

Prospect of Hitachi Nuclear Business (Boiling Water Reactor)

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OVERVIEW: To date, Hitachi has mainly focused on the nuclear-business market in Japan. However, the environment surrounding the nuclear business has changed substantially in the past several years. With the reassessment of nuclear power generation on a global basis, many countries have restarted nuclear development and are considering the introduction of new plants. It is necessary for the development of Hitachi's nuclear business that we steadily move toward entry into the global market which is expected to expand in the future.

DEVELOPMENT OF HITACHI'S NUCLEAR BUSINESS

SINCE the start of various research and development activities around 1953, the nuclear business of Hitachi, Ltd. has grown in step with the development

of Japan's nuclear power industry. Hitachi has been a leader in domestic production in Japan and in improvement and standardization activities for research reactors and light-water reactors for power generation (see Fig.1), and has played an active

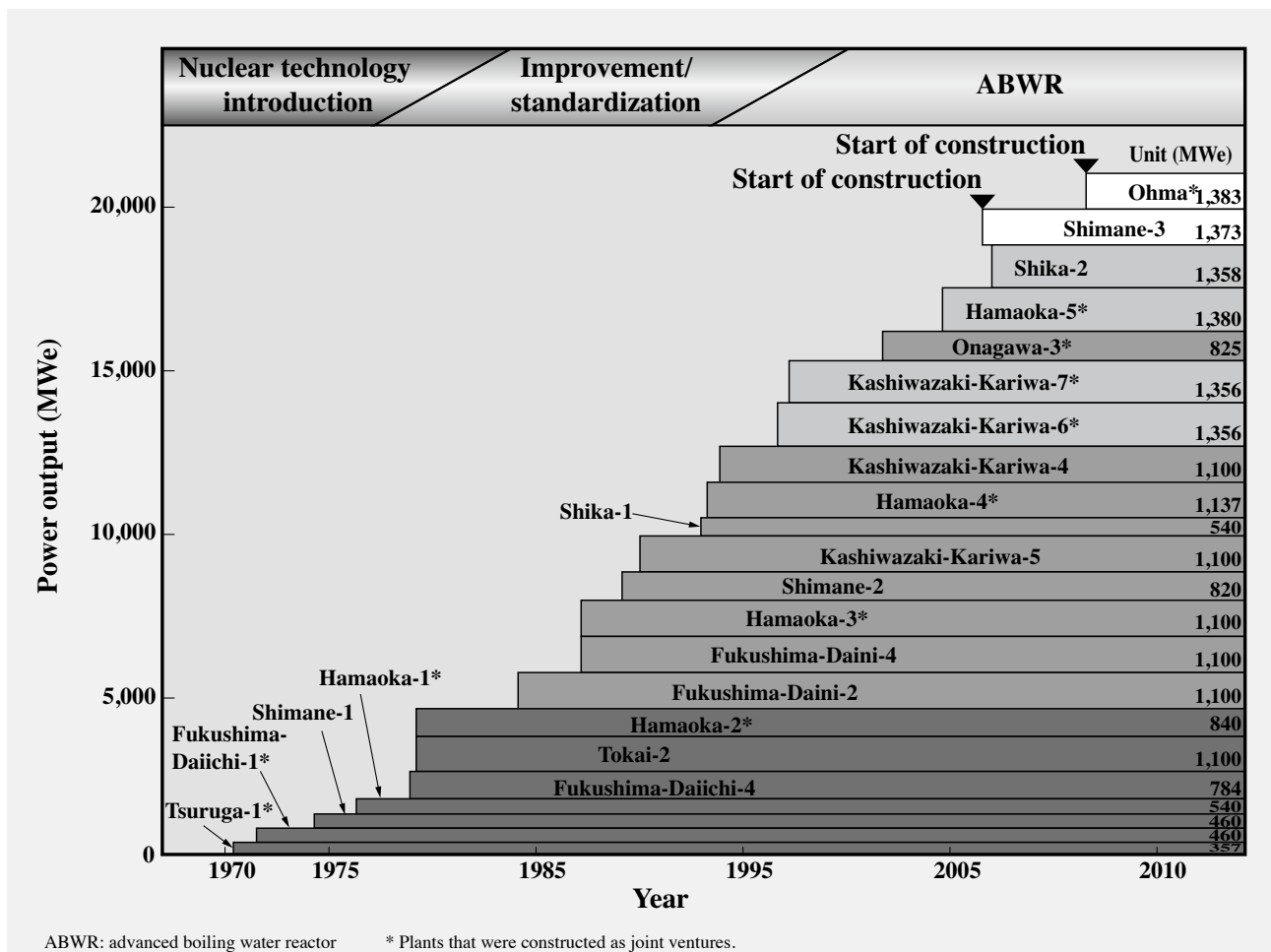


Fig. 1—Hitachi's Past Record in Construction of Boiling Water Reactor Plants (Including Those Under Construction). Hitachi has been continuously involved in the construction of nuclear power plants for more than 30 years and currently has two plants under construction. The combined power output of these plants exceeds 20,000 MWe.

role in **advanced thermal reactors^(a)**, **fast breeder reactors^(b)**, **nuclear fuel cycle facilities^(c)**, **fusion reactors^(d)**, accelerators, and other facilities.

To date, Hitachi has mainly focused on the Japanese market. However, the environment surrounding the nuclear business has changed substantially in the past several years. With the reassessment of nuclear power generation on a global basis, many countries have restarted nuclear

development and are considering the introduction of new plants. It is necessary for the development of Hitachi's nuclear business that we steadily move toward entry into the global market which is expected to expand in the future. Based on these prospects, Hitachi formed a nuclear global alliance with General Electric Company (GE) in 2007 and has kept the business going until today^{(1), (2)}. Associated with this integration, the nuclear business of Hitachi, Ltd. was

