Thermal Energy Technology

Thermal Utilization Technology
Cold Thermal Energy Control Technology

Outlook

Thermal Utilization Technology

One of the most significant topics in Japan in 2012 was the enforcement of the Feed-in Tariff (FIT) Scheme. Moreover, although not yet resolved, the comprehensive review of nuclear energy policy represents a significant turning point for energy policy.

Under these circumstances, geothermal and biomass power generation projects, for which commercialization appears promising as a result of FIT, are beginning to move forward. Meanwhile, as a result of the review of nuclear energy policy, plans for new facilities and for increasing the efficiency and for extending the service life of existing facilities have become active, even in the field of general thermal power generation.

Overseas, in developing countries, the trend toward infrastructure improvements such as ensuring power supplies, and in advanced countries, renewal demand for upgrading aging power supplies to the latest technology, remain strong.

In the field of geothermal power generation, Fuji Electric has completed plants in the United States, Indonesia and Nicaragua, shipped a power plant to Turkey, and is in the process of manufacturing a plant for the Philippines. Additionally, Fuji Electric is currently engaged in specific projects in Japan for binary power generation facilities for small and medium capacity applications.

In the field of thermal power generation, Fuji Electric has received many orders from Brazil and Vietnam, and is constructing or manufacturing plants for the United States, China, Vietnam, Pakistan, Indonesia, Oman and Libya. In Japan, Fuji Electric has completed the No. 1 plant of a high-efficiency gas turbine combined cycle (GTCC) station for the Okinawa Electric Power Company, and is advancing the trial operation of the No. 2 plant for the start of commercial operation in May.

In fuel cell and nuclear power fields, as well, Fuji Electric supplies distinctive technologies and services in order to meet the various needs of customers at home and abroad.

Fuji Electric will continue to contribute its accumulated technology and services to customers in order to utilize energy efficiently for the early realization of a low-carbon society and in order to ensure safe and secure power supplies.

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Energy savings has been approached from various angles. Moreover, in the tight electric power situation that has existed since the Great East Japan Earthquake of March 11, 2011, there has been strong demand for strengthening energy-savings measures. In addition to reducing the consumption of electric energy, efforts to improve the utilization of electric power are also needed.

Fuji Electric's representative products that utilize cold thermal energy control technology include vending machines that heat and cool beverages and the like, showcases that cool and display products for sale in stores, and air conditioning systems for data centers and the like.

In the field of vending machines, Fuji Electric and Coca-Cola (Japan) Company, Limited have jointly developed and launched a long-term low-temperature insulating vending machine that does not require any power during the day. This vending machine cools beverages housed inside itself from 11:00 PM until 7:00 AM only, and does not cool the beverages during the interval from 7:00 AM to 11:00 PM. Such an operating mode results in significantly lower power consumption during the daytime hours of peak power usage, and thus this innovative vending machine can contribute greatly to society through the effective utilization of electric power. This performance was realized by utilizing thermal insulating structure technology and airflow analysis technology for beverage cooling.

Meanwhile, in the field of showcase technology, Fuji Electric has developed and launched the "Eco Max S Series" of showcases that, through improving the internal cooling efficiency and installing LEDs as a standard feature for the first time in the industry, enable a reduction in the total showcase and refrigerator power consumption per supermarket by 30% compared to ex-

isting showcases. This showcase series incorporates a proprietary air flow guide system to smooth the air flow of the front air curtain, and utilizes thermo-fluid analysis technology to realize optimal matching of the air flow of the air curtain and the cooling air flow from the rear of the refrigerator. Moreover, in addition to applications to supermarket showcases, Fuji Electric has begun to expand the market by utilizing energy-saving technology to develop showcases for convenience stores and overseas stores.

In the field of air conditioning, Fuji Electric has developed the "F-COOL NEO" of indirect external air-cooling type air conditioners that utilize heat pump technology, a core technology of cooling control, and has installed these air conditioners in data centers. Furthermore, in order to meet customer needs for short lead times, Fuji Electric began offering "build-in-block" type modular data centers.

