Featured Articles

Case Studies of Solutions Based on Water Operation and Facility Management Systems for Water Business

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OVERVIEW: The "New Water Supply Vision" published by Japan's Ministry of Health, Labour and Welfare in March 2013 identified the issues and policies that those involved in the industry should be dealing with in terms of "safety," "resilience," and "sustainability." The water industry in Japan faces numerous challenges, including a dwindling number of technical staff, aging infrastructure, and the drop off in infrastructural efficiency due to the declining population. Drawing on its experience in manufacturing, Hitachi supplies a wide variety of solutions that incorporate its highly reliable products, systems, and technologies. This article describes case studies involving the installation of systems for overcoming the challenges faced by water distribution networks.

INTRODUCTION

THE "New Water Supply Vision" published by Japan's Ministry of Health, Labour and Welfare presented specific views on what form water infrastructure should take under the headings ("perspectives") of safety (ensuring the safety of water supplies), resilience (ensuring water supply security), and sustainability (ensuring the sustainability of the water supply system), and encouraged industry participants to adopt these as shared objectives.

It also presented "implementation approaches," namely internal approaches, collaborative approaches, and approaches that demands new ideas.

Fig. 1 shows the initiatives being undertaken by Hitachi in response to these "perspectives" and "implementation approaches" of the New Water Supply Vision, and the associated technologies.

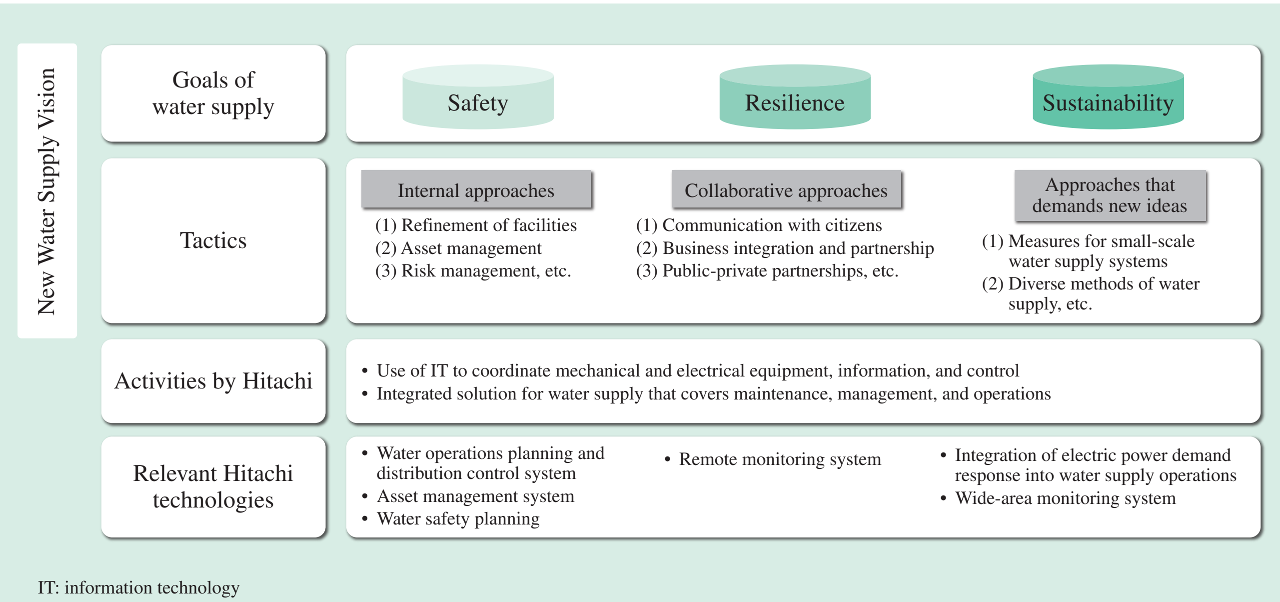

Fig. 1—Tactics and Hitachi's Activities.
Hitachi supplies IT-based solutions for realizing the ideals set for water supply in the New Water Supply Vision.

