Featured Articles

Technologies for Improving Safety of Nuclear Power Generation

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OVERVIEW: This article describes work Hitachi has done in terms of nuclear power generation in regard to safety improvement technologies that are under development or in the process of being implemented. This includes the work on decommissioning of the Fukushima Daiichi Nuclear Power Station being undertaken in Japan, the GDA being undertaken by the Office for Nuclear Regulation on an ABWR that is planned for construction in the UK, and a new nuclear reactor that reduces the load on the environment by cutting the quantity of nuclear waste and serves as an example of progress being made on the development of a next-generation reactor.

INTRODUCTION

SINCE the accident at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Co., Inc. (TEPCO), Hitachi has been providing full-scale cooperation with the recovery and reconstruction of the affected areas and the plant itself, assisting in ways that include surveying the damaged nuclear reactors and treating the contaminated water. In preparation for restarting plants in Japan, Hitachi is also working on the development of safety improvement technologies that further increase safety margins in accordance with the new regulatory standards introduced in July 2013 based on the lessons learned from the Fukushima accident, including measures for dealing with major accidents, natural disasters, and deliberate attacks (terrorism).

Overseas, meanwhile, there is rising demand for the construction of new nuclear power plants, particularly from emerging nations, due to the potential for nuclear power generation to provide a reliable source of energy in response to rising global energy demands, and its characteristic of not emitting greenhouse gases in the generation process. In response to this international need, Hitachi is preparing for the construction of new nuclear power plants in places like the UK and Lithuania based on a strategy of supplying its advanced boiling water reactor (ABWR) design, which features a high level of safety performance and an extensive track record. In a new initiative, Hitachi is proceeding with the development of a next-generation light water reactor that is based on proven BWR technology and can reduce the load placed on the environment by high-level waste.

This article focuses in particular on Hitachi's work on the decommissioning of the Fukushima Daiichi Nuclear Power Station, the construction of new nuclear power plants in Europe, and the progress of development of the next-generation light water reactor.

WORK ON DECOMMISSIONING OF THE FUKUSHIMA DAIICHI NUCLEAR POWER STATION

Removal of Spent Fuel from Unit 4

The underlying functions of Units 1 to 4 of the Fukushima Daiichi Nuclear Power Station were disabled by the tsunami that accompanied the Great East Japan Earthquake of March 2011 and the subsequent hydrogen explosions. As the spent fuel pool (SFP) in the Unit 4 reactor building contained 1,535 rods, more than in Units 1 to 3, there was a need to start removing fuel as soon as possible, and this was one of the completion requirements for Phase 1 of the Mid-and-long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station Units 1–4 to which Tokyo Electric Power Co., Inc. has publically committed.

The steps taken to achieve this unprecedented task of removing spent fuel from a reactor building that has lost its underlying functions consisted of:

(1) Removing debris from the top of the existing reactor building

(2) Selecting or designing and building the machinery needed for fuel removal
(3) Designing the structure of a cover to enable fuel removal to be performed without placing a load on the damaged reactor building and planning the installation of machinery
(4) Installing and commissioning of the cover and machinery
(5) Removing debris from the SFP and transporting fuel (performed underwater by remote control)

The on-site work for steps (1), (4), and (5) in particular involved working under the unprecedentedly high level of radiation present after the earthquake.

Fig. 1 shows the cover and machinery installation for Unit 4.

(1) Removing rubble from the top of the existing reactor building

The hydrogen explosion that occurred in the aftermath of the earthquake left the Unit 4 reactor building with parts of the roof, walls, and floor at the top of the building blown out and with damage to the remaining structure. There was also considerable debris piled up on top of the fuel removal equipment and the lids of the containers that had been left out on the fifth floor due to the periodic inspection in progress at the time of the disaster.

This debris was broken up and craned to the ground using a large crawler crane that was positioned on the west side of the reactor building from October 2011 to October 2012 for this purpose. The removal of debris from the roof, walls, and other structural parts of the building was undertaken by Takenaka Corporation, and the removal of damaged machinery by Hitachi-GE Nuclear Energy, Ltd. (Hitachi-GE).

(2) Design, fabrication, and installation of machinery needed for fuel removal

As the atmospheric radiation level on the operation floor of the Unit 4 reactor building was low enough for workers to enter (lower than the other units), a study of the fuel removal equipment was undertaken to look at using the conventional manual procedure whereby casks would be placed in the SFP, loaded with fuel using the fuel removal system, and transported out of the building using the overhead crane. A study of

