

## Featured Articles

# Operation & Maintenance and Service Solutions for Water Utilities Based on Public-private Partnerships

Hidenori Hasuka  
Takeshi Kurotsu  
Takuya Ando  
Akimasa Izumiyama

*OVERVIEW: The water utilities in Japan continue to face extremely difficult business conditions that include a shrinking customer base and revenues due to the falling population, growing demands for the upgrading of water infrastructure, and a fundamental review of resilience in light of the Great East Japan Earthquake. One of the ways to overcome these circumstances is to make use of public-private partnerships in their business operations. If these utilities that in the past have primarily been operated by local governments instead adopt in their business operations practices that take advantage of the technical capabilities and other know-how of private-sector businesses, there is scope for strengthening the fundamental operating capabilities of the water industry, including providing higher quality services and cutting costs. Based on many years of experience in supplying products, after-sales services, and technology development to the water industry, Hitachi is contributing to the creation of sustainable water operations by supplying public-private partnership solutions such as PFIs and full operation and maintenance outsourcing.*

## INTRODUCTION

AFTER reaching a peak of 128.06 million in 2010, the number of people living in Japan has now started to decline, with demographic projections indicating that the population will fall to 86.74 million in 50 years and 42.86 million in 100 years' time<sup>(1)</sup>. This is a major problem for the water industry, because it means a shrinking customer base and falling revenues as well as problems with skills transfer due to an aging workforce and worker shortages, challenges that are already a reality for many water utilities.

On the other hand, it is anticipated that demand for large-scale upgrades to aging water infrastructure will peak during the 2020s and 2030s, requiring water utilities to increase their budgets and embark on planned refurbishments. Other factors that are exacerbating the conditions facing water utilities include calls for a fundamental review of seismic resilience and disaster management prompted by the experience of the Great East Japan Earthquake<sup>(2)</sup>.

Despite these business conditions, the utilities still need to maintain water supplies that deliver water of the stipulated quality when and where needed, in the

required volumes, and at an appropriate price. The New Water Supply Vision published by the Ministry of Health, Labour and Welfare in 2013 specified policies for achieving the desirable attributes for water supplies in 50 or 100 years' time, namely safety, resilience, and sustainability<sup>(3)</sup>. As described above in this article, ensuring sustainability is a particularly important objective for achieving healthy and reliable water supply operation, even under circumstances that require skills transfer and improved revenues. One way to achieve this is through public-private partnerships. If water utilities that in the past have largely been operated by the public sector (local governments) instead adopt practices that take advantage of the technical capabilities and other know-how of private-sector businesses, this has the potential to help strengthen the fundamental operating capabilities of the water industry by providing higher quality services and cutting costs.

This article describes operational examples involving public-private partnerships that form part of Hitachi's promotion of its water industry solutions for a wide variety of challenges, proprietary support tools that help enhance the efficiency of this work, and likely future developments.

