Present Conditions and Prospects of Power Generation Technology

Masahiro Fujiwara †
Masataka Sunaga †
Masahiro Shirakawa †

1. Introduction

The worldwide demand for energy, and especially the demand for electric energy, is increasing dramatically with increasing population and economic development. Particularly in China and India, the increased demand for electric power has been significant, and has accelerated efforts to develop new power sources. Elsewhere in Asia and in the Middle East, the development of new power sources is also being advanced at a brisk rate.

On the other hand, the preservation of the global environment, and especially the prevention of global warming, are worldwide challenges, and are top priority issues that must be addressed for the future survival of our society. The prevention of global warming was a main theme of the G8 Hokkaido Toyako Summit held in July 2008 where a basic agreement was reached "to establish the long-term goal of reducing emissions of greenhouse effect gases worldwide by at least 50% by the year 2050." Companies must also participate by strengthening their efforts to reduce CO_2 emissions, conserve resources, and utilize energy more efficiently.

By focusing on the keywords of "environment" and "energy," Fuji Electric aims to contribute to the creation of a self-sustaining society. Fuji Electric is helping to preserve the environment through its water treatment technology, lead-free initiative, and so on, and is also contributing to energy saving technology with its inverters and other devices that are driven by power electronics technology. In the field of electric power generation, Fuji Electric has stepped up its efforts in geothermal power generation which is a natural and circulating energy, and has become a global leader. Fuji Electric is also contributing to nuclear power generation technology with which there is no emission of CO_2. For clean energy, Fuji Electric is also strengthening its efforts for fuel cells and solar cells, which can be used as distributed energy sources.

Fuji Electric's Electric Power Division has advanced technical development focused mainly on intermediate capacity thermal power and geothermal power in the thermal power field, and fuel handling equipment and waste disposal facilities in the nuclear power field. Fuji Electric has also advanced technical development for repowering and rehabilitation to increase the performance and reliability of existing electric power generating facilities and devices. This paper introduces a portion of this distinctive power generation technology.

2. Thermal Power Plants

2.1 Market trends of thermal power plants

In the first half of 2008, the worldwide market for thermal power plants maintained the robustness of the 2007 market, but after the effect of the worldwide recession began to be felt, there was a sudden drop in the second half of 2008 as new orders decreased significantly. Orders for gas turbines increased dramatically in the USA, but fell overall by 4% from the prior year to 69.3 GW. Orders for steam turbines decreased in all regions of the world, without exception, by 8% from the prior year to 209.6 GW.

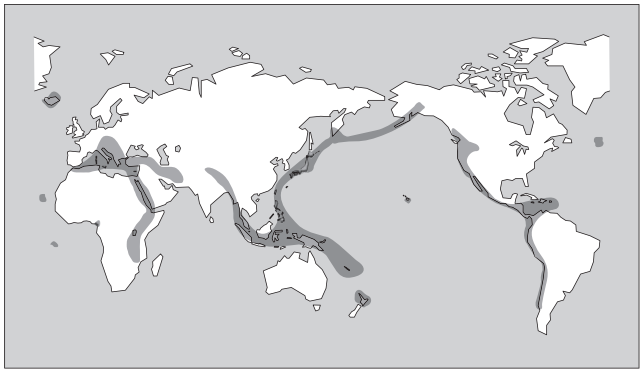
In the Japanese market, due to sluggish demand for electric power and large fluctuations in the price of oil, coal and natural gas, the development of new electric power sources was at a standstill as usual. Implementation of the "Renewables Portfolio Standard" and reduction of CO_2 emissions will have a beneficial effect on the market, but a turnaround is not expected.

In overseas markets, as described above, the outlook is uncertain, but pent-up need remains at a high level. Because circumstances and policies differ by country and region, many different plans exist for developing new power sources and replacing aging facilities. These plans are expected to be realized in the near future. Fuji Electric received 13 orders for steam turbine power generating facilities in 2008. These orders are all to be delivered overseas, mostly to destinations in the Far East and South East Asia, but also to North America and Europe.

The development of geothermal power is being advanced throughout the world in order to help prevent global warming and to efficiently utilize natural energy. Geothermal power is limited to regions in volca-

† Fuji Electric Systems Co., Ltd.

Fig.1 Geothermal zones worldwide



nic geothermal zones, but promising sites also exist in geothermal fields in the Pacific Rim and in regions in Africa and Northern and Southern Europe (See Fig. 1).

At present, robust development is progressing mainly at sites in Indonesia, Philippines, New Zealand and Iceland. Development of geothermal regions in South America and Africa is anticipated in the near future.

Fuji Electric's share of geothermal power facilities delivered over the past 10 years is approximately 40%, and Fuji has contributed greatly to the development of geothermal power throughout the world. At a geothermal plant in New Zealand, Fuji Electric is working to develop a steam separation system that produces steam for electric power generation from the geothermal fluid extracted from a geothermal well, and is also working to construct a turnkey geothermal plant.