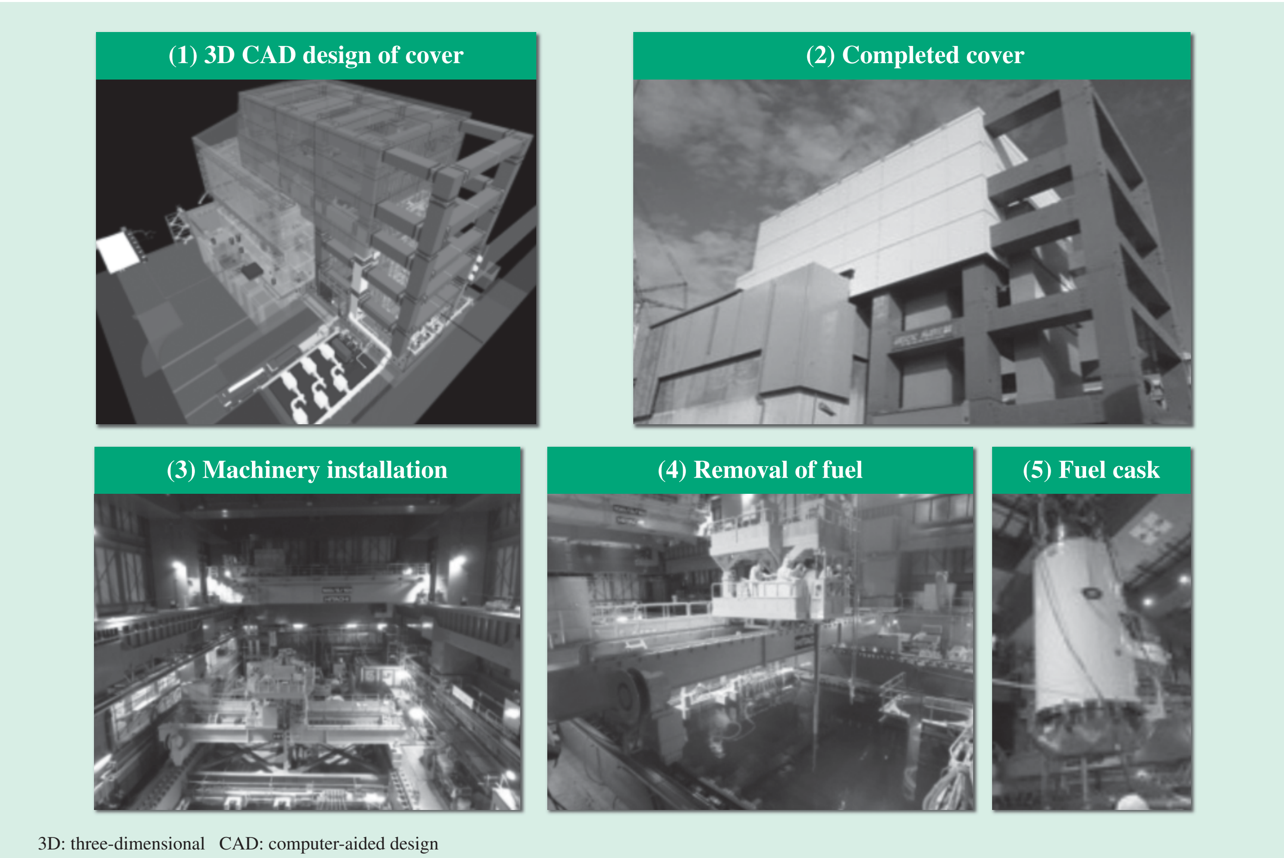

Fig. 1—Cover and Machinery Installation for Unit 4.
The images show (1) the 3D CAD design of the cover, (2) the completed cover, (3) a view of the machinery (fuel removal system and overhead crane), (4) fuel removal in progress (using the fuel removal system), and (5) a fuel cask (being used to transport spent fuel).

the installation of equipment for removing the debris collected in the SFP was undertaken along with planning for minimizing the dispersal or scattering of radioactive material, and how to install ventilation and air conditioning systems to maintain an environment under the cover suitable for human workers and equipment for supplying the water, air, electric power, and other utilities required for the work.

An investigation into the cover intended to provide support for the fuel removal equipment and to prevent dispersal or scattering was considered in cooperation with Takenaka Corporation, and a cantilevered structure was chosen whereby the cover would be supported by newly constructed foundations on the south side of the reactor building in order to avoid placing a load on the building, which had been damaged by the hydrogen explosion. The plan also succeeded in reducing the quantity of ducting and amount of on-site installation work by using part of the cover structure (box shape with 3-m-long sides) as ventilation ducting.

On-site installation of the cover and machinery took place from August 2012 to October 2013. To reduce exposure to radiation, the cover was installed by performing the initial assembly of pillars and beams away from the Fukushima Daiichi Nuclear Power Station site and then performing on-site assembly by having workers bolt the structure together from the inside (with steel plate thickness of approximately 30 mm). Similarly, the amount of machinery installation work inside the reactor building was minimized by initially assembling the machinery into units at an area with a low level of radiation, and then progressively transporting them into the cover for assembly.

(3) Preparing for fuel removal

To prepare for fuel removal, the debris was cleared from the SFP.

The on-site work was not started until adequate preparations had been made by formulating a recovery plan for each item of debris, the nature and size of which had been determined by a preliminary survey conducted using an underwater camera and other

