GUROBI OPTIMIZATION

Minimizing Power Consumption While Satisfying Consumer Demand

Aria Laboratory uses Gurobi to reduce the amount of electrical power consumed by Tokyo's water system by 10%.

TOKYO METROPOLITAN UNIVERSITY

Tokyo Metropolitan University is the only university operated by the Tokyo Metropolitan Government. It leverages a unique position to provide an education that nurtures human resources who can play an active role in responding to societal changes and to promote varied kinds of basic and applied research as well as research into issues in major metropolitan areas. These activities will contribute to the development of Tokyo and pioneer the global future.

Industry: Power and Utilities
Location: Asia
Use Cases: Cost Reduction, Resource Optimization
Website: www.tmu.ac.jp/english

Results

- Cut power consumption by 10%
- System now automatically executes simulations and optimization calculations

Partner Spotlight

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The mission of the Aria Laboratory of the Department of Civil and Environment Engineering, Graduate School of Urban and Environmental Sciences, is to solve water supply system issues in an environmentally conscious way.

As Tokyo continues to seek ways to reduce waste and increase efficiency, the laboratory plays an increasingly valuable role.

Yasuhiro Arai, DME, associate professor at Tokyo Metropolitan University in the Department of Civil and Environment Engineering, is a strong proponent of the laboratory's mission. "We're working on solving the urban issues related to water supply, sewers, and waste material handling, while focusing on the larger theme of water and the environment. Statistical analysis, mathematical modeling, and optimization are core methods for us."

Scope of the problem

The water supply system in Tokyo is made up of 11 purification plants, 29 distribution reservoirs, and 56 total facilities, and consumes a huge amount of energy. There are enormous savings to be had by improving pumping efficiency.

The laboratory collaborated on a study with the Tokyo Bureau of Waterworks to create an optimized water management plan. The purpose of this plan was determine the most economic route from water purifying plants to distribution reservoirs.

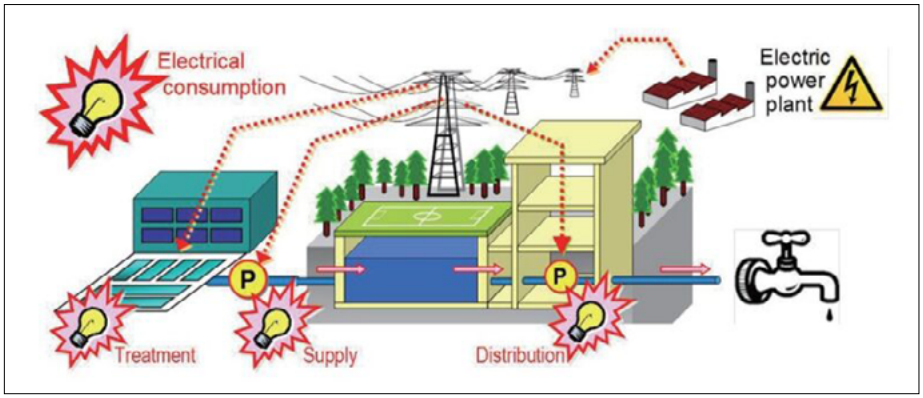
"The power consumption of the water supply process is thought to be about 60% of the total," Mr. Arai said. "Our collaborative study attempted to model 'route/flow volume decisions' in order to minimize the total power consumption."

Problem Solution

Using mixed integer linear programming (MILP), the collaborative study developed a route/flow volume decisions AIMMS model to minimize the total power consumption of the water supply system while satisfying the demand in the water supply area

"With the system in place, we estimate the power consumption levels have fallen 10% relative what would have been needed otherwise," Mr. Aria said.

The model developed by Mr. Arai and the Arai Laboratory focused on the spatial relationship between the purification plants, distribution reservoirs, and facilities, the estimated power consumption of each element, and the varying water needs of each area.



> **“ [We can now] automatically model and execute calculations by just enetering input data for any system, so cumbersome work is no longer needed.”**

Yasuhiro Arai, DME
Associate Professor, Department of Civic and Environmental Engineering, Tokyo Metropolitan University

“The system we have developed automatically executes simulations and optimization calculations. It also incorporates a function that visualizes the layers of the water supply network structure using ISM (Interpretive Structural Modeling), so the relationship of upstream and downstream nodes can be determined, and a visualization of the output result is possible.”

A virtual simulation test run on the existing water supply system verified the effectiveness of the optimization suggestions.

Tokyo Metropolitan University, Minami Osawa Campus, Hachioji, Tokyo

Tokyo Metropolitan University was established in April 2005 by restructuring and integrating the following four universities: “Tokyo Metropolitan University”, “Tokyo Metropolitan Institute of Technology”, “Tokyo Metropolitan University of Health Sciences” and “Tokyo Metropolitan College”.

Civil and Environmental Engineering is literally engineering that helps citizens build beautiful cities, structure a safe and secure lifestyle, and construct a durable infrastructure. It involves the planning, construction, operation and maintenance of infrastructure, such as roads, railroads, waterways, bridges, tunnels, subways, ports, transportation systems, energy systems, water supply and sewerage systems, environmental maintenance, disaster prevention, and the protection of lives and community assets.

The Benefits of Using Gurobi and AIMMS

Gurobi was seen as an improvement over other solutions tested by the Arai Laboratory.

“The prior software we used required a person to write down each issue in order to make formulations,” Mr. Arai said. “This was fine for a small system. But for a large system, like the one targeted by this joint study, it was extremely burdensome, and there were concerns about input errors. By constructing studies based on the use of Gurobi Optimizer and AIMMS, it has become possible to automatically model and execute calculations by just entering input data for any system, so cumbersome work is no longer needed.”

Once the optimization proved successful for a sub-section of Tokyo, the system enabled a smooth transition to managing water systems for the entire prefecture.

Ongoing Benefits of Optimization

“As mathematical planning algorithms and computer processing power advance, I feel that engineers who are not specialized in optimization, and even researchers in general, can use optimization technology as an accessible tool,” Mr. Arai said.

“Real-world improvements, such as ‘the reduction of waste’ and ‘increasing efficiency by x%,’ are increasingly demanded. Because of this demand, I think that ‘useful technology’ which connects directly to the resolution of real-life issues—not ‘theory’ or ‘science’—will be needed. The practical use and application of optimization technology will be increasingly necessary.”

“I studied linear programming during my sophomore year under professor Akira Koizumi, currently a Tokyo Metropolitan University adviser and specially appointed professor in the Department of Civil and Environment Engineering. That was my first encounter with optimization technology. He gave enthusiastic lectures, and I was fascinated with his approach to systems and computer analysis using applied mathematics. Later, I joined professor Koizumi’s lab. I owe everything to professor Koizumi for involving me in research activities that used optimization methods as a core technique.”

“The issues we target are not simple, and since it is believed that they will grow and increase in complexity in the future, I believe that optimization technology will be very useful. I’d like to see expert staff members and field engineers realize that optimization methods can be helpful to their work, instead of depending only on experience and intuition. This system is easy to use. I actively encourage students to use it. They have quickly adapted to it and now use it more often than I do.”

Tokyo Metropolitan University, Department of Civil and Environment Engineering website: www.ues.tmu.ac.jp/civil/index.html Modeling and programming development for this system was carried out with technical support from ITOCHU Techno-Solutions Corporation. ITOCHU Techno-Solutions Corporation production and logistics website: www.engineering-eye.com/en/

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