Energy Management Solutions to Support Energy Conservation Activities

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ABSTRACT

The energy environment that surrounds Japanese businesses is becoming increasingly severe with demands for reductions in energy consumption. Environmental improvements that make day-to-day and continuous energy management possible have become necessary. In order to resolve the many issues that reside in the current state of energy management systems, Fuji Electric is working on energy management solutions that take into consideration both the supply side and the demand side. Energy analysis templates and the energy conservation navigation function based on the MainGATE/PPA process performance analysis package improve operation systems. The energy conservation operation framework contributes to improvements in the customer energy conservation work process.

1. Introduction

With the revision of the "Law Concerning the Rational Use of Energy" (Energy Conservation Law) and the strengthening of regulation and standards such as ISO 50001, an international standard for energy management issued in June 2011, as well as concerns about medium-term tightness in the supply and demand of energy due to a revised national energy policy resulting from the effects of the Great East Japan Earthquake, Japanese companies find themselves surrounded by an environment of increasing demands for lower energy consumption and peak shifting of energy usage.

In the efforts to reduce and peak-shift the energy consumption by companies, limits are already being seen in the effectiveness of individual and local measures, and corporate management needs to be challenged to provide a company-wide environment that supports daily and continuous energy management and improvement.

Among the various energy conservation activities and techniques, this paper focuses on energy management and energy conservation analysis, and categorizes the present challenges. As solutions to overcome these challenges, a framework for energy management solutions provided by Fuji Electric and a newly developed push-type information delivery function known as "energy conservation navigation" are introduced herein.

2. Challenges Facing Energy Conservation Activities

"Energy management" is attracting attention as a key word for energy conservation activities. Table 1 summarizes recommended improvements that were submitted to the Energy Conservation Center, Japan in response to plant energy audits from 1997 through 2005 for various companies. "General management" (mainly energy management) is the most common recommendation, and accounts for one-third of the total. Moreover, if facility operation management, reference value management and the like are included, the improvement recommendations account for more than eighty-percent of the total.

In regards to recent "energy management" activities, attention is focused on the collection of energy supply and consumption data, and on the provision of an information infrastructure to analyze energy savings using that collected data.

It is often observed, however, that the essential energy data cannot be collected, or that the energy data is collected but the various information from measurement values is left as raw data, and is not fully utilized in actual energy conservation management and energy conservation analysis.

In order to improve this situation, solutions are needed to overcome the following three main challenges.

(1) Interdepartmental integrated energy management (1st challenge)

Energy management is typically overseen by an equipment prime mover department that is involved with the energy supply-side, and so the energy management is not integrated with the manufacturing department, business department and the like on the energy demand-side. There is a need for bidirectional integrated supply-demand energy management and energy conservation activities such as energy demand-side operation that is aware of the supply side, and conversely, optimal supply operation whereby the en-

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ergy supply-side is aware of load fluctuations. With energy management based solely on energy data, this challenge would be difficult to resolve, but by implementing management in accordance with the operating state of the facility and the manufacturing conditions at the energy load-side, effective energy management for improving the energy conservation activities becomes possible.

At the stage in which information sharing and total optimization have not yet been implemented among the various departments, measures are needed uppermost to enable energy management that is aware of the energy load-side and to enable improvement activities.

(2) Creation of mechanism for operation and evaluation directly linked to improvement (2nd challenge)

At the stage in which energy data management is performed on a daily basis but a great deal of time is spent performing that data management, and the energy conservation analysis results and managed data are not yet effectively used for improvement, the creation of a mechanism for operation and evaluation that is directly linked to improvement is needed.

(3) Establishment of business processes for energy conservation activities (3rd challenge)

The collection of energy data has been made easier as a result of advances in measurement technology. The construction of an information system for collecting data will establish a means for energy management, the ultimate objective of which to cycle through the PDCA {Plan (to set targets), Do (to improve), Check (to evaluate), Action (to reconsider)} cycle as part of daily work. The establishment of a method for analyzing the collected data and work processes for energy conservation activities are becoming increasingly important.