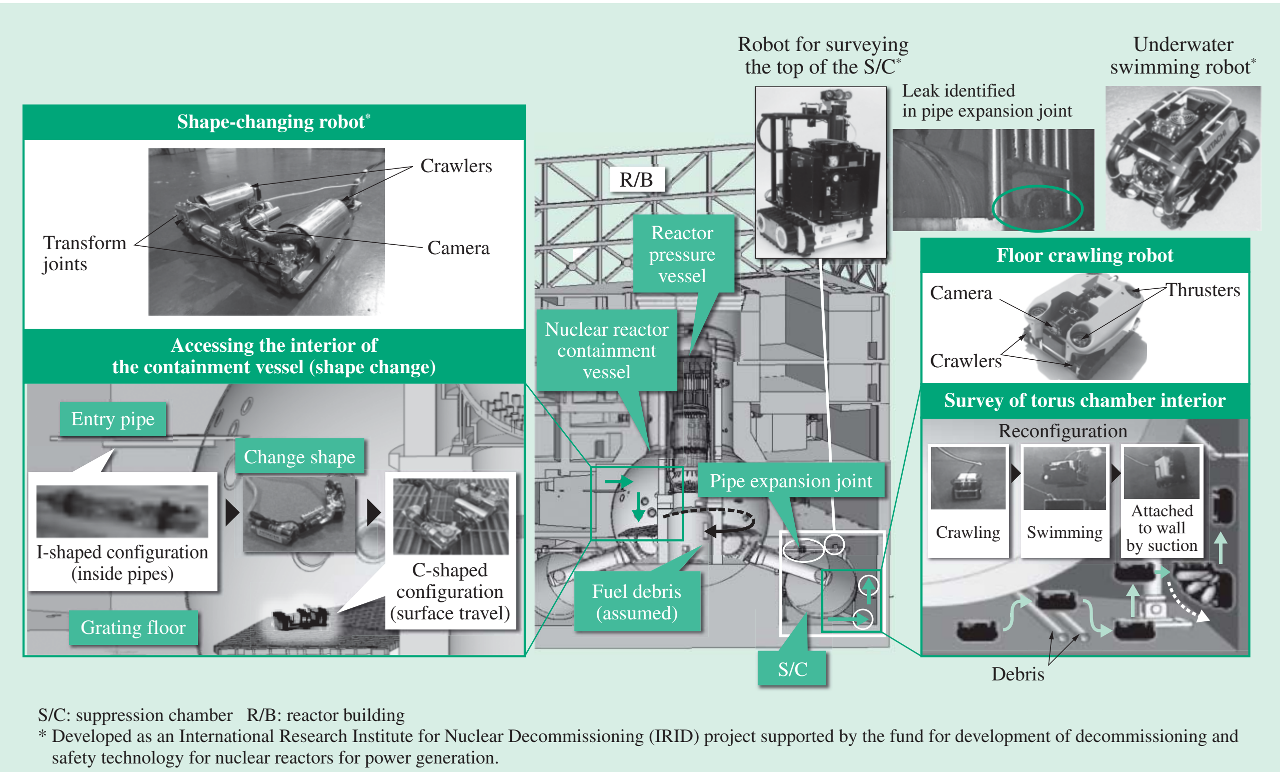

Fig. 2—Robots for Surveying the Interior of a Reactor Building.
To survey the interior of a reactor building, Hitachi developed and conducted on-site trials of three robots for surveying the basement and a shape-changing robot for surveying the interior of the containment vessel. In the survey of the torus chamber in the basement of Unit 1, the robot surveying the top of the S/C found leaks in pipe expansion joints and collected valuable information for repair planning. In the survey of the interior of the containment vessel, the robot traveled about two-thirds of the way around the floor collecting information, including the distribution of temperatures and radiation levels, the condition of equipment, and access routes to the underground floor.

equipment, and obtaining the required gripping and suction equipment. As a result, removal of large items of debris was completed without problems in October 2013, and removal of small items of debris was completed from October 2013 to March 2014.

(4) Fuel removal

After work on the cover was completed in November 2013, fuel removal by Tokyo Electric Power Co., Inc. commenced from November 18. Because of the risk that small pieces of debris might fall through the gap between the fuel and storage racks, the work was undertaken with great care, including a preliminary check using an underwater camera and by paying attention to the load while lifting it using the fuel removal system. As a result, the removal of all spent fuel (1,331 rods) was completed on November 5, 2014 and all fuel removal work was finished by December 22.

Development of Robot for Surveying Reactor Building Interior

A buildup of water occurred at Fukushima Daiichi Nuclear Power Station due to cooling water that had leaked into the basement and other parts of the reactor buildings. To reduce the quantity of this water, it was necessary to find and plug the leaks. Also needed was to work out how to survey and remove the fuel debris that was assumed to have been scattered around the underground parts of the containment vessel.

In response, Hitachi developed a survey robot for finding leaks both underwater and in the air, and another robot for surveying the interior of the nuclear reactor containment vessel, and used them to survey the buildings.

These robots were the subject of an on-site trial funded by the Agency for Natural Resources and Energy for developing technology to use in fuel removal at Fukushima Daiichi Nuclear Power Station.

Fig. 2 shows the survey robots.

(1) Survey robots for reactor building basement

The survey robots for the reactor building basement included a robot for surveying the top of the suppression chamber (S/C) to look for pipes or other leaks, and floor crawling and underwater swimming robots for finding underwater leaks. In particular,