Hitachi has a track record of supplying systems that make use of information technology (IT) and the analysis of operational data to enable the efficient control of water infrastructure and to improve its energy efficiency, and for the use of simulations for know-how transfer, personnel training, and improvements in organizational capabilities.

This article describes two case studies involving the installation of water distribution systems that help enhance the water infrastructure, progressively expand its geographical coverage, and make its maintenance more efficient.

INTEGRATED WATER MANAGEMENT SYSTEM SUPPLIED TO OSAKA MUNICIPAL WATERWORKS BUREAU

Overview of Water Supply in City of Osaka

Osaka's water infrastructure has a history that dates back 120 years to 1895 when it became the fourth city in Japan to introduce a modern water supply system. During this time, the city has upgraded the treatment technologies used at the water treatment plants responsible for supplying water, ensuring trust in its water supply as well as its safety through measures such as its water distribution network, which supplies water treated using advanced treatment techniques achieving complete coverage of the city in 2000. Subsequently, it installed the Integrated Water Management System in 2014 to further boost the efficiency of water infrastructure operation (which had become an issue of concern) and to establish a comprehensive emergency management infrastructure, expand geographical coverage, and improve energy efficiency. Hitachi already had a track record of supplying the City of Osaka with hardware (monitoring and control systems) and software (systems that use control and simulation techniques) for its water supply infrastructure. This section describes the Integrated Water Management System, which utilizes technologies for the integration of these information and control functions.

Features of Water Infrastructure in City of Osaka

The water supply system for the City of Osaka currently consists of three water treatment plants (Kunijima, Niwakubo, and Toyono), nine water distribution stations, and two pumping stations for boosting water pressure. The network covers 5,000 km of water pipes with work in progress to enable the redistribution of capacity between treatment plants.

Prior to the introduction of the Integrated Water Management System, the three treatment plants each prepared their own operating plans and handled their own demand forecasting and water distribution planning.

This meant that information needed to be shared between operating staff to enable capacity redistribution between plants.

Integrated Water Management System

Located at the Kunijima Purification Plant and designed to provide centralized demand forecasting and data collection throughout the City of Osaka, the Integrated Water Management System provides "total" integrated system operation extending from intake to distribution, together with efficient operational management that includes information sharing between water treatment plants. The main functions of the Integrated Water Management System are as follows.

(1) Demand forecasting

To maintain the smooth operation of the three water treatment plants, the system uses statistical analysis to predict water demand based on variables such as the weather, day of the week, and maximum temperature. Among these variables, it also considers the proportion of water carried by each section of the water distribution network ("distribution ratios"), taking account of factors such as changes to the network. The predictions are produced in 30-minute increments covering the next two days, and are sent to the existing monitoring and control systems at the water treatment plants on a daily basis.

(2) Centralized management of water flows within city

This function performs centralized management of water flows within the city and enables capacity reallocation in the event of an emergency by taking account of factors such as loss of distribution capacity at the water distribution stations and other infrastructure.

(3) Water treatment plant reporting

This function receives important data such as water volume and quality measurements from the management systems at the three water treatment plants and uses it to produce combined reports for the plants.

To implement these functions, the Integrated Water Management System is made up of water treatment monitoring consoles for each treatment plant, water system operation consoles and servers that handle functions such as operational demand forecasts, and IT connections to the existing water treatment management systems, distribution management

