Electric Power Generation Systems

Thermal/Geothermal Power Plants
Wind Power Generation Systems
Fuel Cells
Nuclear Power

Outlook

In Japan, Feed-in Tariff (FIT) Scheme for renewable energy was enforced in 2012, and a full-scale process for approving and constructing mainly photovoltaic power generation facilities has been promoted since 2013. On the other hand, as a result of prolonged suspension of nuclear power plants, Japanese power utility companies have started to renew and reinforce their thermal power sources. In addition, to ensure the stable supply of electricity, there are an increasing number of business transactions with independent power producers (IPP) and power producers and suppliers (PPS) in the field of gas turbine combined cycle (GTCC), high-efficiency coal-fired thermal power systems and biomass power systems, etc.

Overseas, mainly in developing countries, it is expected that the need for power generation will grow over the long term. Moreover, despite some delays, the plans to develop geothermal power plants are being materialized primarily in Southeast Asia and Africa.

In the field of thermal power generation, the commercial operation of Unit 2 in Yoshinoura Thermal Power Station, which adopted GTCC, has started in May 2013; and overseas, the thermal power facilities (total of 783.4 MW) Fuji Electric supplied to seven power plants have started operating. In Thailand, by renewing turbines in existing plants on a massive scale, we have tried to increase their operation life and achieved an increased output.

Despite taking a long time to develop resources for domestic businesses, we are aggressively promoting activities to propose geothermal power systems. Concerning transactions with plants overseas, the power generation facilities in Turkey and Philippines (total of 80 MW) Fuji Electric has supplied started operation in FY2013. Furthermore transactions relating to several units are in progress, and we are currently producing them.

In the field of photovoltaic power generation, Fuji Electric is supplying the market with power conditioners for photovoltaic power generation (power conditioning systems, or PCS), step-up transformers, interconnection systems with grid and their components [ring main unit, protective relay and vacuum circuit breaker (VCB)]. Moreover, there is an increasing need for high-voltage direct current for photovoltaic panels and highly efficient PCSs themselves to improve power generation efficiency in solar power plants. We have developed indoor stand-alone 660 kW PCSs—maximum direct current inlet voltage of 1,000 V, three-level insulated gate bipolar transistor (IGBT) module-type and electric conversion efficiency of 98.4%. Three units of this PCS can comprise a power plant whose capacity is less than 2 MW (high voltage interconnection), which results in a space-saving design and reduces construction cost in comparison with conventional plants with four 500 kVA PCSs. Meanwhile, with the aim of increasing efficiency, Fuji Electric has completed the development of PCSs that employ silicon carbide (SiC).

In the field of wind power generation, demand for wind power systems that have a highly efficient power generation capacity is increasing mainly among power generation businesses including investors. Fuji Electric will actively push ahead with its business while placing priority on the following three pillars: components (generators for wind turbines and converters), systems (electric distribution facilities and stabilization equipment) and prime contractor business.

In the field of fuel cell industries, there are increasing expectations for fuel cells to be used in systems that generate power from the sewage digestion gas, and they have a high power generation efficiency compared with other power generation systems. Fuji Electric will make efforts to receive more orders by making use of its many years of achievements regarding systems that generate power from sewage digestion gas. In addition, by using high-temperature exhaust from fuel cells for air conditioning and the preheating of boiler supply water, we are verifying smart factories which will save on the energy consumed in overall systems. Overseas, Fuji Electric delivers products to Germany, typically fuel cells for fire prevention systems with a low-oxygen air supply function.

In the field of nuclear power, three years have passed since the accident at Fukushima Daiichi

Nuclear Power Station. The Station has changed to the phase of the steady site recovery and the preparation for its decommissioning and the construction plan of the intermediate storage facilities are being progressed positively. Under such situation, while participating the activities toward the recovery and decommissioning of Fukushima Daiichi Nuclear Power Station, Fuji Electric is providing proposals and promoting development concerning the following technologies: the radioactive waste treatment technologies which are needed more and more; and the technologies to remotely control equipment and handling and transportation of materials under the high radiation conditions. Fuji Electric is also continuously developing technologies required for the decommissioning. To follow the new regulatory standards relating to the earthquake and the safety, we are cooperating with our customers in the review of seismic evaluations and safety design and manufacturing and delivery of the enhanced safety equipment primarily in the nuclear fuel cycle field which Fuji Electric has already delivered.