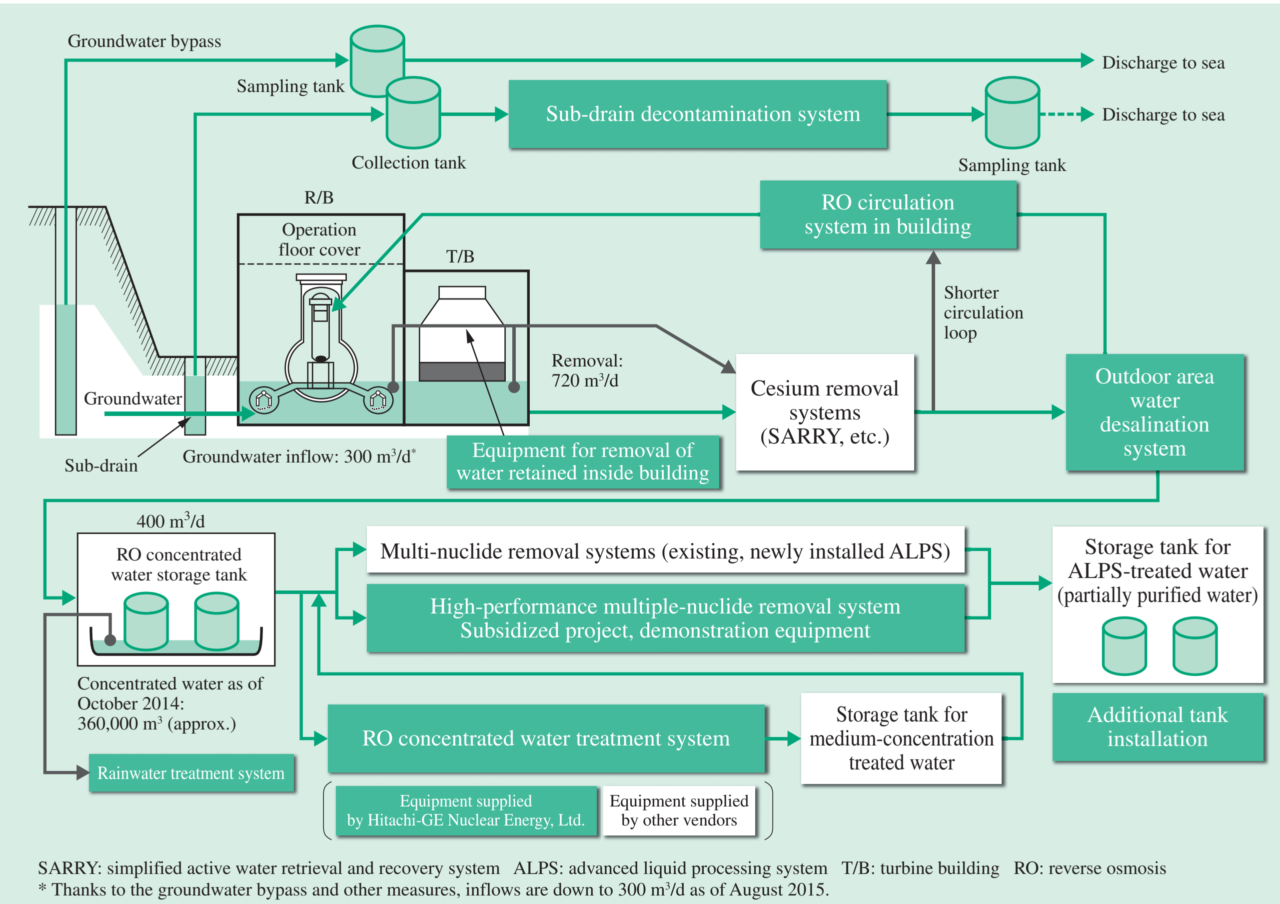

Fig. 3—Overview of Systems for Dealing with Contaminated Water.
Hitachi-GE supplies a large number of key systems for treating contaminated water.

the floor crawling robot for finding underwater leaks was equipped with a pair of crawler mechanisms and six propellers for thrust in the vertical and horizontal directions that gave it the ability to swim around obstacles or reorient itself to move along walls.

When trialed on site, these robots found leaks in expansion joints in piping exposed to the air at Unit 1, providing valuable information for planning how to plug the leaks.

(2) Robot for surveying inside nuclear reactor containment vessel

The challenge for enabling the survey robot to gain access to the interior of the nuclear reactor containment vessel was that it needed both to move through piping with an entrance diameter of only 100 mm and to be able to move reliably over floors. To achieve this, Hitachi changed the propulsion mechanism and developed a shape-changing robot that could switch between an I-shaped configuration for traveling through confined spaces and a C-shaped configuration for reliable travel over floors. This shape-changing robot conducted a survey of the grating on the first floor of the Unit 1 nuclear reactor containment vessel and provided valuable information for assessing the spread of fuel debris in the basement.

Measures for Dealing with Contaminated Water

Fig. 3 shows the progress made by Hitachi-GE on dealing with contaminated water at the Fukushima Daiichi Nuclear Power Station and in the main treatment systems. The underground parts of the buildings at the site still retained water contaminated with radioactive material, made up of seawater from the inundation of the building by the post-earthquake tsunami in 2011 and the injection water used for cooling the reactor cores of Units 1 to 3.

Furthermore, the inflow of groundwater into the buildings meant that the total amount of contaminated water was increasing by 400 t each day. To deal with this, purification equipment was installed and decontamination was performed by circulating the water in a loop. Meanwhile, to minimize the ever-growing quantity of contaminated water (due to the inflow of groundwater and so on), work commenced on minimizing groundwater inflow by pumping out the accumulated water from the buildings to lower the water level, shortening the circulation loop to reduce the risk of leaks, and removing the accumulated water and drying out the buildings. The main equipment supplied for this purpose was as follows.

- Sub-drain decontamination system (see Fig. 4, left)
- High-performance multiple-nuclide removal system (see Fig. 4, right)
- Reverse osmosis (RO) concentrated water treatment system
- In-building RO circulation system
- In-building retained water pumping system
- Storage tanks (63 × 1,000 t)

(1) Overview of main equipment and current situation

(a) Sub-drain decontamination system

The sub-drain decontamination system draws lightly contaminated groundwater from the numerous sub-drain pits located around facilities such as the

