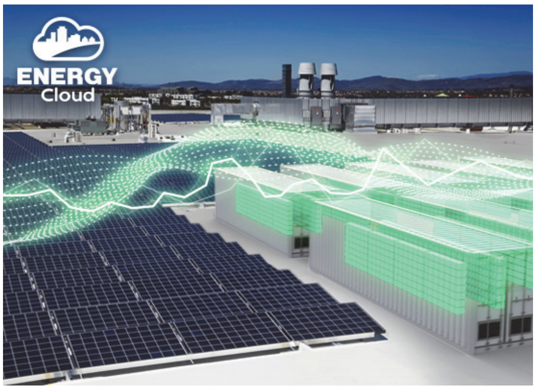
New Step for Renewable Energy Utilization Energy Management Using PV Prediction and Operation Support



YUSUKE YASHIRO[*1] TEPPEI TESHIMA[*2]
HIDEKI HASHIMOTO[*3] MANABU INOUE[*4]

*As the introduction of renewable energy such as solar photovoltaic power generation continues to expand year by year with the background of increased environmental awareness, how to operate power generation facilities and storage equipment (ESS[*1]) in the plant under varying weather conditions is an issue for power consumers. In this project, Mitsubishi Heavy Industries, Ltd. (MHI) developed a system that predicts the amount of power generation of renewable energy with prediction technology utilizing machine learning to derive charge and discharge guidance for ESS from the results. This system was verified by the power management department of our plant to extract the necessary functions and interfaces for users who manage facilities and evaluate the effectiveness of the system. We will continue to improve the functions and promote preparations to provide our external customers with the expertise obtained from the research in our plant to contribute to the effective use of renewable energy by our customers.*

*[*1]: Energy Storage System (Power storage facility)*

1. Introduction

In recent years, from the perspectives of climate change problems and sustainability, social environmental awareness is further increasing. Also in the industrial field, environmental measures represented by carbon free, ESG investment[*2], etc., are beginning to influence business policies. Among them, the expansion of renewable energy is remarkable in the energy industry. Also in Japan, in parallel with the liberalization of electric power, the proportion of renewable energy, mainly solar photovoltaic power generation, continues to increase.

In the case of renewable energy such as solar photovoltaic power generation (PV[*3]) and wind power generation, the amount of electricity generation fluctuates from moment to moment depending on the weather conditions. Therefore, unlike power generation methods that can be actively adjusted by the amount of fuel, etc., such as thermal power generation, measures to balance supply and demand are necessary. As such, case examples of relieving fluctuations of renewable energy by charging and discharging at the necessary timing using a power storage facility (ESS) such as lithium ion batteries have been announced in Japan and other countries.

However, if users who introduce ESS together with renewable energy in their plants prepare for a decrease in the power generation amount beyond the assumed amount in anticipation of fluctuations of renewable energy, the ESS capacity needs to be increased to be on the safe side and the cost increases, which makes the introduction of ESS difficult. On the other hand, if the renewable energy source is insufficient, the amount of the electricity shortfall will be covered by purchasing power. Since it is necessary to always avoid exceeding the power purchase contract electricity amount, a rapid decrease of renewable energy cannot be overlooked. These issues are just some of the obstacles for customers to introduce renewable energy, so it is necessary to

*1 CIS Department, ICT Solution Headquarters
*2 Power & Energy Solution Business Planning Department, Power & Energy Solution Business Division, Power Systems
*3 Manager, Power & Energy Solution Business Planning Department, Power & Energy Solution Business Division, Power Systems
*4 Senior Manager, Power & Energy Solution Business Planning Department, Power & Energy Solution Business Division, Power Systems

quantitatively clarify the relationship among the power demand to be consumed, the amount of power generation of renewable energy, and the ESS charge and discharge capacity to deal with the change in the amount of electric power, and to predict the amount of change.