In the future, Fuji Electric will continue to develop and deploy eco-friendly products that utilize thermal energy technology.

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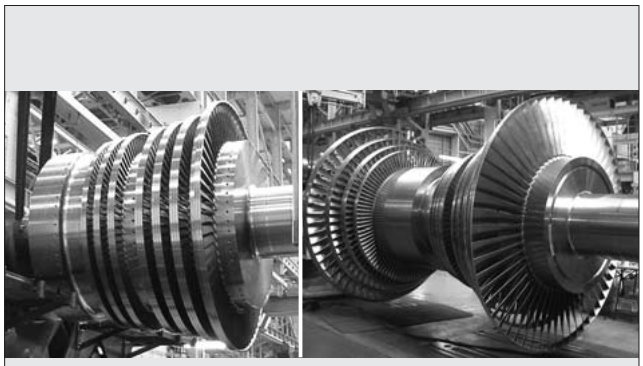
1 Power Facilities for Turkey Kizildere Geothermal Power Plant

In August 2012, the 60 MW steam turbine and generator for the Kizildere Geothermal Power Plant were shipped out. With this project Fuji Electric has newly entered the Turkish geothermal market.

This power plant adopts a triple-flash system. The steam turbine and generator are rotated with the steam with three different pressures (high, medium and low) to generate electricity. A back-pressure system is adopted for a high-pressure turbine which uses high-pressure steam, and a condensing system is adopted for a medium and low-pressure turbine, which uses medium and low pressure steam. This turbine system is tandem by coupling these two turbines to a single shaft.

The high-pressure steam is unique because it includes 16.7 weight percent non-condensable gas, which is extremely high concentration compared with other geothermal power plants. The final evaluation of consequence of the highly concentrated non-condensable gas will be performed based on the commissioning results. The equipment is currently being installed and the commissioning is expected to start from the spring 2013.

Fig.1 60 MW steam turbine



High-pressure turbine　　Medium and low-pressure turbine

2 Construction of Philippine Maibarara Geothermal Power Plant

In December 2011, we received an order for one 20 MW geothermal power plant from EEI Corporation, which is a major construction company in the Philippines. The scope of the supply includes a geothermal steam turbine, generator, condenser and auxiliary equipment such as gas extractor, cooling tower and hot well pumps.

An axial exhaust flow type was adopted for the turbine and a direct-contact type barometric-condenser was used for the condenser. In March 2013, the equipment was delivered by Free on Board (FOB) and installed at the foot of Mt. Makiling (Elevation: 200 m) located in Santo Tomas City, Province of Batangas, Island of Luzon, Philippines.

Fig.2 Progress of foundation work at the site

3 Hybrid Gas Extractor for Mori Geothermal Power Plant of Hokkaido Electric Power Co., Inc.

In September 2012, we completed the exchange construction to a hybrid system gas extractor for Mori geothermal power plant of Hokkaido Electric Power Co., Inc. This construction removed a gas compressor in operation connected directly with a steam turbine and exchanged it for three stages-style hybrid system (1st and 2nd stage of ejectors and 3rd stage of vacuum pump) newly. Currently, the machine is operated at the maximum steam amount (primary steam: 200 t/h) and noncondensible gas amount decreases to 3% from the planned amount 10%.

The purpose of this construction raises a condenser vacuum degree by changing the capacity of the gas extractor in 25 MW specifications (the generation output has been changed to 25 MW) from 50 MW specifications in consideration of the present maximum amount of steam (quantity of primary steam 200 t/h) and decrease in non-condensation gas (it decreases from 10% to 3%) and is to increase the generation output. As a result, a condenser vacuum degree rose to 8.4 kPa from 16 kPa and became able to increase by 20 to 30% of generation output.