Moreover, Fuji Electric is also promoting the commercialization of binary cycle power generating equipment as intermediate- and small-capacity geothermal power generating equipment. Demonstration equipment that has been installed and that continues to run at the Kirishima Kokusai Hotel is providing results as expected.

2.2 Technical development for thermal power plants

Fuji Electric is developing various technologies in response to recent market needs. A simplified overview of a portion of this technical development is presented below.

(1) Technical development of general thermal power devices

(a) Single-casing reheat steam turbine

To realize a 100 to 150 MW reheat steam turbine in a more compact size than the two-casing type that had been used previously, a single-casing type was developed, achieving a reduction in the required installation area, shorter delivery time, and improved economic efficiency and maintainability.

(b) Welded shaft for single-casing steam turbine

Technology was developed to integrate the high pressure and low pressure parts of a turbine by welding heterogeneous materials, each having the required characteristics for their respective part. As a result, lead times were reduced and economic efficiency was improved.

(c) Steam turbine for desalination plant

A large capacity single-casing non-reheat steam turbine suitable for desalination plants, which are actively being constructed in Middle Eastern countries, was developed, and Fuji Electric aims to enter this new market.

(d) Global vacuum pressure impregnation insulation system

The application of a global vacuum pressure impregnation insulation system to a 400 MVA-class large capacity hydrogen-cooled generator resulted in improved reliability, maintainability and economic efficiency.

(2) Technical development for geothermal power plants

(a) High corrosion-resistant geothermal steam turbine

Technology for improving the corrosion resistance of critical internal components of a steam turbine at a geothermal power plant has been developed, enabling an improvement in device reliability and maintainability.

(b) Steam purity monitoring system

A monitoring system that automatically measures the properties of geothermal steam at regular intervals and promptly detects any deterioration in those properties has been developed. By proactively preventing corrosion and scaling, reliability and maintainability are improved.

(c) Geothermal binary cycle power generation

Geothermal binary cycle power generation capable of generating electric power at a lower temperature than flash cycle power generation has been developed. This technology is applied to intermediate- and small-scale geothermal energy generation, and an expanded range of usage and more efficient utilization of geothermal energy are anticipated.

(3) Technical development for improved maintenance

(a) Leak buster

The vacuum region surrounding the condenser deteriorates with age, and the intake of air leads to decreased plant performance. A device has been developed that improves the maintainability and economic efficiency of a plant by accurately locating air leaks and measuring the amount of leakage without shutting down the plant.

(b) Remote monitoring system

A remote monitoring system capable of monitoring the status of an operating plant from a remote location at a Fuji Electric factory has been constructed, enabling a specialist to provide the customer with timely and suitable advice.

3. Nuclear Power Plants

3.1 Market trends of nuclear power plants

The environment surrounding nuclear power dif-

fers from the sluggishness that had existed since the late 1990s, and nuclear power is recently being reconsidered by all countries as a power generating system that helps to meet the increase in energy demand and reduce CO_2 emissions. Construction plans for nuclear power plants are putting into practice in such countries as United State, China and India. Only France and Japan have continued to construct and commission nuclear power facilities. Consequently, as construction plans materialize, highly reliable Japanese technology is again attracting attention.

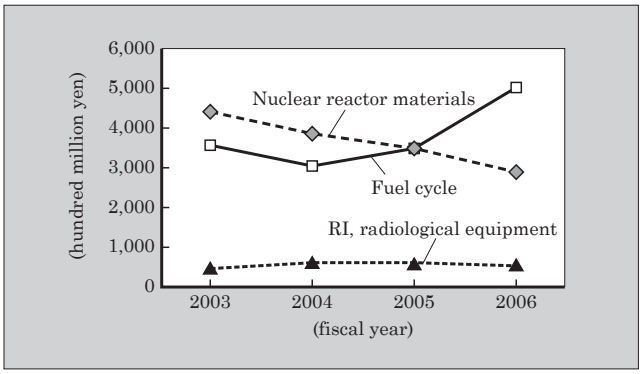
Meanwhile, in relation to environmental issues and targeting the G8 Hokkaido Toyako Summit in Japan, a report of the Nuclear Safety and Security Group was assembled under the auspices of the Japan Atomic Energy Commission (JAEC), and subsequently, a systematic promotion of nuclear power was incorporated.

In 2007, Tokyo Electric Power Company Inc.'s Kashiwazaki-Kariwa Nuclear Power Plant shut down operation because of the Niigata-Chuetsu-Oki Earthquake. This attracted the attention of the nation via reports from various media outlets. This time, however, the public opinion was different from that of several years earlier and a calm attitude was adopted toward the problem of aseismic design of nuclear power facilities. Therefore, other plans are progressing without significantly delays or suspensions. In particular, the Ohma Nuclear Power Plant of the Electric Power Development Co., Ltd. has a plan to load MOX (uranium-plutonium mixed oxide) fuel into the full core for which a safety review had been cancelled in the aseismic performance evaluation, and the Ohma Nuclear Power Plant's application for a nuclear power reactor plant license has been approved by the Ministry of Economy, Trade and Industry.