Table 1 Recommended improvements based on plant energy conservation audits

Recommended improvement items	Percentage to total number of recommended improvements
General maintenance (5,393 items)	(33.6%)
Energy management system	7.0%
Measurement and recording implementation status	6.1%
Management of amount of energy usage	5.8%
Energy specific unit management of main products	5.2%
Management of device maintenance	4.4%
Load leveling measures	3.2%
Process improvement	1.9%
Air conditioning & refrigeration equipment (2,200 items)	(13.7%)
Energy conservation measures	5.2%
Management of air conditioning & refrigeration equipment operation	5.0%
Management of cooling equipment operation	1.6%
Management of auxiliary operation	1.4%
Cold storage & refrigerating equipment	0.5%
Pumps, fans, etc. (2,249 items)	(14.0%)
Management of pneumatic equipment operation	8.1%
Management of pump & fan operation	4.1%
Installation plans for cogeneration, etc.	1.8%
Boiler, industrial furnace, steam system, etc. (2,830 items)	(17.6%)
Management of boiler & industrial furnace combustion	3.4%
Heat insulation, heat retention and prevention of heat dissipation	2.4%
Management of boiler & industrial furnace operation and efficiency	2.4%
Exhaust gas temperature control, Waste heat recovery	2.3%
Utilization of steam drain recovery	1.9%
Management of steam leaks & heat retention	1.8%
Steam operation management	1.1%
Utilization of waste heat & waste water	1.0%
Optimization of steam piping system	0.6%
Management of heat exchanger operation	0.5%
Load leveling of the steam system	0.2%
Lighting, electrical equipment, etc. (3,380 items)	(21.1%)
Management of lighting equipment operation	6.8%
Management of power receiving facility	5.5%
Management of transforming facility	4.2%
Management of electric motor capacity & operation	3.0%
Management of electric heating equipment and operation	1.6%

(Source: Guidebook on Energy Conservation for Factories. The Energy Conservation Center, Japan)

3. Fuji Electric's Energy Management

To realize optimal energy management, energy management that visualizes the challenges (performs a factor analysis of the results) involved in integrating energy supply and demand (Fig. 1), and a PDCA cycle for an energy conservation improvement activity process are important. Through constructing an optimal energy management infrastructure, a "mechanism

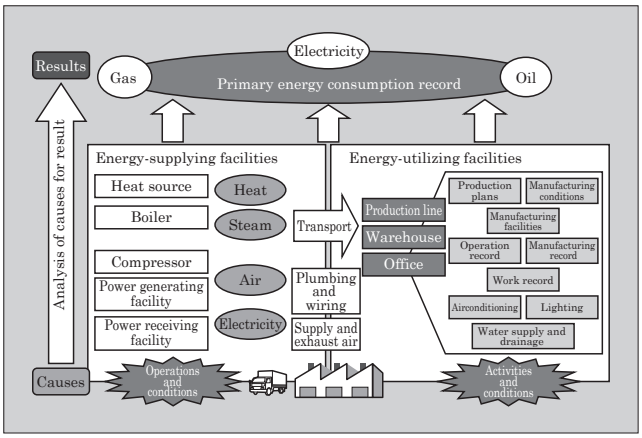

Fig.1 Fuji Electric's "energy management that visualizes challenges"

capable of predictive planning" and a "mechanism capable of carrying out activities" can be provided. The construction of a mechanism for optimal energy management leads to a "visualization of challenges" for energy conservation and countermeasures, and allows the correction of production activities, leading to improved energy operation and energy conservation in accordance with the particular challenge, and the adoption of energy saving devices and control technology, thereby enabling effective evaluations and corrective actions that can be incorporated into daily and regular cyclic energy conservation activities.

In order to realize "energy management that visualizes challenges," Fuji Electric provides an energy management system (EMS) that uses the "MainGATE/PPA" process performance analysis support package.

For the manufacturing industry, the ability to organically combine energy measurement data with operation information about utility facilities and production facilities, production volume, and other manufacturing information, and to perform energy analyses is a major advantage of this system. Moreover, this system can also be used in energy analyses for heat sources, transport dynamics, lighting, electric outlets, air conditioning, and the like for building energy management systems (BEMS) as well.

Moreover, based on the knowledge Fuji Electric has acquired from many years of experience in EMS construction, an "energy analysis template" can be used to construct such a system easily.

For the 1st challenge described above in section 2, Fuji Electric has utilized "energy analysis templates" and MainGATE to realize better visibility of energy management and energy conservation improvement issues with integrated energy supply and demand. For the 2nd challenge, Fuji Electric has developed an "energy conservation function" as a MainGATE add-on function, and has constructed a mechanism for improved operation that directly addresses the challenges. Additionally, for the 3rd challenge, Fuji has prepared an "energy conservation operational framework" that aims to improve customer energy conservation work processes.