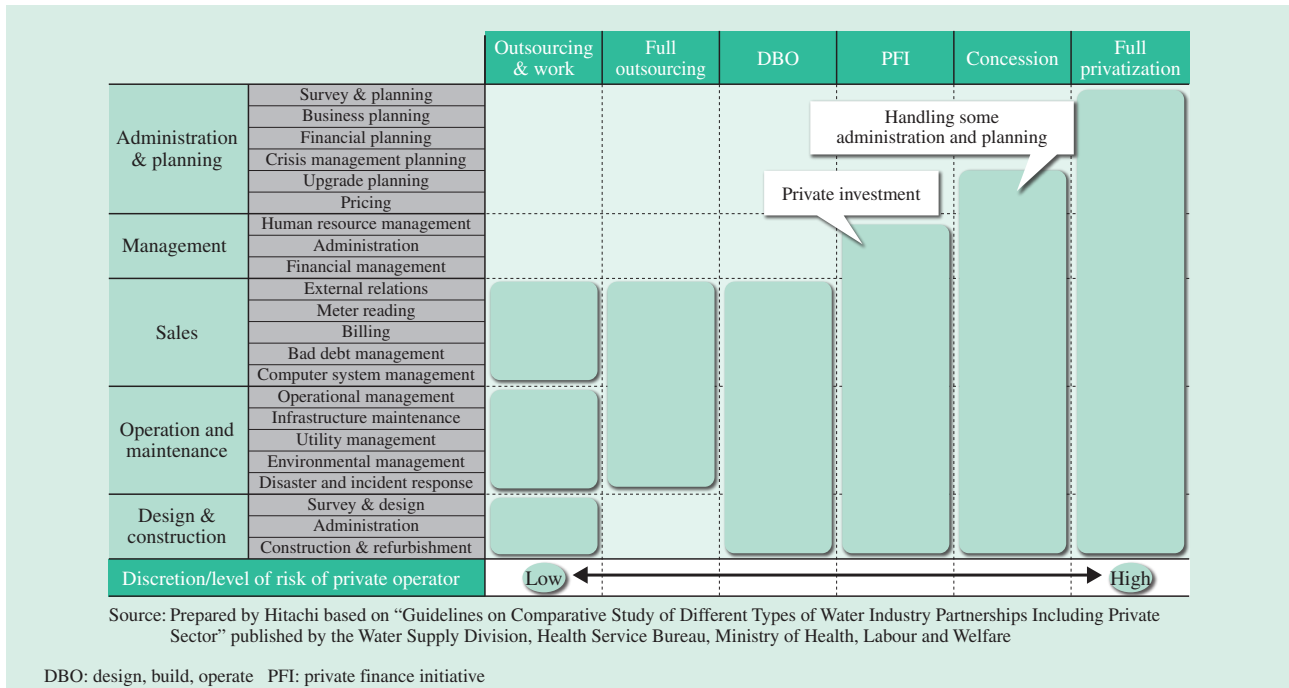


Fig. 1—Hitachi’s Public-private Partnership Business Models. Hitachi acts as a “best partner” supplying solutions to water utilities in a wide variety of forms, ranging from partial to full outsourcing and including DBO, PFI, and concession arrangements.

**ACTIVITIES BY HITACHI**

The legal framework facilitating public-private partnerships has been progressively strengthened with a growing diversity of available business models that includes the recognition in 2011 of concession arrangements (private operation of public services) whereby private sector businesses can take responsibility for operating services, including fee collection. This wide diversity of business models for public-private partnerships includes partial outsourcing, whereby the private company undertakes a limited range of activities such as managing operations; full outsourcing, whereby the private company undertakes a wide range of operation and maintenance tasks not limited to operational management only; Private Finance Initiatives (PFIs) whereby the private company undertakes everything from design, construction, and financing of facilities through to their long-term post-construction operation and maintenance; and the concession arrangements referred to above (see Fig. 1).

Based on many years of experience in supplying products and systems to the water industry, along with after-sales services and technology development, Hitachi is involved in a wide variety of activities aimed at establishing sustainable water supplies, ranging from partial outsourcing to PFIs<sup>(4), (5)</sup>.

**EXAMPLES OF OPERATION & MAINTENANCE AND SERVICE SOLUTIONS**

**Renovation Project Related to Power Facilities to Asaka Water Purification Plant / Misono Water Purification Plant (PFI Project with Bureau of Waterworks Tokyo Metropolitan Government)**

The main objectives of this project include installing an on-site power generation plant that can act as a countermeasure against disaster by providing a backup power supply for the water treatment plants, and improving energy efficiency by installing a co-generation system as an environmental measure. Since April 2005, Hitachi has been operating a PFI business that encompasses the construction and operation of the on-site power generation plant and a sodium hypochlorite production facility, and utilization of the soil produced as a byproduct of water treatment (see Table 1). The system supplies approximately 110,000 MWh of electric power and 25,000 GJ of steam annually. The sodium hypochlorite production facility has an annual production of approximately 600t-Cl<sub>2</sub>, and approximately 7,000 t-wt a year of byproduct soil is recycled.