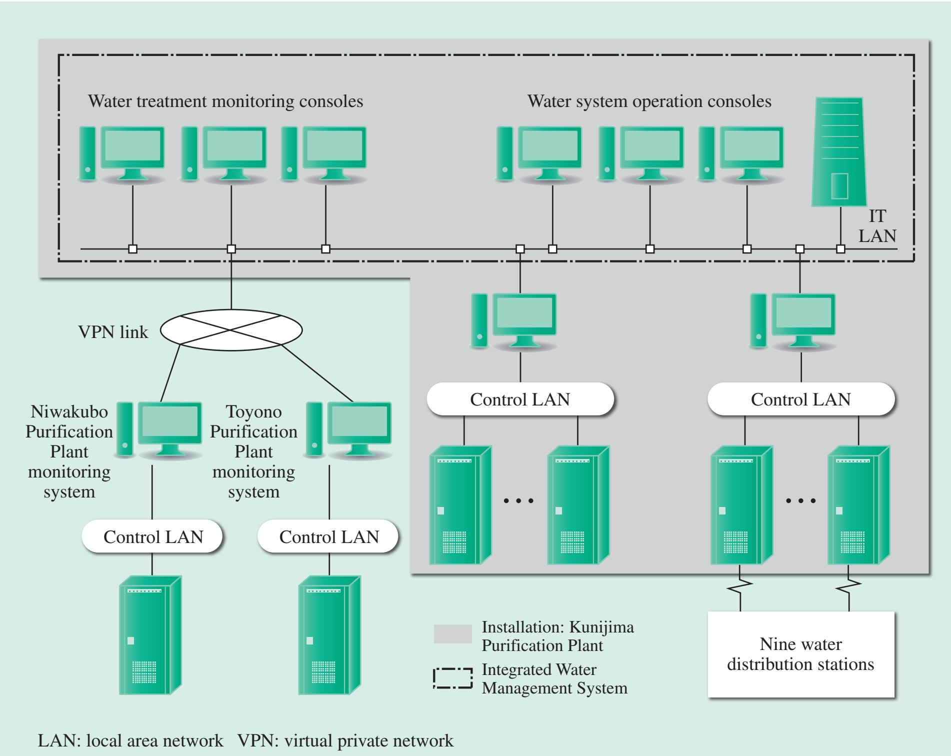

Fig. 2—Block Diagram of Integrated Water Management System.
The Integrated Water Management System handles demand forecasting for the entire City of Osaka and sends its predictions to the existing systems via a communication network.

systems, and distribution station monitoring systems (see Fig. 2).

Demand Forecasting Technique

This section summarizes how the Integrated Water Management System forecasts demand (see Fig. 3).

The technique is based on statistical analysis and uses the following three steps to predict demand.

(1) Predict daily demand for the entire city
(2) Predict daily demand for each section of the water distribution network
(3) Predict demand for each section of the water distribution network in 30-minute increments

Each step is described below.

The starting point for predicting daily demand for the entire city (Step 1) is the "week-day/fine-weather demand" obtained by statistical analysis. This is then modified to allow for the relevant variables, namely the weather, maximum temperature, whether demand is different from usual, and the day-of-week. The weather and maximum temperature are entered based on the weather forecast. Days when demand is different from usual are those that have non-standard demand patterns, such as the New Year holiday period. The correction coefficients used for this purpose are also obtained by statistical analysis of past demand data.

Next, to predict daily demand for each section of the water distribution network (Step 2), the demand

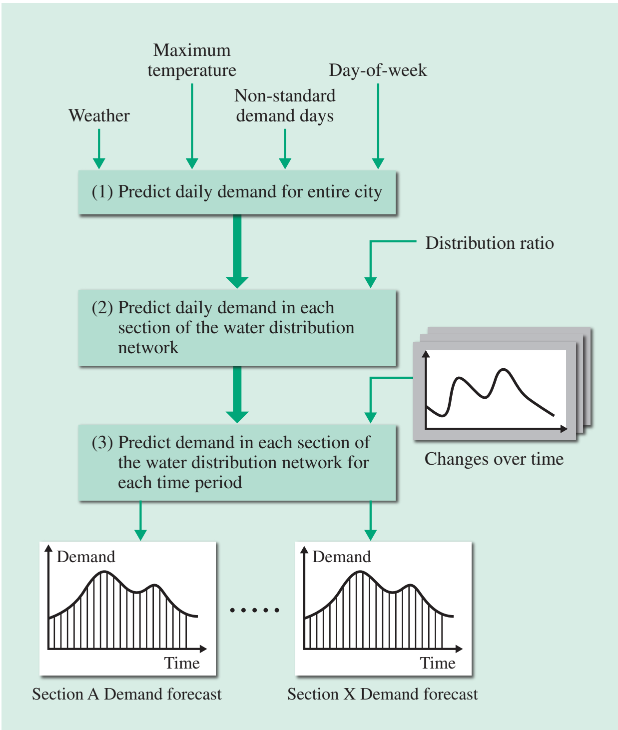

Fig. 3—Demand Forecasting Calculation.
The calculation consists of three steps and predicts water demand in each section of the water distribution network for each time period. To keep up with changes over time, periodic automatic updates are made to the corrections for weather, maximum temperature, non-standard demand days, and day-of-week, and the distribution ratios for each section of the water distribution network.

