Improvement of Energy Efficiency According to International Standards–EMS Add-On Functions Using Data Analytics

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ABSTRACT

As international regulations and standards become increasingly stringent, Japanese companies are being compelled to enhance energy efficiency by the environment situation surrounding them. Fuji Electric has reviewed current operating and developed new features for our energy management system, leveraging data analytics to improve energy efficiency in compliance with international standards. These features will facilitate the development of the framework of the SDCA cycle to maintain and manage energy-saving activities and will in turn speed up improvement, innovating activity and policy management through the PDCA cycle.

1. Introduction

Japan agreed to reduce the greenhouse gases emission by 26% compared to FY2013 by 2030 as the international public promise under "Paris Agreement" in December 2015. Ministry of Economy, Trade and Industry decided the energy innovation strategy in April 2016 to achieve the target. They set 35% energy efficiency improvement by FY2030, whose level is almost same as post-oil crisis, as the target, with "thorough energy savings" as one pillar of the strategy.

It is predicted that energy demand will increase and energy costs will continue increasing during medium and long term globally with the background of expansion in energy usage in developing countries. To support such world circumstances, the international standard ISO 50001 on energy management system (EMS) has been issued and actively introduced by overseas companies in Germany, the United States, China and other countries.

While regulations and standards are strengthened globally, in addition to the energy saving measures for each facility, finer and efficient operation of facilities according to energy demand is being required recently. Company measures of energy efficiency improvement locally or by departments has reached the limitation. Positioning the energy efficiency improvement as company management task and establishing the energy management base to proceed on improvement daily and continuously are required.

This paper presents the current operation tasks by focusing on the energy efficiency improvement with the current EMS and energy saving analysis approach. Moreover, it describes new functions of EMS that use data analytics, which contribute to the energy operation efficiency improvement according to international standards to settle these issues.

2. Issues in Current Energy Analysis Management System

Fuji Electric has provided the energy analysis management system that uses "MainGATE/PPA" manufacturing result analysis support package (see Fig. 1) to efficiently analyze energy[1].

This package can be used to build a factory energy management system (FEMS) to analyze and manage factory energy by organically combining not only energy measurement data but also operating data of utility and production equipment, production output, and other production data. In addition, a building and energy management system (BEMS) can also be built to manage office and office building energy, namely, heat source, transport power, lighting, socket outlets, air conditioning, and other power sources. We have pro-

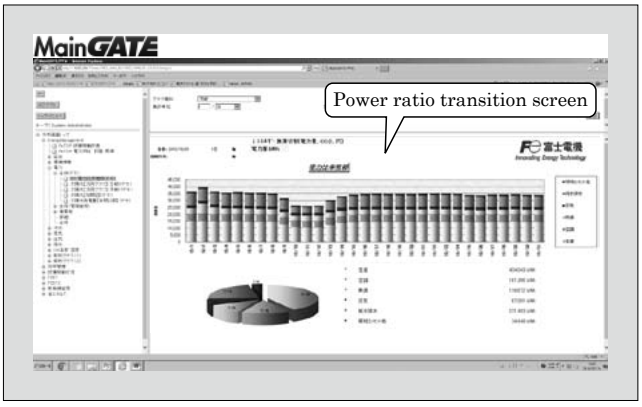

Fig.1 "MainGATE/PPA" analysis display example

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vided energy analysis templates based on the knowledge obtained from long time EMS construction experience to easily build BEMS systems.

Fuji Electric provides an EMS package solution for each of 3 areas below (see Fig. 2).

(a) STEP 1: Visualization
Energy data collection and visualization

(b) STEP 2: Comprehension
Multiangular analysis of collected result data

(c) STEP 3: Optimization
Whole plant optimization with usage of renewable energy, cogeneration and storage batteries

Fuji Electric has provided "comprehension" solutions to support improvement of the energy saving activities cycle (issue extraction from analysis and management and individual measures) by a customer with MainGATE/PPA. However, in many cases, the energy savings activities have not been established and cannot be executed continuously because there are 2 main issues in the operation aspect.