This fiscal year will be the project’s 11th, halfway through the contract period. Drawing on the knowledge

TABLE 1. Overview of PFI Project with Bureau of Waterworks Tokyo Metropolitan Government  
The table lists the main elements of the PFI project for the Asaka and Misono Purification Plants.

<b>Project name</b>	Renovation Project Related to Power Facilities to Asaka Water Purification Plant / Misono Water Purification Plant
<b>Operator</b>	Asaka Misono Utility Services Corporation
<b>Contract period</b>	April 1, 2005 to March 31, 2025
<b>Project type</b>	BOO
<b>Description</b>	(1) Construction and operation of on-site power generation equipment (co-generation system). The system supplies heat and power during routine operation and power during emergencies. (2) Construction and operation of sodium hypochlorite production facility, and supply of sodium hypochlorite. In the event of a disaster, production of sodium hypochlorite using stored stocks of salt, power from on-site power generation plant, and treated water. (3) Utilization of the soil produced as a byproduct of water treatment.

BOO: build own operate

gained during this time, particularly experience from the Great East Japan Earthquake, Hitachi is continually striving through this work to contribute to the resilience and sustainability of these water treatment plants.

### PFI Project in Yubari City, Hokkaido Adoption of PFI Project

With more than 40 years having passed since the completion of the Asahimachi and Shimizusawa water treatment plants (in 1967 and 1969 respectively); the aging of equipment at these two critical facilities in the water infrastructure of Yubari City was becoming increasingly apparent. The sustainability of water services had become a major issue for the city, which anticipated a falling income from water rates and a need for plant downsizing due to the shrinking population. Accordingly, as part of its plans for its 8th expansion program, Yubari City decided in July 2010 to upgrade and rebuild its water infrastructure through a PFI arrangement.

Subsequently, Yubari Reisui Co., Ltd., a company set up by Hitachi and two other investors, signed a contract with Yubari City in March 2012 and the project got underway in April of that year. This was the first PFI project for water in Hokkaido and, at that time, only the second in Japan to combine the construction and operational management of a water treatment plant in a single package.

#### Project Overview

The project involved not only the construction of new water treatment plants at the sites of the existing

TABLE 2. Overview of Yubari City PFI Project  
The table lists the main elements of the PFI project for construction and operation of the water treatment plants.

<b>Project name</b>	8th expansion program for Yubari City water infrastructure through a PFI arrangement
<b>Operator</b>	Yubari Reisui Co., Ltd.
<b>Contract period</b>	April 1, 2012 to March 31, 2032
<b>Project type</b>	BTO
<b>Description</b>	(1) Design and construction of Asahimachi water treatment plant (planned treatment capacity 3,100 m <sup>3</sup> /day) and Shimizusawa water treatment plant (planned treatment capacity 4,100 m <sup>3</sup> /day) (2) Partial upgrade of mechanical, electrical, and instrumentation equipment for off-site facilities (distribution reservoirs, pumping stations, etc.) (3) Management of facility operation and maintenance (4) Water meter reading, billing, and customer relations, etc.

BTO: build transfer operate

Asahimachi and Shimizusawa plants and taking responsibility for their operation and maintenance, but also managing the operation and maintenance of the existing plants during the period prior to completion of the new plants (see Table 2).

The plan involved downsizing the combined capacity of the Asahimachi and Shimizusawa plants from 18,320 m<sup>3</sup>/day to 7,200 m<sup>3</sup>/day and adopting the membrane filtration method of water treatment that can efficiently remove protozoan pathogens and other harmful substances.

#### Project Progress

Responsibility for managing the operation and maintenance of the existing plants commenced from the outset of the project. This included taking active steps to improve efficiency, including the installation of a plant and asset management system (described below) and an inspection system based on the use of portable tablets. This work is continuing to proceed smoothly.

Work on the design and construction of the Asahimachi and Shimizusawa water treatment plants is also proceeding smoothly in the lead up to the commissioning stage (see Fig. 2).

