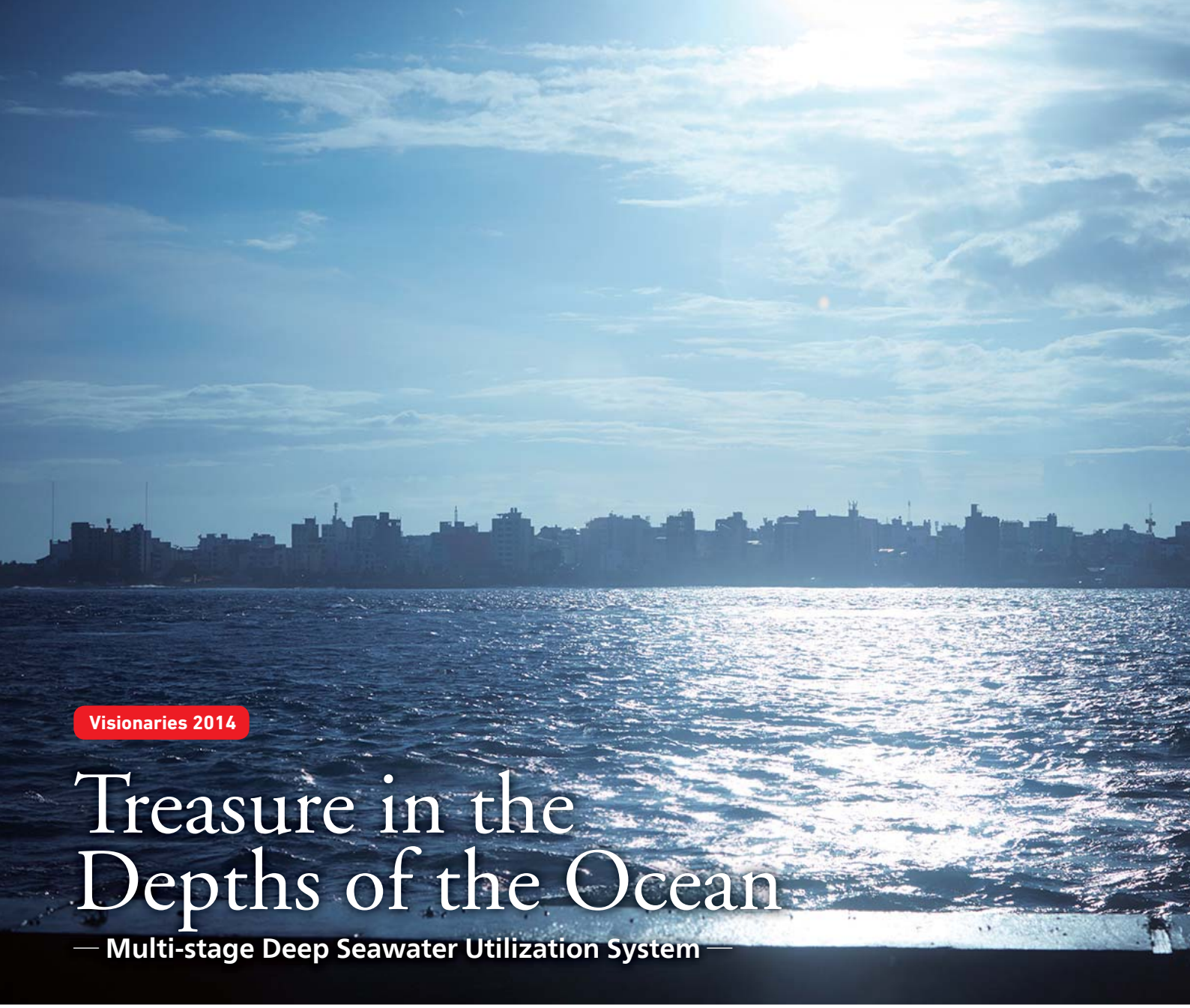


Visionaries 2014

Treasure in the Depths of the Ocean

— Multi-stage Deep Seawater Utilization System —

The growth of the global population is bringing with it severe water shortages in different parts of the world. With a history of taking on the many challenges associated with water, Hitachi is now embarking on a new project that will bring relief to this situation. This groundbreaking initiative will help provide drinking water and facilitate the creation of new industry by taking water from the deep ocean and utilizing it, firstly as a source of cold energy, and also to produce fresh water. Research and other studies are currently underway aimed at commercializing the technology for coastal nations or offshore islands such as those in the Pacific and Indian Oceans.

