Overview

Hitachi's Involvement in Fukushima Revitalization and Development of New Reactors

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1. Introduction

Nine years have passed since the Great East Japan Earthquake and the accident at the Fukushima Daiichi Nuclear Power Plant of Tokyo Electric Power Company Holdings, Inc. in March 2011. Recognizing the seriousness of the accident, Hitachi has been fully engaged in the recovery and revitalization of the affected area and the plant while also taking action to restore confidence in nuclear energy. Meanwhile, global warming is a serious problem that strikes at the foundations of human sustainability, with climate change bringing an increase in the severity of natural disasters around the world. Led by the Paris Agreement, action on addressing this problem is picking up pace in many countries, with Japan having set itself targets for reducing greenhouse gas emissions (relative to 2013 levels) of 26% by 2030 and 80% by 2050. The coexistence of both renewable energy and nuclear generation that provides a reliable source of electric power without CO_2 emissions will play an important part in achieving this target.

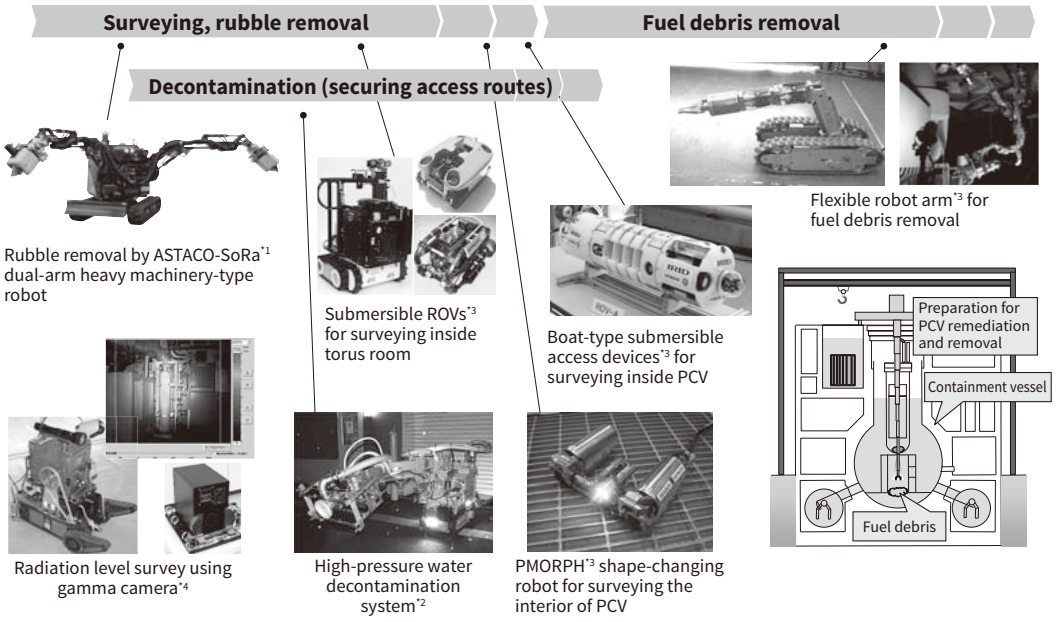
Accordingly, Hitachi is participating in the Fukushima revitalization that is crucial for restoring public confidence in nuclear energy while pursuing measures for increasing plant operation availability on the basis of assured safety. These are part of wider measures for the development of value-adding technologies for nuclear power generation that create new value through the use of digital technology that will contribute to improved utilization rates, with new reactor designs being developed in response to the needs of society in order to advance three reactor types with simple and multi-purpose boiling water reactor (BWR) technology, including by reducing the load imposed on the environment by spent fuel and improving their economic performance. This article describes Hitachi's work on Fukushima revitalization, the progress of new reactor development, and the knowledge management (KM) activities that are essential for maintaining and advancing these nuclear energy technologies.

2. Hitachi's Involvement in Fukushima Revitalization

The overall decommissioning of the Fukushima Daiichi Nuclear Power Plant is being undertaken on the basis of a medium- to long-term roadmap[(1)]. While the priority to date has been to take action on contaminated water and the removal of fuel from the spent fuel pool, a way forward is starting to emerge. As upcoming work will require an extended period spent removing fuel debris, action needs to be undertaken from a medium- to long-term perspective. There has been ongoing development of various types of remotely operated equipment for use in decommissioning that can operate in environments such as the reactor building or containment vessel that are difficult for human workers to approach.

