Overview

Water Industry Solutions for Ongoing Development of Social Infrastructure

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MAINTAINING A HEALTHY WATER ENVIRONMENT

PEOPLE'S daily lives and corporate economic activity are supported by a variety of social infrastructure. Included in this is the water infrastructure, which along with being important because it is vital for life, also faces a variety of challenges that need to be overcome, including how to maintain a healthy water environment and ensure efficient water distribution.

Hitachi operates its Social Innovation Business, which seeks to transform social infrastructure by making the most of information technology (IT), and its work on overcoming the challenges of the water industry (water industry solutions) forms a part of this business. Specifically, by supplying products, systems, and services, Hitachi is working to overcome challenges such as conserving water sources, flood control, water supply and sewage, supplying water as a resource (producing or recycling water), and wastewater treatment.

There has been interest in recent years in using the interoperation of different forms of social infrastructure as a way of making more efficient use of energy and other resources, one example being the study of how to coordinate water and electric power to make efficient use of electricity.

This article gives an overview of this issue of *Hitachi Review* and looks at trends in the water industry in Japan and elsewhere. It also presents examples of water industry solutions that contribute to the ongoing development of social infrastructure.

WATER IN JAPAN AND ELSEWHERE

Current Status of Water and Water Resources

While the total global volume of water amounts to 1.4 billion km^3, only 0.01% of this is believed to be fresh water suitable for drinking or use in daily life[(1)]. Moreover, this fresh water is unevenly distributed, with a number of communities suffering from water scarcity, particularly in low-latitude (equatorial) regions.

There are also the issues of water shortage and pollution that accompany economic development and rising living standards. In terms of the volumes of water taken for human use in different parts of the world, rapid rises are anticipated in places like Asia in particular, with the total estimated to grow by 30% between 2000 and 2025[(2)].

In Japan on the other hand, while there has been little sign of worsening water scarcity over recent years beyond a few isolated exceptions, if agricultural imports are thought of as representing an indirect import of water, then the country is not unaffected by overseas water shortages. There have, however, been frequent instances of localized heavy rainfall or flood damage, meaning there is a need for water resource management that includes storm water.

Trends in Water Industry

The size of the global water industry is predicted to grow from 36.2 trillion yen in 2007 to 86.5 trillion yen in 2025[(1)]. Nearly 90% of this is accounted for by water supply and sewage, of which 40 to 50% is estimated to involve management and operations. The remaining 10% or more is made up of seawater desalination, industrial water, and recycling, all markets that are expected to grow.

There is a lot of competition in the utility operations sector of the market for water supply and sewage from local and European companies, among others. This means that there is potential for Japanese companies with little overseas experience to expand their activities gradually by building up experience over all areas of activity, including design, construction, and maintenance management, as they