Accordingly, in this project, we enhanced the power demand prediction system(1) of the ENERGY CLOUDTM Service, added a renewable energy prediction function and ESS guidance function to invent and verify a mechanism to support the user's introduction of renewable energy and ESS charging and discharging control. The developed system has function of supporting ESS operation such as prospective charging and discharging, an issue that was attempted to be solved by rule of thumb, and realizes the display of factors for user judgment on the screen along with the flow of the guidance as the visualization.

The system configuration was standardized with the intention of using it in combination with private power generation equipment that takes time to start up. For system verification, we conducted a test at our Isahaya Plant of Nagasaki Shipyard, one of our plants where PV power generation has been introduced. As shown in **Figure 1**, the target plant was selected based on the fact that the introduction ratio of PV power at the rated value was as high as about 34%, and therefore a significant effect on the improvement of operational efficiency thanks to the system was expected. Chapters 2 and 3 explain the system and the verification test details, and the final chapter introduces future developments.

*2: Investment activities related to the Environment, Society, and corporate Governance

*3: Photovoltaic. Solar photovoltaic power generation.

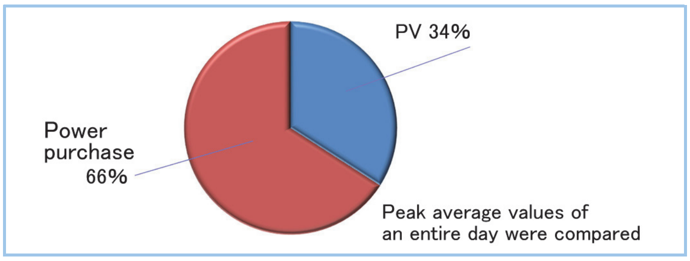


Figure 1 Ratio of PV power amount to demand in plant

2. Explanation of system

Figure 2 presents an overview of the system. This system is based on the "demand prediction system" that predicts power demand with machine learning using data in a database, with a renewable energy prediction function and a guidance function being added.