### Continuation of Operation & Maintenance and Service Business

This section describes a public-private partnership that continued after the expiry of the contract period.

#### Tagajo City (Miyagi Prefecture) Full Outsourcing Contract

Hitachi had already been active at this site providing operational monitoring, plant inspection, utilities

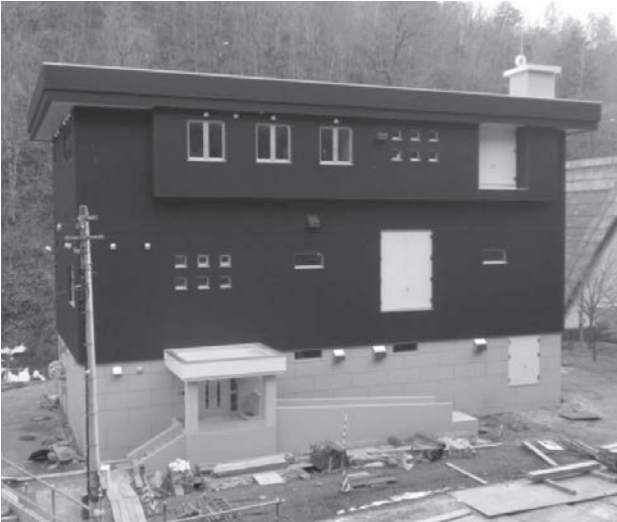


Fig. 2—Shimizusawa Water Treatment Plant Under Construction (March 2015).

*The compact design includes housing the settling ponds and membrane filtration equipment in the water treatment building (three above-ground and one basement floor).*

procurement, water quality testing, and minor repairs for the five years from April 2010 to March 2015 under an earlier contract for full outsourcing of operation and management of the Suenomatsuyama water treatment plant and other facilities. During this period, efforts had been made to improve operational efficiency by installing an inspection system using portable devices, batch mail delivery, and a water demand prediction system that helps overcome differences in staff experience level when planning water treatment volumes.

Hitachi also contributed to recovery work after the city suffered significant damage from the Great East Japan Earthquake, providing support for emergency water supplies and emergency recovery work. In particular, Hitachi played a substantial role in work such as providing water supplies to the city, and the ongoing supply of fuel for on-site generators, a commodity that was in short supply.

Having won a renewal of the full outsourcing contract for a further five years from April 2015, Hitachi will continue making contributions to the city.

**Operational Monitoring for Daito City (Osaka Prefecture) Waterworks and Sewerage Bureau**

Hitachi commenced a partial outsourcing project for operational management of water distribution stations at this site in FY2003.

Since FY2009, Hitachi has also been providing ongoing services that include operational monitoring of water distribution, routine inspections, and water

quality monitoring. After the expiry of this contract in FY2014, Hitachi was awarded a new five-year contract commencing in FY2015, becoming better placed to take advantage of the innovative ideas of a private-sector company. This project is recognized as an example not only of providing ongoing benefits to the city but also of contributing to advances in the field of public-private partnerships.

## TECHNOLOGIES THAT FACILITATE OPERATION & MAINTENANCE AND SERVICE SOLUTIONS

The adoption of tools that facilitate operational efficiency, including but not limited to the management of human resources at each site, is essential to the provision of efficient, high-quality service solutions. The following sections describe some of the technologies and systems that underpin Hitachi's service solutions.

### Equipment and Asset Management System

Asset management is an essential part of ensuring the sustainability of water supply operations<sup>(6)</sup>. In the process of collating this management data, the management and analysis of routine inspection results and maintenance records is an important aspect of operation and maintenance. Hitachi has an equipment and asset management system that provides the tools for performing this work. Based on a journal for each item of equipment, these tools can manage the operating life, maintenance plan, and inspection and maintenance records for each item in a database. The data can also be used for spare parts management, location management, and statistical analysis. Furthermore, with its item update tool, new site-specific data fields ("items") can be added as required after the system has been installed, allowing its use to be tailored to suit the differing requirements of different sites (see Fig. 3). The technology has been installed to assist with operation and maintenance work at the Yubari City PFI project where it is used as a database for maintenance work and for data evaluation. Being cloud-based, the system reduces the risk of data loss in the event of a disaster and is a useful tool for data sharing.