(1) Operation issue 1: Analysis operation process of energy saving activities

PDCA rules and judgment standards of issue extraction approach for energy efficiency improvement do not take root in the customer.

Furthermore, the human and time resources that can be allocated to analysis operation are limited and knowledge of individuals varies. Therefore, establishing and operating the series of energy saving activities analysis and operation process cannot be fixed, such as who sees what information and how the result is evaluated and operated for improvement, even if large amount of data can be collected with a lot of efforts.

(2) Operation issue 2: Crossing departments and integrated energy saving improvement activities

The energy saving activities are responsibilities of energy utility equipment departments related to the energy supply side and activities integrated with the manufacturing departments and operation departments at the energy demand side are not executed. The energy utility equipment departments would like the energy saving awareness and activities to take root in the manufacturing departments and administration departments; however, a valid measure cannot be found.

In addition, each layer-independent energy saving activities at the site are disturbed because energy management efforts have become one-way forced management requirement. However, user capability and operation system must be depended on when to use the current functions of MainGATE/PPA by Fuji Electric. Therefore, the energy saving issue settlement process (daily management, issue extraction and individual measures) cannot be established in many cases of improvement activities.

3. "MainGATE/PPA with DD" Energy Operation Efficiency Improvement Package

3.1 Development concept

Fuji Electric has developed the new functions for EMS according to ISO 50006 (energy performance measurement), standard cited from international standard ISO 50001 (EMS) to settle the issues in energy saving activities described in Chapter 2.

For the operation issue 1, we have developed the analysis function for energy loss factors of each energy management unit (organizations, lines, facilities, etc.) specified according to the management frame of ISO 50006 and the automatic diagnosis function. For the operation task 2, we have developed the general-purpose dashboard function where the energy efficiency achievement rate (results/targets), loss factors (control threshold values), etc. are displayed and operation is managed in real-time.

Using these functions allows constructing the operation environment for SDCA cycle to promote the maintenance and management activities for the energy saving activities. Furthermore, reducing loads of analysis operations by a customer allows higher speed improvement and innovation activities and policy management in PDCA cycle (see Fig. 3).