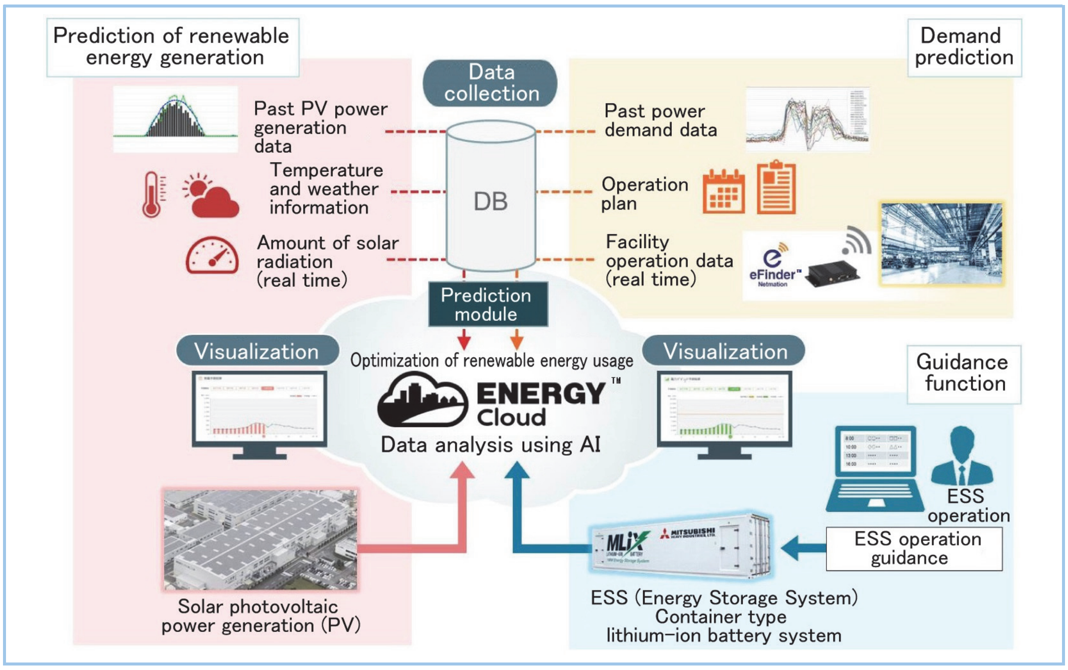


Figure 2 System overview

The prediction module with machine learning realizes high prediction accuracy by acquiring data in a database at the time of processing and repeating generation of the prediction model and derivation of the prediction results. The database collects data such as the amount of electric power and the plant operation plan sequentially, and the prediction accuracy improves when sufficient data is accumulated by completing a round of all operation cycles. For this reason, the system can start up even with a small amount of data at the beginning, and can quick-start when improvements are added.

The renewable energy prediction function added this time to the demand prediction system uses a demand prediction method and is realized by simply changing the data acquired from the database. There are no particular restrictions on the data stored in the database, and measurement data and data obtained from the web, etc., can be acquired through various interfaces. With these mechanisms, it is possible to respond flexibly and quickly to renewable energy requirements that are different for each customer, and efforts such as continuous accuracy improvement after starting operation can be easily made.

Figures 3 and 4 give examples of prediction results of demand and PV power generation, respectively. As the system predicts the plant demand and the PV power generation amount and compares them with the actual values, the user can confirm future prediction and past actual values. It is indicated that the prediction accuracy improves with machine learning. The prediction results are configured so as to be updated every time a predetermined time elapses from the perspectives of balancing and contract power. For example, in the prediction of PV power generation amount presented in Figure 4, it is indicated that the prediction error for the power generation peak around 12:00 was large in the early prediction made in the morning, but the accuracy increased due to an update performed 30 minutes before and the prediction error gradually became smaller.

