

Intelligent Water System for Smart Cities

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OVERVIEW: Japan is rich in water resources with little experience of water shortages. Internationally, however, examples can be seen both of locations where lack of water is a physical phenomenon and where it is an economic one, and it is predicted that water shortages will become more severe as populations rise and become more concentrated in the urban areas. Effective ways of supplying water to afflicted cities include production of water by seawater desalination and use of recycled water, and there is a need to manage the overall circulation of water around the city efficiently. To provide smart cities with water infrastructure systems, Hitachi is promoting its intelligent water system concept for integrating water treatment systems with information and control systems for the efficient utilization of recycled water.

INTRODUCTION

MANY countries and regions around the world are confronting severe water shortage problems. Countries with low rainfall include Central Asia, India, the Middle East, North Africa, and North America while countries that are rich in water resources but are unable to provide access to clean water for economic reasons include Southeast Asia, South America, and Africa (see Fig. 1).

Factors such as population increase and especially urbanization mean that the world is forecast to use about 30% more water in 2025 than it did in 2000, with further water shortages expected.

Hitachi has been involved in numerous water-related projects over its 100-year history, including

approximately 2,800 sewage treatment plants and 550 water treatment plants, mainly in Japan. Outside Japan, it has participated in nearly 250 projects in about 40 different countries.

Based on the technology and experience it has built up along with its customers and its activities over many years in manufacturing, technology development, and ensuring product reliability, Hitachi intends to create smart cities by making effective use of water resources and providing an efficient water infrastructure.

This article describes the intelligent water system concept for smart cities and Hitachi's water infrastructure solutions for achieving this.

INTELLIGENT WATER SYSTEM

Circulation of Water Resources

Drinking water is typically supplied by collecting rainwater or snowmelt in a lake or behind a dam and taking water off for treatment from the outflowing river. The water is used for various purposes, after which it is collected again as wastewater or sewage for treatment before being returned to the river for ultimate discharge into the ocean. The water resource cycle completes when evaporation of the water produces clouds from which the water falls to earth again as rain (see Fig. 2).

However, this circulation of water resources does not work effectively for the countries and regions suffering from water shortages. Also, it is anticipated that new means and technologies for producing water will be needed in those places where this water resource cycle does currently work, albeit only barely. This is because the cycle will be insufficient on its own due to water shortages caused by growing urbanization

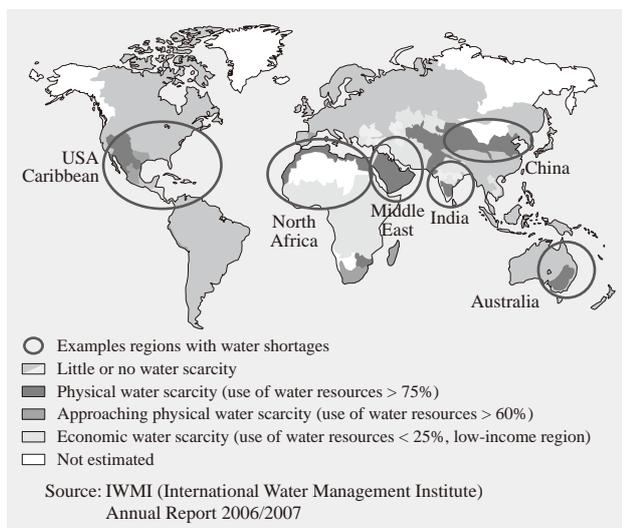


Fig. 1—Global Distribution of Water Shortage.
Water shortages are a physical phenomenon in some locations; an economic one in others.