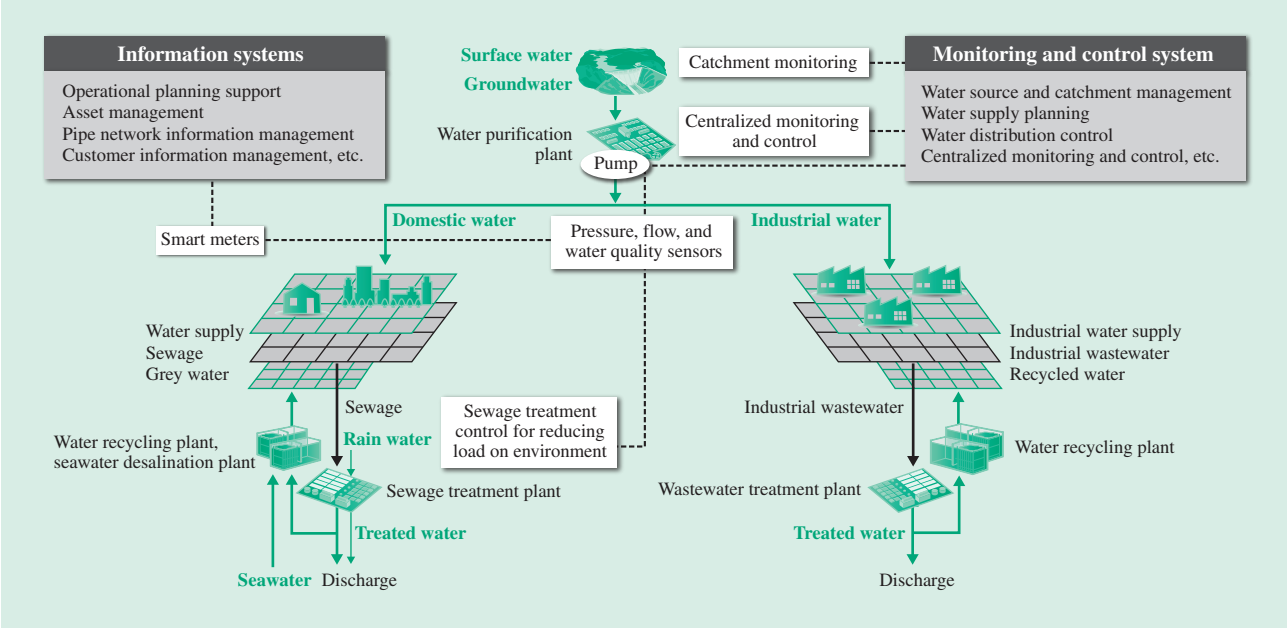

Fig. 1—Examples of Intelligent Water Systems.
The integration of information and control systems with water treatment systems helps optimize the water cycle within cities and catchments.

develop an understanding of the challenges facing each country or region and contribute to their solution. There is also scope for Japanese companies to draw on their expertise in membrane-based treatment and efficiency improvement to play a part in the markets for seawater desalination and water re-use, which are expected to grow.

In Japan meanwhile, with water supply coverage having reached 97.7% of the population as of the end of FY2013, and with the equivalent figure for sewage being 77.0%, these markets now primarily involve the replacement of existing equipment or its maintenance and management. A variety of challenges need to be confronted if water supply and sewage assets are to be passed on to the next generation in a healthy condition. These include the appropriate replacement and maintenance of aging equipment, the transfer of skills from the large number of experienced staff approaching retirement, improvements to operational efficiency by consolidating activities and covering larger areas, and dealing with the fall in water demand resulting from the shrinking population and changes in lifestyle.

It was against this background that the Ministry of Health, Labour and Welfare published its New Water Supply Vision in March 2013, and the Ministry of Land, Infrastructure, Transport and Tourism published its New Sewerage Vision in July 2014, which included their long term visions for water supply and sewage, strategies for overcoming challenges, and the division of responsibilities between the parties concerned. Furthermore, the Basic Act on the Water Cycle was enacted in April 2014 to ensure that policies relating to the water cycle are pursued in a comprehensive and consistent manner.

TABLE 1. Components of Intelligent Water Systems
Hitachi intends to work on implementing the "intelligent water" concept through the interoperation of various technologies, systems, and services.

Field	Typical systems or services	Typical benefits
Operations	• System planning and engineering • Operation planning support system • Asset management (EAM) • Pipe document and drawing management • Customer data management • Billing management • Use of smart meters	• Operational efficiency • Investment smoothing • Service improvement
Water supply	• Catchment simulation • Water supply (planning) • Water distribution control	• Stable supply of water • Reducing load on environment
Flood control	• Flood simulation • Rainwater drainage	• Safe water environment
Water treatment control	• Monitoring and control • Water safety management • Operations outsourcing service	• Reliability improvement • Efficiency improvement
Water treatment facilities	• Water purification plant • Sewage treatment plant • Wastewater treatment plant • Membrane filtration plant • Seawater desalination plant	• Reliability improvement • Efficiency improvement

EAM: enterprise asset management

OVERVIEW OF WATER INDUSTRY SOLUTIONS

Hitachi offers water industry solutions as a means of contributing to the ongoing development of social infrastructure by overcoming the challenges facing the water industry. Its aim is to provide comprehensive solutions by combining various products and systems as appropriate and integrating them with services such as maintenance and operations.

Hitachi proposed the Intelligent Water System concept to represent its basic approach to the appropriate management of water resources and water-related infrastructure across entire cities or catchments, and to undertaking system-wide optimization. This involves seeking to overcome challenges by putting information and telecommunications technology and control technology to work over a wide area, and seeks to help with things like reducing the load on the environment as well as improving reliability and the efficiency of operational management. Fig. 1 and Table 1 show examples of the components of such systems.

WATER INDUSTRY SOLUTIONS IN JAPAN

This section describes work aimed at overcoming the challenges facing water supply and sewage in Japan from three perspectives.

