



Navigating Increased Complexity in Renewable Energy

As the Japanese energy industry transitions to renewables, J-POWER leverages Gurobi to match supply with demand.



J-POWER Business Service Corporation is an affiliate of Power Development Corporation (J-POWER). It provides a variety of energy-industry IT, engineering, and business services, including logistics, facilities management, and software development.

Industry: Power & Utilities

Location: Asia

Use Cases: Resource Optimization

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The MR Program: Managing Supply and Demand across a Broad System

J-POWER Business Service Corporation's MR Program (also known as the "wide-area supply-demand adjustment program") simulates future energy supply and demand. We use MR to analyze many key variables, including fuel costs, the potential output capacity of each generator, weather and time effects on renewable energy sources, and shifting demand based on time and season. By using MR to simulate many scenarios at once, we can plan for immediate energy needs and long-term responses to shifting demands (e.g., electric vehicle growth).

Group, I lead the development of the MR program with the Gurobi Optimizer. This program has been key to optimizing the energy market in Japan, which changed dramatically after the 2011 earthquake.

After the disaster, the market shifted from nuclear power to renewables. This switch changed the analytical framework we used to match supply and demand across the grid. While we were able to temporarily expand our old model (known as EPDC System Planning Program Reflecting Interconnection and Transmission (ESPRIT)), we eventually needed a new program that could handle the complexity and frequency of change inherent to a renewable energy system. To facilitate this more complex approach, we created the MR program.

Results

- Facilitated planning supply and demand logistics during Japan's post-earthquake transition to renewable energy.
- With Gurobi, J-POWER more than doubled their development efficiency compared to their previous in-house algorithms.

Adapting Time Scales

To start, we needed the MR program to accommodate variations in the amount of energy different generators create at a given time. Under the old, nuclear dependent power system, we calculated

MR Development and Background

As the sub-leader of J-POWER Business Service Corporation's Power Technology

Solution Provider Spotlight



OCTOBER SKY
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and simulated supply and demand models using monthly units. Since nuclear power can provide constant supply, this made sense.

Renewable energy, however, varies much more over time. Solar and wind generator output, for example, changes significantly depending on weather conditions. Other sources, such as thermal power generators, continue generating power even when the generator stops. Since inertia keeps the turbines going for a while after “stopping” the process, energy continues to be generated. Because of this variation, we needed to project energy demands on an hourly basis over one-year simulations.

To optimize energy allocation, we incorporated those weather- and inertia-based variations into our optimization model at appropriate frequencies to make the best supply and demand decisions, anticipate congestion on the grid, and identify potential shortages before they happen. Unlike our old model, we designed the MR program to adjust based on four time domains, giving us the flexibility necessary to respond to the diversity and variability of energy supply over relatively short periods of time.

Changing Consumer Demand

Another key market shift we incorporated into the MR program was on the demand side: the rise of electric vehicles (EVs). The demand for EVs has only grown, and EV owners vary widely in their charging and discharging needs, from infrequent users to professional drivers who use their cars all day. We designed the MR program to simulate 15 different EV use patterns in each region. This will allow us to accommodate these new demands as they change over time.

Collaborating with MR

The University of Tokyo uses the MR program with public and private sector research partners. As both supply and demand sides of the Japanese energy sector become more complex and diverse, we plan to expand MR as a service that can be adopted by various industry stakeholders.

Using Gurobi

We were one of the first companies in the Japanese energy industry to adopt the Gurobi Optimizer in the late 2000s. Back



then, we used it to optimize generator start-up and shutdown planning. Because of that early adoption, we have years of experience and in-house expertise leveraging the Gurobi Optimizer for our mathematical optimization needs, and we decided to adopt it for the MR program.

Before the Gurobi Optimizer, we used in-house algorithms that were not fast enough to be practical for many questions. Now, we can solve many of our complex questions in about one minute. Currently, we calculate 365-day simulations for 600 generators and optimize in one-day units. Gurobi Optimizer helps us find the optimal solution overnight. With Gurobi, we have more than doubled our development efficiency compared to our previous approach.

As renewable energy sources continue to grow, the energy system will become even more complex. In the future, we will add new constraints and variables to our models. Though the intricacy will grow, we are confident that Gurobi will continue to be even faster, enabling us to deliver high-speed solutions to customers.

Advice for Implementing Mathematical Optimization Techniques

While experience will help a team develop a good model efficiently, I believe that anyone with mathematical knowledge can develop a model with Gurobi. Some

models can even be turned into standard templates, which allows optimization novices to use the Gurobi Optimizer quickly. I hope that over time, more people in a variety of fields will become proficient with this tool.

By employing Gurobi Optimizer, the development of MR's basic functions was completed in just two months. If we had developed this part in-house, it would have taken several times longer to develop and the performance would have been far below that of the Gurobi Optimizer.

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