Fig.3 Full view of vacuum pump for hybrid system

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4 Shipping Turbine and Generator for US Biomass-Burning Power Plant

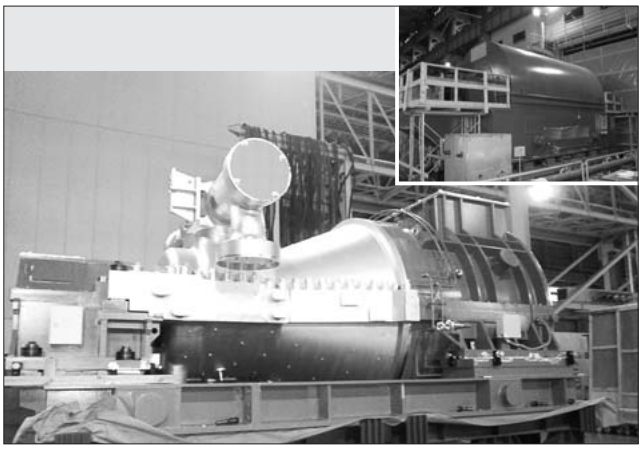
In September 2012, we completed shipping of a set of axial-flow-type single-cylinder condensing steam turbine and air cooling power generators for a newly constructed 75 MW class biomass-burning power plant in Berlin, New Hampshire, the United States.

In order to respond to a strong request from Babcock & Wilcox Construction Co., Inc. (BWCC) for shortening the construction period, a skid-type steam turbine and air cooling generator were adopted. The skid-type product of this class is the first machine of its type to be built by Fuji Electric.

BWCC remodeled the existing black-liquid collection boiler, which stopped operations in 2006, to a woody biomass-burning bubbling fluidized bed boiler, which generates power with a turbine and generator manufactured by Fuji Electric.

The power plant is expected to start selling electric power by the end of 2013.

Fig.4 Skid-type steam turbine and air cooling generator



5 Fuel Cell Equipment for Sewage Innovative Technology Demonstration Project (B-DASH Project)

The Feed-in Tariff Scheme in Japan for renewable energy has been started since July 2012. In the power generation field using sewage digestion gas, which is attracting attention, Fuji Electric's fuel cell equipment was adopt as a power generator for Sewage Innovative Technology Demonstration Project (B-DASH Project). The fuel cell equipment was installed in a sewage treatment plant in Osaka city in February 2012 and its demonstration test has been executed since April 2012.

It is expected to expand the market for sewage treatment plants including small-scale plants, as this fuel cell equipment can be operated by mixing digestion gas of lower yield with city gas.

Fig.5 Fuel cell equipment under demonstration test

6 Delivery of CE-Marked Fuel Cell Equipment to Germany

Fuel cell demonstration equipment with supply function of air containing low-concentration oxygen for fire prevention was delivered to Germany in 2010. Then CE-marked equipment with installation permission in the EU has been developed by using the demonstration equipment. The 1st. commercial CE-marked equipment was delivered to an automobile dealer in Germany in May 2012 and then has been running since August 2012. This equipment is the first CE-marked fuel cell product made in Japan for business use and has been completed by solving many subjects such as secure explosion prevention of flammable gas and EMC conformity.

Hereafter we are going to expand the sales of low-oxygen air supply type equipment for data centers and warehouses in the EU.

Fig.6 Fuel cell equipment delivered to Germany

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7 Fuel Cell Equipment Installation in Kawasaki Factory

In February 2012, fuel cell equipment was installed in Fuji Electric's Kawasaki factory. This equipment contributes as a co-generation system using normally city gas for fuel to energy saving and reduction of carbon dioxide emission in the factory.

This equipment can provide power to essential systems during electrical grid's outage. Moreover, it can also continue to generate power by stocked LP gas even when city gas supply is stopped. By these functions, power supply security of the fuel cell equipment is improved. In addition, high-temperature exhaust heat is used for air conditioning in the office building by introducing it to the absorption-type water cooling/heating apparatus, and low-temperature exhaust heat is used for preheating the water supply of the boiler in the factory.

