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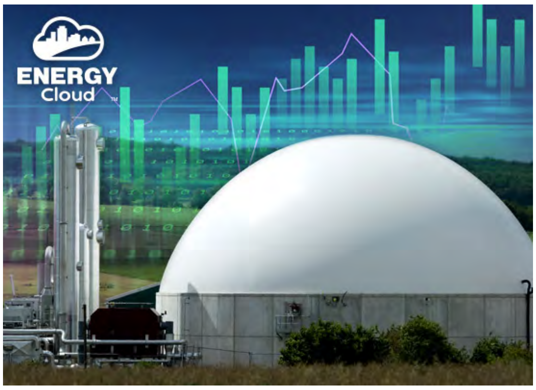
One Stop Solution for Everything from Prediction to Failure and Influencing Factor Detection AI Support for Biomass Power Plant Business



YUSUKE YAMASHINA[*1] YUDAI KATO[*2]
TAKANOBU MATSUBARA[*3]

Among renewable energy sources that are spreading toward the realization of a low carbon society, biomass power generation is expected to contribute to waste reduction. Meanwhile, against the background where operation & maintenance (O&M) has been advanced due to the progress of AI&IoT technology, the optimization of entire production lines across equipment or entire plants, in addition to the stable operation of individual pieces of equipment, is desired.

This report presents a case study of utilizing AI&IoT technology for the O&M of a biomass power plant and realizing the improvement of efficiency in operation management.

1. Introduction

The use of renewable energy has been spreading toward the creation of a recycling-oriented society aiming at reducing waste in response to growing interest in greenhouse gas control on a global scale. In recent years, making a contribution to regional revitalization is becoming more important, so biomass power generation that can use food waste and livestock manure as an energy source is attracting attention.

However, there are many biomass power plants that are not operated and controlled by a distributed control system (DCS), etc., because they are smaller in scale than thermal power plants and chemical plants. In particular, biomass power generation has the problem that it is difficult to make a power generation plan because the amount of generated biogas accompanying methane fermentation largely depends on the properties of collected resources to be used and the activity state of microorganisms and the monitoring and control of these with sensors is difficult. In addition, management of amount of biogas generated is based on implicit matters such as the knowledge and experience of workers, so the succession of skills is also a problem.

This paper introduces how the O&M of a biomass power plant changes by applying the ENERGY CLOUD™ Service, which is a comprehensive energy solution service utilizing proprietary AI&IoT technology, based on the case example of Biomass Power Shizukuishi Co., Ltd.

2. BPS

2.1 Business scheme

Biomass Power Shizukuishi Co., Ltd. (BPS) is the first private-sector-led biomass power generation company in Japan established through investments by Koiwai Farm, Ltd., Shizukuishi Town, Tohoku Electric Power Engineering & Construction Co., Inc., Tokyo Sangyo Co., Ltd., and Mitsubishi Heavy Industries Environmental & Chemical Engineering Co., Ltd. BPS conducts regional recycling of resources and energy through the complex processing of livestock waste and food waste from Koiwai Farm.

Figure 1 shows the processing flow of BPS. Livestock manure collected from Koiwai Farm is solid-liquid separated into solid matter and residue-removed liquid. The residue-removed liquid

*1 CIS Department, ICT Solution Headquarters
*2 Power & Energy Solution Business Planning Department, Power & Energy Solution Business Division, Power Systems
*3 Chief Staff Manager, ICT Project Department, ICT Solution Headquarters

is put into a methane fermentation tank together with food residue collected from the surrounding area. In the methane fermentation tank, biogas including methane gas and digestive liquid (liquid after methane gas recovery), which is a fermentation residue, are generated. The methane gas is used for power generation, the generated electric power is used on-site, and the surplus electricity is sold. The digestive liquid, which is a fermentation residue, is returned to agricultural land as liquid fertilizer, and the solid content of livestock manure resulting from solid-liquid separation is sold as good compost.