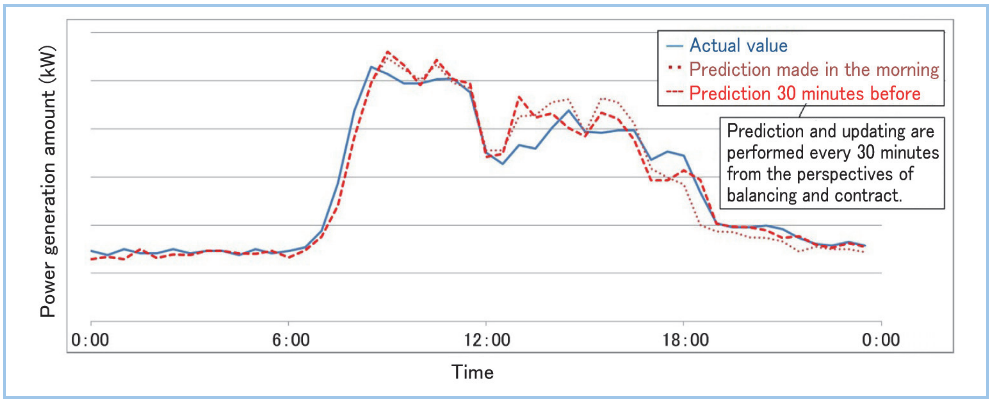


Figure 3　Example of demand prediction

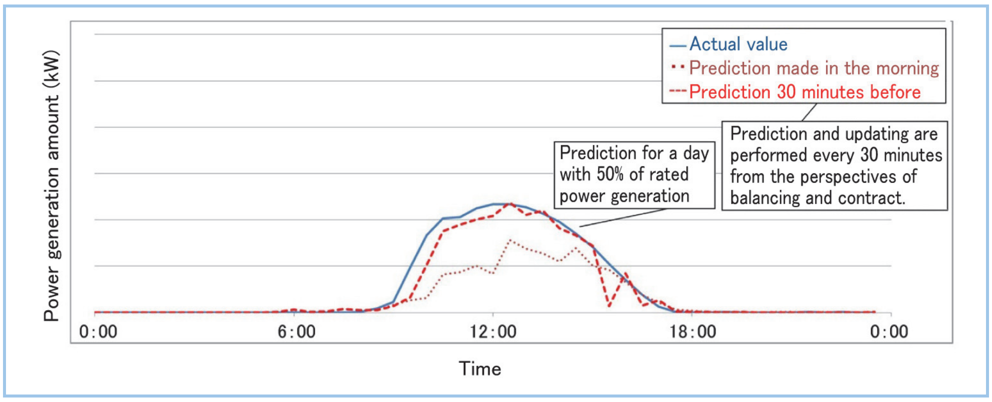


Figure 4　Example of solar photovoltaic power generation prediction

Figure 5 depicts an example of the guidance indication screen. In ESS control guidance, the recommended charge and discharge timing is indicated based on the predicted power purchase amount, which is the difference between the demand and PV power generation amount predictions described above. The improvement of usability based on opinions of the electric power management department of our plant was realized, including emphasized display of the time zone and date, which are especially important among the numerical values that should be obeyed such as the contract power, etc. This example targeted peak-shaving using ESS and obtained the charge and discharge timing for lowering the peak of the purchased power as a result. However, it is also possible to change to a calculation method that meets other needs, such as minimizing the hourly accumulation kWh, making full use of nighttime electric power, etc.

As an effect of guidance based on prediction, more proper operation and a longer service life of ESS are expected due to the factors including the following.

(1) Avoidance of unnecessary charge and discharge by enabling prospective operation
(2) Avoidance of urgent requirement of a large amount of charge and discharge
(3) Combined use with private power generation equipment that requires time to start up

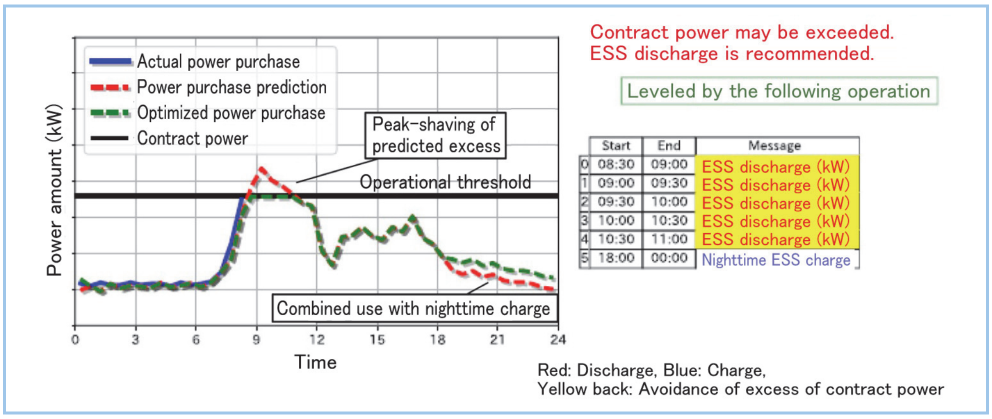


Figure 5 ESS control guidance indication screen

3. Verification test

To verify the effectiveness of the system, a verification test was conducted at the Isahaya Plant of Nagasaki Shipyard in the following two steps.

(1) The person in charge of power monitoring confirmed the guidance screen twice in the morning and at noon.
(2) The time zone requiring discharge was read and a discharge command was input to ESS.

Past verification tests of combinations of renewable energy and ESS in Japan and overseas generally discharged ESS by automatic control. Some consumers independently incorporate automatic ESS control logic. In particular, automatic control target values such as peak-shaving target and recharge amount are required. On the other hand, there is no prediction of the demand and renewable energy power generation amount, so there are cases in which it is difficult to specifically determine those figures. With an emphasis on that, in this test, to increase the leeway of the system while allowing the user to set guidance command values only based on prediction as the control target values of ESS, a step where the user who receives the guidance determines whether discharge is necessary is provided. In addition, verification was carried out characteristically at a plant that is actually operating, not a verification test facility. To allow the introduced system to have an effect with additional work that does not interfere normal work, the operation of ESS was not performed based on the guidance at all times, but only at times when it was predicted that discharge was necessary. This results in an operational framework that does not affect the other management tasks of the person in charge of monitoring.