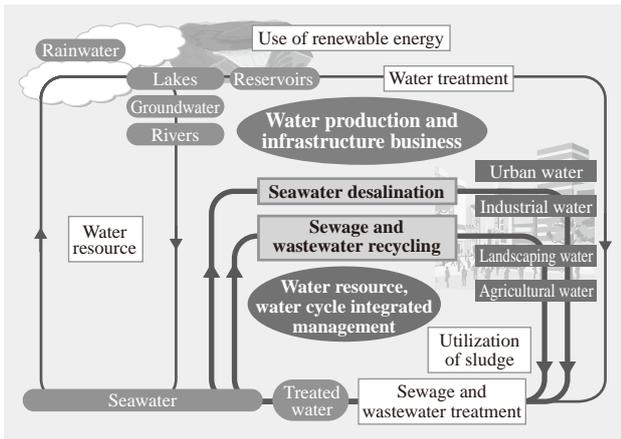


Fig. 2—Overview of Water Resource Cycle. Whereas Japan can obtain enough water from the outermost cycle, elsewhere many places exist where this is not sufficient or where the cycle is not feasible at all.

and the concentration of population that are predicted for the future.

One potential approach is the use of seawater desalination technology to produce clean water from the ocean. Another is to use water recycling technology to make effective use of treated sewage and wastewater.

The intelligent water system is made up of technologies and systems that make effective use of water resources by increasing the number of pathways for water circulation. It will be an essential element in the realization of smart cities.

Intelligent Water System Concept

Fig. 3 shows the intelligent water system concept proposed by Hitachi.

The figure shows the water cycle for an example region. More efficient operation of treatment plants and improved business efficiency across the entire region is achieved by taking a proactive approach to using treated effluent (which in the past would have been discharged into a river) as recycled water, returning it for use in residential districts, factories, or other sites, and by collecting information (such as operational data from these plants or water usage in the distribution system) in a single location where it can be managed centrally. Hitachi believes that this is precisely the sort of approach that a smart city should aim to achieve.

Technologies for implementing an intelligent water system include conventional treatment technologies for water supply and sewage, industrial wastewater treatment technology, monitoring and control system technology, seawater desalination using RO (reverse

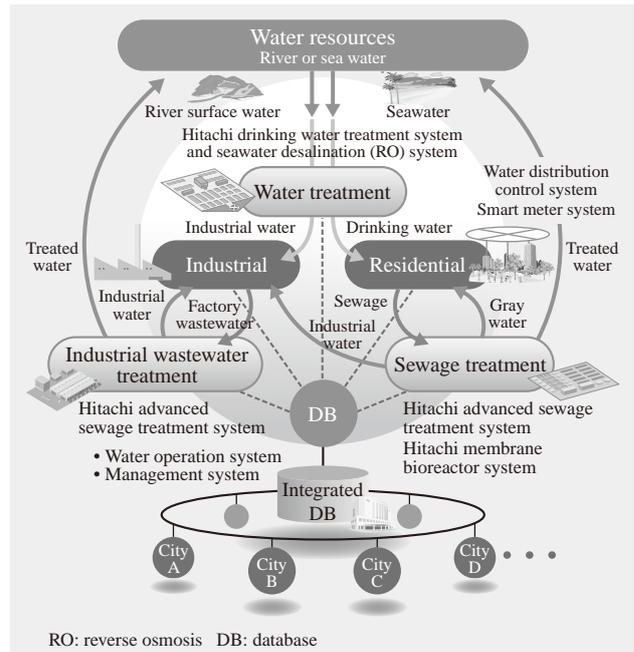


Fig. 3—Intelligent Water System. The intelligent water system provides a water resource cycle for smart cities by combining IT (information technology) with technology for supplying high-quality recycled water.

osmosis) membranes, technology for the reliable supply of drinking water using water distribution control systems to reduce the rate of leakage, customer information management technology using smart meter systems, and advanced sewage treatment technology using methods like membrane bioreactor systems. Hitachi believes it is possible to improve the business efficiency of the water cycle across an entire region by collecting information such as water usage in the distribution system and operational data from water treatment plants in a single database where it can be managed centrally and used interactively.

HITACHI WATER INFRASTRUCTURE SOLUTIONS

(1) Water treatment systems

Water distribution plant supplied by Hitachi includes a wide range of solutions extending from intake to transportation, purification, distribution, and supply equipment as well as various types of chemical dosing and sterilization machinery and also electrical equipment, instrumentation systems, and monitoring and control systems. Also, membrane-based purification systems such as UF (ultrafiltration) membrane systems and RO membrane systems can be used to supply high-quality tap water by eliminating problems such as turbidity, bacteria, and salinity.

