

Energy Solution Technologies for Energy-saving Society

Authors: *Yoshio Izui**, *Kazuyuki Mori** and *Yasuhiro Kojima**

1. Introduction

The prevention of global warming is an urgent issue. This paper describes the development of energy solutions that fully utilize optimization technologies, that is, energy-saving technologies for large-, medium- and small-size buildings, energy-saving technologies for large factories, and optimum microgrid operation control technology.

2. Technologies for Energy-saving Solutions for Buildings

2.1 Energy-saving technology by optimizing air conditioning in large-size building

We are developing a building energy management system (BEMS) for a large-size building with a total floor space exceeding 10,000 m², which is equivalent to a designated energy management factory.

This section describes the air conditioner central control system⁽¹⁾ consisting of multiple facilities, and optimizing the total operation, connecting a central heat source to air conditioners respectively. The control system incorporates multiple local controls from a broader perspective to minimize the energy consumption of the entire air conditioner system. Figure 1 illustrates the central air conditioner system, featuring the above operation, and its constituent facilities managed by the central control system. It also shows the results of simulations performed on the actual building data.

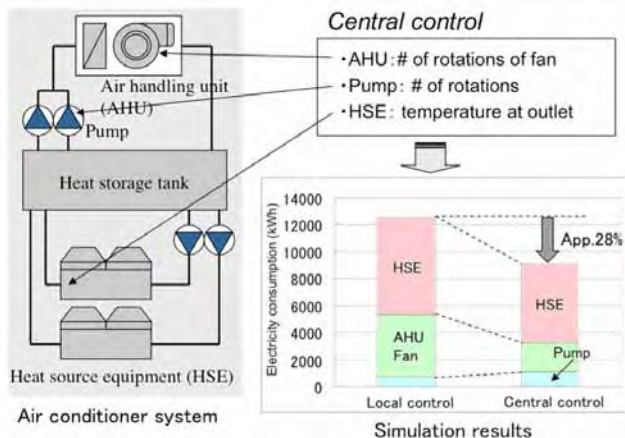


Fig. 1 Central control for air conditioner system

This system models the air conditioner system as shown in the figure, and then applies an optimization algorithm called PSO (Particle Swarm Optimization) to obtain setting values for the central control. The simulation results indicate that the central control system reduces the energy by about 28% compared with existing local controls.

2.2 Energy-saving Services for Medium- and Small-size Buildings

We are working on a system development of energy-saving service in the way of “remote monitoring system,” for medium- and small-size buildings with a total floor space of less than approx. 7,000 m² where energy saving is not heavily promoted. As illustrated in Figure 2, this service is provided from the central information center to medium- and small-size buildings at remote locations. The center collects data on power consumption from the remote buildings and issues a monthly energy analysis report to assist energy-saving activities at those buildings. In the energy analysis report, energy consumption amount is analyzed from various aspects such as a comparison with other buildings, comparison with past data, and correlation with temperature, etc. Also in the report, electric power consumption is predicted for the next month based on the seasonal forecast. This service started in April 2008.

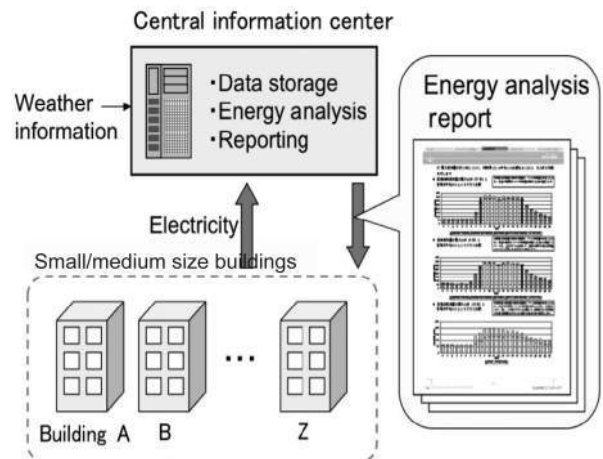


Fig. 2 Energy report service system

3. Technologies for Factory Energy-saving Solutions

3.1 Background of introducing FEMS

In factories' assembly lines such as paper mills and oil refineries where a large amount of thermal and electric energy is consumed, the annual energy cost (hereafter simply called "the cost") may exceed several billion yen. Thus, it is important to reduce this cost, which has led to the introduction of FEMS (Factory EMS) as illustrated in Figure 3.

3.2 Multi-objective optimization technology for factory energy management system

In addition to cost reduction, FEMS is recently required to simultaneously reduce the energy consumption and CO₂ emissions. In the daytime, although in-house power generation with coal is more cost effective than commercial electricity, it increases CO₂ emissions, so there is a conflict between the two objectives of reducing the cost and reducing energy consumption and CO₂ emissions (trade-off relation). It is very difficult to determine which objective should have higher priority.

