

Decentralizing Energy Management Systems to Balance Power Supply and Demand

Creating an energy management system that benefits both consumers and power companies.

OGIMOTO LABORATORY

Aiming for long-term sustainability of energy and material supply, Ogimoto Laboratory studies energy system integration to materialize transition strategies for domestic and worldwide energy systems through innovation, infrastructure development, and institutional measures.

Industry: Power and Utilities

Location: Asia

Use Cases: Resource Planning, Routing

Website: www.ogimotolab.iis.u-tokyo.ac.jp/html_e/research_e.html

Results

- Developed a mix integer linear programming method
- Optimized household appliance operations
- Created energy management systems that benefit customers and the power companies

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The use of renewable energy sources, especially photovoltaic (PV) and wind power generation, is now expanding on a global scale. Japan has set high goals for the introduction of these technologies, which have attracted more and more attention following the Great East Japan Earthquake and the Fukushima nuclear accident in March 2011. However, PV and wind power generation are characterized by seasonal and hourly variations as well as irregular variations caused by Komaba II Campus of the University of Tokyo in changes in the weather. Therefore, in addition to balancing supply and demand, to ensure a sufficient and stable power supply we have to also solve various technical problems such as voltage increases and frequency changes.

Supply-Demand Balance

To achieve a supply-demand balance in future power systems, it is imperative

that we should not only apply pumped-storage power generation or large-scale batteries on the supply side but also focus on residential power usage, storage, and generation on the demand side.

The Ogimoto Laboratory is a leader in studies about using the Home Energy Management System (HEMS) to better manage energy through the use of optimization techniques across both supply and demand, including controlling equipment on the demand side to contribute energy to the overall electric power system.

Figure one shows the system for balancing supply and demand where centralized and decentralized energy management work together to address the needs of both the overall power system, as well as the needs of a single building or community.

Under a centralized energy management system, power companies forecast the amount of PV generation and electricity demand in the service area and calculate the optimal load dispatch across the power plants. In situations where there is insufficient

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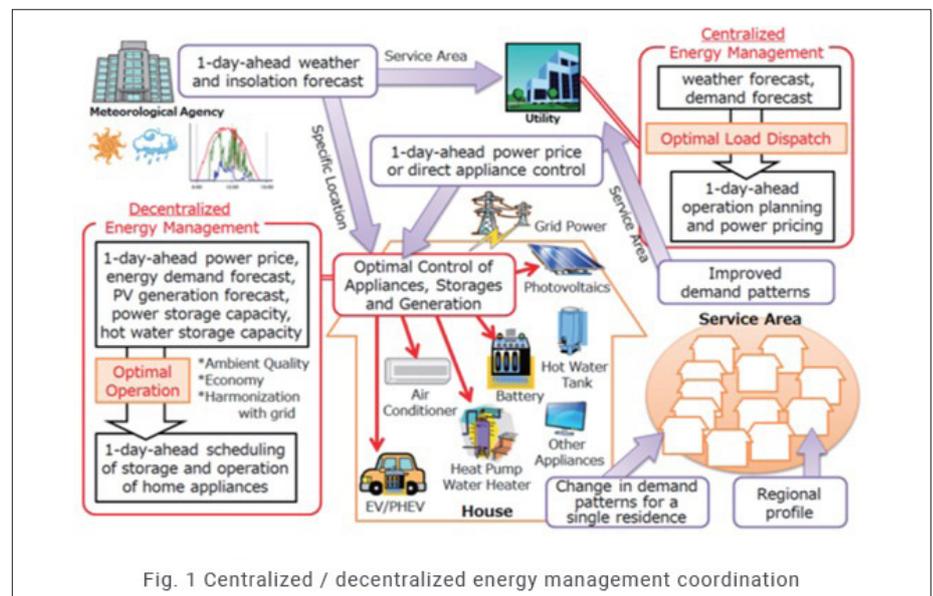


Fig. 1 Centralized / decentralized energy management coordination



capability to balance supply and demand through equipment controlled by the power company, a signal for managing residential power usage could be sent directly to customers prior to the fact. For example, if an increase in demand is desired, a method could be used in which the price for electrical power would be lowered and customers notified a day in advance, or a higher price for power set when a decrease in demand is desired.

On the other hand, the decentralized energy management calculates the most economical operation schedules of domestic electric appliances, within a range that will not interfere with the comfort of living or working environments, by using forecasted energy demand and PV generation and also using next-day electricity prices sent from the utility.

By coordinating localized optimization, attained by implementing decentralized energy management for residences and office buildings, with overall regional optimization, based on centralized energy management performed by power companies, we aim for a system that can fully benefit both consumers and power companies.

Results

The Ogimoto Laboratory is engaged in development of a scheduling model for optimized household appliance operation, which would utilize the

functions of the Gurobi Optimizer mixed integer linear programming method (MILP) to quantitatively evaluate effects of the optimal control of household appliance, using forecasted levels of next-day energy service and PV generation demand, as well as information on demand adjustment incentives from power companies.

As a result of the application of actual residential data, it was discovered that setting lower daytime power rates for clear weather days in May, when the supply-demand adjustment is most difficult in Japan, can create more daytime power demand for residential heat pump water heaters or storage batteries, thus consuming surplus PV power and suppressing reverse flow. In addition, it was confirmed that residential power demand can be used to adjust the supply-demand balance, through a suitable setting of power prices in response to weather conditions.

Using the Gurobi Optimizer

While my research up until this point has utilized other mathematical programming solvers, I began using the Gurobi Optimizer in 2010 after a fellow researcher introduced me to it. Since my research is in the energy field and not in optimization research, an important issue for me was determining how quickly Gurobi could be introduced into the research. Despite the decentralized energy

management model requiring high-speed solutions to complex mixed-integer linear programming (MILP) problems, the Gurobi Optimizer does not require any particularly difficult settings at the time of installation, and I was able to become familiarized with its use in a short time.

With the help of the Gurobi Optimizer, I am now able to solve the MILP problems in much less time, greatly improving research efficiency. While the Gurobi Optimizer is capable of solving MILP problems at high speed, with their focus on continued improvements, we are looking forward to even faster speeds and a more compact size in future. The ability to immediately solve large-scale MILP problems at speeds that make it practical for regular use, marks the first step toward marketability of decentralized energy management systems.

“ I am convinced that with the speed of the Gurobi Optimizer, it will be of great assistance as an optimization technology for solving energy problems.”

Takashi Ikegami, PhD

Ogimoto Laboratory, The University of Tokyo

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