May 2024 Technical Information

Nuclear Energy

Green Energy & Mobility

#Carbon Neutral #Disaster Prevention and Resilience #Sustainability #IoT/Data Utilization #Energy

1. Development and Commercialization of 3D Digital Twin System for Remote and Automated Construction Work

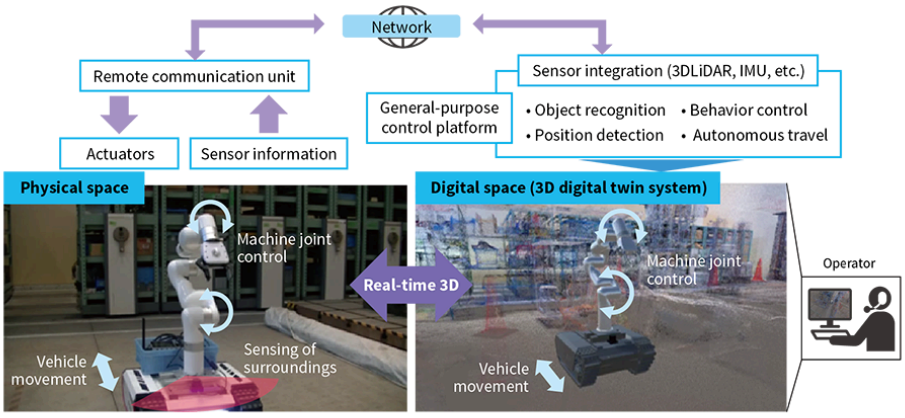
The construction industry has sought in recent years to boost productivity through the application of digital technology to building work. One area that has attracted attention in this digital transformation (DX) of construction is the potential for remote operation to make on-site work more efficient. Past practice in this area has been to equip newly developed machinery with networked cameras that can be viewed while operating them remotely. The problems with this approach have included the high levels of experience and skill that are required.

In response, Hitachi has developed a three-dimensional (3D) digital twin system that is intended to reduce the skill level requirements of remote operation by providing an intuitive sense of where equipment at the site is located and what it is doing. The system has wide application with the potential to ensure that remote work is done safely. It provides a real-time indication of equipment location and movement by attaching networked sensors to the equipment to be remotely operated.

Hitachi intends to contribute to the safety of demolition work by incorporating the system into heavy machinery. Further into the future, the goal is to put it to use with a diverse variety of robots in the provision of remote maintenance inspection services.

(Hitachi Plant Construction, Ltd.)

[01] 3D digital twin system



LiDAR: light detection and ranging
IMU: inertial measurement unit

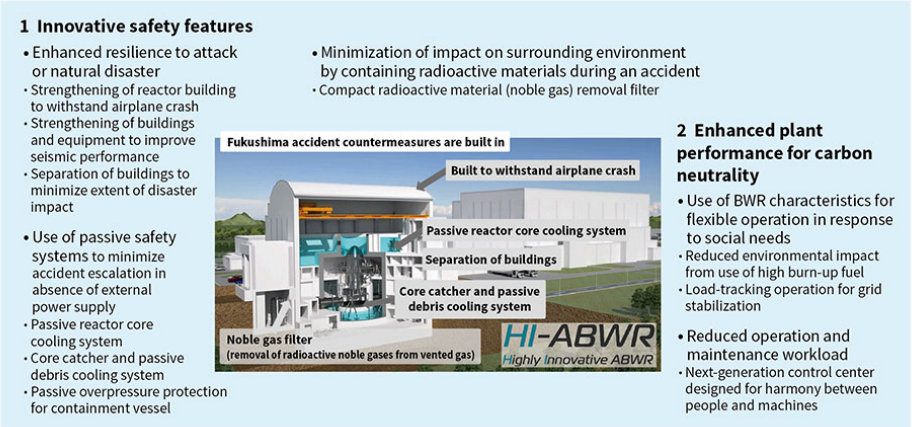
2. Work on HI-ABWR

Work undertaken at other Japanese power plants since the accident at Fukushima Daiichi Nuclear Power Station has included the installation of new equipment that provides higher safety margins in accordance with new regulatory standards that incorporate what was learned from the accident. Hitachi-GE's advanced boiling water reactor (ABWR) for the UK underwent a Generic Design Assessment (GDA) in 2017 and is now recognized as a globally standardized plant that complies with international safety standards. The UK ABWR was designed from the outset to incorporate the lessons learned from the Fukushima nuclear accident into the widely used ABWR design, where this made sense.