3.1 Energy analysis templates

Energy analysis templates support energy conservation in terms of the three perspectives of "energy consumption analysis," "facility/system control analysis" and "facility/system performance analysis" in order to spiral up energy conservation activities. By systematizing the work sequence and points to be visualized in the course of carrying out the management, the templates help to visualize the energy management work processes.

(1) Energy consumption analysis

By organizing energy management flow diagrams from various perspectives, such as energy summaries for each hierarchical layer and summaries for each application (area, process, facility), and by analyzing each load pattern and the energy share of each load time interval, important targets that promise to exhibit a large improvement effect can be identified. Templates for this use are provided.

(2) Facility/system control analysis

Comparative analysis of the energy status of important targets and their respective operating states can lead to improvement of the important targets. Templates for reassessing operation control according to the load, reviewing optimal control methods, and the like are provided in order to transition from individual optimization to total optimization.

(3) Facility/system performance analysis

Through visualizing key performance indicators (KPI) such as the standalone operating efficiency of energy supply facility and the system efficiency of group control facility, the operation of facility having high standalone operating efficiency can be prioritized so as to lead to an improvement in total system efficiency. Templates are also provided that enable the continuous analysis of production volume fluctuations and energy consumption as a result of specific energy consumption (see Supplemental Explanation 2 on page 46) management on the energy usage-side.

Energy analysis templates from these three perspectives are interrelated and are incorporated in Fuji Electric's "MainGATE/PPA" energy management system. "Energy consumption analysis" enables the user to focus on problem locations, "facility/system control analysis" enables identification of factors that contribute to the problems and "facility/system performance analysis" enables operation evaluation directly linked to improvement.

Through activities based on these perspectives, energy conservation activities can be enhanced. Fig. 2 shows examples of the energy analysis templates.

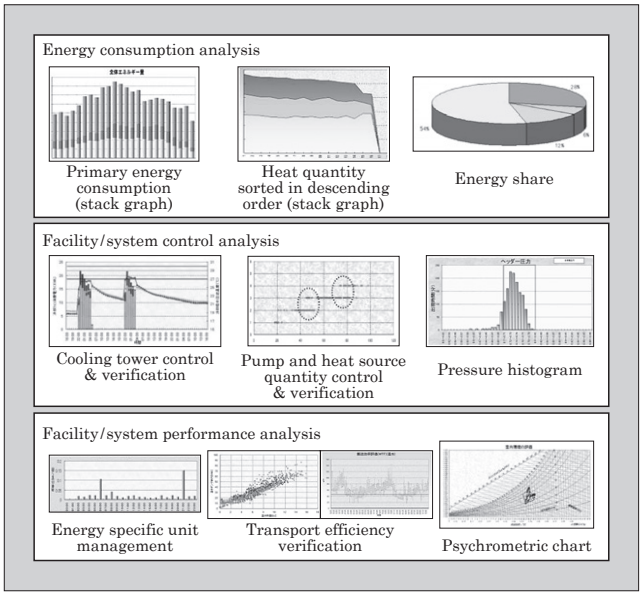

Fig.2 Examples of energy analysis template

Additionally, the MainGATE/PPA package was developed based upon the concept of EUC (end user computing), and when installed, it facilitates the addition of content and performance of maintenance by end users themselves, and provides powerful support for continuous energy conservation activities in accordance with the "energy analysis templates."

3.2 Energy conservation navigation function

To date, Fuji Electric has utilized energy analytic techniques and the MainGATE/PPA from the three perspectives of "energy consumption analysis," "facility/system control analysis" and "facility/system performance analysis" to provide customers with solutions for improving their energy conservation activity cycles. However, there are limits to the human resources and time resources that customers have available for analytic work, and in recent years, in order to discover additional energy conserving items, an environment that supports more efficient energy conservation analysis is sought.

In response to such customer needs, an analysis support environment known as the "energy conservation navigation function" has been developed as an add-on feature to the MainGATE/PPA. This energy conservation navigation function allows relevant energy conservation knowledge of experienced energy managers to be shared and the analytic workload to be streamlined.

(1) Concept

The energy conservation navigation function periodically monitors the status of energy supply and demand in terms of the three perspectives described above in section 3.1, and configures "scenarios" that lead to "awareness" of the relevant issues and that are used to discover energy conservation issues automatically.

