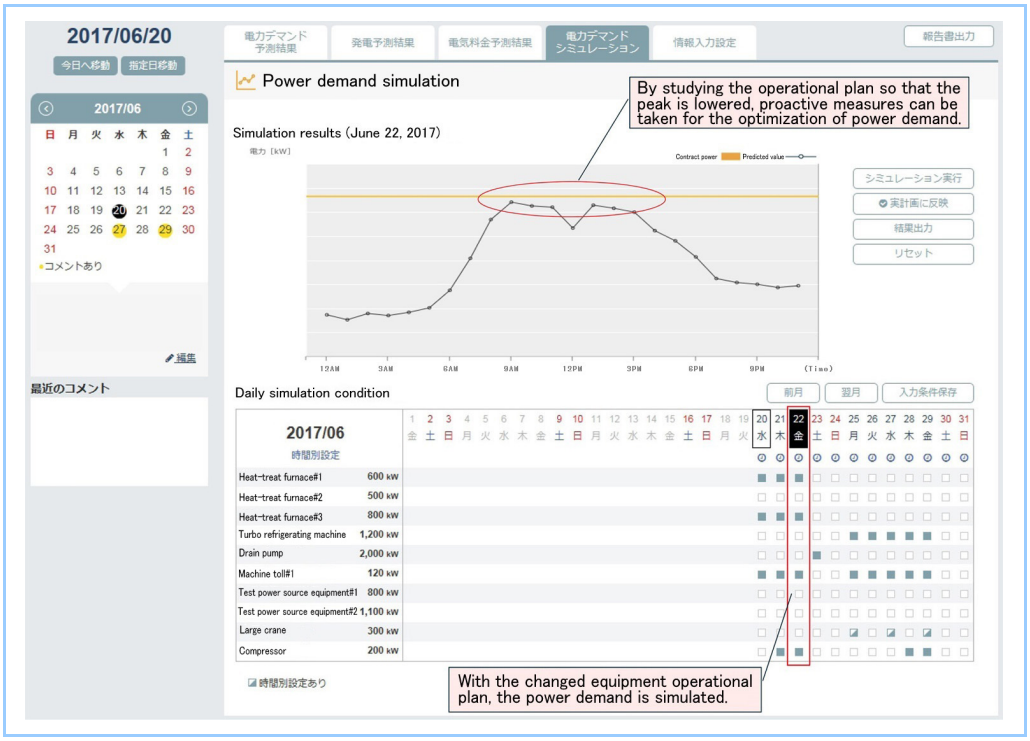

Figure 3 Simulation function of the power demand prediction system

3. Verification of effects by in-company demonstration

The developed power demand prediction system was introduced to four plants of MHI (Main Plant and Futami Plant of Kobe Shipyard & Machinery Works, Main Plant and Koyagi Plant of Nagasaki Shipyard & Machinery Works), which have different power supply and demand characteristics, and the use of the prediction system was implemented at the actual plants. By using the demand prediction system onsite where the actual power supply and demand operations were conducted, the power demand prediction accuracy and the effects of the use of the prediction system were verified.

As representative verification results of prediction accuracy, the results of the prediction at 12 AM and 9 PM can be seen in **Table 1**. The accuracy is defined as the difference between the prediction error rate (rate of the prediction error to true value) and 100%. Although the plants have different scales of power demand, manufacture different products and have different surrounding environments, an average prediction accuracy of about 85% was achieved in the prediction at 12 AM. Compared with the average prediction accuracy at 12 AM, the average prediction accuracy at 9 PM was increased to about 90%. Therefore, it was verified that the periodical prediction correction based on the day's real time data improved the accuracy. At the Futami Plant where the prediction accuracy was low, the operation of the electric furnace largely contributed to the power demand. Therefore, the addition of the products being manufactured and the production quantity to the explanatory variables to be input may improve the accuracy.

Table 1 Results of the verification of prediction accuracy at the plants of MHI

Period Introduction day to the end of March 2018		Kobe Shipyard & Machinery Works		Nagasaki Shipyard & Machinery Works	
		Main Plant	Futami Plant	Main Plant	Koyagi Plant
Prediction accuracy	Prediction at 12 AM	86%	72%	89%	87%
	Prediction at 9 PM	92%	80%	94%	92%

In the future, the prediction system will be applied to the operation process at each plant (**Figure 4**) to verify the effectiveness of its use in power management operations.

Thus, it is considered that the optimization of operational and production plans of factories, as well as the operational plans of utility facilities, not only reduces power cost, but also has other effects such as increased production efficiency, the stabilization of operations and labor saving, resulting in the optimization of energy supply and demand which is required in factories.

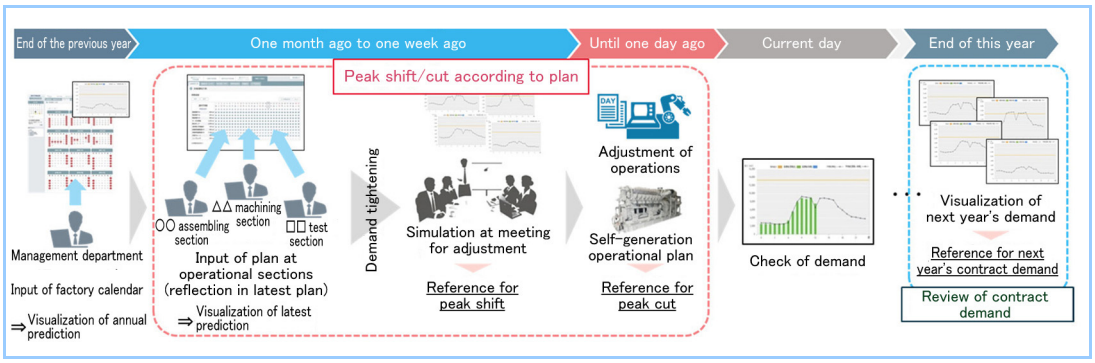

Figure 4 Power management operational process using the power demand prediction system

4. Conclusion

MHI developed the "power demand prediction system" for the prediction of factory power demand using its proprietary AI. With this system, we started the provision of services, based on the previously described verification results, for both inside and outside of the company this year.

The power demand prediction system has the effects of the "reduction of peak power," the "reduction of power usage amount" and the "optimum operation of self-generation" as described in this report. Furthermore, this system can be applied to demand prediction of not only power demand, but also various utility demand such as steam, water and fuel. Going forward, we will improve the prediction system and expand the application scope for the support of management operations of various energy supplies at factories.

In the ENERGY CLOUD^{TM} Service, the creation of commands for onsite operation based on the prediction results, and in the future, automatic control of equipment according to its commands, are positioned as a series of solution services and we will promote the provision of energy solutions beginning with demand prediction as the starting point.

References

(1) K. Wakasugi, et.al., Development of High-precision Demand Forecasting Technology for Factories, Mitsubishi Heavy Industries Technical Review Vol. 55 No. 2