obtained by Step 1 is divided between the different sections of the network. This is done using distribution ratios obtained by statistical analysis of past data. The resulting demands are then used to predict demand for each section of the water distribution network in 30-minute increments (Step 3). The estimated variation in demand over time used for this purpose is updated by a learning algorithm using actual data.

The correction coefficients for weather, maximum temperature, non-standard demand days, and day-of-week are periodically revised based on actual data to keep up with changes over time. These revisions are performed annually for the weather, maximum temperature, and non-standard demand days, and weekly for day-of-week. Similarly, the distribution ratios for each section of the water distribution network are updated daily to account for any changes to these sections.

To reduce operator workload, the prediction process is automatic, as are the revisions to correction coefficients and distribution ratios.

Field Testing of Demand Forecasting

After verifying the data acquired from field testing and tuning the system, the error in daily demand predictions for the entire City of Osaka was less than 2% on average for domestic water and less than 3% on average for industrial water (over the period when data verification was being performed). Having achieved this level of accuracy, the system commenced operation.

WATER INFRASTRUCTURE MONITORING SYSTEM SUPPLIED TO NIIHAMA CITY WATERWORKS BUREAU

Overview of Water Supply in Niihama City

The water supply system in Niihama City was commissioned in 1954 and has been operating ever since. A series of six expansion projects were undertaken during this time to ensure that consumers could remain confident of the safety of the water while also increasing the number of people being supplied and the water distribution network coverage area. (The