Currently, Hitachi is considering whether to customize the technology to provide tools for micromanagement (evaluation) of equipment health, operating life, risk, and life cycle cost (LCC) as part of an asset management implementation.

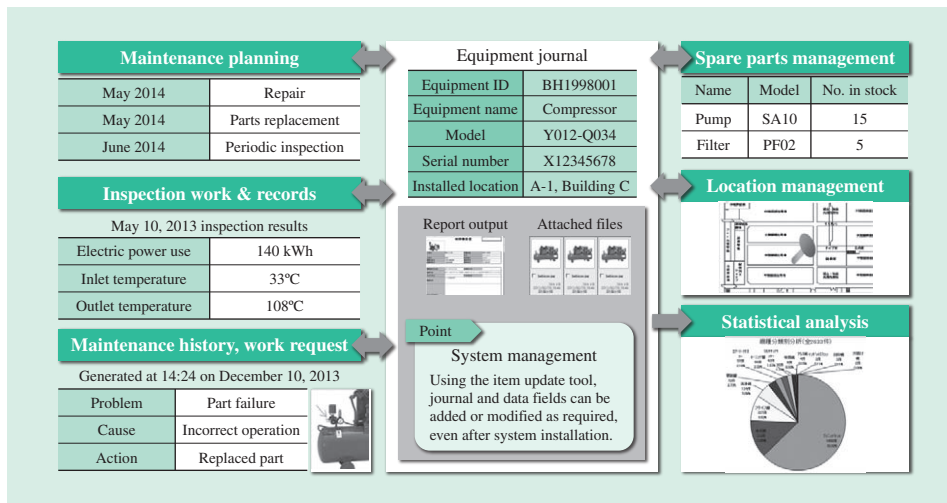


Fig. 3—Functions of the Equipment and Asset Management System. To allow use to be tailored to suit the differing requirements of different sites, additional data fields can be added as required after the system is installed.

### Use of AR Technology to Support Operation and Maintenance

Skills transfer is a major challenge for the water industry. While staff training plays a fundamental role in overcoming this problem, because training requires adequate staffing and long periods of time to achieve, there is also a demand for support tools that can provide effective ways to implement skills. In response to this challenge, Hitachi has developed a “navigation system tool” that uses augmented reality (AR) to support operation and maintenance.

AR is a generic term for the use of information and communication technology (ICT) to overlay digital information on the real world. It works by displaying information linked to specific coordinates (which are determined using techniques such as markers or image processing) on top of the camera images of that location (that is, by overlaying image data onto the real world), putting the five human senses of sight, smell, hearing, touch, and taste to work and augmenting reality with additional information. Hitachi has developed an inspection navigation system that uses AR to help inexperienced staff perform operation and maintenance work correctly.

Workers invoke the system after selecting the work they intend to perform. When the worker points the camera on the back of the tablet at an AR marker indicating an inspection site, the system provides a realtime overlay that gives instructions on what to do and which items to inspect (see Fig. 4). The worker then taps the inspection item on the overlay display to enable the performance of tasks such as entering the inspection results using intuitive operation of visible prompts. Which of the three available input methods (tapping, selecting, or entering numeric data) to use

can be selected based on the type of equipment being inspected. After entry of the inspection results for the specified items has been completed, the system indicates what to inspect next. It also displays a completion screen to indicate when all inspections