Fuji Electric has selected the following as keywords in FY2014: high-efficiency, space-saving and low-carbon. In line with them, we will contribute to the social community by making efforts for environmentally-friendly and highly-efficient power generation; renewable energy which is represented by geothermal power generation, photovoltaic power generation and fuel cells; technologies necessary for the recovery and decommissioning of Fukushima Daiichi Nuclear Power Station; and the field of the nuclear fuel cycle field.

Thermal/Geothermal Power Plants

1 Indonesia ISM Thermal Power Plant Starts Operation

In January 2014, steam turbines and generators (100 MW×2 units), which were ordered through POSCO Engineering & Construction Co., Ltd. in South Korea, finished commissioning test, and the Indonesia ISM Power Station in Krakatau Steel Company Limited started commercial operation.

This power generation system is a reheating and regenerative cycle thermal power plant which is combined with a combustion boiler using heavy oil and by-product gas generated from the steel plant. It will supply electric power and high-pressure steam extracted from turbines to the adjacent Krakatau Steel Company Limited—the largest steel plant in Southeast Asia.

Fuji Electric has delivered steam turbines, generators and their control facilities, and electric facilities. This plant has employed compact single-cylinder condensate reheat steam turbines and adopted brushless excitation air cooling generators, for which we have an extensive delivery record.

Fig.1 100 MW steam turbine and generator

2 Units 1 and 2 in Yoshinoura Thermal Power Station Starts Commercial Operation

Units 1 and 2 in the Yoshinoura Thermal Power Station of the Okinawa Electric Power Company, Incorporated started commercial operation in November 2012 and May 2013 respectively. This power station is LNG-fired single shaft combined cycle power plant, which was established with the objective of stable electricity supply and reduction of greenhouse gases. The power generation facilities were delivered under a turnkey contract by a joint-venture group including Fuji Electric. The main component is comprised of a SGT6-4000F gas turbine made by Siemens, a single-cylinder axial-flow exhaust type steam turbine, and a hydrogen cooled generator made by Fuji Electric. The total gross power output is 502 MW, which is the largest capacity on the main island of Okinawa.

Being a small electrical grid, due to geographical factors, the plant takes role of faster start-up/shut-down and flexible response to demand. It is continuing to operate while playing an important role in promoting environmental measures such as CO_2 emission reduction and low NO_X emissions, etc.

Fig.2 Panoramic view of Yoshinoura Thermal Power Station

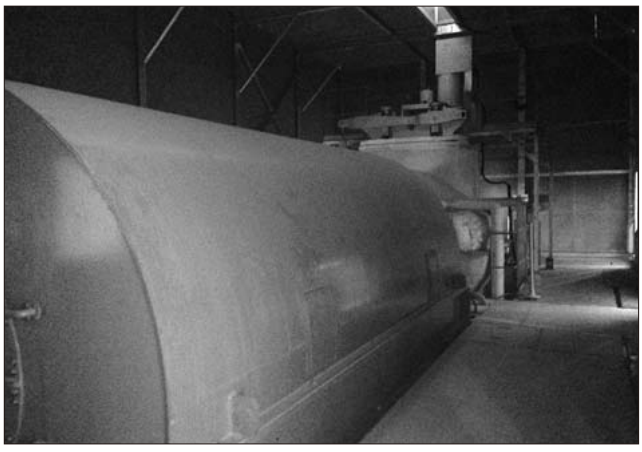
3 PJG#1 Cogeneration Power Plant for China Starts Operation

In February 2014, the steam turbine and generator (71.4 MW×1 unit) for the PJG#1 cogeneration power plant delivered for Chang Chun Chemical Co., Ltd. (China) completed its commissioning work and began full-scale service started commercial operation.

This power plant is a cogeneration plant with coal-fired drum boilers and is used to supply electricity and process steam for chemical factories. Accordingly, it has applied the back pressure turbine which is suitable for supplying steam from turbine to factories.

The back pressure turbine applies a three external extraction control system and can, supply steam to factories without losing their turbine efficiency under a wide range of the load, from high to low by controlling automatically three external extraction control system according to the load.