Work is now underway on the highly innovative ABWR (HI-ABWR) that incorporates new safety mechanisms while still being based on this globally standardized ABWR design. The HI-ABWR is equipped with safety functions protected by enhanced resilience to natural disasters, terrorism, and internal hazards. It also includes measures for preventing accident escalation that utilize self-sustaining passive safety systems, and innovative safety features that significantly reduce the impact on the surrounding environment should a major accident occur. To help achieve carbon neutrality, it has also been designed to take advantage of the distinctive flexibility and high-performance operational capabilities of boiling water reactors (BWRs).

(Hitachi-GE Nuclear Energy, Ltd.)

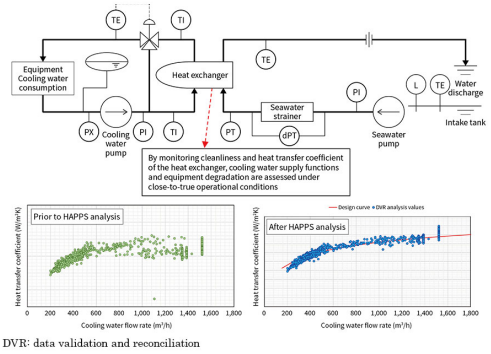
［02］Overview of HI-ABWR



3. Development of System Monitoring Using HAPPS in Partnership with Hamaoka Nuclear Power Station of Chubu Electric Power

The Hitachi Advanced Plant Performance diagnosis System (HAPPS) was developed to monitor and diagnose the operation of nuclear power plants to improve their utilization and reliability. Based on plant design information, the system helps to improve the utilization and reliability of nuclear power plants by providing value in many different forms. These include continuous monitoring of instrumentation malfunctions and degradation in equipment during operation, checking for drift in flow meters or steam leaks from valves that are normally closed, improvements in the performance of thermal output calculations, longer instrument calibration intervals to allow for longer operation cycles, reducing the quantity of calibration, and normalizing high-load auxiliary power.

［03］Cooling system monitoring by HAPPS



DVR: data validation and reconciliation

HAPPS was used in collaborative creation work undertaken in partnership with the Hamaoka Nuclear Power Station of Chubu Electric Power Company, Inc. To provide operational support for the plant, this involved assessing the soundness of auxiliary cooling water systems that supply cooling water to equipment by monitoring the heat transfer performance of heat exchangers and functions for supplying cooling water to each equipment at the required temperature. This was accomplished by getting system functions and equipment condition monitoring to estimate the true operating conditions of the measured conditions when the plant is shutdown, undergoing testing, or during operation.

(Hitachi-GE Nuclear Energy, Ltd.)

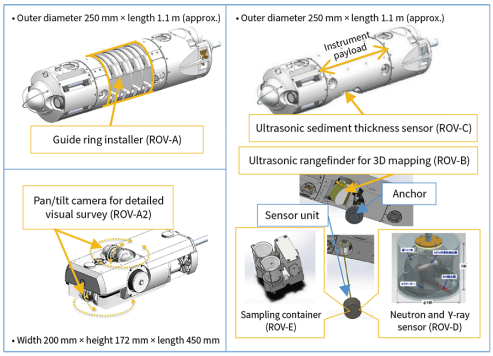
4. Detailed of Investigation of the Inside the Primary Containment Vessel of Unit 1 at Fukushima Daiichi Nuclear Power Station

This work involved the development and on-site demonstrations of investigation techniques through a project funded by the Ministry of Economy, Trade and Industry and a project run by the International Research Institute for Nuclear Decommissioning. It was undertaken to gather useful information for purposes such as the study of fuel debris retrieval methods and included a detailed visual survey of the inside of the Unit 1 primary containment vessel (PCV), measurement of neutrons and γ-rays, measurement of sediment thickness, 3D mapping, and sample collection. Underwater remotely operated vehicles (ROVs) and a variety of sensors were developed to operate in the high-radiation environment inside the PCV and with a water level of approximately 2 m, with six different special-purpose underwater ROVs being built.