Fig.7 Fuel cell equipment installed in Kawasaki factory

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1 Energy-Saving Cup Type Drink Vending Machine "FX21"

Based on the concept of "environmental response" and "improvement of customer satisfaction," a full model change was conducted and the industry's top-class energy-saving high-performance machine, "FX21," was developed as a medium-cup-type drink vending machine. Compared to machines in FY2008, annual power consumption was reduced by 69%. The main features are as follows:

(1) Introduced a heat insulated structure with three layers by combining vacuum insulation material and resin foam and optimized the heater shape and operation control, and realized a high insulation and small-size hot water tank.
(2) By using resin for the part of the coffee extractor that comes into contact with the liquid, the machine is made highly insulated and small in size, and the need for a space heater was eliminated.
(3) Non-illuminated interface door was developed for the first time in the industry.
(4) With a new cup mixing system, the quality of beverages and efficiency of operation were improved.

Fig.8 "FX21"

2 Coffee Machine for Seven-Eleven Japan Co., Ltd.

While tasty coffee to customers is gaining attention, convenience stores are focusing on sales of coffee. Fuji Electric developed a one-cup coffee machine by utilizing the original paper drip extraction technology. The main features are as follows:

(1) Achieved good taste of fresh hand drip coffee by means of detailed extraction setting such as steaming time and air stirring, and uniform and optimal granularity using a new model coffee mill.
(2) Refined design with stainless exterior and space-saving compact-size safety design with cover on the ejection part.
(3) Achieved operability focusing on access from inside the counter such as ease of replacing paper from rear surface and making daily cleaning easier with an auto-rinse function.

Fig.9 One-cup coffee machine

3 Energy-Saving Display Case for Convenience Stores

Recently, there have been increasing needs for energy saving in the world of convenience stores in order to reduce environmental impact. Fuji Electric developed an open display case with reduced power consumption that meets the required refrigerating capacity by optimizing the blowout structure to improve cooling efficiency by means of controlling outdoor air infiltration and employing LED lamps.
The main features are as follows:

(1) Striving for optimization of blowout structure (air curtain) by controlling blowout opening structure at the optimum ratio of inner duct and outer duct, honeycomb angle and the rotation speed of fan, and reduced refrigeration capacity by 10% compared with machines in 2009.
(2) By installing LED lamps and optimizing the above-mentioned blowout structure, dew prevention heater capacity was reduced and power consumption was reduced by 35% compared with the machines in 2009.

Fig.10 Energy-saving display case for convenience stores

4 Refrigeration Showcase for Overseas

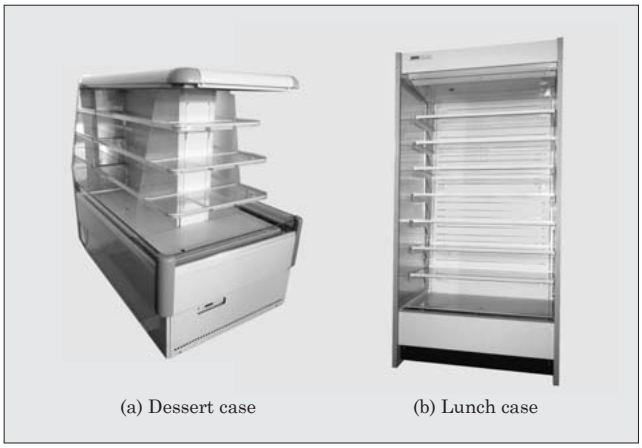
Recently, modernization of food distribution in China and South East Asia has been developing and the advance of Japanese convenience stores into overseas market has accelerated.

Under such circumstances, a separate placement type of showcases has become subject to a labeling system in China and enforcement of energy-saving management is underway. Fuji Electric developed a refrigeration showcase for overseas markets, which employs energy-saving technology.