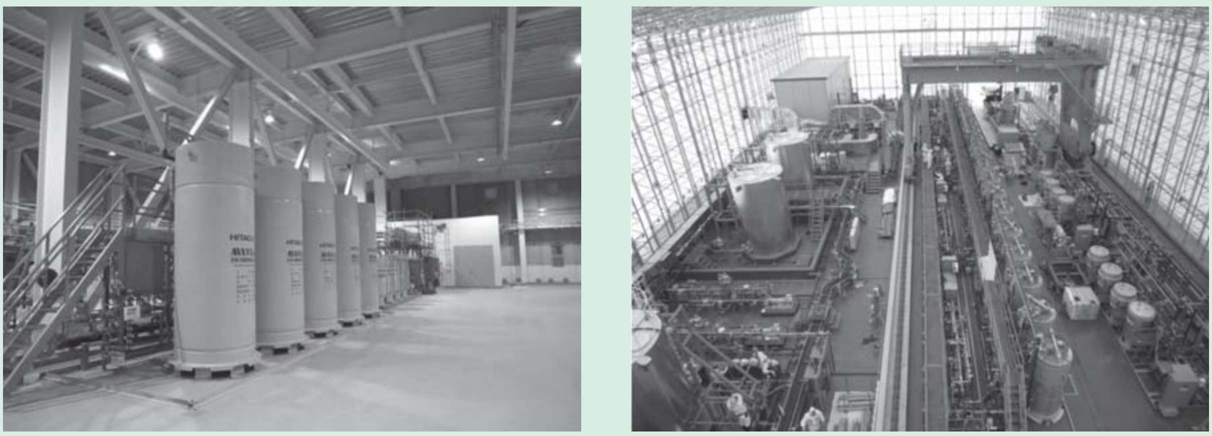

Fig. 4—Sub-drain Decontamination System and High-performance Multiple-nuclide Removal System.
The sub-drain decontamination system and high-performance multiple-nuclide removal system shown here were provided to deal with the contaminated water.

turbine rooms in Units 1 to 4 and separates out the radioactive isotopes. It is essential for limiting the inflow of groundwater into the buildings, and for reducing the level of contaminated water retained in the buildings in the future.

Hitachi-GE undertook the design and fabrication through a joint venture with AVANTech, Inc. of the USA, and completed the installation in only six months, an exceptionally short time for nuclear power equipment (see Fig. 4, left). In preparation for full-scale operation, treatment commenced in September 2015, with the discharge of water into the ocean beginning on September 14.

(b) High-performance multi-nuclide removal equipment

Intended for use on the approximately 360,000 t of heavily contaminated water stored at the Fukushima Daiichi Nuclear Power Station site, this system is able to reduce 62 different nuclides (not including tritium) to below detectable levels (and reduce strontium-90 to one part in 100 million; project funded by the Agency for Natural Resources and Energy). As of the end of August 2015, it had treated approximately 90,000 m^3 of contaminated water (see Fig. 4, right).

(2) Future work

As described above, Hitachi-GE is working on a variety of ways of dealing with contaminated water to help with the Fukushima recovery.

Fukushima recovery poses major challenges, including rethinking the nuclear power industry to improve the energy situation. In response to these challenges, Hitachi-GE is taking steps to contribute through its work on the treatment of contaminated water, which represents one type of measure. In the four years since the 2011 earthquake, Hitachi-GE believes that steady progress has been made. Hitachi-GE intends to continue working on measures for the recovery through a variety of future initiatives.

NEW CONSTRUCTION OF NUCLEAR POWER PLANTS IN EUROPE

UK

The UK government has since 2007 supported the construction of nuclear power plants with the aim of creating a low-carbon society. While the UK currently has 16 operating nuclear power plants that together supply about 20% of the nation's electric power, the plants are aging and coming due for reconstruction. As a result, there has been growing activity directed toward new construction.

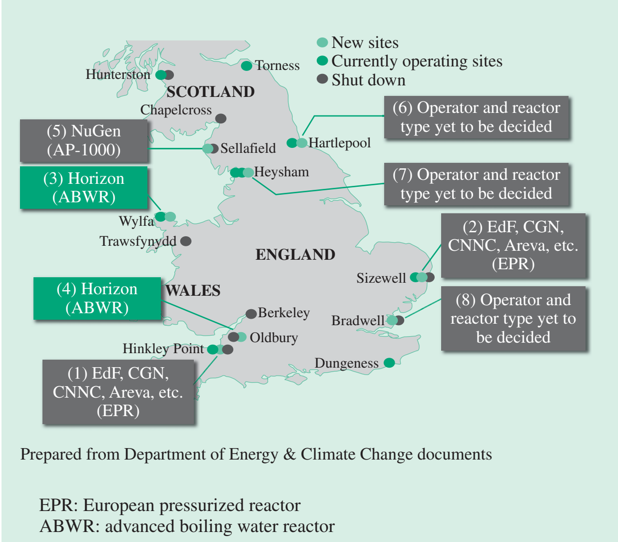

Fig. 5—Planned New Nuclear Power Plants in the UK.
Plans for new plants in the UK include the Horizon projects at Wylfa and Oldbury [(3) and (4) in the figure].

Hitachi, Ltd. acquired Horizon Nuclear Power Limited, a UK company involved in the development of nuclear power generation, in November 2012, and has formulated a plan to build two or three 1,300-MW-class nuclear power plants at each of Horizon's two sites in the UK (at Wylfa and Oldbury) (see Fig. 5). Hitachi, Ltd. intends to obtain all of the licenses and permissions required for the initial project at Wylfa Newydd from the UK government by 2018 and to have the first reactor in service during the first half of the 2020s (see Fig. 6). The four-step approval procedure for the generic design assessment (GDA) of the UK ABWR design has been in progress since April 2013, with all steps to be completed by December 2017. In

Fig. 6—Planned Construction Site at Wylfa Newydd.
The Wylfa Newydd Nuclear Power Plant is planned for construction at this site.

Fig. 7—Cutaway Diagram of UK ABWR.
The UK ABWR, shown here as a cutaway diagram, is scheduled to commence operation in the first half of the 2020s.

the GDA, the ABWR is expected to achieve higher safety due to lessons learned from the accident at the Fukushima Daiichi Nuclear Power Station as well as from the experience of building and operating four reactors operating at three sites in Japan.