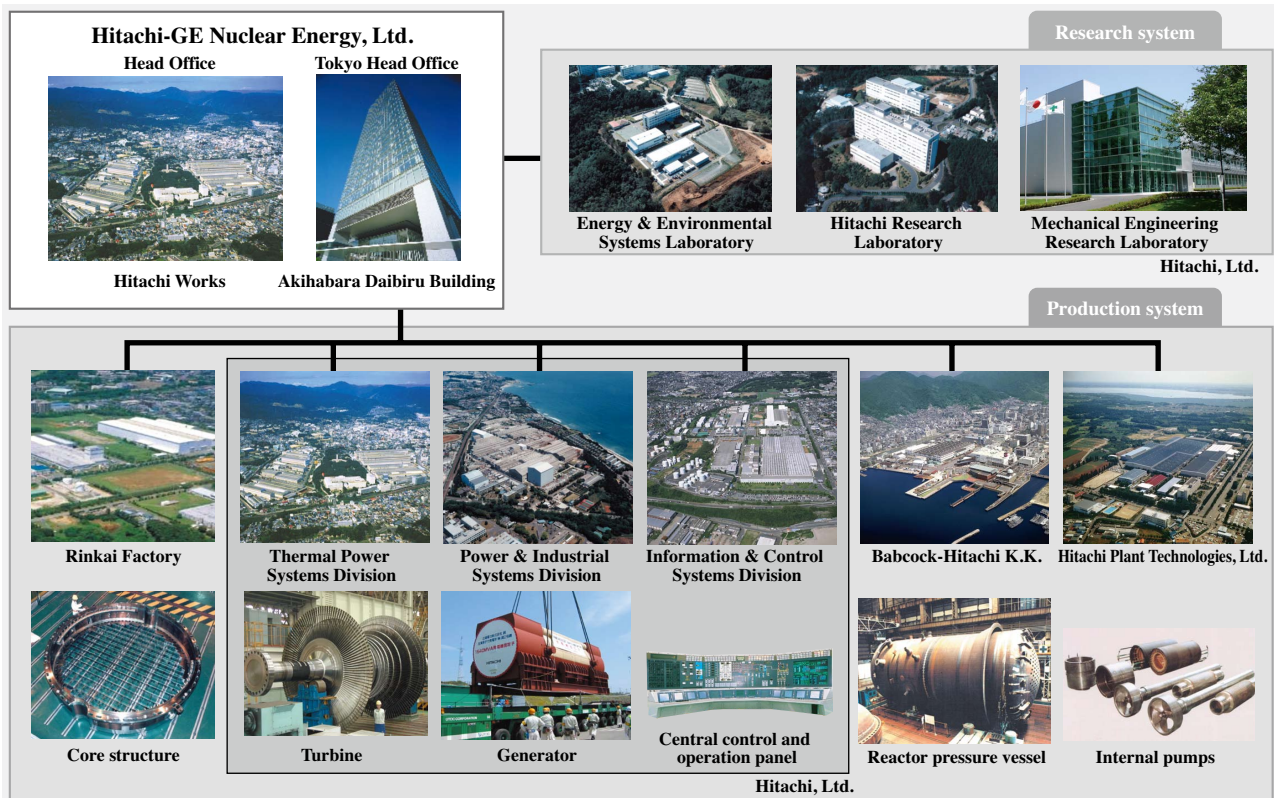


Fig. 2—Construction System for Light-Water Reactors in Japan.

Hitachi, Ltd. and other Hitachi Group companies work together to construct nuclear power plants in Japan under the leadership of Hitachi-GE Nuclear Energy, Ltd.

(a) Advanced Thermal Reactor

Developed independently in Japan, advanced thermal reactors use heavy water as a moderator. This makes more efficient use of the nuclear fuel because heavy water absorbs fewer neutrons. Other characteristics of this reactor type include the ability to use natural uranium for fuel and to utilize the plutonium obtained from the reprocessing of spent fuel. The “Fugen” reactor was used for experiments using MOX (uranium-plutonium mixed oxide) as a fuel and has provided useful data.

(b) Fast Breeder Reactor

There are two types of uranium: uranium-235, which is easy to fission (easy to use as fuel), and uranium-238, which is difficult to fission (difficult to use as fuel). More than 99% of natural uranium exists as uranium-238. The percentage of easily fissionable uranium-235 is increased to between 3 and 5% in the uranium fuel used for nuclear power generation in regular light-water reactors. On the other hand, a fast breeder reactor is capable of producing more fuel than it consumes by efficiently converting uranium-238 into plutonium-239, which is highly fissionable. This method dramatically improves the efficiency of use of uranium resources compared with the case when plutonium is not used.

(c) Nuclear Fuel Cycle Facilities

The nuclear fuel cycle is the series of activities from mining natural uranium in uranium mines through to ore refining, uranium fuel processing, use in power plants, reprocessing of spent fuel, and recycling. Accordingly, the facilities used for the nuclear fuel cycle include smelting and processing facilities for the nuclear fuel, spent fuel storage facilities (interim storage facilities), and reprocessing facilities.

(d) Fusion Reactor