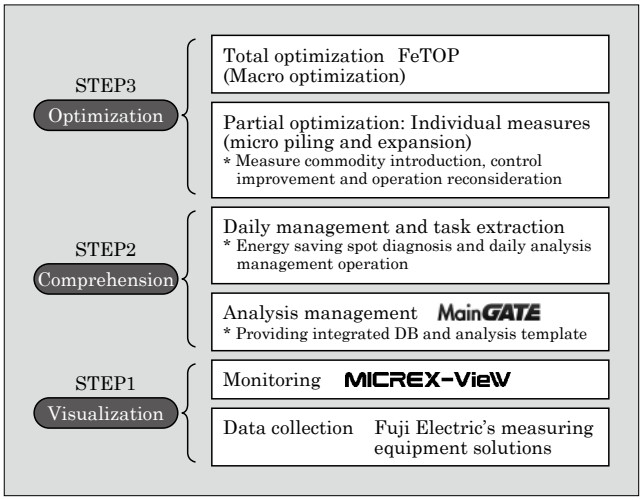

Fig.2 EMS structure by Fuji Electric

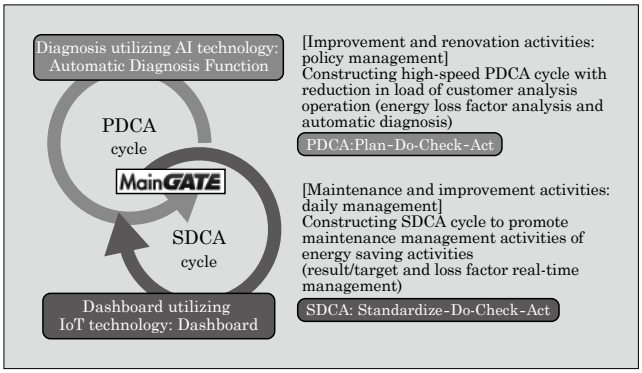

Fig.3 High-speed PDCA cycle and SDCA cycle

3.2 ISO 50006 management frame application

For the energy management, it is important to specify targets to evaluate the energy efficiency change (improvement/drop). In ISO 50006 management frame, the unit to manage some energy performance indicator*1 (EnPI) is called energy managed unit (EMU). We attach importance to daily management of energy efficiency and identifying the related variable (impact factors) that affects the energy efficiency. It is important to specify the management target standard from the past efficiency result data to manage the energy efficiency (energy consumption rate, equipment efficiency, etc.) and to manage the related variable that deeply affects the efficiency (see Fig. 4).

The energy operation efficiency improvement function is configured with EMU as the core. This system structure provides the function that organize the functions group (automatic diagnosis, real-time management function, etc.), which leads various energy operation efficiency improvement, as long as the user only defines data to be collected and their related factors on EMU (see Fig. 5).

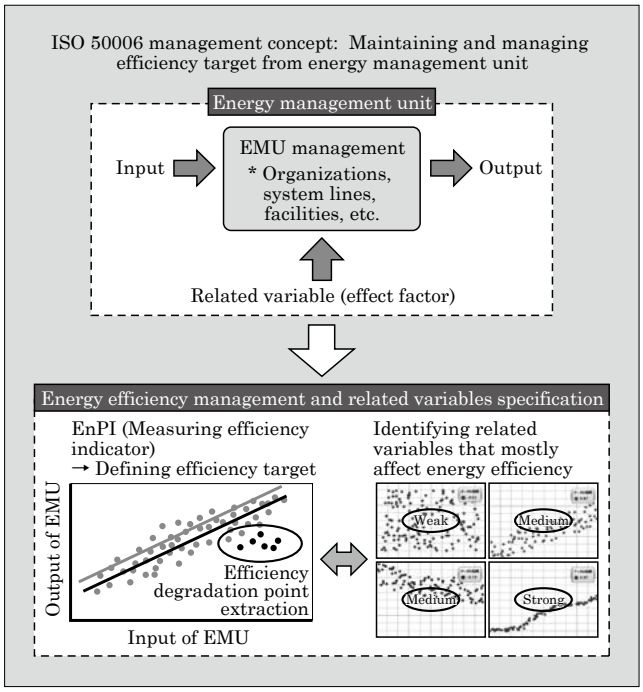

Fig.4 ISO 50006 management frame conceptual diagram

*1: Energy Performance Indicator (EnPI): Measurable result related to energy use amount, energy use purpose, energy efficiency is totally called energy performance. Specifically, they are energy use amount, peak power, energy consumption amount by purposes and various energy efficiency items. Their quantitative values (or scale) specified by an organization are called energy performance indicators (EnPI). They correspond to a ruler to measure energy performance and any indicators can be used for each purpose with judgment of the organization.

