Gas turbine cogeneration system for energy conservation and better power supply security

Cogeneration is capable of contributing greatly to energy conservation, energy cost reduction, and greenhouse gas emission reduction. Moreover, new demands, such as the need to "improve power supply security," have emerged from the Great East Japan Earthquake. Under these circumstances, we are striving to provide gas turbine cogeneration that responds to this change in market needs.

Preface

Cogeneration has been introduced mainly for the purposes of energy conservation, energy cost reduction, and greenhouse gas reduction. However, power shortages and concerns over power service interruptions after the Great East Japan Earthquake have created new needs such as "the reinforcement of power supply security." Table 1 shows typical reasons for introducing cogeneration systems among our list of received orders.

① Reinforcement of power supply security
② Reduction in energy costs
③ Conservation of electric energy

Responding to such changes in market needs, we are constructively engaged in providing high efficiency, high reliability gas turbine cogeneration.

1 Market trend for cogeneration

(1) Japan

At present, the current basic energy plan is undergoing a radical review, following the impact of the Great East Japan Earthquake and the subsequent accident at a nuclear power plant in March 2011. In laying out a new basic energy plan, the Ministry of Economy, Trade and Industry released a plurality of "energy mix options." The release by the Ministry refers to the following matters as basic courses for an energy mix.

・Efficient utilization of fossil fuels as implemented by a shift to natural gas with the maximum possible consideration given to environmental load; (Clean use of fossil fuels)

Table 1 Major orders received after the Earthquake and reasons for introducing cogeneration systems

Case of introduction	Reason for introduction
Site A	Stable supply of electricity in summer and winter, and electricity conservation
Site B	Reinforcement of power supply security for the plant in the wake of the shutdown of nuclear power plants
Site C	Securing of power supply for safeguarding medical equipment (Reinforcement of power supply security)
Site D	Relocation to the Kyushu region of some functions of the plant in the Kanto region for the purpose of stable supply of electricity to production facilities
Site E	Stable supply of electricity and energy costs reduction as measures against an increase in electricity charges

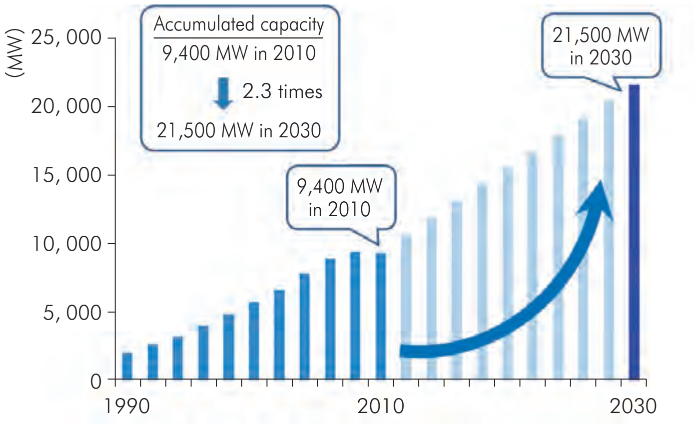


Fig. 1 Anticipated introduction of cogeneration systems
(Note: Fuel cells excluded from data for 2030.)

・The importance of the expansion of clean use of fossil fuels as well as of the expansion of use of cogeneration systems (including fuel cells) that integrate the use of electricity and heat from the viewpoint of accelerating the effective use of waste heat and the widespread use of distributed power supplies; the necessity to this end of immediately materializing a policy aiming at the expansion of the introduction and development of a framework to efficiently use surplus power in grids.

The individual cases described in the "energy mix options" proposed on the basis of the above basic courses assume that the power generating capacity from cogeneration will increase from the current 9,400 MW to 21,500 MW, which will cover 15% of the power demand in 2030 (Fig.1).

(2) Foreign countries

The International Energy Agency (IEA), in its report entitled "Cogeneration: Evaluating the Benefits of Greater Global Investment[1]," defines cogeneration as "low-cost and reliable technology that is capable of contributing to solving the problems of global climate change and increasing power demand." The Agency also estimates, in its "Accelerated Combined Heat and Power (CHP) Scenario," an increase in the introduction of cogeneration in various countries between 2015 and 2030 (Fig. 2).

2 Gas turbine cogeneration

Cogeneration can be defined as an energy system in which a prime mover such as a gas turbine is driven by a kind of primary energy (fuel) to obtain electric power and to simultaneously extract heat in the exhaust gas and cooling water of the prime mover in the form of steam or hot water in order to use the heat for space air conditioning, hot water supply, process heating, and similar purposes.

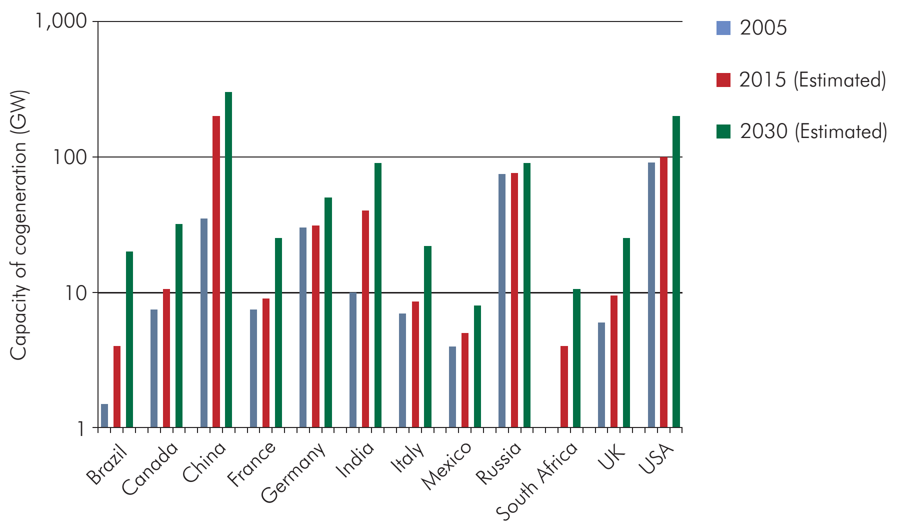


Fig. 2 Introduced cogeneration systems by country (IEA estimate)[1]