Inexhaustible Supply of Water with Valuable Uses

As the global population continues to grow, particularly in emerging and developing nations, providing the water infrastructure needed to support this population has become a matter of urgency. Annual worldwide demand for water is anticipated to grow by 30% or more over the 30-year period from 1995 to 2025*.

Hitachi has been supplying products, systems, and services to various different parts of the water industry for many years, drawing on this experience to help resolve water-related issues around the world. Akira Yokoyama (General Manager, Water Environment Solutions Business Management Division, Infrastructure Systems Company, Hitachi, Ltd.), who is involved in these global operations, described the situation as follows.

"The size of the global water business is expected to grow rapidly in the future. To contribute to water infrastructure in different parts of the world, Hitachi is seeking to keep in step with the Japanese government and its promotion of infrastructure

system exports, not only through conventional official development assistance (ODA), but also by utilizing new frameworks like public-private partnerships (PPPs)."

One notable example of a solution for the water sector is a multi-stage deep seawater utilization system on which Hitachi started work in FY2010. The initial objective of the project was to save energy.

Hitachi has for some time been developing numerous technologies for saving energy in air conditioning, including systems that utilize the cool outside air available at high-latitude locations to cool plant and equipment, or air conditioning systems that utilize the abundant solar heat available in low-latitude locations. There is also a demand for energy saving technologies that utilize geographic advantages in the low-latitude equatorial regions where many emerging nations are found.

As Mr. Yokoyama commented, "When struggling to decide how to proceed, we recalled our involvement in the construction of a food processing plant in Toyama Prefecture with a cooling system that utilized deep seawater. Of course the natural environment in Toyama, Japan is very different to that in equatorial regions. When we looked into it, however, we found that the temperature of deep seawater below 1,000 m is a steady 5 to 6°C, even at the equator."

Akira Yokoyama

"Deep seawater" typically means water at depths of 200 m or more, where the lack of sunlight inhibits microorganism growth, making the water much purer than at the surface. At 1,000 m and below, the water quality becomes stable with a temperature of about 5°C or less. Because organic material that has decomposed at the surface tends to collect at these depths, they are rich in inorganic nutrients. Most of all, they are sustainable because of constant replenishment at polar regions.

Of course, the obstacle to actual use of deep seawater is finding a way to make it a profitable business. In turn, overcoming this requires a site with high demand for cold energy at which water can be raised from the deep ocean over as short a distance as possible. For these reasons, the Republic of Maldives and Republic of Mauritius were identified as sites for a model business, with plans already in progress at both these countries.

Supporting a Tourism-based Economy

The seabed condition around the Maldives is favorable for deep seawater intake, and the Maldives' tourism-based economy means strong demand for energy. With an average height above sea level of only 1.5 m, making it particularly vulnerable to the effects of global warming, the Maldives takes environmental measures seriously. Meanwhile, having taken a stake in the locally based Male' Water & Sewerage Company Pvt. Ltd., Hitachi is already involved in operating water supply and sewage services in the Maldives, along with seawater desalination.

Given these circumstances, Hitachi has sketched out a blueprint for utilizing cold energy extracted

The Maldives are popular with tourists, having been described as a South Seas paradise. Hitachi took a stake in the company that operates the local water supply and sewage systems in 2010 and is involved in its business activities.

A plan is underway in the Maldives to use deep seawater first to produce chilled water for air conditioning, and then for a series of other uses.

A bathymetric survey is being conducted in the Maldives in preparation for the use of deep seawater.

Male' Water & Sewerage Company Pvt. Ltd. is currently engaged in seawater desalination and the production of bottled water. In addition to these businesses, deep seawater is also to be used in applications such as fisheries or agriculture.