This is a future technology for power generation and is the subject of ongoing research around the world with the aim of making it ready for commercial use in the late 21st century. Unlike current nuclear power generation produced from the fission energy of uranium and plutonium, a fusion reactor uses the energy produced by the fusion of hydrogen or other nuclei. It is based on the same principle as the generation of thermal energy in the sun and other fixed stars. It is expected that the practical application of fusion reactors will solve certain problems with fission-based nuclear power generation including obtaining the uranium raw material and high-level radioactive waste.

taken over by a new company, Hitachi-GE Nuclear Energy, Ltd. (Hitachi-GE). The new company works closely with many divisions and research institutes of Hitachi, Ltd. and other Hitachi Group companies (see Fig. 2). Note that, unless stated otherwise, the articles in this feature use the company name “Hitachi” to refer both to Hitachi, Ltd. and Hitachi-GE.

The advantage of Hitachi’s nuclear business lies in the comprehensive strength that allows it to provide a wide range of products and services covering design, production, construction and maintenance services, as well as in the human resources and technological capabilities of the business which are maintained and developed by the continuous construction of nuclear power plants.

Based on these core advantages, Hitachi’s mission for its nuclear business is to continue to provide reliable products and services to customers inside and outside Japan in the years to come.

Currently, construction and planning of new nuclear power plants are ongoing in Japan. In the field of preventive maintenance, Hitachi has worked on advanced preventive maintenance techniques for aged facilities. On the other hand, Hitachi is also working to establish the systems and structures that will allow it to undertake overseas projects based on its past construction experience in Japan.