The investigation techniques and the tasks of launching, operating, and collecting the underwater ROVs in the PCV were trialed in a full-size mockup of the plant that was built in a factory. Training was also conducted to cover the different eventualities that may occur during on-site operation. The survey collected useful information for assessing sediment and fuel debris outside the pedestal and information on the condition of the equipment inside the pedestal, and the planned work was completed in March 2023. The information obtained will be used in future studies of decommissioning and evaluation of the progress of the accident.

(Hitachi-GE Nuclear Energy, Ltd.)

［04］Six underwater ROVs



Note: Prepared from information posted on the website of Tokyo Electric Power Company Holdings, Inc.

5. Achievement of Market Dominance through Drop Testing of Scale Model Metal Casks

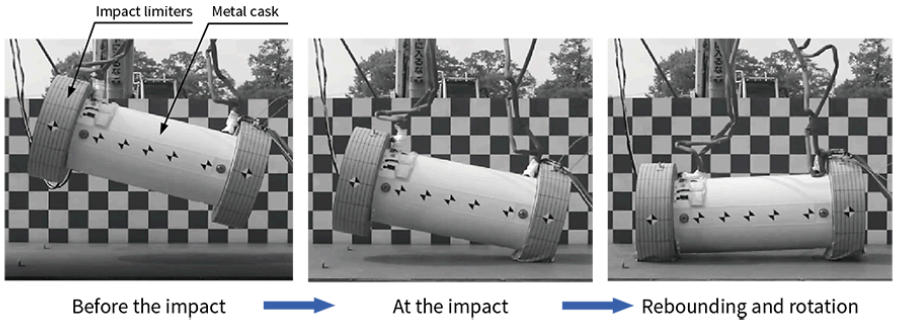
In addition to wet storage of spent fuel from nuclear power plants in spent fuel pools, dry storage in metal casks is also being adopted. Hitachi-GE Nuclear Energy, Ltd. has developed its HDP-69B metal casks that can be used for both transportation and storage. These are achieving market dominance based on actual operational experience ahead of similar products from other companies.

In recent years, it has become clear that the impact force of a metal cask falling at an inclined angle will be high. To address this, Hitachi-GE Nuclear Energy has conducted slap-down drop testing of scale models to assess the complex behavior of a metal cask, including the crushing of impact limiters. The company developed its own evaluation technique with sufficiently general applicability for use in future new designs.

As revisions to the rules regarding dry storage by metal casks equipped with impact limiters have removed the requirement for high-level seismic strengthening of buildings and ground, much higher growth of the market is expected for dry storage at power plants using metal casks with impact limiters. With general applicability for new designs of the impact limiters, the method developed by Hitachi-GE Nuclear Energy is intended to maintain dominance in the growing dry storage market.

(Hitachi-GE Nuclear Energy, Ltd.)

［05］Photographs of the dropped scale model of HDP-69B cask at the impact to the ground



6. Development of Electrical Penetration Modules for Severe Accidents

The severe accident at the Fukushima Daiichi Nuclear Power Station during the Great East Japan Earthquake caused a loss of PCV boundary functions due to rises in temperature and pressure in the PCV that exceeded design parameters. During the accident, electrical characteristics were degraded by the high level of radiation and high-temperature steam and this took out temperature and other instrumentation required for reactor operation. In response, Hitachi-GE Nuclear Energy, Ltd. has partnered with Proterial, Ltd. to develop an electrical penetration module able to withstand severe accidents and maintain PCV boundary functions and electrical characteristics even under these conditions.