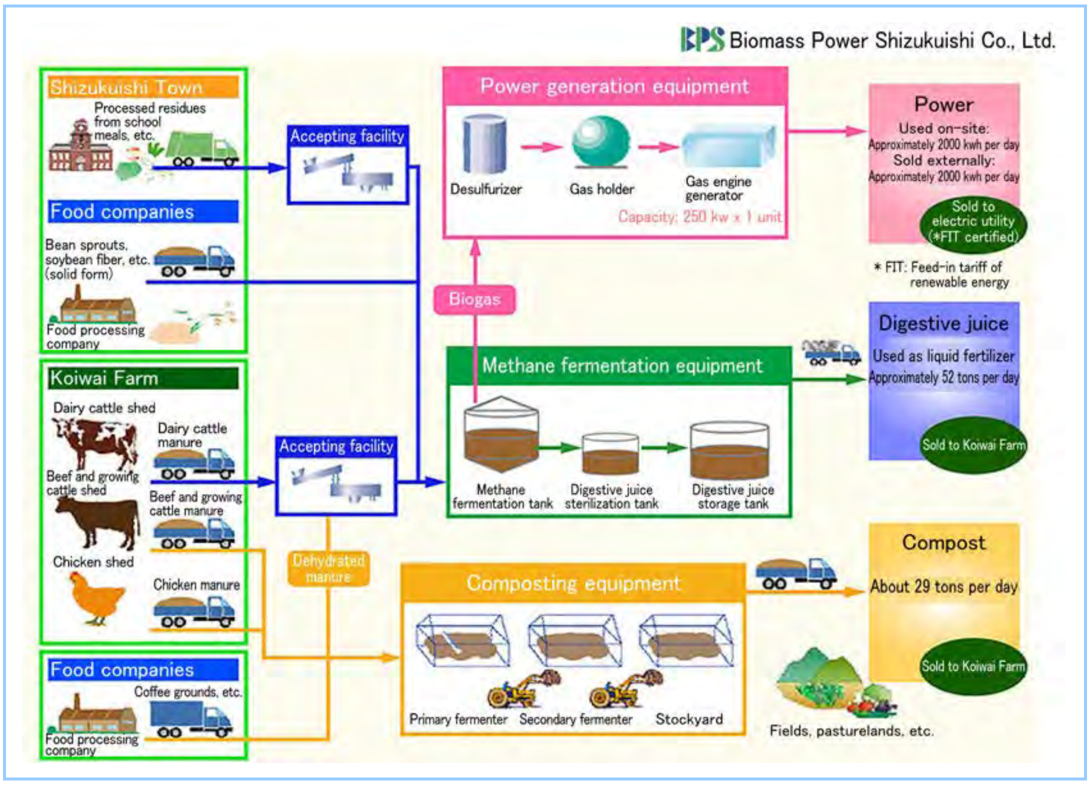


Figure 1 Processing flow of Biomass Power Shizukuishi

2.2 Problems of O&M in BPS

Biomass power generation business that supplies regional-recycling carbon-free energy requires improvement of business profitability through efficient operation. **Figure 2** illustrates the problems in BPS.

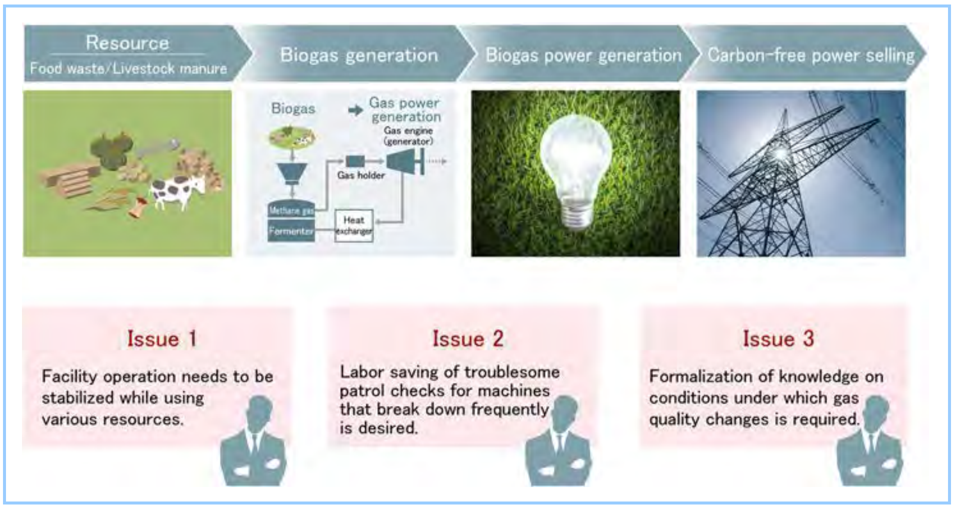


Figure 2 Problems in BPS

(1) A wide variety of resources are delivered to BPS. In addition, BPS accepts such resources every day, because farms have no days off. Therefore, it is extremely difficult to accurately ascertain when and how much biogas will be generated. Biogas is temporarily stored in the gas holder, but the surplus is burned when the generated biogas exceeds the storage capacity

of the gas holder. Conventionally, the timing and amount fed into the fermentation tank is adjusted so that no surplus occurs based on empirical judgment.