The main features are as follows:

(1) In the control section, cost reduction and linkage with various energy-saving systems were realized with a structure combining a microcomputer basic unit, which is limited to the basic function, with an extension unit for improved function.
(2) By using feedback control to keep the number of rotations of the fan to be constant, maintaining the optimal air flow of air curtain from the cooling initial stage, and controlling the amount of inclusion of fresh air, cooling efficiency was significantly improved.

Fig.11 Refrigeration showcase for China



5 Plant Factory Unit and Growing Conditions Control System

Recently, there has been rapidly growing interest in plant factories that can stably produce farm products without using agricultural chemicals by artificially controlling the environment within the facility. Fuji Electric developed a plant factory unit by using a display case. This unit has doors with which cultivation with a high degree of hygiene in a semi-closed space is possible. The unit introduced in the demonstration building (not announced to the public) of Asahi Kasei Homes Corp. can be used as a wine cellar by providing two temperature zones. In addition, a control system for a cultivation environment for large-scale plants was developed. We achieved an environment suitable for growing plants by controlling the concentration of nourishing solution and CO_2 concentration using PLC. Furthermore, environmental information and facility operation information are gathered into the server and combined control is performed.

Fig.12 Wine cellar built-in plant factory unit

6 Air Conditioning Unit with Indirect Fresh Air Introduction for Data Centers

Recently, the calorific value of servers used in data centers has been increasing dramatically due to their high performance and high density. Because of this, introduction of a system using fresh air cooling is being promoted to pursue energy saving. Fuji Electric developed an air conditioning unit for data centers which uses the indirect fresh air introduction method. This unit is equipped with a built-in heat pump, and performs only heat exchange with fresh air. The main features are as follows:

(1) Providing cooling capacity of 25 kW/unit.
(2) By combining fresh air and cooling machine operation, it is possible to perform cooling throughout the year and achieve a coefficient of performance (COP) of 10 as the annual average.
(3) Because of the use of indirect fresh air, it is not necessary to take measures against corrosive substances (salt damage) and humidity adjustment.
(4) It is an independent and stand-alone facility that is easy to install and requires no auxiliary air conditioning.

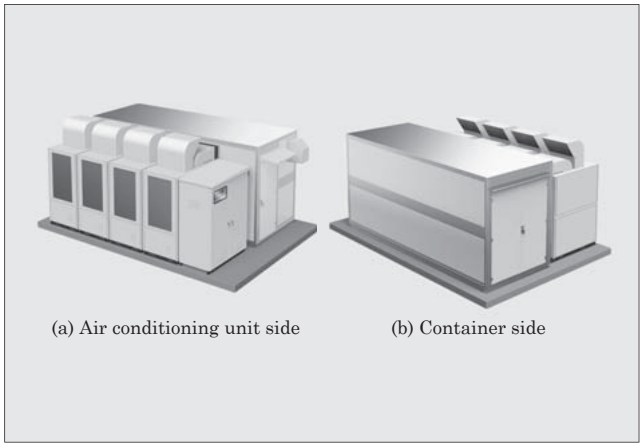
Fig.13 Air conditioning unit with indirect fresh air introduction (heat pump type)

7 Container Type Data Center for Fujitsu Limited

Recently, container type data centers have been attracting attention from the perspective of early construction and small start against the background of increasing demand for data centers. Under such circumstances, container type data centers using fresh air cooling are being commercialized in terms of energy conservation. However, in order to directly bring in fresh air, measures are required against fine particles and high humidity that exert a bad influence on ICT devices.

Fuji Electric developed an air conditioner that uses the indirect fresh air introduction method that resolves this issue. Air conditioning unit and container chassis, and power equipment are integrated as a package. This solution, a container type data center, which allows a short construction period and energy conservation, is jointly provided by Fujitsu Limited and Fujitsu Laboratories Ltd.

Fig.14 Container type data center



(a) Air conditioning unit side (b) Container side