Among the causes of PCV boundary loss and degradation of electrical characteristics during a severe accident is the inability of organic materials used in the boundary region to withstand the radiation and heat. Accordingly, the companies developed a mineral-insulated (MI) electrical penetration module that uses metal or other inorganic materials that are not vulnerable to radiation. As this MI electrical penetration module contains only 16 conductors, a heat-resistant electrical penetration module was also developed with the same number of conductors as existing modules (118) using heat-resistant materials with sealing performance and electrical characteristics that will perform well in a severe accident. (Deliveries commenced in June 2023.)

［06］Electrical penetration modules for severe accidents

MI electrical penetration module

Heat-resistant electrical penetration module

Product certification testing that simulated an actual plant demonstrated the ability of the MI and heat-resistant electrical penetration modules to maintain adequate boundary functions and electrical characteristics in a severe accident. In doing so, Hitachi-GE Nuclear Energy was ahead of competing companies and the new products are to be released on the market, including under an original equipment manufacturing (OEM) brand.

(Hitachi-GE Nuclear Energy, Ltd.)

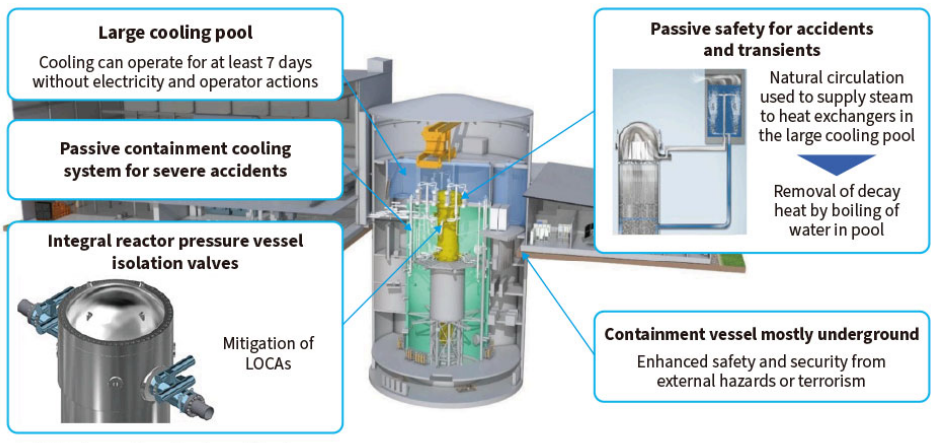
7. Work toward Early Deployment of Small and Economical BWRX-300 Reactor

While the benefits of nuclear power generation are being reevaluated in efforts to achieve a carbon-neutral society, liberalized electricity markets call for a reduction not only in generation costs, but also in investment risk through control of construction costs. It is against this background that global interest has grown in small modular reactors (SMRs). This has led to the development of the BWRX-300 SMR with an electrical output of 300 MW in partnership with US sister company GE Hitachi Nuclear Energy. The BWRX-300 combines the simplification of plant systems with enhanced safety provided by its advanced design concept in which the isolation valves are integrated into the reactor pressure vessel to mitigate as far as possible the consequences of a loss-of-coolant accident. The simplification of plant systems achieves higher reliability and lower capital, construction, operations and maintenance costs by reducing the number of plant components, also reducing the quantity of material to be dealt with during decommissioning. The reactor design was selected by Ontario Power Generation Inc., a government-owned corporation in the province of Ontario, Canada. The construction approval process is already underway with a planned construction completion date as early as 2028. The goal is to supply the SMR initially to North America and Europe, and ultimately to Japan and globally.

Drawing on skills and experience acquired from its past work, Hitachi-GE Nuclear Energy is collaborating on the early commercialization of the BWRX-300 in ways that include demonstrating key technologies and designing major plant components.

(Hitachi-GE Nuclear Energy, Ltd.)

［07］Overview of compact and economical BWRX-300 reactor



LOCA: loss of coolant accident

Hitachi Review

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The *Hitachi Review* website contains technical papers written by Hitachi engineers and researchers, special articles such as discussions or interviews, and back numbers.

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