(2) Since the facilities are not fully equipped with various sensors, the state of equipment is confirmed by patrol checks, so abnormalities are dealt with when they occur. Delays in response to abnormalities are directly linked to business operational risks, but there is no mechanism to easily detect abnormalities at present.

(3) Since the properties of produced biogas vary depending on the resources being used, the amount of electricity generated varies even when the amount of biogas is constant, making it difficult to plan for selling the power.

ENERGY CLOUD™ is used to solve these problems, and **Figure 3** presents an outline of how they were solved. For the details of ENERGY CLOUD™, refer to the introduction in this feature issue.

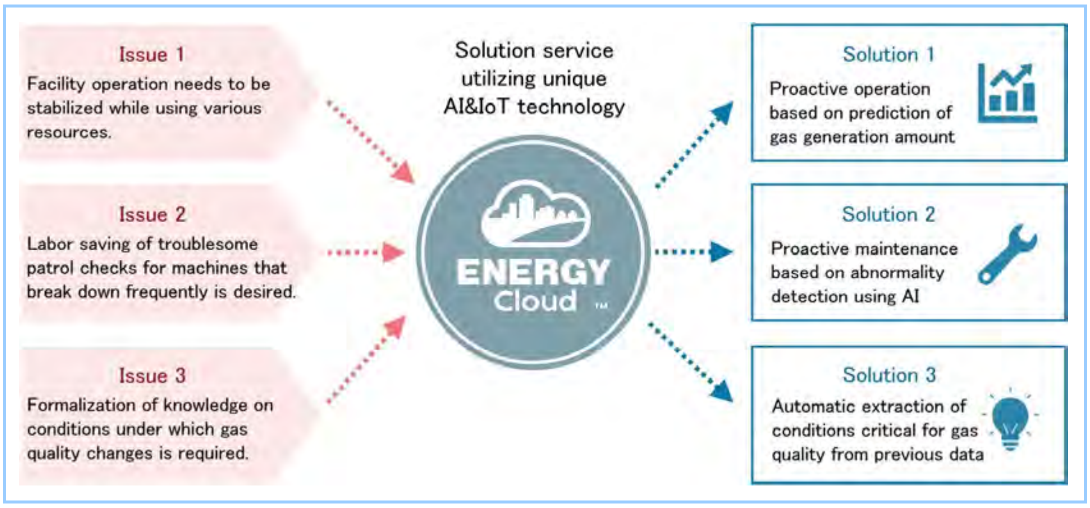


Figure 3 Outline of how problems are solved

3. Business operation utilizing AI

3.1 Prediction of amount of biogas generated

To efficiently generate electricity while accepting a wide variety of resources, the amount of biogas generated is predicted using AI technology and the possibility of making operational decisions in advance is verified.

To predict the amount of biogas generated, it is necessary to construct prediction expressions in a deductive manner based on the components of the delivered materials, the decomposition rate, etc. However, it is not easy to uniformly define these factors for a wide variety of resources. In addition, because such a wide variety of resources is accepted, there is the possibility that the resources may contain toxic substances that inhibit the activity of organisms. Furthermore, as can be seen in the process flow in Figure 1, there is a residence time of several days at each facility, and a time lag occurs between the feeding of resources and the generation of biogas, so previously it was difficult to accurately predict the amount of biogas to be generated.

With ENERGY CLOUD™, it is possible to perform analysis utilizing not only the operational data and various sensor data acquired by DCS, but also information such as daily operational reports and production plans. In the case of this verification as well, whether the inductive prediction of the 1-day later, 2-day later, and 3-day later gas generation amounts is possible is examined. For analysis with ENERGY CLOUD™, a prediction technique adopting an ensemble learning method incorporating proprietary technology is used. **Table 1** gives the verification conditions and results, and **Figure 4** presents the prediction results on August 26, 2016. The error is only 13% even for the amount of biogas generated after 3 days, for which the divergence is largest, meaning that accurate prediction is possible. As a result, it was confirmed that applying ENERGY CLOUD™ makes it possible to make operational decisions in advance. In this verification, the prediction error is defined as the value obtained by averaging over the verification period the values obtained by calculating the ratio of the difference between the true value and the predicted value on a daily basis.