The UK ABWR design currently going through the GDA approval process is essentially based on the same plant concept as the ABWRs in Japan, which are currently undergoing safety enhancements for compliance with new Japanese regulations (see Fig. 7). The greatest strength of the ABWR design is that examples have already been built and operated in Japan. The following design optimizations and site adaptations are being undertaken using this design as a base.

(1) Safety enhancements based on experience from the accident at Fukushima Daiichi Nuclear Power Station

Based on lessons from the accident, the design includes measures for dealing with hazards that exceed design assumptions. In addition to improving measures for dealing with flooding of important buildings and providing portable equipment that will be made available for use if a serious accident occurs, these measures also include constructing a new backup building located some distance from the reactor building that can hold equipment such as an alternative water injection system or backup alternating current (AC) power supply to enable functions such as reactor core cooling to be performed even during a serious accident. The concept is the same as that for the measures for dealing with major accidents or other incidents at ABWRs that comply with the new Japanese regulations.

(2) Design changes for compliance with national regulations and standards

In addition to compliance with UK regulations and standards, the design also takes account of factors such as the design concepts used in existing reactors. For example, because the practical effect of the safety assessment criteria in the UK nuclear power regulations is to prohibit the installation of equipment with a high fire risk in the reactor building, the intention is to build a separate dedicated building to house the emergency diesel generator. There is also a need to comply with requirements relating to the diversity of electrical systems and instrumentation and control systems that are unique to the UK.

(3) Adaption to different site conditions to those in Japan

When building overseas, it is necessary to consider the different weather conditions as well as different seismic conditions. For example, due to the high latitude of the UK, the ventilation and air conditioning systems and heating equipment are designed to take account of more severe low winter temperatures than assumed in Japanese designs.

Lithuania

One of the three Baltic states, Lithuania is dependent on Russia for approximately 80% of its domestic energy consumption (when gas imports are included). With the aim of resolving energy security concerns of this nature, Estonia, Latvia, and Lithuania agreed in 2006 to the construction of the Visaginas Nuclear Power Plant in anticipation of future energy market integration (see Fig. 8). The Visaginas Nuclear Power Plant is included in the Baltic Energy Market Interconnection Plan (BEMIP) agreed to in 2009 by the eight nations fronting onto the Baltic Sea. In the 2011

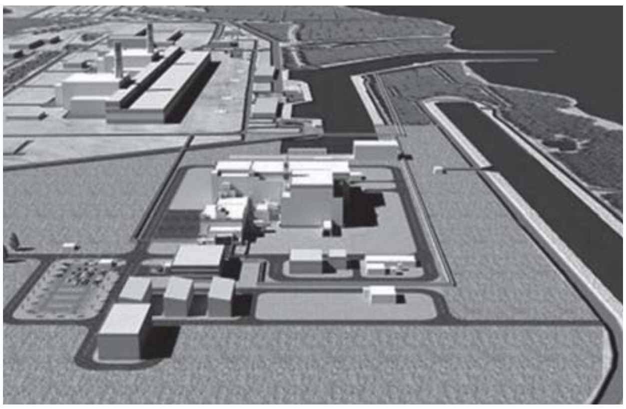

Fig. 8—Conceptual Drawing of Completed Visaginas Nuclear Power Plant.
The drawing shows the completed Visaginas Nuclear Power Plant.

tender for selection of a strategic investor (SI), Hitachi proposed a 1,300-MW-class ABWR with safety that would be further enhanced by measures taken in response to the Fukushima Daiichi Nuclear Power Station accident, and was granted preferred bidder status. Subsequently, the plan became the subject of a transfer of business rights contract between the government of Lithuania and Hitachi, Ltd. (in March 2012), and was approved in June of that year at the conclusion of a parliamentary debate together with the related laws. Following a change of government and the result of a national referendum, however, a special committee of the Lithuanian parliament was requested in October 2012 to undertake a review of energy strategy. Currently, Lithuania is still working on its national energy strategy, with the status of the Visaginas Nuclear Power Plant construction expected to be clarified during 2016. Meanwhile, a joint committee of the three Baltic states undertook a study of the technical issues associated with connecting the Visaginas plant to the transmission network and found no problems. Furthermore, the viability of the project is being enhanced by a training program for nuclear industry personnel that is proceeding with assistance from the Japanese government and elsewhere and by incorporating features from the Horizon project in the UK (which has an earlier timeframe).

Hitachi has extensive construction experience and believes it can contribute to the development of social infrastructure in different countries and to the creation of low-carbon societies by building nuclear power plants that are safer, more secure, and that incorporate lessons learned from the Fukushima Daiichi Nuclear Power Station.

DEVELOPMENT OF NEXT-GENERATION LIGHT WATER REACTOR

Range of Reactors that Match the Market

Hitachi has taken advantage of the generation of steam (voids) due to the boiling of water, a feature of the boiling water reactors (BWRs) it has developed, to develop a new type of reactor that matches market needs (see Fig. 9).

Large reactors are suitable for regions with transmission networks designed to cope with high demand for electric power, where they offer a centralized source of power that benefits from economies of scale and other improvements in economic performance. Hitachi is working on developing a next-generation BWR with hybrid safety systems that combine active and passive safety, and the economic simplified BWR (ESBWR) with natural circulation that takes advantage of the voids that occur in the reactor and utilizes enhancements to the ABWR, which has a history of use in Japan.