(1) Contribution to water safety and reliability

The water supply in Japan delivers water that is safe to drink directly from the tap, 24 hours a day and 7 days a week. One of the technologies Hitachi supplies to help ensure safe water quality is a system that automatically modifies treatment plant control of dosing for chemicals such as flocculants in response to sudden changes in the quality of intake water, without relying on manual intervention by experienced staff. This is helping deal with the falling number of such skilled staff by expanding the range of conditions under which the control system can operate.

For water quality analysis, Hitachi is working on the development of small sensors that can perform on-site multi-factor testing of water quality in realtime. By enabling a response to sudden changes in water quality, this should help ensure a safe water supply.

The failure of infrastructural equipment can have serious consequences for both the public and industry. In order to respond quickly to failures that result from aging and other factors, Hitachi is currently developing a fault prediction and recovery support technology that performs statistical analysis using adaptive resonance theory (ART)[(a)] and operational data from plant and equipment. Hitachi is also strengthening cybersecurity for control systems and supplying physical security technologies that prevent the unauthorized intrusion of people or objects into the water infrastructure.

The Great East Japan Earthquake has prompted measures to improve the resilience to disaster of social infrastructure, and Hitachi has responded by developing and testing temporary emergency sewage infrastructure for use in times of disaster, including high-speed coagulation sedimentation[(b)] or membrane bioreactors (MBR)[(c)].

Work is also underway on the international standardization of control security and of crisis management for water and sewage. Hitachi is participating in this work through an industry-government-academia partnership, and is taking steps to acquire compliance certification.

(2) Contribution to efficiency and reducing the load on the environment

Other challenges include protection of the environment, energy efficiency, and operational efficiency. Hitachi is helping water utilities improve the efficiency of their routine operations by supplying a water supply planning system.

For asset management, Hitachi is helping to improve maintenance efficiency and reduce infrastructure replacement costs by developing technology for things like estimating the distribution of water leaks or using life cycle cost analysis as a basis for assisting with water pipe replacement.

(a) Adaptive resonance theory (ART)
ART is a self-organizing neural network model (a type of information processing model) used for category learning without learning from sample patterns (without a "teacher"). What normally happens with neural network learning is that learning new input patterns results in a loss of past memory (categories), and conversely that placing an emphasis on retaining past memories is detrimental to new learning. ART avoids this problem by comparing and classifying the consistency of input and memory against reference parameters and then adaptively generating and expanding categories based on the result. It has attracted attention in recent years in pattern recognition and classification model applications.

(b) High-speed coagulation sedimentation
A water treatment system that speeds the rate of sedimentation by adding two different flocculants during the coagulation sedimentation process (the agglomeration and sedimentation of colloidal particles and suspended solids).

(c) Membrane bioreactor
An advanced water treatment system that combines biological treatment with the use of a membrane to separate solids and fluids. An issue with the previous activated sludge method of biological treatment was the large size of the equipment needed for the removal of sludge from the final settling ponds where it forms as sediment after the action of microbes on the sewage in the reaction tanks. In contrast, rather than working by sedimentation, the membrane bioreactor method uses a membrane filter with microscopic pores to separate out the sludge. This reduces the equipment size and improves the quality of treated water.

In the case of sewage and wastewater treatment, Hitachi is reducing the load on the environment and boosting efficiency in terms of both water treatment and operational control, including by installing an anammox treatment system that uses an inclusive immobilization technique(d) to treat industrial wastewater, and trialing a new operation control technique for denitrification.

(3) Contribution to utility operations and maintenance

Hitachi is contributing to operations through public-private partnerships (PPPs) with water utilities that take on a variety of forms, including partial outsourcing, full outsourcing, and private finance initiatives (PFIs).

A 20-year PFI project that includes on-site electric power generation has been running at the Asaka Water Purification Plant / Misono Water Purification Plant of the Bureau of Waterworks Tokyo Metropolitan Government for nearly 11 years, and Hitachi intends to continue striving to contribute to these plants through its involvement in the project. Also in progress is a PFI project that combines both the construction and ongoing maintenance management of a water treatment plant at Yubari City in Hokkaido that uses the membrane filtration method(e).

The introduction of inspection, equipment management, and other systems that use mobile devices is also boosting maintenance and management efficiency. By introducing new products and systems to improve the efficiency of services, and by taking advantage of the synergies that arise from incorporating improvement ideas obtained through this work into technology developments, Hitachi is seeking to supply high-quality, comprehensive solutions (see Fig. 2).