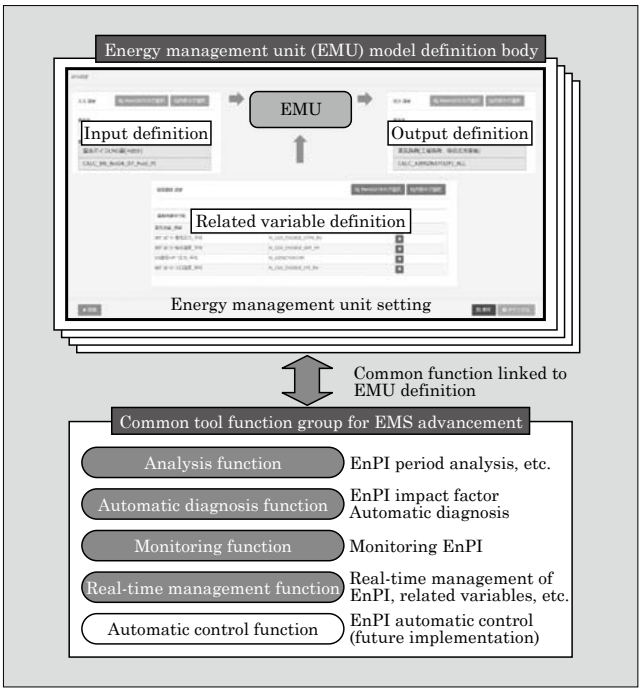

Fig.5 Modeling example based on EMU

For example, in the unit consumption management in some manufacturing process, the user assigns the consumption energy of a process for the EMU input, the production outputs of the process to the EMU output, and unit consumption-related impact factors (facility running information, operation information, etc.) to the EMU control function. After these settings, this product can analyze and automatically diagnose the unit consumption worsened period and impact factors (facility running state, etc. most contributing to unit consumption). Furthermore, deviation from the unit consumption target value can be monitored regularly with the monitoring function. The real-time management function can obtain an energy efficiency target, result separation and related factors that affect efficiency every day, providing an appropriate energy consumption-related operation suggestion on the manufacturing site. In addition, reproducing a model based on the defined EMU for the similar process and facility allows horizontal development and a new energy saving activity can be started quickly.

3.3 Energy operation efficiency improvement function (with DD)

The energy operation efficiency improvement function is an add-on function of MainGATE/PPA, developed on the basis of the development concept described in Section 3.1. It has the following major functions.

(1) Energy management unit (EMU) and energy baseline (EnB) definition function

(a) EMU definition function

EMU can be defined according to the tree layers of the units of facilities, lines, organizations and factories. Internal tags for input and output signals

and factor related information of EMU are created and allocated from MainGATE/DB (database) that is the base of the data. It also has the computing function (4 arithmetic operation functions).

(b) EnB definition function

EnB is an evaluation standard (baseline) to quantify EnPI of each EMU definition in the specified period. Multiple efficiency target baselines can be defined from the past result value narrowed down to arbitrary period grouped by seasons and operation forms and operation condition for each defined EMU. In addition, the result values deviated from a normal range can be checked on Graphical User Interface (GUI) and the result value deviated on GUI can be removed to improve the baseline accuracy (see Fig. 6).

(2) Energy efficiency factor item extraction and monitoring function

(a) Analysis function in impact factor related strength calculation

When the related strength is calculated for the impact factor defined on EMU, analysis can be executed such as extracting the impact factor with high related strength based on the size of the correlation coefficient of the impact factor on EnPI for defined multiple EnB. In addition, there is a function where setting specific period data (manufacturing shift switching time, rest time, etc.) and related factor data boundary (specific temperature area, etc.) on EnB extracts the efficiency worsened point factor on GUI.

(b) Automatic efficiency monitoring function

The target baseline and alert baseline can be defined besides the baseline set with EnB definition function. The periodic monitoring function can monitor the point that is deviated from the alert baseline boundary (efficiency drop point) (see Fig. 7).

(3) Real-time management function

(a) General-purpose dashboard function

The dashboard function is included so that site operators can see information that they would like to see when they would like to see. Selecting a layer in the dashboard list (the same organization tree as