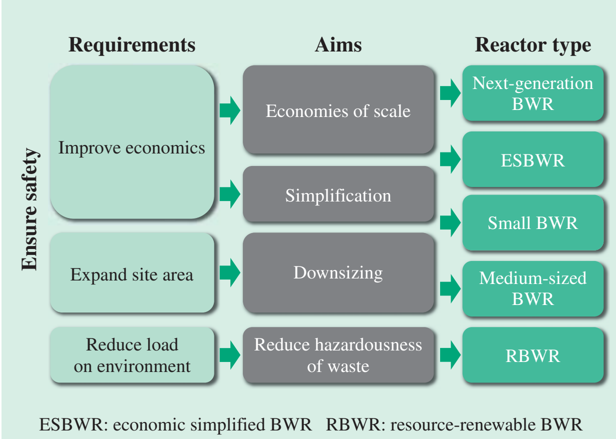

Fig. 9—Development of New Reactor Types to Suit Diverse Needs.
The development of reactors is continuing with the aim of satisfying various requirements.

Hitachi is also developing medium- and small-size BWRs that can adapt flexibly to the needs of regions with limited transmission capacity or users who want to minimize their initial investment. Rather than just being a downsized version of the ABWR, the medium-size BWR also features system simplifications while still maintaining adequate safety. The small-size BWR provides further simplifications by taking advantage of the voids that occur in the reactor to achieve natural circulation. Another development is the resource-renewable BWR (RBWR) that is based on proven BWR technology and reduces the load on the environment by reducing the hazardousness of high-level waste.

The following section describes the progress of development of the RBWR that can reduce the load on the environment.

TRU Burner Reactor

Hitachi is working on the development of an RBWR[1] that is fueled by long-lived transuranium elements (TRUs). The accumulation of the TRU waste produced as a byproduct of burning uranium fuel is a problem for nuclear power generation. TRU-containing waste is so hazardous that it takes approximately 100,000 years for it to attenuate to about the same degree of hazard as natural uranium. However, if these TRUs can be burned up and eliminated from the nuclear waste, that time can be reduced to a few hundred years.

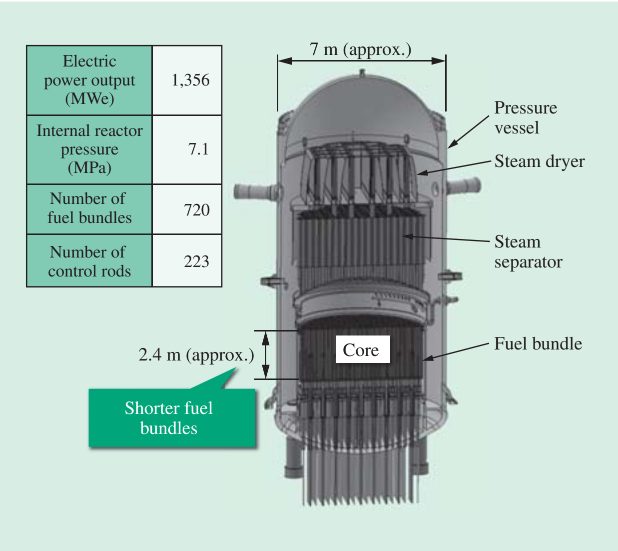

Fig. 10—Internal Reactor Equipment for RBWR Designed to Reduce Load on the Environment.
The plant concept and design use proven ABWR technology to reduce the load on the environment by minimizing the hazardousness of high-level waste while still maintaining safety.

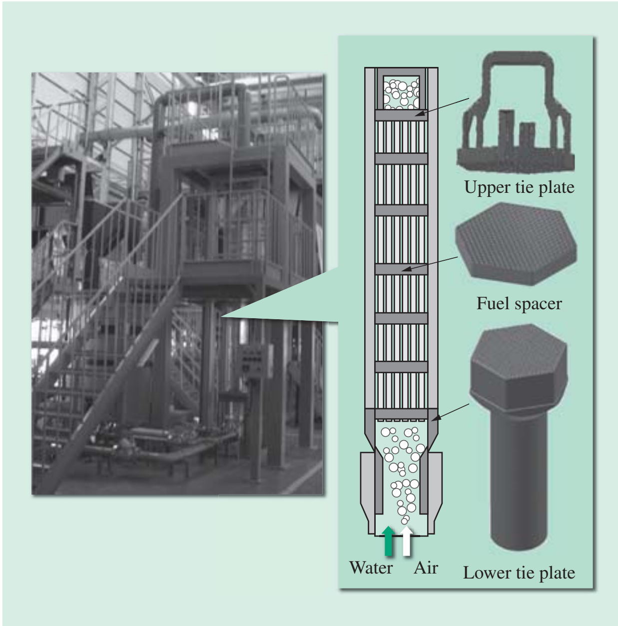

Fig. 12—Flow Vibration Testing of RBWR Fuel Bundles.
The robustness of the small-diameter fuel rods packed into RBWR fuel bundles with respect to fluid vibration was confirmed by conducting tests that simulated the flow at the plant.

The RBWR is based on BWR technology and, apart from the use of a reactor core with shorter fuel rods and fuel bundles, uses the same internal reactor equipment (including steam dryer, steam separator, and recirculation pumps) and safety systems as the latest ABWR (see Fig. 10). The operating conditions (such as electric power output and internal reactor pressure) are similar to the ABWR. To lower the amount of coolant relative to fuel in the core in order to achieve an efficient TRU burn, the fuel bundles are larger than in an ABWR, and small-diameter fuel rods are packed into hexagonal channel boxes and narrower gaps between the channel boxes (see Fig. 11).