Koji Suzuki

from deep seawater in the air conditioning of buildings and industrial sites, and also for supplying this water to seawater desalination, bottled water production, and industrial users. Koji Suzuki (Manager, Project Promotion Department, Water Environment Solutions Business Management Division, Infrastructure Systems Company, Hitachi, Ltd.), who has been involved in this work from the field survey stage, made the following comments about its feasibility.

"When used as the raw water for a desalination plant, deep seawater can reduce running costs significantly because its purity minimizes the amount of pre-treatment required. The amount of energy required to collect the water can also be minimized by building an underground pumping station below sea level, in which case water pressure alone is enough to bring deep seawater up to sea level of its own accord."

These cost and energy efficiency benefits also reduce the load on the environment.

"We have estimated that, depending on the conditions, we can reduce the emission of greenhouse gases associated with air conditioning by around 80% compared to conventional systems. The concordance between Hitachi's aim of having the system more widely adopted and the Japanese government's desire to establish a **joint crediting mechanism**[(a)] is another major driver behind the plan."

Based on the assumption that the joint crediting mechanism would apply, Hitachi was able to obtain funding for preliminary work, including identifying and formulating potential projects, from sources such as the Ministry of Economy, Trade and Industry and New Energy and Industrial Technology Development Organization (NEDO). This made it possible to carry out detailed feasibility studies covering issues such as candidate sites, water quality and bathymetric survey, and local energy use.

Production of Safe Drinking Water

A host to high-class resort development, the politics and economy of Mauritius are relatively stable compared to other African nations. Like the Maldives, the nearby seabed condition is favorable for deep seawater intake. However, the benign climate means that air conditioners do not need to operate all year round.

These circumstances meant that Hitachi's proposal to utilize deep seawater cooling at a data center coincided well with plans by the government of Mauritius to promote the information technology (IT) industry. A very-high-capacity undersea cable linking USA and the BRICSs (Brazil, Russia, India, China, and South Africa) is currently being planned, and is scheduled to go live in the latter half of 2014. Mauritius is to be one of the relay points for the cable, and there is also demand for the nation to act as a host for data backup by the BRICS nations.

Mr. Yokoyama said, "Because cooling is essential for data centers, their being such intense heat sources, it occurred to us that we could use deep seawater for this purpose. Used in combination with Hitachi's energy-efficient spot air

(a) Joint Crediting Mechanism
The Joint Crediting Mechanism (JCM) is a program in which Japan's contribution to the reduction and removal of greenhouse gas emissions in partner countries through transferring Japan's low-carbon technology and products is calculated and evaluated as credits for contribution.

Contributing to National Development through Good Relations

Ahmed Mujthaba

Ahmed Mujthaba (Engineering Manager, Male' Water & Sewerage Company Pvt. Ltd.) is dedicated to building a good relationship between Hitachi and the relevant agencies of the Maldives, including senior government officials and other people involved, by supporting the deep seawater project.

"Hitachi has maintained a close relationship with the government since taking a stake in the Male' Water & Sewerage Company in 2010. We are looking forward to exposure to the technology, knowledge, and know-how of Hitachi.

The long time taken from feasibility study to approval could be seen as an issue for this project. While this was to some extent a consequence of the changes in the political situation in the Maldives, with factors such as the need to keep the investment cost to a minimum meaning that government approval was required, it is my hope that the project can proceed comparatively quickly once this approval is obtained.

I hope that Hitachi can continue to be involved in the development of the Maldives through its many solutions for water environment and saving energy."

Building Stronger Relations between the Two Countries

Ahmed Khaleel

Ahmed Khaleel (Ambassador Extraordinary and Plenipotentiary of the Republic of Maldives to Japan, Embassy of the Republic of Maldives) is working to build cordial relations between the Maldives and Japan through official inter-government communications.

"This project involving the utilization of deep seawater is the first of its nature in the Maldives and faces numerous difficult hurdles. However, since it is aimed at combining sustainable growth with protection of the environment through improvements in energy efficiency, I believe there is a strong motivation to overcome these challenges. Hitachi is one of the world's leading companies in the field of water resource management, and we believe their technology will be essential to meeting our goals. The project also serves as a positive example for the Joint Crediting Mechanism (JCM) between our two countries, and I see it as further strengthening the cordial relations of friendship and understanding that exist between the Maldives and Japan."