(2) Sewage advanced processing system: Immobilized Microorganism Treatment System

The water treatment process at a sewage treatment plant consists of “first treatment” that covers the processes of separating and removing solid matter and other physical material up until the first sedimentation tank, and “secondary treatment” that involves the use of microorganisms and other mechanisms for eliminating organic matter up until the final sedimentation tank.

The treated water is disinfected and is discharged into public waterways. However, “advanced processing” to remove nitrogen, phosphorous, organic substances, and other contaminants that cannot be removed by the above two processes is needed in cases when action is required to prevent eutrophication of public waterways, or when the treated water is to be reutilized.

Immobilized Microorganism Treatment System is a processing system for retrofitting advanced processing into existing sewage treatment plants. It is a nitrification reaction and denitrification process that uses nitrifying pellets and was developed by Hitachi Plant Technologies, Ltd. through joint research with the Japan Sewage Works Agency. The conventional biological reactor is split into anaerobic and aerobic tanks and the slow growth of the nitrification reaction bacteria is countered by adding nitrifying pellets containing immobilized microorganisms into the aerobic tank. This halves the time taken for treatment (see Fig. 4).

(3) Membrane bioreactor system: Biological processing and membrane

Membrane bioreactor technology combines a membrane and biological reactor and is known as the membrane bioreactor.

A feature of a membrane bioreactor is that, using a membrane, it can completely remove suspended solids called “activated sludge,” which multiply by a biological reaction. As the membrane pores are smaller than bacteria, it can also remove bacteria and other larger microbes to produce high-quality treated water. Hitachi’s membrane bioreactor consists of a membrane module with a flat membrane. The sedimentation required in the previous activated sludge method is eliminated by immersing it in the biological reactor. Accordingly, the system takes up less space and is simpler to maintain than previous methods. It produces good-quality treated water suitable for irrigation and other forms of reuse. As a result, it can be seen as an important form of water treatment in the intelligent water system (see Fig. 5).

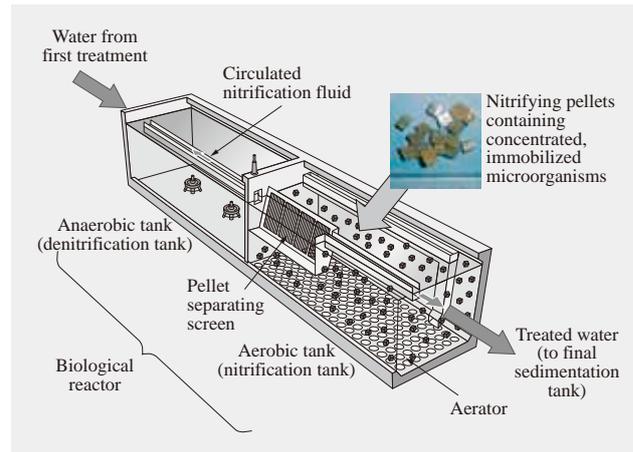


Fig. 4—Immobilized Microorganism Treatment System. Processing time can be halved by using nitrifying pellets that contain nitrification reaction bacteria.



Fig. 5—Hitachi Flat Membrane Bioreactor Unit. The unit features small size and ease of maintenance.

(4) Monitoring and control systems

Hitachi has delivered approximately 900 monitoring and control systems for water and sewage infrastructure to date in Japan, supplying its information and control know-how built up over many years in the form of solutions such as water treatment processes, water operation systems, water distribution control systems, and water quality control systems that run on monitoring and control system platforms. In addition to being equipped with user-friendly human-machine interfaces, these systems have a client/server architecture with a distributed server configuration that allows for progressive upgrades. Their design also supports seamless interconnection with wide-area systems.