The following sections outline the current situation and future outlook for new domestic construction, preventive maintenance, and overseas expansion in the field of **light-water reactors**^(e), which is a major area in Hitachi’s nuclear business.

TRENDS IN NEW CONSTRUCTION IN JAPAN

Both Unit No. 3 at the Shimane Nuclear Power Station of The Chugoku Electric Power Co., Inc. and the Ohma Nuclear Power Station of the Electric Power Development Co., Ltd. are currently under

construction by Hitachi. Respectively, these are the fifth and sixth **ABWRs (advanced boiling water reactors)**^(f) in Japan.

Jointly developed based on conventional boiling water reactor technology by Japanese power companies, plant manufacturers, and GE in the USA, the ABWR is a landmark for boiling water reactor plant technology. Hitachi is involved in the construction of all six ABWR plants in Japan, and has made efforts to optimize and standardize designs and sought to upgrade the construction technology based on its considerable construction experience.

Following on from Unit No. 2 at the Shika Nuclear Power Station of the Hokuriku Electric Power Company, Hitachi received a full-plant contract to construct the Shimane Nuclear Power Station’s Unit No. 3 that is scheduled to become operational in December 2011. In this project, Hitachi Group companies together are responsible for all the processes from basic planning through to the production of major equipment and the installation and commissioning of the reactor and associated plant. The major reactor equipment, turbines, generators, condensers, and similar will be supplied by Hitachi, Ltd., Babcock-Hitachi K.K. will produce the pressure vessel for the reactor, and Hitachi Plant Technologies, Ltd. is responsible for the construction work.

Ohma Nuclear Power Station, which is scheduled to become operational in 2014, is the world’s first ABWR able to use **MOX (uranium-plutonium mixed oxide) fuel**^(g) throughout the entire core. In this project, Hitachi has received orders for equipment associated with the reactor.

All of the boiling water reactor plants scheduled to become operational in the de44cade in Japan ahead are ABWRs. This will facilitate the construction of highly reliable plants based on even more

(e) Light-water Reactor

Reactor types for nuclear power generation include light-water reactors, gas reactors and heavy-water reactors. Light water is another name for ordinary water and is so-called to distinguish it from heavy water which has a higher specific gravity. Light-water reactors use light water as their reactor coolant and neutron moderator and use low-enriched uranium fuel. Light-water reactors account for more than 80% of the world’s reactors due to their advantages which include smaller size and greater power than other types of reactors thanks to the greater effectiveness of light water in moderating neutrons.

(f) Advanced Boiling Water Reactor (ABWR)

Light-water reactors are classified into two broad categories: boiling water reactors and pressurized water reactors. BWRs (boiling water reactors) are so-called because the coolant water is boiling during operation. The reactor pressure vessel also serves

to generate the steam which is passed directly to the turbine to generate power. On the other hand, PWRs (pressurized water reactors) operate with water at high temperature and pressure, and this high pressure prevents the coolant water from boiling. The high-temperature/high-pressure water from the reactor is passed through a steam-generating unit and the generated steam is fed into the turbine. Compared with conventional BWRs, the advantages of ABWRs include improved safety and reliability, easier operation and control, better economics, and less radioactive waste.

(g) Uranium/plutonium Mixed Oxide (MOX) Fuel

In place of uranium-235, MOX (uranium/plutonium mixed oxide) fuel is a mixture of approximately 10% plutonium, which is extracted from spent fuel, and 90% uranium. MOX fuel is used in more than 30 power plants in the world mainly in France, Germany, and Belgium.

sophisticated technology that will provide a key source of power. Taking advantage of their past experience, Hitachi intends to continue playing a leading role in the construction of nuclear power plants in Japan based on the group's highly reliable manufacturing capabilities and by introducing more advanced construction technology.

OUTLOOK FOR PREVENTIVE MAINTENANCE BUSINESS

There is also a strong requirement at existing reactors in Japan to improve plant reliability and availability in order to ensure that the plants are utilized effectively.

Large-scale maintenance work on the reactor and other major equipment is carried out in a planned manner to counter the aging of existing reactors and to improve plant reliability. Measures aimed at improving plant availability include extending the operating period, better reliability through status monitoring and maintenance, and reduction of inspection period made possible by various improvements to inspection techniques.