Figure 1 — Remotely Operated Robots and Other Research and Development Activities to Support Fukushima Revitalization

Development by Hitachi has included robots for rubble removal in the reactor building, decontamination equipment and radiation measurement instruments, and robots for surveying inside the PCV. Plans for the future include a flexible robot arm that can operate in high-radiation environments for fuel debris removal and further enhancements to remote operation techniques.



PCV: primary containment vessel ROV: remotely operated vehicle

*1 Utilizes technical know-how from the FY2006 to FY2010 Project for Strategic Development of Advanced Robotics Elemental Technologies commissioned by the New Energy and Industrial Technology Development Organization (NEDO).
The name "ASTACO-SoRa" is an abbreviation of "advance system with twin arms for complex operation" and "*sora*," a Japanese word that conveys the idea of restoring a blue-sky future to Fukushima.

*2 Developed as a project of the International Research Institute for Nuclear Decommissioning (IRID) funded by the Agency of Natural Resources and Energy's (ANRE's) fund for the Technology Development Project of Decommissioning and Safety Technology and so on.

*3 Developed as a project of the IRID funded by the ANRE's fund for the Project of Decommissioning and Contaminated Water Management.
The name is made up of "P" from PCV and "morph" from metamorphosis.

*4 Developed as part of NEDO's Research and Development Project for an Unmanned Disaster Response System.

Development by Hitachi has included robots for rubble removal in the reactor building, decontamination equipment, and radiation measurement instruments, as well as devices for surveying inside the primary containment vessel to enable fuel debris removal (see **Figure 1**). Making more substantial progress on fuel debris removal in the future will require ways of overcoming restrictions on operating time due to the degradation in high-radiation environments of the electronic and other components fitted to remotely operated equipment as well as capabilities for obstacle-avoidance and for the precise sensing of the surrounding area to prevent collisions with obstacles in locations with poor visibility. Achieving these things will also require the development of advanced remote operation techniques. To overcome these challenges, Hitachi has developed a flexible robot arm that can be controlled without the need for sensors, which are unable to withstand exposure to radiation. Featuring a flexible structure that is not damaged by collisions with surrounding objects, the arm is built without the use of electric motors or hydraulics, using instead a combination of pressurized water cylinders and springs. Hitachi is also developing a remote operation system to support the real-time remote control and monitoring of work robots operating under high levels of radiation that function by using information from radiation-hardened external sensors (sensors located away from the robot body). Based around these remote operation and other technologies, Hitachi is taking a medium- to long-term approach to providing the necessary means for assisting with decommissioning work. The article entitled "Development and Application of Robotics for Decommissioning of Fukushima Daiichi Nuclear Power Plant" (page 148) provides an update on the progress of this robot development.

3. Development of New Reactors

While there has been ongoing investment in renewable energy as part of global moves toward achieving a decarbonized society, high expectations continue to be placed on nuclear energy as a reliable source of electric power that is carbon-free and has a weight of inertia behind it. In recent years, however, problems such as repeated delays in plant construction have threatened to increase construction costs and this has been among the factors behind a stalling of investment in nuclear power generation.

In response, Hitachi has put forward a vision for nuclear power that seeks to reduce initial investment risk, provide a reliable supply of power over the long term, and make radioactive waste less hazardous. Three new reactor designs are currently under development with the aim of realizing this vision. These are the BWRX-300 small modular reactor, the resource-renewable BWR (RBWR) light-water-cooled fast reactor, and the power reactor innovative small module (PRISM) small modular sodium-cooled fast reactor (see **Figure 2**). The BWRX-300 takes advantage of the simplicity of the BWR concept and has been comprehensively simplified to provide a combination of safety and economic performance, the RBWR is a fast reactor based on proven light-water cooling technology, and the PRISM uses innovative technology to deliver a high level of both intrinsic safety and economic performance. Hitachi is utilizing open innovation for the joint international development of these three new reactor designs with a view to their global deployment.