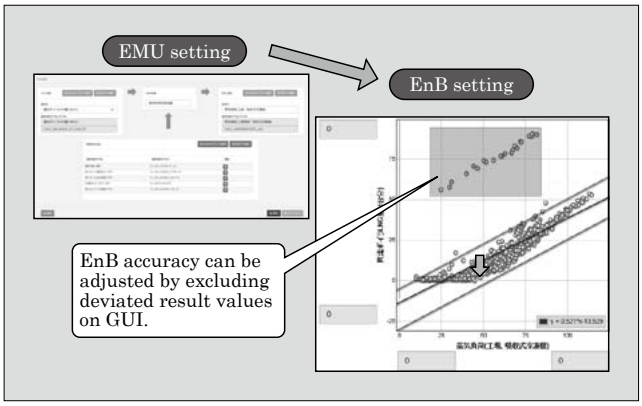

Fig.6 Baseline setting for energy management unit

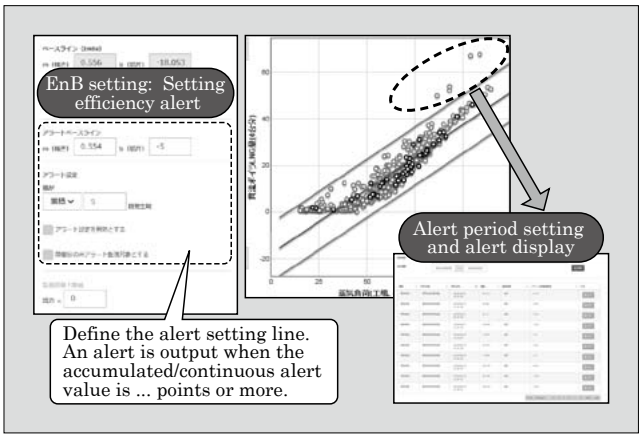

Fig.7 Energy efficiency factor item extraction and monitoring function

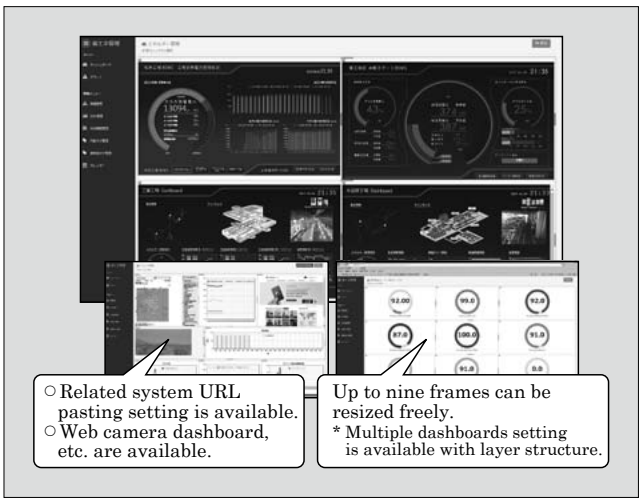

Fig.8 General-purpose dashboard function

EMU) displays the dashboard according to the setting. The dashboard can be changed to arbitrary frame size and consists of 9 frames (areas) (see Fig. 8). Each frame can display a line/bar graph, meter display, numeric value display, target/result management, simple screen creation, URL link, etc. In addition, the setting screen can be called any time to set and change the display format and display target data freely.

4. Automated Diagnosis Engine for Energy Efficiency Factors

We have developed the analytics engine to automatically diagnose the energy efficiency factors from the result data in addition to the function described in Chapter 3, to get higher speed and advancement of the analysis operation cycle in energy efficiency improvement activities.