Through performing scenario monitoring in real-time, energy consumption factors such as facility deterioration and abnormal behavior, load fluctuation factors, control factors, external factors can be detected in a timely manner, and the energy utilization state can be improved.

In a number of scenarios, in the case of specific energy consumption management, for example, the specific energy consumption may be affected by the operation of energy-consuming facility that exhibits energy usage characteristics uncorrelated to fluctuations in production volume, and by work fluctuations due to human intervention.

The energy conservation navigation function can be used to register scenarios related to the specific energy consumption so that the correlation between the specific energy consumption and the operation state of fasility can be monitored. By automatically specifying the point in time when the specific energy consumption becomes greater than the average value, and then extracting the facility operation status during that same time band, facility that degrades the specific energy consumption and that does not contribute to the production can be identified. Based on the findings of the energy conservation analysis, scenarios for which automatic monitoring is possible can be organized and registered so that facility operation states can be suggested with awareness of the appropriate energy utilization for the manufacturing floor.

(2) Functions

The energy conservation function is an add-on to the MainGATE/PPA, and consists primarily of the following two functions. Fig. 3 shows the relationship among energy conservation functions.

(a) Scenario selection and registration function

With the scenario selection and registration function, a scenario is selected from a list of scenario judgment logic (specific energy consumption evaluation, efficiency evaluation, system loss, comparative judgment, management curve, etc.), and condition setting and management data registration can be carried out according to the selected scenario. Two-stage judgment level settings, reminder messages that correspond to the level, and e-mail message destinations can be registered.

(b) Periodic scenario monitoring and energy conservation advisory action function

This function performs the real-time monitoring of registered scenarios at an appropriate period, and sends a reminder message if the scenario judgment condition is satisfied. Additionally, this function displays a list of energy conservation advisory actions, and outputs an energy conservation analysis template graph that can be used to specify the energy fluctuation factors corresponding to the scenario. Fig. 4 shows the extraction of outstanding values of the specific energy consumption, and specifies the operation time (fluctuation factor) of fluctuating facility affected by the specific energy consumption.

The energy conservation navigation function, through performing real-time monitoring of a variety of KPI, specific energy consumptions and operation control conditions, and comparing a normal energy supply and demand scenario to the actual re-