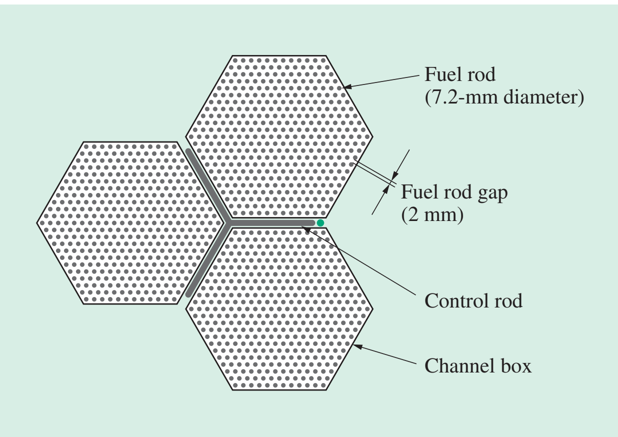

Fig. 11—Fuel Bundles.
To lower the amount of coolant relative to fuel in the core in order to achieve an efficient TRU burn, while still maintaining safety, small-diameter fuel rods are packed into hexagonal channel boxes with narrower gaps between the channel boxes.

While the fact that the RBWR is based on the same equipment concepts as the ABWR means there are few technical issues, there remains a need to demonstrate the viability of the newly developed fuel bundles and core equipment.

As the RBWR fuel bundles are made from tightly-packed small-diameter fuel rods with the possibility of different flow-induced vibration characteristics, testing of the vibration integrity of the fuel rods was conducted using an air-water test apparatus at ambient temperature and pressure (see Fig. 12). The experiment was conducted using model fuel rods fitted with accelerometers, upper tie plate, fuel spacers, and lower tie plate.

The upper tie plate was designed to provide adequate strength while also presenting a low resistance to the two-phase flow of coolant. The fuel spacers have a cell structure to ensure fuel bundle heat removal performance and to reduce flow resistance. The top surface of the lower tie plate includes fuel rod support holes and flow channel holes to allow the coolant access to the packed fuel rods. The lower part of the lower tie plate is fitted with a connecting pipe that inserts into the fuel support to provide independent support for the fuel bundle.

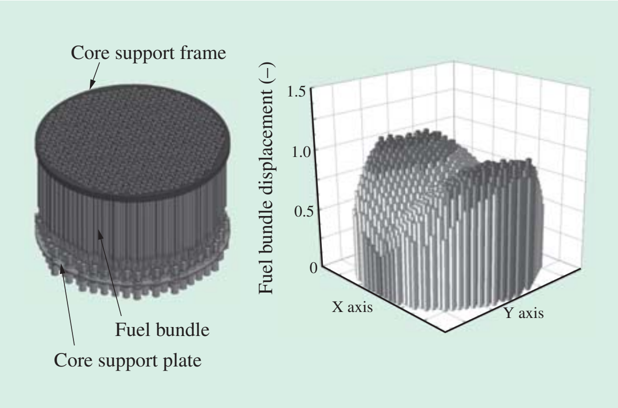

Fig. 13—Seismic Analysis of Core Structure.
Soundness during an earthquake was confirmed by developing a vibration analysis model to simulate the RBWR fuel bundle and core support structures.

Air-water testing at ambient temperature and pressure found that the maximum fuel rod vibration amplitude was equal or less than that of the ABWR and was sufficiently less than the gap between fuel rods to not pose any viability problems[(2)].

The top of an RBWR fuel bundle is in contact with the adjacent fuel bundles, and the fuel bundles on the circumference of the core are supported by the core support frame (see Fig. 13). The bottom ends of the rods are held up by the fuel supports on the core support plate. As the means of supporting the tops of the fuel bundles is different from other ABWRs, a vibration analysis of the fuel bundles during an earthquake was performed to assess their integrity. A total of 720 fuel bundles were modeled as beams and the extent to which the fuel bundles influenced each other by way of the coolant was modeled in terms of the imposed hydrodynamic load. To simulate how fuel bundles come into contact with each other, adjacent fuel bundles were linked using gap elements.

An analysis of the vibration response when the fuel bundles were subjected to artificial seismic waves was conducted and found that the maximum displacement of the fuel bundles occurred on the edges of the core due to the influence of the core support frame, as shown in Fig. 13. Testing also found that the maximum bending moment in the fuel bundles was similar to the ABWR[(3)]. In the future, Hitachi intends to make improvements to this analysis technique and use it to study control rod insertion performance.

In research undertaken under contract with the Electric Power Research Institute (EPRI), Hitachi requested a US university to conduct studies from 2007 to 2011 that included TRU fission performance and safety. These studies found no fatal flaws that would prevent the design from being implemented[(4)]. Subsequently, Hitachi embarked on joint research using a more accurate analysis technique developed by the US university[(5)]. Hitachi also intends to participate in ongoing study of the nuclear and thermal viability of the RBWR and to work on improving the accuracy of techniques for predicting the critical power of fuel bundle[(6)].

This section has presented an overview of the RBWR and recent development progress. In the future, Hitachi hopes to establish technology for reducing the load on the environment by conducting further studies on reducing the hazardousness of high-level waste.

CONCLUSIONS

This article has described the status of some of the work done by Hitachi on technology for improving the safety of nuclear power generation. While the situation surrounding nuclear power generation has changed significantly since the accident at the Fukushima Daiichi Nuclear Power Station, Hitachi will continue striving to restore faith in nuclear power through ongoing work to make the industry even safer while drawing on the lessons learned from the accident.

Hitachi also intends to make an active contribution in response to increasing international demand for energy by applying the results of this work to nuclear power generation in Japan and other countries, and by supplying it in the form of safe and reliable technology.

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