Table 1 Verification conditions and results

Item	1-day later prediction	2-day later prediction	3-day later prediction
Learning data	Nov. 1, 2006 - Jun. 30, 2016		
Verification data	Jul. 1, 2016 - Sep. 30, 2016		
Prediction condition	Prediction of 1-day later gas generation amount	Prediction of 2-day later gas generation amount	Prediction of 3-day later gas generation amount
Explanatory variable	Daily report (delivered amount)		
Prediction error	10%	12%	13%

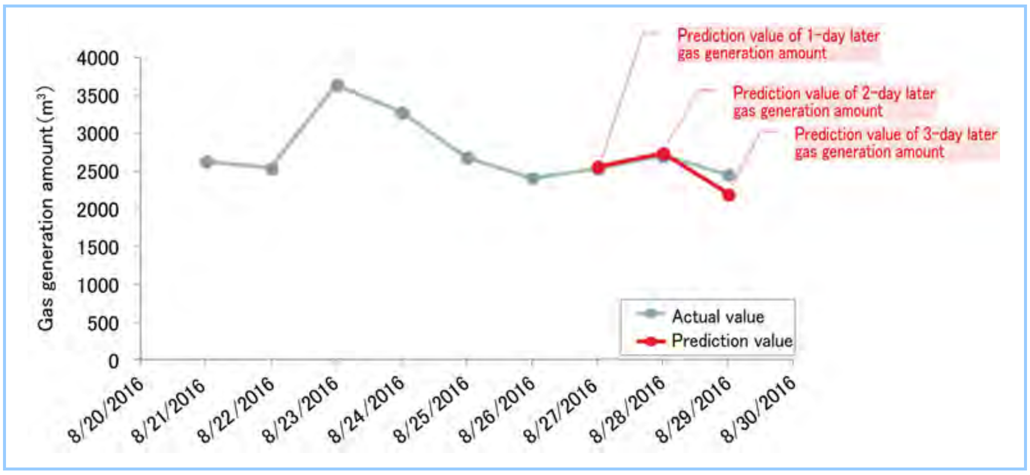


Figure 4 Prediction results (on August 26 for example)

3.2 Condition management of machinery and equipment

This section presents condition management using IoT technology. The receiving facility of BPS uses a crushing pump with cutting blades to make utilized resources finer. However, since various kinds of resources are delivered, sometimes problems caused by blockage occur. These problems, which are difficult to detect using methods other than daily patrol checks, are dealt with when they occur. However, the delay in response is one of the factors that increase the business operational risk. Therefore, the condition management of machinery and equipment utilizing Netmation eFinder^{TM}, which is introduced in another report in this feature, is verified.