Fig.3 Steam turbine and generator/power generation facility



Thermal/Geothermal Power Plants

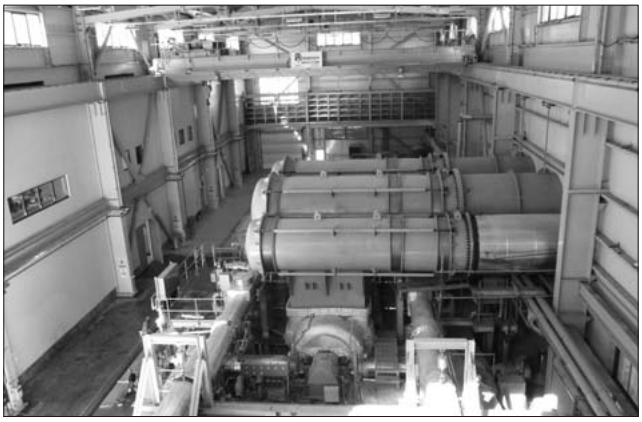
4 Turkey's Kizildere II Geothermal Power Plant Starts Commercial Operation

In October 2013, the Kizildere II Geothermal Power Plant, located in Denizli Province in the west of Turkey, started commercial operation.

Fuji Electric supplied the main equipment (60 MW steam turbines and a generator) and control equipment. Though the development of tandem turbines with back pressure-type high pressure (HP) turbine and condensing-type intermediate and low pressure (ILP) turbine was the first trial for Fuji Electric, we have achieved the smooth start-up/stop and load control by optimally controlling steam flow into each turbine. The HP steam contained an extremely high concentration of non-condensable gas, 16.7 weight percent. we have, however, achieved the performance just as planned by analyzing the effect of gas on the power generation performance.

Turkey has set the goal of increasing the geothermal generation capacity up to 600 MW by 2023, and Fuji Electric will contribute to the goal with this Kizildere II experience.

Fig.4 Tandem steam turbine in Kizildere II Geothermal Power Plant



5 The Philippines' Maibarara Geothermal Power Plant Starts Commercial Operation

Fuji Electric received an order for a 20 MW geothermal power generation system from EEI Corporation, a major general contractor in the Philippines in December 2011. In addition to main equipment such as turbine for geothermal power generation, generator and steam condensers, Fuji Electric provided single units including gas extraction facilities, a cooling tower and hot well pumps. An axial exhaust flow structure is employed for the turbine and direct-contact type barometric-condensers are used, which are the features of the system.

In this project, facilities were shipped in March 2013 just as planned, and the turbine and generator were installed under supervision of instructors of Fuji Electric. Furthermore under the supervision of electric, instrumentation and trial operation instructors, adjustment/trial operation began in January 2014; and performance test and reliability run test were completed in succession. The plant started commercial operation in February 2014.

Fig.5 Panoramic view of Maibarara Geothermal Power Plant

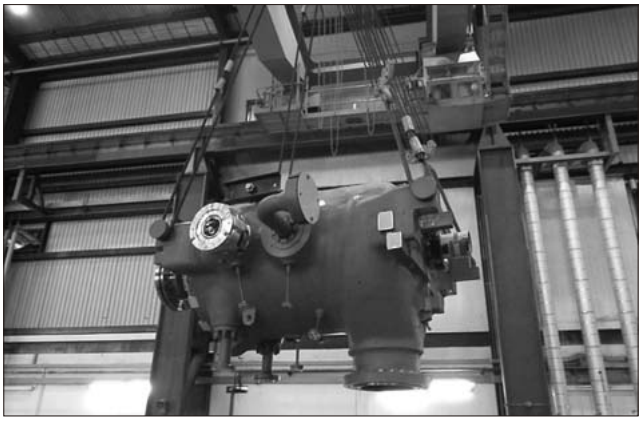
6 Renewal of Turbines in Mae Moh Thermal Power Plant of Electricity Generating Authority in Thailand

The Mae Moh Thermal Power Plant of the Electricity Generating Authority in Thailand is located in the north of Thailand and is the largest class coal-fired thermal power plant in Southeast Asia. Fuji Electric has supplied 10 steam turbines and power generation facilities (Units 4 to 7: 4×150 MW, Units 8 to 13: 6×300 MW).

Fuji Electric manufactured new high-pressure and low-pressure turbines for Unit 12 composed of three cylinders (high-, intermediate- and low-pressure turbines), and replaced the turbines with the new ones to prolong the operation life. In manufacturing the new turbines, Fuji Electric has applied the state-of-the-art technologies to the turbine blades and the gland packing parts to achieve higher efficiency, increasing the output of the steam turbine generator unit.

The construction period in the field was from October to December 2013, and the unit has been in operation successfully.