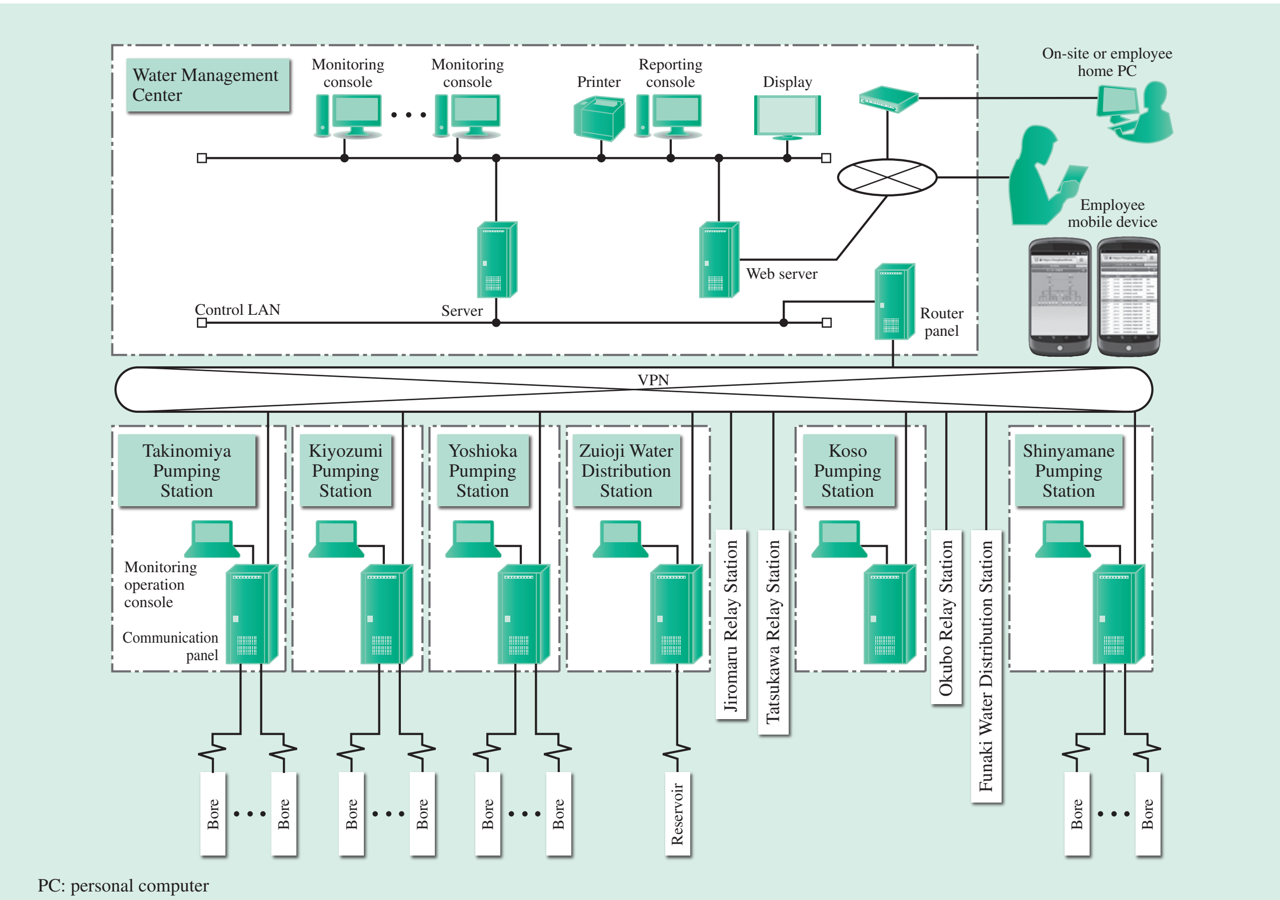

Fig. 4—Block Diagram of Water Infrastructure Monitoring System.
As water is supplied to the city from bores spread over a wide area, the Internet and other IT is used to provide a wide-area monitoring system.

network currently serves 120,000 consumers, with a planned maximum daily supply volume of 56,300 m^3.)

Niihama City sources all of its water from the ground via bores. These bores are spread around the city, and while this means that each bore does not need to produce a large volume of water, the downside is that all of the water needs to be pumped to the final reservoir.

The city completed its Water Management Center in FY1996 to centrally manage this entire infrastructure.

Since then, the infrastructure administrators have been progressively downsized, leading to the installation in April 2014 of a Water Infrastructure Monitoring System intended to provide more reliable and efficient infrastructure operation and more efficient administration, issues that had become matters of concern.

Features of Water Infrastructure in Niihama City

The water supply system in Niihama City consists of 22 bores scattered over a wide area of the city, 10 main or relay pumping stations, nine reservoirs, and 21 water quality and flow monitoring stations installed at the network edge. This entire infrastructure operates automatically (unmanned). A feature of the system is that the main pumps and relay pumps use significant amounts of electric power to pump water from the bores via the pumping stations to the reservoir.

Prior to the installation of the Water Infrastructure Monitoring System, the procedure when an equipment problem occurred was for the person on duty to notify the infrastructure administrator by telephone. The administrator would then need to go to the Water Management Center to find out what was happening on the network.

Water Infrastructure Monitoring System

The Water Infrastructure Monitoring System is installed at the Waterworks Bureau itself, and the system enables the water supply infrastructure to be monitored remotely (not just at the Water Management Center) using a smartphone or tablet via the Internet (see Fig. 4).

Furthermore, a variety of water level control setting combinations (“patterns”) for daytime and nighttime operation can be stored to avoid having to change individual pump control settings each time. The aim of this function is to shift daytime power consumption to the night when tariffs are lower.

The system is also designed to have a comprehensive range of simulation functions for checking operating water levels in advance to test the daytime and nighttime “patterns” (see Fig. 5).