Meanwhile, in response to damage to the Kashiwazaki-Kariwa Nuclear Power Station of The Tokyo Electric Power Co., Inc. caused by the Niigata-Chuetsu-Oki Earthquake, Hitachi undertook work on checking the integrity of the power station after the earthquake and on improving its earthquake resistance, and also work on improving safety

margins and on assessing the ability of all nuclear power plants to withstand earthquakes under the new guidelines on earthquake resistance. As the earthquake resistance assessment and safety margin improvement work are targeted at all nuclear plants, Hitachi has significantly increased the number of designers involved in earthquake resistance analysis and assessment work. It has also taken an active role in various trials aimed at checking earthquake resistance.

As nuclear power plants age, the need to establish detailed maintenance plans based on the plant lifecycle will become increasingly important. Along with this, Japan is also likely to join in the worldwide trend towards uprating plant power output. Uprating power output requires a broad assessment of what impact this will have across the entire plant. In addition to taking advantage of the experience gained in the USA which has been the leader in this area, Hitachi will also continue to utilize its leading-edge technology to develop high-performance equipment in the field of high-performance turbines and elsewhere (see Fig. 3).

As discussed above, the needs in the maintenance area of nuclear power generation are expected to grow further. In response to these needs, Hitachi intends to contribute to improving nuclear plant availability by training engineers and continuing to develop various maintenance techniques and inspection methods.

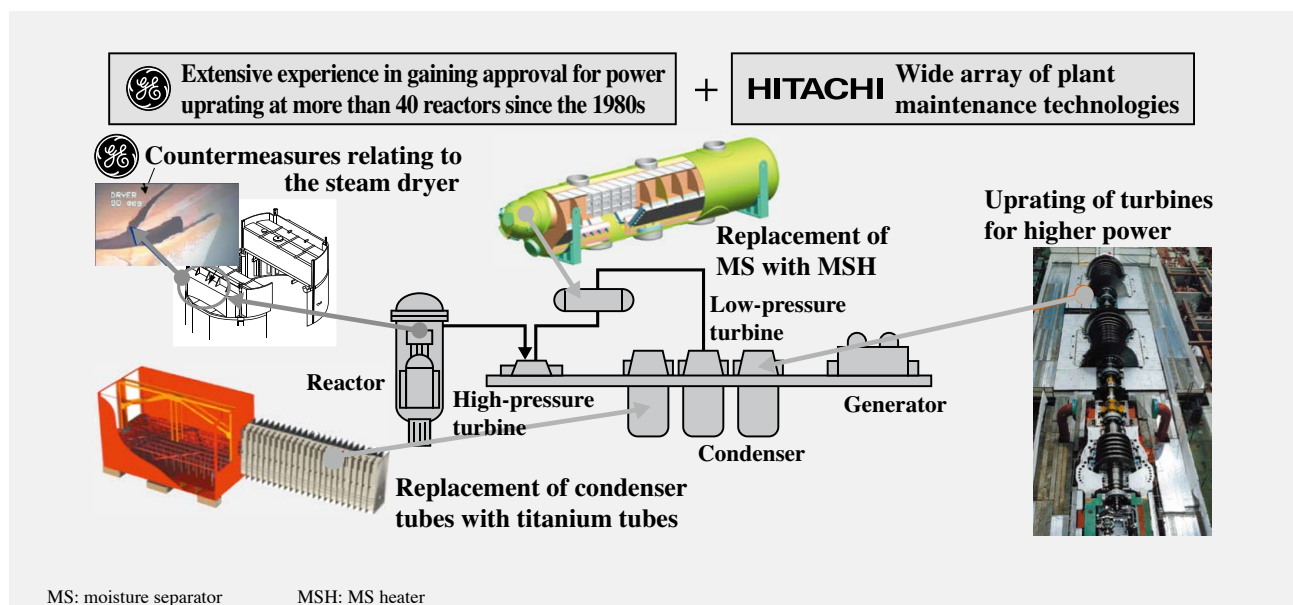


Fig. 3—Technologies for Increasing Power Output.

By bringing in the considerable experience of General Electric Company in the USA, Hitachi intends to put forward proposals for increasing power output that are appropriate for plants in Japan.