Fig.6 High-pressure turbine of Unit 12 undergoing renewal in the field



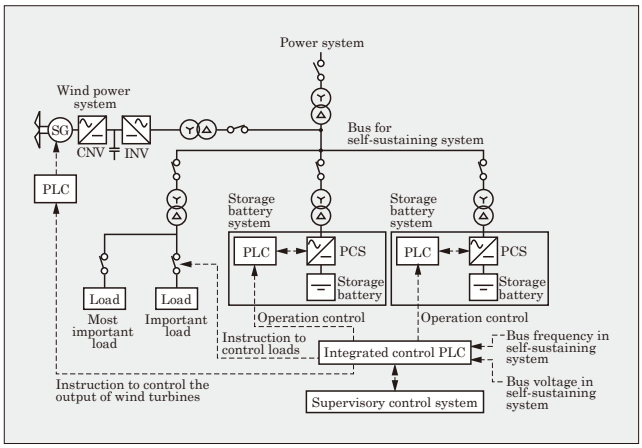
Wind Power Generation Systems

1 Isolated Operation System for Emergencies with Wind Power and Storage Batteries

In association with the further introduction of wind power generation systems and renewable energies, there is increasing demand for emergency power sources using such energies. By installing a storage battery system, Fuji Electric has developed an emergency isolated operation system, which reduces fluctuations in wind power output when it is connected with electrical systems, and supplies electricity to important loads in case of emergencies such as disasters.

For an emergency, wind power generation systems and important loads will be connected with the isolated operation system with a storage battery system to keep them operating independently. During such operation, the system controls the output of wind power, regulates the instruction to adjust and cut off the load and maintains a balance between supply and demand. Moreover, the storage battery system can be used simultaneously with two or more units, and therefore it is possible to apply this system flexibly depending on the scale of the power supply systems. During the simultaneous operation of the system, thanks to the control function to stabilize the state of charge (SOC) of each storage battery, it is possible to supply electricity to important loads for a long time.

Fig.7 Mechanism of emergency self-sustaining system



Fuel Cells

1 Deliveries of Fuel Cells in Japan

Fuji Electric has installed photovoltaic cells and fuel cells in its own factories, and is verifying smart factories which will save the energy consumed in a whole factory.

The fuel cell installed at the Mie factory in December 2013 is used as a city gas-fired cogeneration system in normal operation and has function to switch to LPG-fed operation when city gas supply is stopped. High-temperature exhaust heat of the fuel cell is used for air conditioning.

In addition, in March 2014, Fuji Electric delivered a fuel cell having the same functions to a training center in Japan. There, the exhaust heat is used to preheat water to be supplied to the boiler installed in the accommodation facility in the center.

Reference: FUJI ELECTRIC REVIEW 2013, vol. 59, no. 2, p. 135

Fig.8 Fuel cell installed at Mie factory

2 Overseas Deliveries of Fuel Cells

Germany is taking a positive stance in introducing renewable energies as an alternative to nuclear power generation, and has a high expectation for natural gas-fed cogeneration system which will back up fluctuations in power output by the renewable energies.

Fuji Electric has achieved conformity for our fuel cell CE marking, which is required to get into the German market, and delivered the first unit to a commercial building in 2012. Furthermore, we have developed fuel cells for fire prevention systems that can supply low-oxygen air in addition to electricity and heat which are generated in the conventional system, and delivered the the products to a data center or a factory having a warehouse.

For hydrogen infrastructure has been constructed in Germany, Fuji Electric will put highly efficient fuel cells on the market. And we will make efforts to expand the sales by marketing which utilize the advantages of the fuel cell.

Reference: FUJI ELECTRIC REVIEW 2013, vol. 59, no. 2, p. 135

Fig.9 CE-marked fuel cell delivered to Germany

1 Delivery of Temperature Variable Current Lead

Fuji Electric has produced and delivered, for the National Institute for Fusion Science (in National Institutes of Natural Sciences, Inter-University Research Institute Corporation), current leads which can be cooled with helium gas that is between 4 and 50 K. The National Institute for Fusion Science is pushing ahead with the research and development of fusion power reactors and engaging in research to employ high-temperature superconductors (20 K level) for magnets. The current leads we have delivered this time have a wide temperature setting range and will be used to evaluate both of the high-temperature superconductors and proven conventional low-temperature superconductors.

These current leads have a continuous current rating of 30 kA when the operation temperature is 4 K, and the short-time rating of 75 kA. The short-time rating was determined through a thermal analysis based on the evaluation results we have obtained over the course of our production. A maximum current-carrying capacity of 30 kA is possible when the temperature of helium gas is 50 K, if cooling condition is adjusted.

Fig.10 Temperature variable current lead