Web-based Monitoring with Tablets

This section describes the web-based monitoring system included in the Water Infrastructure Monitoring System. This web-based monitoring system, which is

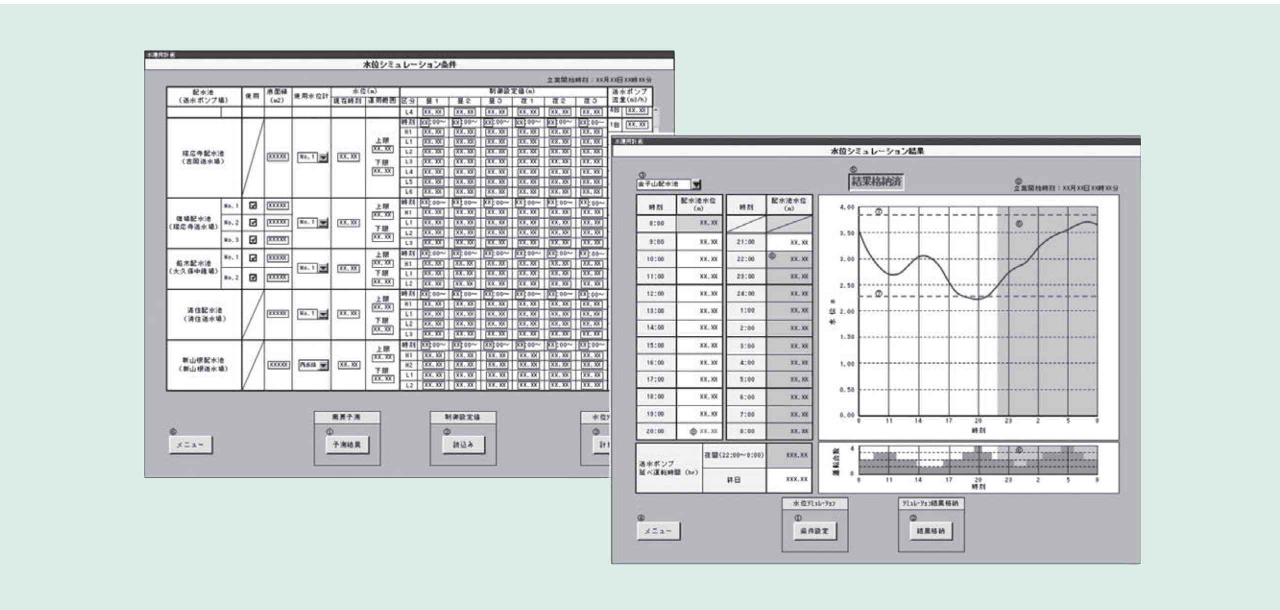

Fig. 5—Water Level Simulation Screen.
Water level settings are specified for daytime and nighttime operation, and simulations are used to perform advance checks of the changes in water level.

Fig. 6—Web Services Displayed on a Tablet.
The web screens display the same graphics and alarm messages as the monitoring consoles at the Water Management Center. They also use familiar touchscreen operations such as pinch-out and swiping.

part of Hitachi's information and control systems is used to display the same graphics screens, alarm messages, and other content as the monitor consoles at the Water Management Center on a smartphone or tablet connected via the Internet. Although these devices have small screens (5 to 8 inches), screen display can be enlarged using typical touchscreen operations such as pinch out.

This web-based monitoring system can also detect equipment alarm signals and forward these to infrastructure managers via e-mail. On receiving such an e-mail, an infrastructure manager can check the details of the alarm message and the status of the equipment and use this as a basis for decision-making, such as deciding on the initial response (see Fig. 6).

CONCLUSIONS

This article has described two case studies involving the installation of water distribution systems that help enhance the water infrastructure and progressively expand its geographical coverage, objectives that were highlighted in the New Water Supply Vision.

The future possibilities for water distribution systems include operational functions that provide a boost to energy efficiency by coordinating the planning of water supply from water treatment plants or reservoirs to optimize overall operation.

Also anticipated is a growing need for energy optimization achieved through integration with power system infrastructure, such as operational functions that cut peak power demand or help reduce costs through use of a demand response regime that is expected to be introduced in the wake of electricity market liberalization.

Hitachi intends to adopt an earnest approach to the challenges facing customers and other parts of society, and to contribute to the safety, resilience, and sustainability of the water infrastructure through the supply of tailored solutions and the development of technology based on technologies already acquired.

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