The BWRX-300 and PRISM are to be developed through joint US-Japan projects involving collaboration with GE Hitachi Nuclear Energy, Ltd. in the USA, with commercialization in Japan and elsewhere to follow after the construction of the initial plant or experimental reactor in North America. Similarly, the RBWR project is to be undertaken on the basis of a robust development framework involving cross-border partnering that is centered around collaboration between Japan, the USA, and the UK. The intention is to undertake technology development with consideration for how to improve public acceptance and encourage investment in clean energy, including by taking account of nuclear power policy and user opinions, and thereby to expedite the practical realization of these designs. The article entitled "Hitachi's Vision for Nuclear Power and Development of New Reactors" (page 156) provides more details of this work.

4. Knowledge Management Activities

The continued lack of progress on restarting the nuclear power plants shut down in the aftermath of the accident at Fukushima Daiichi is complicating the task of passing on the skills required for plant construction and preventive maintenance. Given the looming retirement of a generation of staff who have played leading roles at the plants and acquired a wealth of experience, the question of how to pass on this knowledge and expertise to the next generation is a pressing issue.

Based on this sense of urgency, Hitachi-GE Nuclear Energy, Ltd. has, as part of internal reforms, embarked on KM activities that aim to formalize knowledge and

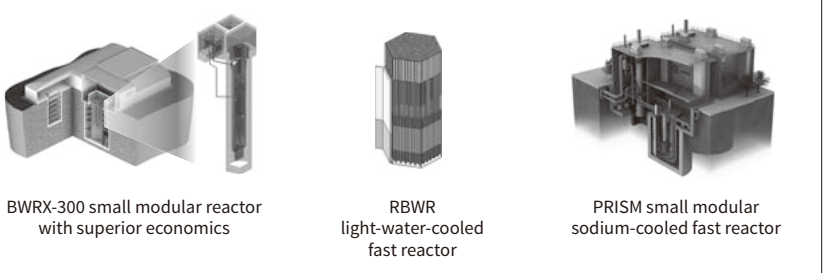


Figure 2 — Provision of Attractive Plants that Satisfy Needs of Both Public and Customers
Three new reactor designs are under development that reduce initial investment risk, provide a reliable supply of power over the long term, and make radioactive waste less hazardous. These are the BWRX-300 small modular reactor, the RBWR light-water-cooled fast reactor, and the PRISM small modular sodium-cooled fast reactor.

raise the level of its use. To achieve this formalization of knowledge, Hitachi-GE started by benchmarking itself against American companies that have high staff turnover and have been engaging in KM since around the year 2000, routinely treating knowledge as something that is held by the organization rather than by individuals. While KM takes many forms, among the common factors crucial to increasing the level of KM activity are the identification of which knowledge represents important intellectual property in terms of the company's strategic priorities, and for managers to encourage the technical staff who make up this intellectual property to take pride in their role, highlighting that this expertise represents an important mission in terms of the company's business case.

Hitachi-GE also learned from this benchmarking that establishing governance measures and proceeding in a step-by-step manner on the basis of an activity roadmap were among the keys to successful KM. A roadmap was duly formulated based on the activity objectives of "transferring knowledge from person to person," "connecting people," and "connecting people with information." The roadmap lays out a step-by-step program in which Stage 1 is to grasp the situation, Stage 2 is to develop a strategy, Stage 3 is to conduct a pilot, Stage 4 is to scale up KM activities (company-wide rollout), and Stage 5 is to institutionalize KM. The article entitled "Knowledge Management for Transferring Nuclear Industry Technical Knowledge to Next Generation" (page 163) provides more information about these activities.

5. Conclusions

This article has described what Hitachi is doing on the decommissioning of Fukushima Daiichi Nuclear Power Plant; the development of new reactor designs that reduce initial investment risk, provide a reliable supply of power over the long term, and make radioactive waste less hazardous; and KM activities for passing on technologies and knowledge of nuclear energy to the next generation.

Along with helping to enhance social, environmental, and economic value for its customers in its role as part of the energy industry, Hitachi also intends to support the security of energy supply and contribute to achieving a sustainable society.

Reference

1) Nuclear Damage Compensation and Decommissioning Facilitation Corporation, "Technical Strategic Plan 2019 for Decommissioning of the Fukushima Daiichi Nuclear Power Plant of Tokyo Electric Power Company Holdings, Inc.," (Sep. 2019), http://www.dd.ndf.go.jp/jp/strategic-plan/book/20190909_SP2019FT.pdf in Japanese.

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