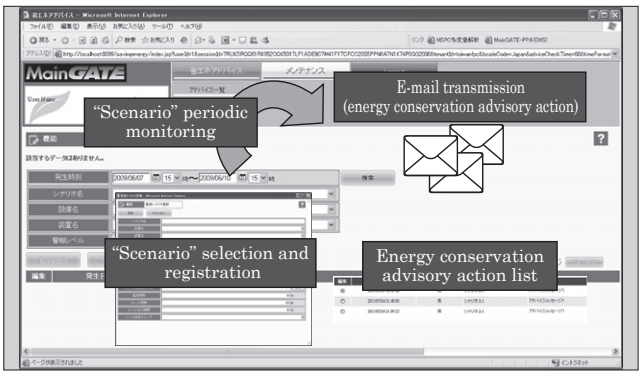

Fig.3 Relationship among energy conservation navigation functions

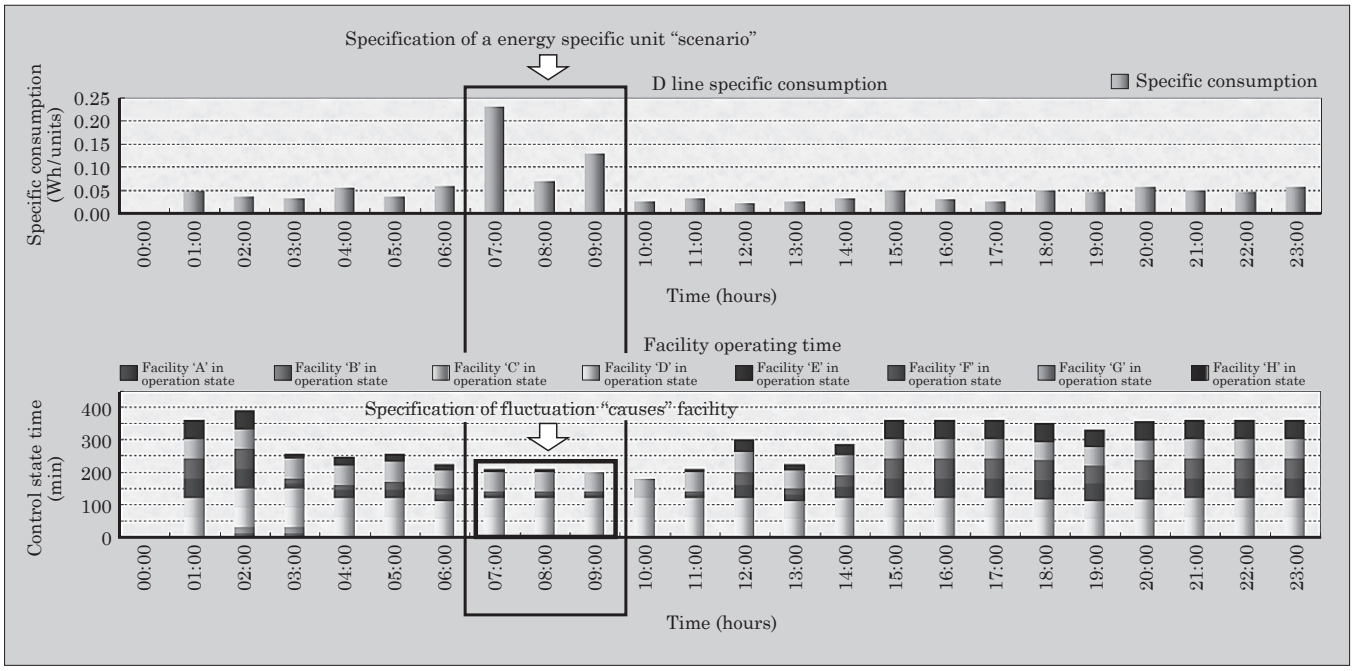

Fig.4 Example of automatic monitoring by energy conservation navigation function

sults, provides energy conservation factors (awareness) and leads to daily improvements.

The various scenarios in the energy conservation navigation function are provided with energy conservation know-how and are also converted into templates, so that they can easily be introduced into customer energy conservation activities.

3.3 Framework for energy-conserving operation

Based on experience in energy conservation and EMS construction, Fuji Electric has systematized the energy analysis templates and energy conservation activity perspectives, management standards, viewpoints and the like, and has entered analysis evaluation specifications into a database to create a database of energy conservation know-how (Fig. 5).

Additionally, based on the workflow of ISO 50001, an international standard for EMS, in each of the various phases of system installation, analysis, revision and so on, customer energy conservation activities and system operation support workflow have been systematized as an energy conservation activity PDCA cycle.

The "energy conservation operational framework" begins with an overall image of the framework, and in accordance with the facility and operation categories shown in Fig. 5, classifies and organizes pre-operation advance preparation materials, perspectives for energy conservation activities, analysis and evaluation specifications that extract effective measurement locations, and examples of energy conservation.

By applying the energy conservation framework to customer energy conservation activity cycles, energy

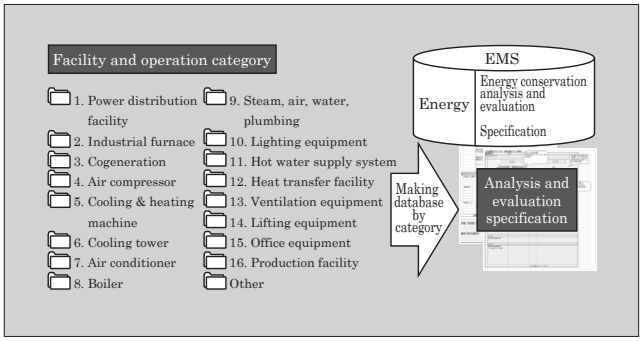

Fig.5 Energy conservation know-how database (Analysis and evaluation specification)

waste can be detected easily and an operation standard for efficient energy management can be provided.

4. Postscript

This paper has introduced Fuji Electric's energy management solutions that support energy conservation activities. Upon this foundation, Fuji Electric aims to build a next-generation EMS that achieves "total optimization of energy supply" and "total optimization of energy consumption" by organically combining renewable energy, electrical storage facilities, heat storage facilities, and utility facilities, for which demand is expected to increase.

References

(1) Guidebook on Energy Conservation for Factories. The Energy Conservation Center, Japan, 2008.