Therefore, we have developed an improved version of Multi-Objective Particle Swarm Optimization (MOPSO)⁽²⁾ that efficiently finds various optimum solution sets. With this method, various "Pareto" optimum points can be simultaneously obtained. The operation planner need not weigh up the objectives in advance, and thus MOPSO can easily be used for FEMS. We have also developed a method that predicts the effect of introducing FEMS, and have confirmed that the prediction error can be reduced below 1/10 of that of the conventional multi regression analysis.

4. Microgrid Solution Technology

4.1 Background of introducing microgrid

Recently, the introduction of renewable energy systems such as photovoltaic systems and wind farm systems is accelerating. However, these power sources are easily influenced by the weather, and so could have a negative impact on the grid operation if a large number of them are introduced. Consequently, attention is

focused on the "microgrid," which consists of renewable energy systems, electricity and heat demands, and other multiple distributed energy resources (including cogeneration and storage facility systems).

4.2 Optimum Microgrid Operation Control Technology

Our target is to control the supply and demand balance within the microgrid, while considering the power quality and optimizing the economic and environmental metrics, such as the cost and CO₂ emissions. To achieve this target, we have to design each control function with an appropriate time resolution for the characteristics of the corresponding issue. We have been participating in the "Hachinohe City Micro-grid Project," which is one of the "Demonstration Projects for Regional Centralized Power Grids with Various New Energies," sponsored by the New Energy and Industrial Technology Development Organization (NEDO). In this project, we have developed and conducted a demonstration test of the four-levels of supply-demand control system shown in Figure 4, which achieves both optimum control and power quality⁽³⁾.

We have analyzed the operational data from November 2005 to July 2007. The results show that the energy consumption and CO₂ emissions were reduced by 71.3% and 68.9%, respectively compared to those before the microgrid was introduced. Regarding the power quality in terms of the power fluctuation at the interconnection point between the microgrid and the commercial system, the 6-minute moving average error was controlled within 3% and the remaining rate was 99.98%. These results confirmed the effective use of renewable and other new energy sources. In addition, from November 3 to 10, 2007, we conducted an isolated operation control test on private distributed lines. In this test, the city hall and six other users successfully maintained normal operation after being isolated from the commercial system.

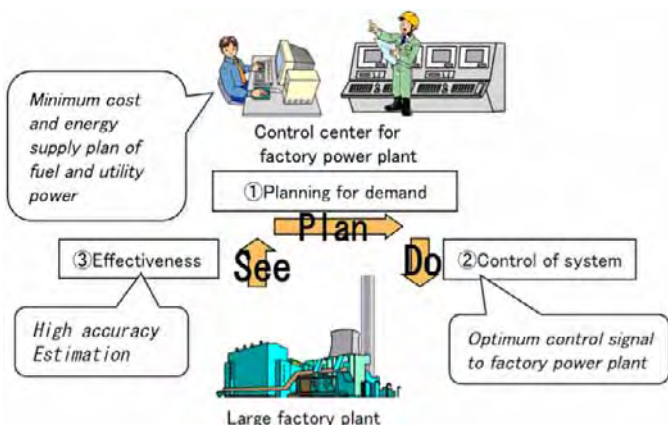


Fig. 3 PDS (Plan/Do/See) flowchart for FEMS

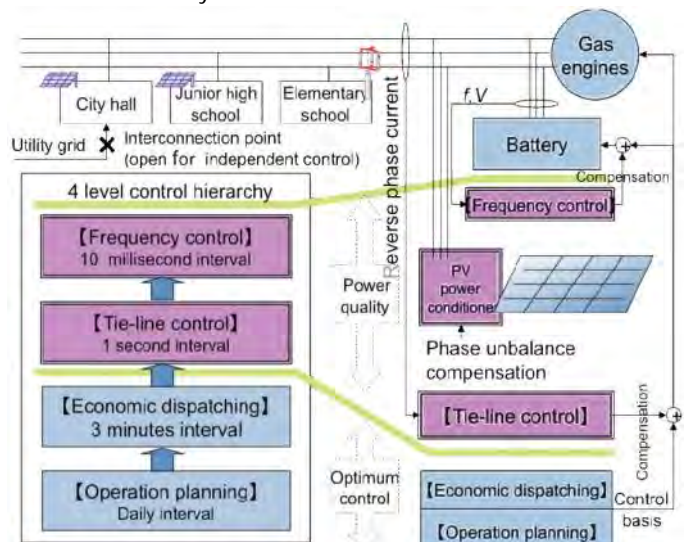


Fig. 4 Four-level control hierarchy with quality control

5. Conclusion

We will continue to improve our optimization technologies and system control technology embedded in high-efficiency energy equipment used in buildings, factories and microgrid systems.

References

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