4.1 Engine function

(1) Input to analytics engine

To diagnose the energy efficiency factors, the fac-

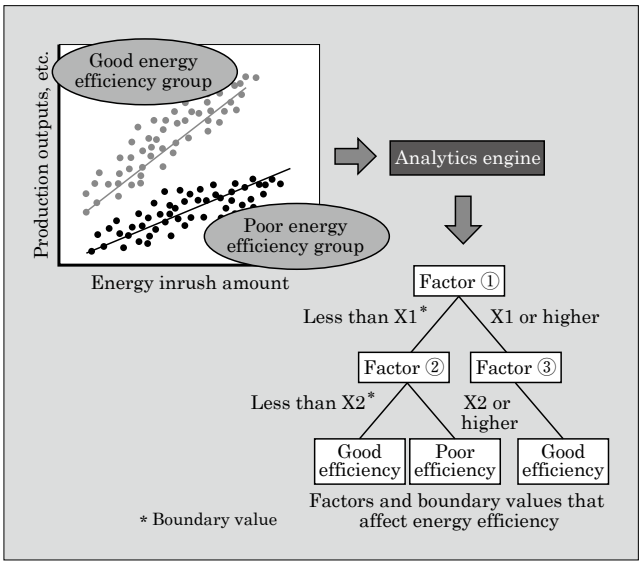

Fig.9 Analytics engine conceptual diagram

tors that generate differences between when the energy efficiency is good and when it is not good, must be extracted. Data groups with labels of good efficiency and no good efficiency each shall be input to the engine to extract the factors. These labels shall be attached based on EnB described in Section 3.2. The labels may be attached to the data groups specified by a user on GUI.

(2) Functions of analytics engine

The analytics engine learns the labeled data as teacher data and automatically creates a model to explain (predict) the label. Extracting explanation factors from the model, the user can determine the factors that significantly affect the label (good/not good of energy efficiency). In addition, values of what related variables and what period affects the energy efficiency can be analyzed because the label prediction boundary values (related variable boundary and time boundary) can be extracted (see Fig. 9).

4.2 Analysis case and evaluation

To evaluate the analytics engine functions, analysis was executed with result data of a plant (see Fig. 10).

(1) Target case

Plant utility steam supply boiler

(2) EMU definition

(a) Input to EMU: Boiler fuel

(b) Output from EMU: Steam supply amount

(c) Related variables: Boiler operation-related various measured values

(3) Analysis result

The result that steam differential pressure largely affects the energy efficiency was obtained as the factor that affects the energy efficiency of EMU defined above.

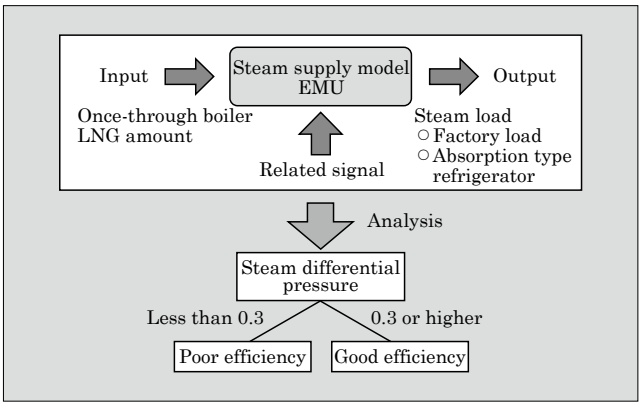

Fig.10 Analytics engine analysis case

(4) Result evaluation

The result that the steam differential pressure affects the energy efficiency of boiler operation was obtained through the analytics engine. This result was the same as the result of analysis executed by an experienced operator with a lot of manpower and time. In addition, for the boundary value of the impact of steam differential pressure on the energy efficiency, the result with the analytics engine was almost the same as the result with manpower.

5. Postscript

EMS add-on functions that use data analytics which contributes to the energy operation efficiency improvement according to international standards were described.

The necessity of energy customers to solve their own energy and environmental problems as management tasks has been increasing with the viewpoints of various laws and regulations, international standards and CSR, and impact of energy unit price jump.

Fuji Electric will take advantage of the current energy management solutions (visualization, comprehension and optimization) and the newly developed efficiency improvement function for energy operation. We will then organically combine the information on energy storage equipment, utility equipment and production equipment, and new energies including renewable energies whose future demand is expected to increase. In this way, we intend to aim establishing the automatic diagnosis technology and automating control that allows constant highly-efficient operation.

We will support customer activities to save energy and contribute to settle customer issues more than ever.

References

(1) Azumaya, N. et al. Energy Management Solutions to Support Energy Conservation Activities. FUJI ELECTRIC REVIEW. 2012, vol.58, no.1, p.9-13.

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