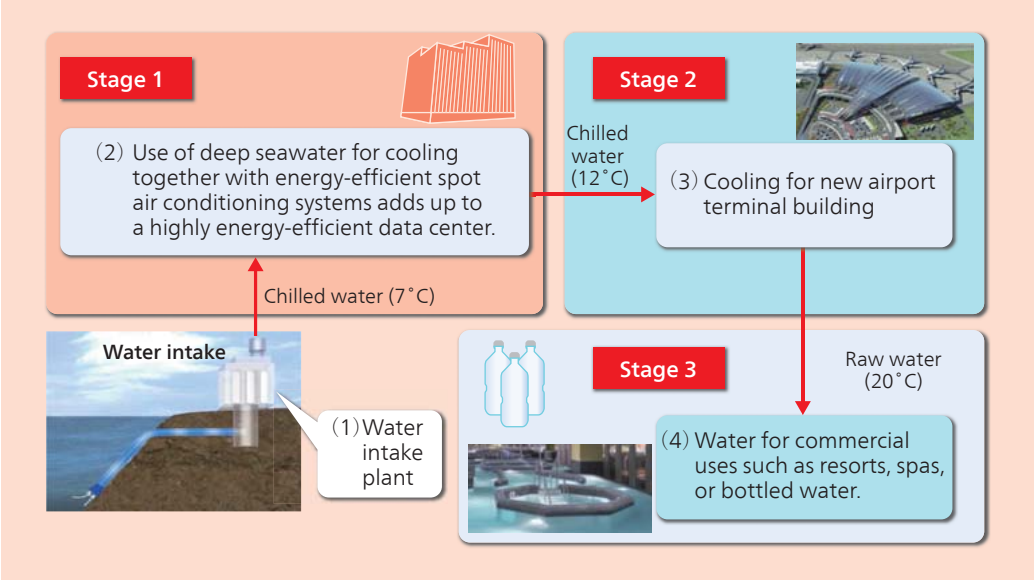
conditioning systems, it can provide an extremely efficient cooling system."

The project was also aided by the fact that the government of Mauritius had itself been pursuing research into the use of deep seawater since about 2008.

As Mr. Suzuki said, "Mauritius is actively seeking to establish a new industry based on the use of deep seawater, and has been investigating its use in fields like aquaculture, cosmetics, and drinking water. A number of businesses have already shown a desire to utilize the deep seawater used for data center cooling."

Because deep seawater is cool, clean, and rich in mineral content, the scope of potential uses is broad. In the Toyama example referred to above, deep seawater discharged after its cold energy has been harvested is used for purposes such as the

Mauritius is an island in the Indian Ocean with roughly the same land area as Metropolitan Tokyo. Its main industries are textiles, sugar, and tourism.



Business model for Mauritius. The rich mineral content of the deep seawater has the potential for a variety of commercial uses.

(b) thalassotherapy
Use of marine resources such as seawater, sediment, or seaweed in the restoration or enhancement of mental and bodily functions through techniques such as exercise, meditation, relaxation, massage, and food. The term was first coined in the late 19th century by the French doctor, Joseph de la Bonnardiere, from the Greek word "thalassa," meaning "sea."

Tomoyo Shiina

cultivation of abalone. There is genuine scope for the "multi-stage use" of this water in applications such as table salt or cosmetics production, agriculture, and thalassotherapy[b].

Tomoyo Shiina (Project Promotion Department, Water Environment Solutions Business Management Division, Infrastructure Systems Company, Hitachi, Ltd.), who has worked with on the field survey and planning along with Mr. Yokoyama and Mr. Suzuki, expressed her expectations for the project as follows.

"Of particular interest is the bottled water business. Not only can we take advantage of the brand image of the place itself, scientific work is also being done to elucidate the health benefits of the minerals in deep seawater. Other investigations are looking at the potential for this deep seawater to be combined with other active ingredients to produce health supplement drinks that aid the prevention of obesity and other lifestyle diseases, or that are good for one's appearance."

Internationally, places where it is customary to drink the tap water are rare, being limited to a dozen or so counties like Japan and the nations of Europe. The production of bottled water from deep seawater is a way of meeting what must be one of the most basic of human needs, namely access to the safe drinking water that is essential to life.