SOLUTIONS FOR GLOBAL WATER INDUSTRY

Water problems are global challenges that are closely interlinked with the problems of food and energy, and the competition to acquire water business markets is intensifying, involving not only private-sector companies but also national and other government agencies.

Given these circumstances, Hitachi is accelerating its activities aimed at overcoming the challenges of the global water industry through joint ventures such as public-private partnerships and collaborations with other companies from Japan or elsewhere. The following sections describe some examples.

(1) Water supply and sewage

Hitachi is helping rationalize the overall operations of water supply and sewage in the Maldives through its participation in the running of Male' Water and Sewerage Company Pvt. Ltd. (MWSC). MWSC currently operates eight seawater desalination plants that use reverse osmosis (RO) membranes(f) to

(d) Anammox treatment system using an inclusive immobilization technique
An advanced treatment system capable of reliable denitrification with smaller space and energy requirements through the use of inclusive immobilization carriers in which anaerobic ammonium oxidation (anammox) microbes that remove nitrogen from sewage are immobilized in a polymer.

(e) Membrane filtration method
An alternative to the previous rapid filtration method, which combined coagulation, sedimentation, and filtration, this technique uses membrane filtration for continuous water purification. It is entering wider use as a safe and reliable water purification technique that can also deal effectively with pathogenic protozoa that have resistance to the widely used chlorine disinfection of water supplies. Membranes in a variety of materials and forms are used, each of which has different characteristics.

(f) Reverse osmosis (RO) membranes
These are membranes with microscopic pores (diameter of 1 nm or less) that allow water to pass but not impurities such as salt. If water with different concentrations of salt is separated by an RO membrane, the process of osmosis would normally cause water to flow from the low- to the high-concentration side. This can be reversed, however, by raising the pressure on the high-concentration side above the osmosis pressure, thereby causing water to flow to the low-concentration side. This principle of reverse osmosis is used with water treatment membranes for applications such as seawater desalination.

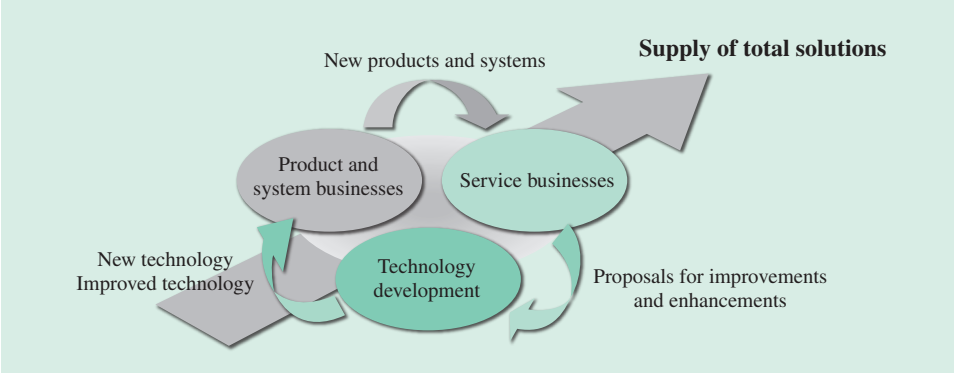

Fig. 2—Overview of Coordination between Technology Development, Product and System Businesses, Service Businesses.
Hitachi aims to supply high-quality service solutions by coordinating the operation of these different businesses.

Fig. 3—Hitachi's Participation in Water Business in Maldives.
Hitachi is participating in the operations of Male' Water and Sewerage Company Pvt. Ltd. in the Maldives. The drinking water bottling plant is located next to the seawater desalination plant.

produce fresh water from groundwater drawn from on-site wells. This process is subject to rigorous water quality management to ensure a safe water supply to the 110,000 population of the island of Male'. The desalinated water is also shipped and sold as bottled water to enhance people's way of life (see Fig. 3). Hitachi intends to continue helping to overcome the challenges associated with water in the Maldives, and to put this experience to use in other activities.

(2) Large seawater desalination projects

Hitachi is focusing on the seawater desalination business as one way to overcome water shortages. There are concerns about places around the world that suffer from physical water scarcity, particularly in equatorial regions, and places that suffer from water scarcity for economic reasons due to a surge in demand for water resulting from population growth or economic development. While seawater desalination is one effective way of dealing with this, its challenges include improving energy efficiency and reducing the cost of construction and operation.