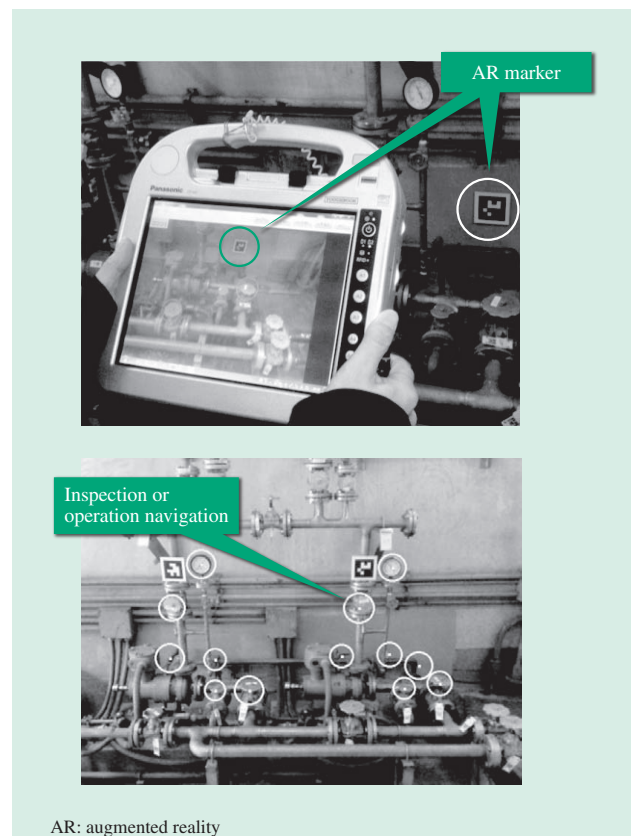


Fig. 4—AR Inspection Navigation System. When the camera on the back of the tablet is pointed at an AR marker indicating an inspection site, the system assists inexperienced workers by providing a realtime overlay that gives instructions on what to do and which items to inspect.

have been completed. The adoption of this technology has the potential to enable “skill-free” operation and maintenance in which even inexperienced workers can operate or work on equipment correctly.

## CONCLUSIONS

This article has described Hitachi’s work on public-private partnership solutions for the water industry, examples of these solutions, and operation and maintenance technologies that support this work.

To keep water supply infrastructure in good condition, Hitachi intends to continue contributing to the provision of resilient and sustainable water supplies through the supply of water industry solutions in its role as a “best partner” to water utilities.

## REFERENCES

- (1) National Institute of Population and Social Security Research, “Population Projections for Japan,” (Jan. 2012) in Japanese.
- (2) Local Public Finance Bureau, Ministry of Internal Affairs and Communications, “Local Public Enterprises Yearbook” (Mar. 2013) in Japanese.
- (3) Health Service Bureau, Ministry of Health, Labour and Welfare, “New Water Supply Vision” (Mar. 2013) in Japanese.
- (4) H. Kobayashi et al., “Contribution to Water Service Solution Business,” *Hitachi Hyoron* **91**, pp. 660–663 (Aug. 2009) in Japanese.
- (5) Y. Nishigami et al., “Public-private Initiatives for Water Services,” *Hitachi Hyoron* **95**, pp. 548–551 (Aug. 2013) in Japanese.
- (6) Water Supply Division, Health Service Bureau, Ministry of Health, Labour and Welfare, “Water Business Asset Management Guide Book,” (Jul. 2009) in Japanese.

## ABOUT THE AUTHORS

---



**Hidenori Hasuka**

*Strategy & Planning Department, Water & Environment Solutions Division, Infrastructure Systems Company, Hitachi, Ltd. He is currently engaged in managing public-private partnership businesses in the Japanese water industry.*



**Takeshi Kurotsu**

*Strategy & Planning Department, Water & Environment Solutions Division, Infrastructure Systems Company, Hitachi, Ltd. He is currently engaged in public-private partnership businesses in the Japanese water industry.*



**Takuya Ando**

*Strategy & Planning Department, Water & Environment Solutions Division, Infrastructure Systems Company, Hitachi, Ltd. He is currently engaged in public-private partnership businesses in the Japanese water industry.*



**Akimasa Izumiyama**

*Asaka Misono Utility Services Corporation. He is currently engaged in managing public-private partnership businesses in the Japanese water industry.*