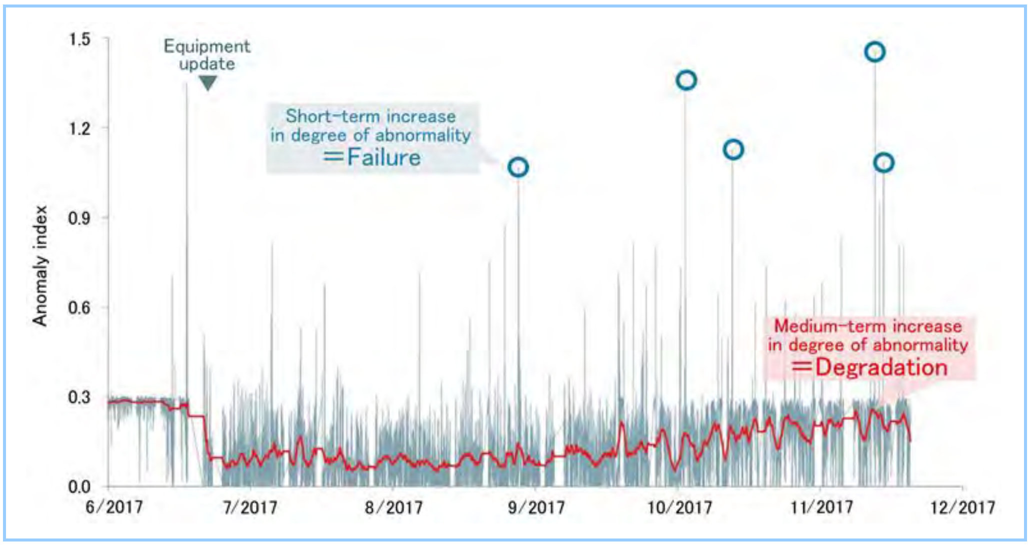


Figure 5 Abnormality detection results

For condition management, an anomaly detection technique using the crushing pump operational data acquired by Netmation eFinder^{TM} is used as an explanatory variable. The anomaly detection technique is a method of defining a normal space for time series data and calculating the degree of abnormality by obtaining the distance from the space. **Figure 5** shows the calculation results of the degree of abnormality. As a result of interviews with project participants, the timing at which the degree of abnormality sharply increased coincides with the occurrence of blockage, so it was confirmed that abnormalities could be detected. With ENERGY CLOUD™, the analysis results can be checked on a browser, which makes it possible to detect blockages from an office and contributes to the lowering of the business operational risk due to the quick response time and also to a reduction of the frequency of patrol checks (labor saving). The short-term increase in the degree of abnormality given in Figure 5 indicates a problem associated with blockage. On the other hand, the medium or long-term increase in the degree of abnormality, which decreases after the maintenance of the equipment, can be regarded as age-related deterioration of the equipment. As a result, it was confirmed that not only can detection of sudden abnormalities be achieved, but so can the optimization of part replacement timing.

3.3 Biogas properties

Finally, by using ENERGY CLOUD™, the properties of the biogas to be generated (the amount of power generation per unit amount) can be visualized and conditions that will affects the biogas properties if they occur simultaneously are automatically extracted to clarify the conditions under which the amount of power generation increases or decreases. **Figure 6** and **Figure 7** provide examples of the visualization of the biogas properties and the results of condition extraction, respectively. Figure 6 indicates that the amount of power generation fluctuates even with a constant amount of biogas generated. The condition extraction illustrated in Figure 7 uses the high power generation zone and the low power generation zone that are classified by the visualization of the biogas properties as objective variables to extract the conditions classified into each zone using a decision tree. This example indicates that when the gas generation amount on the previous day is large, high power generation tends to occur. In this way, planning of power selling can be supported by grasping the biogas properties in advance. In addition, it is possible to formalize the knowledge cultivated by the experience of skilled workers and support the sharing and transfer of technology.

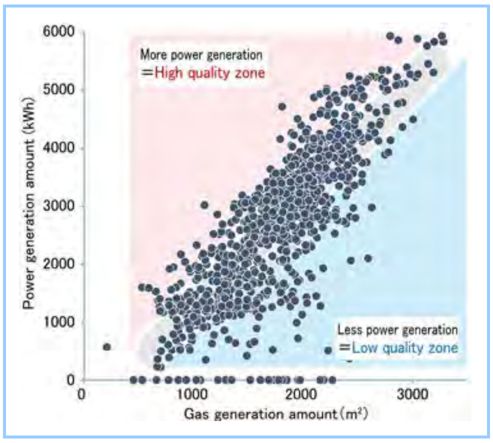


Figure 6 Visualization of biogas properties

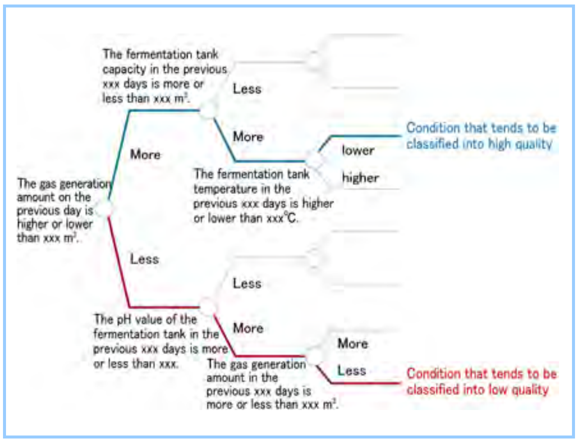


Figure 7 Results of condition extraction

4. Conclusion

This paper presented the O&M of a biomass power plant applying the ENERGY CLOUD™ Service, which is a comprehensive energy solution service utilizing proprietary AI&IoT technology.

The ENERGY CLOUD™ Service made possible the prediction of the amount of biogas generation, which was conventionally difficult, with high accuracy based only on daily report data and changes of the preceding operation conditions, and also facilitated stable and efficient operation. In addition, by utilizing the IoT device Netmation eFinder™, it is possible to manage the condition of machinery and equipment, to detect abnormalities early on and to optimize and visualize the maintenance timing. Furthermore, by extracting the conditions that affect the biogas properties, a contribution to technology transfer can be made.

Going forward, we will consider the utilization of AI from a management perspective, such as the pricing of utilized resources according to the amount of generated biogas, and develop technologies that can support O&M from a wider perspective.

References

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(2) Biomass Power Shizukuishi Co., Ltd., http://www.bps-koiwai.co.jp