Hitachi is participating in the Mega-ton Water System[(g)] project of the Japanese Cabinet Office's Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST Program), and the Project on Water-saving Recycling Systems[(h)] of the New Energy and Industrial Technology Development Organization (NEDO), which are public-private-academia collaborations engaged in the development and testing of large seawater desalination plants, a market that is expected to grow in the future. The projects have succeeded in cutting costs and improving energy efficiency by 30% or more compared to previous seawater desalination systems. This includes a system that helps reduce the load on the environment by reducing the concentration of salt in discharged water by incorporating certain processes used in sewage treatment for use in seawater desalination. There is scope for this system to be deployed at water treatment plants designed for use in regions of water scarcity.

In May 2015, Toray Industries, Inc. and Hitachi signed a memorandum of understanding with Saline Water Conversion Corporation, a seawater desalination company, and Abunayyan Trading Company Limited, a water and energy business, both of Saudi Arabia, to conduct trials of the Mega-ton Water System. By drawing on experience gained from the development of advanced technologies, such as low-pressure RO membranes that help conserve energy and the use of a two-stage design for the RO membrane pressure vessel to make systems more efficient, the aim is to

(g) Mega-ton Water System
One of the projects undertaken as part of the FIRST Program that ran from FY2009 to FY2013. Aimed at helping overcome worsening water problems around the world, the project involved the research and development of core technologies for large, low-cost seawater desalination systems that are energy efficient and place a low load on the environment. A total of 31 organizations participated, including universities and private-sector companies such as Hitachi and Toray Industries, Inc., and the project achieved its research goals. A pilot plant demonstration is planned to commence in 2015 based on the results of the Mega-ton Water System project.

(h) Project on Water-saving Recycling Systems
A project that ran from FY2009 to FY2013 with the aim of developing technologies that can help reduce the load on the environment in energy-efficient ways to enhance further Japan's strengths in water treatment and water resource management techniques. The project developed technologies associated with the water cycle, including innovative membrane separation, energy-efficient membrane bioreactors, separation and recovery of valuable metals and toxic substances, and the highly efficient decomposition of persistent materials. It also included conducting trials and surveys aimed at deploying water resource management techniques in Japan and elsewhere.

build a large seawater desalination plant (in the one million m^3/day range) in the near future that features a low load on the environment and low cost.

(3) New business development

Hitachi is working on collaborating with non-Japanese companies to improve and expand its solution marketing capabilities.

Hitachi signed a memorandum of understanding with the water treatment company, Veolia Water Solutions & Technologies SA, in April 2014 relating to the companies working together on water infrastructure projects. The intention is to organize joint ventures on a project-by-project basis for water and sewage treatment, seawater desalination, and other such projects in Middle East, Africa, and Asia. It will also provide opportunities for utilizing Veolia's know-how and sales channels for engineering, procurement, and construction (EPC), as well as operation and maintenance (O&M).

In January 2015, Hitachi acquired Aqua Works and Engineering Pte. Ltd., a Singaporean water treatment equipment and engineering company. This will strengthen overall marketing capabilities in the Southeast Asian region by combining Aqua's water landscaping equipment, such as fountains and pools, with the RO membrane systems of Hitachi Aqua-Tech Engineering Pte. Ltd.

Elsewhere, water treatment for the oil and gas industry is another sector where Hitachi is engaging in new initiatives. With environmental regulation of the oil and gas industry becoming progressively stricter, one of the challenges faced by the industry is how to treat the water produced as a byproduct of oil and gas extraction.

Meanwhile, there is growing demand for sulfate removal units (SRUs) for use with waterflooding, a technique for increasing oil production by injecting pressurized water into oil-bearing strata. The technique requires the elimination of sulfates because of the role they play in the formation of scale (sediment). Another market is that for water treatment equipment used in applications such as offshore oil fields, where special specifications apply because of limitations on things like installation space and power supply.

Hitachi is working on new initiatives that draw on its extensive knowledge of water treatment technology to supply solutions to the challenges specific to the oil and gas industry.

CONTRIBUTING TO SUSTAINABLE WATER THAT IS SAFE AND RELIABLE

This article has given an overview of trends in the water industry in Japan and elsewhere, and Hitachi's involvement in water industry solutions. Based on its many years of experience and extensive track record, Hitachi intends to continue contributing to the ongoing development of social infrastructure, including safe and reliable water.

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