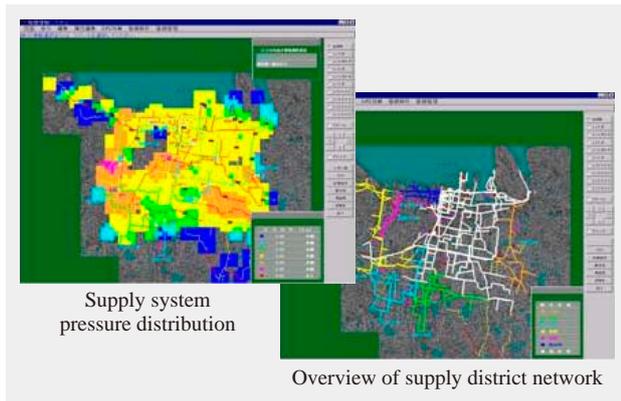


Fig. 6—Example Screen from Water Distribution Control System. The system manages the pipe network in the district being supplied and predicts the pressure distribution.

(5) Water distribution control systems

The distribution of drinking water produced at water treatment plants requires separate reservoirs and other distribution infrastructure for each region being supplied. Because the pumping of water is a key part of this infrastructure, it consumes a large amount of electric power.

Water distribution control systems seek to reduce power consumption and regulate the pressure distribution within each section of the water supply network to achieve a reliable water supply with fewer leaks (see Fig. 6).

HITACHI'S WATER INFRASTRUCTURE BUSINESS OBJECTIVES

To realize its intelligent water system, Hitachi recognizes that it needs to participate actively in the operational side of the water business. Its aim is to help improve regional water infrastructures by working more closely with local operators and supplying better solutions. The following sections describe examples of participation by Hitachi in the recycled water business and water distribution business along with its future plans for the large-scale seawater desalination business.

Water Recycling Business in Dubai in UAE

In August 2008, Hitachi Plant Technologies, Ltd. established Hi-Star Water Solutions LLC. as a joint-venture company with Al Ghurair Group, a notable local conglomerate, to collect and treat domestic wastewater for sale as recycled water in the Emirate of Dubai in the United Arab Emirates (UAE).

The company established a water recycling business based on Hitachi's membrane bioreactor



Fig. 7—Recycling System at Recycled Water Business in Emirate of Dubai.

The business supplies good-quality recycled water using a membrane bioreactor and RO system.

technology in response to the problem of treating the domestic wastewater resulting from the rapid increase in the number of workers associated with the urban development rush in Dubai. The business model involves collecting domestic wastewater from the workers in return for a processing fee, and installing treatment equipment close to the domestic wastewater outlet and selling the treated water to nearby factories for industrial use at a cheaper price than tap water.

The treatment equipment uses a system that combines membrane bioreactor and RO. The treatment equipment for the initial plant is installed in a cement works where it treats domestic wastewater from the neighborhood and supplies the recycled water for industrial use on site (see Fig. 7).

Water and Sewage Business in Republic of Maldives

In January 2010, Hitachi Plant Technologies, Ltd. acquired a 20% stake in Male' Water & Sewerage Company Pvt. Ltd. (MWSC) from the government of the Republic of Maldives. MWSC operates the country's water and sewage systems.

Established in 1995 in the capital, Male', MWSC operates water and sewage systems on seven islands including Male' itself, serving approximately 40% of the country's population. It also has licenses for water and sewage operations on a further six islands. Hitachi group company Hitachi Aqua-Tech Engineering Pte. Ltd. has already supplied approximately 200 RO seawater desalination units to the Maldives. Hitachi is involved in the running of MWSC and is using its intelligent water system to contribute to improvements in the country's living standards by delivering reliable water and sewage services and improving operational efficiency.

Large Seawater Desalination Plants

International demand for large seawater desalination plants is growing as a way of coping with water shortages. In addition to accelerating its own research and development, Hitachi is also participating in the Mega-ton Water System, an advanced research and development support program sponsored by the Cabinet Office of the Government of Japan, which aims to develop large seawater desalination plants with capacities in the 1,000,000-m³/day class that significantly reduce both CAPEX (capital expenditure) and OPEX (operational expenditure).

CONCLUSIONS

This article has described Hitachi's intelligent water system concept for smart cities.

A feature of the intelligent water system is that it can improve the efficiency of water resources in a region by combining IT with various different water treatment systems to make effective use of recycled water.

The intelligent water system has an essential role in coping with water shortages throughout the world and the development of the ideal smart cities of the future. Hitachi intends to draw on its past experience to make further improvements in regional water cycles.

ABOUT THE AUTHORS



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