New Tools that Support Major Projects

Before proceeding with a major project like those in the water and other social infrastructure sectors, it is first necessary to investigate the numerous uncertainties that surround it.

As Mr. Yokoyama said, "In the initial stages of a project, it can be very difficult to assess its long-term business viability, including such considerations as operation and maintenance. Estimates can be out by a factor of two in either direction depending on the initial assumptions."

Hitachi's proprietary economics simulator was developed to provide a tool for such business feasibility assessments. The work was done by Youichi Horii (Chief Engineer, Desalination Systems Department, Matsudo Research Center, Infrastructure Systems Company, Hitachi,

Example screen from the economics simulator. The simulator is used for business feasibility assessments, allowing the user to see things like the interdependencies between factors that influence income and expenditure, and how income and expenditure trend over time.

Prospects for Reducing Burden on Environment and New Business Development

Ken Poonoosamy (Managing Director, Board of Investment, Mauritius) is responsible for attracting foreign direct investment to Mauritius. In addition to his involvement in the Deep Ocean Water Applications project, he has also assisted with market research for Hitachi's seawater air conditioning business and multi-stage deep seawater utilization.

"Air conditioning systems that use deep seawater will help reduce fuel consumption and CO_2 emissions and are well aligned with the government's vision of sustainable development. The multi-stage utilization of deep seawater will also create new economic opportunities for high-end aquaculture and algal culture, premium water bottling, pharmaceuticals, and cosmetics.

While challenges remain in implementing the project, we have high expectations for the technical capabilities of Hitachi, a company involved in social infrastructure businesses around the world that brings newly developed expertise in the multi-stage utilization of deep seawater. Although we are still at the commercial feasibility stage, I have already been impressed by the professionalism of the team. It is fortunate that Mauritius has been chosen by Hitachi for its project in the Indian Ocean. I look forward to the success of the project and to Hitachi and Mauritius moving forward together."

Ken Poonoosamy

Ltd.), who has also worked in the Research and Development Group on research into innovative interfaces for devices and displays. He described the functions of the economics simulator as follows.

"The simulator calculation considers all items that relate to income and expenditure, regardless of whether they are technical or commercial. Uncertainties such as the cost of electric power, chemicals, and components can be specified together with a margin of error. In other words, it is possible to make a rational assessment of business viability even when treating unknowns as unknown."

In this way, not only can the simulator indicate the ranges of income and expenditure at a glance, even during the initial planning stage, it can also instantaneously calculate things like internal rate of return (IRR) or long-term scenarios. Also, because it is based on standard spreadsheet software and designed for simple operation, it is easy enough for anyone to use after only about half an hour of training.

Mr. Horii said, "I wanted to make it so that business viability could be assessed without relying on the experience or intuition of the person doing the assessment, and in a way that made it easy to share the assessment among the people involved. To be a genuinely useful tool, it needed to be simple to understand and use. In this sense, I made the most of my knowledge of interface development."

Naturally, the economics simulator can also be used in fields other than water. As Hitachi is involved in numerous major projects, it seems likely that, through its use as a tool for business process standardization, the economics simulator will play an essential part in meaningful discussion based on data.

Toward a World with Abundant Water

While businesses that utilize deep seawater are already active in different parts of the world, few companies have the total capabilities to handle everything from the intake to cooling systems and multi-stage use of the water. In its deep seawater business and beyond, a feature of Hitachi is its ability to offer comprehensive and multi-faceted solutions based on intelligent water systems that fuse IT with engineering capabilities built up over time.

Mr. Yokoyama said, "Deep seawater is an abundant global resource, and we are seeking to draw on Hitachi's strengths to explore this potential in partnership with local communities so that it can be put to use in ways that suit their specific circumstances."

Fresh water suitable for people to use in their daily lives is estimated to make up only 0.01% of the world's total water resources*. There are many communities that find it difficult to obtain enough water for domestic use despite being close to the ocean, or in some cases because they are close to the ocean. Multi-stage deep seawater utilization systems may well offer promising solutions to the problems faced by people who live in these communities.

Youichi Horii

* Source: "Water Resources in Japan," Ministry of Land, Infrastructure, Transport and Tourism