Figure 6 illustrates an example of the peak-shaving for the prediction and guidance in Figure 3 to Figure 5. At the point of confirmation at 9:00 in the morning, the amount of power purchase is predicted based on the prediction results of the demand and PV generation amount, and guidance is generated so that the ESS operation threshold will not be exceeded. At this time, the person in charge of electric power monitoring of the user determined that discharge as described in the table on the right of the guidance screen was necessary, and input the discharge amount as a command to ESS. As a result, the amount of power purchase decreased due to discharge. In addition, the peak power purchase amount was understood by the prediction at 9:00, and it is indicated that a peak-shaving of about 7% was achieved by ESS discharge.

The guidance function being verified this time can be similarly applied to private power generation facilities such as gas engines, for example. This versatility is one of the features of the

ENERGY CLOUD™ Service, and we will continue development toward maintaining versatility even if the system configuration changes in the future.

Increasing the accuracy of the renewable energy prediction itself is an issue in development, but we plan to further improve this through the future utilization of highly-accurate weather information which has been extensively studied outside the company. In addition, by allowing users to not only use the results derived by machine learning directly, but also to later add adjustments such as reflecting the weather and operation information that the user confirmed on that day, we will continue to improve both functions and accuracy to meet more diverse needs and work on the improvement of serviceability.

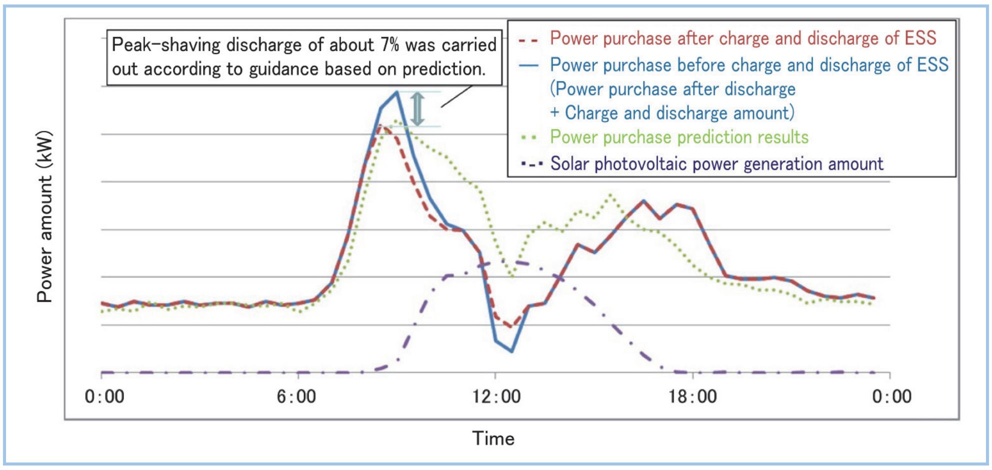


Figure 6　Example of peak-shaving based on guidance

4. Conclusion

As a method to utilize renewable energy, we developed a system using the prediction of demand and renewable energy and a guidance function, and carried out an effectiveness verification test at an operating plant. It was indicated that peak-shaving is possible by charge and discharge operation using only prediction results without using automatic control and that the system is effective.

Looking ahead to future developments for customers outside our company, we plan to continue to improve the system in the future. Firstly, we will study cooperation with equipment owned by the user, aiming at the maximization of the power cost reduction effect through guidance directives and then will enhance machine learning prediction, a core technology, aiming to provide a new solution service. We will also continue preparations to provide customers outside our company with the knowledge gained through our efforts in our plants and contribute to the effective utilization of the renewable energy sources of customers.

References

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