VENTURING INTO OVERSEAS BUSINESS

Plans to construct new nuclear power plants are in place around the world, but the market on which Hitachi is focusing its greatest efforts is that in North America where the construction of new plants is expected in the near future. The USA is seeing a steady stream of new COL (combined construction and operating license) applications and already plans for more than 30 new plants have been announced. Working with its partner, GE-Hitachi Nuclear Energy Americas LLC (GEH), Hitachi has made proposals based on its ESBWR (economical and simplified boiling water reactor) and ABWR to a number of electricity companies.

A distinctive feature of the US market is that customers expect Hitachi to provide not only major equipment but also modular construction and other construction technologies and the construction management capabilities that have allowed Hitachi to complete projects in Japan on schedule. In the USA, where there have been no orders for new nuclear plants since the late 1970s, the largest risks faced by customers are regulatory risk and the potential for construction costs to blow out. These factors explain the attention being focused on Japan's experience in continuing construction of nuclear power plants during this time and its success in doing so quickly and on schedule.

These circumstances represent an unprecedented challenge for Hitachi and offer significant business opportunities. Hitachi's first overseas experience in the nuclear industry involved the export of major reactor equipment as a subcontractor to GE in 1970s. In the 1980s, Hitachi delivered replacement pipes to the USA when measures for countering **SCC (stress corrosion cracking)**^(h) were at their peak in that country, and in the 1990s we supplied reactor equipment for the Lungmen Nuclear Plant in Taiwan (as a subcontractor to GE) and turbine, generator and other equipment for the Qinshan Nuclear Plant in China. All of these equipment exports took advantage of Hitachi's high-quality production technology. Although Hitachi has been

successful in the areas of construction technology and construction management, there are still many challenges to be met before Hitachi's experience in Japan can be put to work on overseas projects. In addition to establishing a supply chain that covers equipment procurement and module fabrication sites, such projects require the adoption of optimal construction techniques and processes by partnering with construction companies in the USA. These systems are currently being put in place.

Hitachi is also working on a number of projects to construct new power plants in countries other than the USA, with different levels of involvement depending on the respective circumstances. In Canada, Hitachi is responsible for supplying major turbine equipment as a member of Team CANDU (Canada deuterium uranium), and we hope to play an active role in the nuclear power plans of Asian countries such as Vietnam and Thailand and in Middle Eastern countries such as the United Arab Emirates (UAE) and Turkey.

The activities associated with Hitachi's alliance with GE are not limited to collaborating on the construction of new plants outside Japan. Instead, the partners are looking to create new value and exploit synergies to improve efficiency in a range of business areas including research and development, procurement, production, and expansion of their service businesses by jointly utilizing their respective technologies.

OPENING UP FUTURE NUCLEAR BUSINESS OPPORTUNITIES

Hitachi believes that the interest currently being paid to its nuclear technology by the international market is due to recognition of Hitachi's past performance in supplying reliable products and services in its construction and preventive maintenance businesses in Japan. To ensure that Hitachi can continue to deliver this level of reliability in the future while expanding its business in the growing global market, it is important that Hitachi maintains its technologies at the highest level internationally by dependably executing its construction projects in Japan, including both those in the construction stage and those in the planning stage, and by achieving high levels of plant utilization through the introduction of more advanced preventive maintenance technologies. The goal of Hitachi's nuclear business is to provide reliable products to the global market based on a

(h) SCC

SCC stands for "stress corrosion cracking." Stainless steel and other materials used in reactor structural components and piping have a thin film on their surface to prevent them from corroding. However, the interaction between the tensile stresses on these materials and the corrosive environment may cause cracks which can widen over time. This phenomenon is called SCC. It has been demonstrated that SCC can be prevented by improving either the material, the stresses to which it is subjected, or the environment. Various countermeasures have been developed.

solid technical foundation and through collaborating with partners depending on the circumstances in each country. The alliance with GE is a key partnership for Hitachi in its aim of expanding its business globally and opens up possibilities for various different collaborations that can be realized in the future. Based on a belief that nuclear power will play a key role in solving global environmental issues, the Hitachi Group companies involved in the nuclear business intend to work together to exploit the future potential of nuclear power.

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