To complete the nuclear fuel cycle, which is important for providing a steady supply of nuclear fuel, Japan Nuclear Fuel, Ltd.'s reprocessing plant has been constructed in Rokkasho-mura, Aomori Prefecture, Japan, and testing has been performed. The final commissioning test stage is completed, and testing for startup operation has entered the final stage. For the "Monju" fast-breeder reactor, a highly anticipated successor to the light-water-reactor era, sodium leakage preventative measures have been completed and a secondary safety review concerning the loading of fuel to cause the reactor core to reach a critical state has been completed.

Japan's total nuclear power-related expenditures per sector are shown in Fig. 2. The portion for construction of nuclear power-related facilities is for projects involving the major plant manufacturers in Japan. With remote handling technology for nuclear fuel and high dose rate waste material containers, Fuji Electric has made contributions from the design stage, to the construction and modification/renewal stages for each facility. Making full use of these technologies, research and development efforts are being advanced for applications ranging from nuclear power plants to nuclear fuel cycle facilities, and also to devices for other large-scale research facilities.

Fig.2 Total nuclear power-related expenditures per sector in Japan



3.2 Technical development for nuclear power plants

(1) Development of remote handling an auxiliary system

A remote handling auxiliary system was developed after observing an increase in operations involving the handling of solid matter in a radioactive environment. At these types of facilities, many radiation tolerant cameras are installed, and skilled operators use the limited video information from these cameras to operate remote control equipment.

Fuji Electric has developed a remote handling auxiliary system that applies 3-dimensional shape recognition technology to identify the position and orientation of a handling object (target) virtually. With this system, multiple virtual screens can be set in arbitrary directions, without using a large number of radiation tolerant cameras, and remote control equipment can be operated easily, regardless of the skill level of the operator. In the development of this system, the development work had concentrated on shape recognition technology, and initial goals have been achieved. In the future, a simple and easy-to-use human-machine interface will be developed in consideration of a more realistic work environment. The remote handling auxiliary system is also expected to be used in fields other than nuclear power where dangerous substances and large heavy loads are also handled.

(2) Development of devices for J-PARC Material and Life Science Facility

Devices for the J-PARC Material and Life Science Facility are devices that have been remotely handled and delivered to the Japan Proton Accelerator Research Complex (J-PARC) which is being constructed by the Japan Atomic Energy Agency, an independent administrative agency. At this facility, neutrons and other secondary particles (mesons, neutrinos, muons, etc.), generated when the world's largest-class high intensity proton beam is aimed at a target are used to conduct research in various fields such as life science,

materials science, atomic nuclei and elementary particles, astrophysics and energy research. Leveraging its remote handling technology which has been acquired over many years, from 2002 to 2007 Fuji Electric designed, manufactured and installed the following three devices: a target trolley (having a total length of approximately 14 m and mass of approximately 300 t) for setting up and moving a mercury target, moderator-reflector remote handling devices for replacing moderator pipes and the like, and irradiated component storage facilities for storing the mercury target and moderator pipes after having been replaced and that also include a cutting device for cutting 90 mm-diameter multi-layered pipes.

Because these equipment are required to provide remote operation and remote maintenance, and are also related with another equipment both structurally and operatively, coordinated tests were carried out at the factory test stage and onsite installation test stage, and the design and performance of each device were verified to be adequate for the entire facility. All of these activities were completed by March 2008.

(3) Other research and development

Fuji Electric's efforts in the field of nuclear power, not limited to remote handling devices for such types of large equipment, also include devices that handle small objects in a glove box such as the MOX fuel manufacturing process. In Japan, the construction, expansion and renewal of facilities are planned for both front-end (such as a "MOX fuel plant" that processes reprocessed uranium-plutonium into nuclear fuel) and back-end (decommissioning, the treatment and disposal of radioactive waste, and so on) fields relating to nuclear power generation, and technical development is being advanced according to those needs to provide highly reliable device systems.

Moreover, as a next-generation nuclear power generation system, research and development continues into a high-temperature gas-cooled reactor capable of supplying a high-temperature heat source that can be used for power generation and hydrogen production at the same time.

4. Postscript

The worldwide demand for energy continues to increase, and the positioning of electric energy relative to other forms of energy will obviously become a critical factor. Meanwhile, to safeguard the earth's environment, measures for reducing the environmental load must be addressed as a top priority issue. Continuing to pursue higher efficiency and economic performance for power generating devices, Fuji Electric intends to contribute to the creation of a self-sustaining society by advancing the research and development of geothermal power that effectively utilizes natural energy, and by actively promoting research and development in the field of nuclear power, which is a clean form of energy.

Reference

(1) McCoy Power Reports. 2008.