Table 2 Lineup of Kawasaki gas turbine cogeneration products

Model	Generating end output (kW)	Generating end efficiency/ Overall efficiency (%)
PUC07D	650	24.4 / 75.0
PUC15D	1, 455	24.1 / 82.0
PUC17D	1, 660	26.5 / 84.2
PUC30D	2, 865	23.9 / 81.9
PUC60D	5, 250	28.9 / 83.1
PUC70D	6, 500	30.0 / 81.0
PUC80D	7, 290	32.7 / 84.3
PUC180D	17, 530	33.5 / 81.9
PUC300D	28, 350	38.8 / 83.1

We have an extensive lineup of products with outputs ranging from 600 to 30,000 kW, driven by gas turbines developed on its own efforts (Table 2).

The features behind our products are as follows.

① Integrated system from the development of engines to their after-sales services

② Extensive track record (517 units delivered with an accumulated capacity of 1,000 MW or more)

③ Capability of running on diverse fuels (City gas, liquid fuel, etc.)

④ Availability not only in normal time but also as standby power supply in disasters (Limited to model PUC30, inclusive)

⑤ Around-the-clock after-sales service system

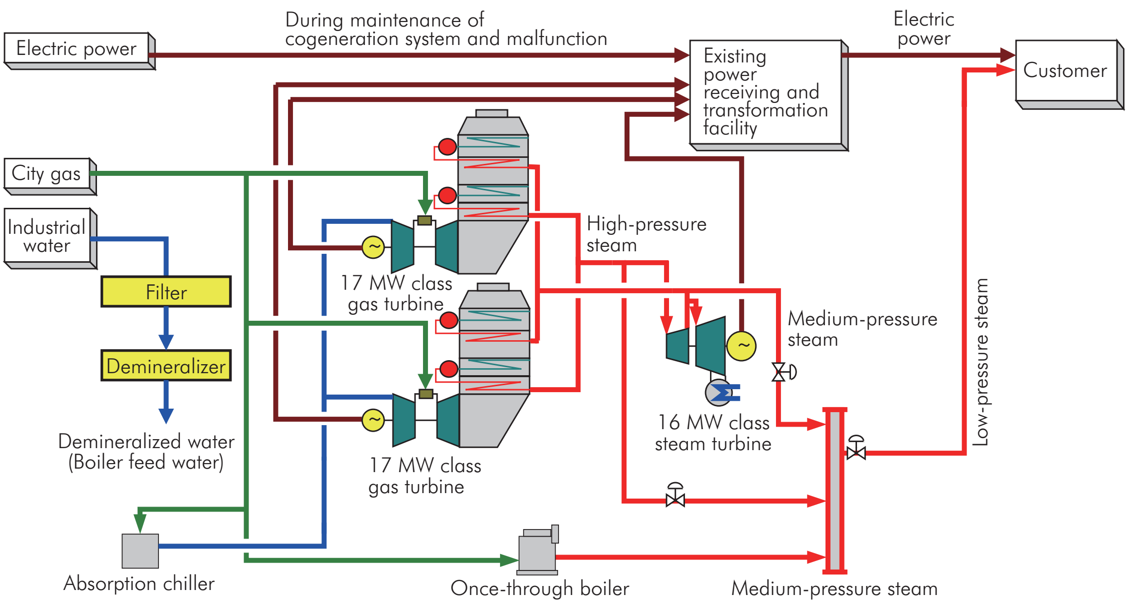
3 Market needs for cogeneration and examples of cogeneration introduction

(1) Reinforcement of power supply security

Figure 3 shows the outline of the PUCS500 50 MW class combined cycle generator set, composed of two 17 MW class L20A gas turbines and a 16 MW class steam turbine, that was delivered to Summit Mihama Power Corporation. Using clean city gas, the combined cycle generator set supplies electricity to seven companies in the food processing complex in Mihama Ward, Chiba Prefecture

■ Plant performance
Gas turbine generating output : Approx. 34,000 kW
Steam turbine generating output: Approx. 16,000 kW
Quantity of steam supplied : Approx. 65 t/h

(a) Appearance



(b) Facility flow

Fig. 3 50 MW class combined cycle power generation plant PUCS500 delivered to Summit Mihama Power Corporation and steam to four companies there. In addition, the utility company sells surplus power to bulk customers in the Greater Tokyo Metropolitan area via its subsidiary, Summit Energy Corporation.

One of the important features of the generator set is, instead of the common practice of the conventional combined heat and power supply business characterized by in-house consumption on a one-company-one-plant basis, the combination of a business supplying electricity and steam to two or more plants within an industrial complex via the electric power retail business, and the forming of an unprecedented new business structure as a 50 MW class power station. Distributed power generation can exert its full potential under such a business structure if it cannot make the most of its advantages in reducing costs and environmental load when introduced to a single plant.

During planned power service interruptions after the Great East Japan Earthquake, this generator set ensured a stable supply of electricity and steam to the companies in the food processing complex, thus helping those companies continue stable supply of their products. This in turn helped Kawasaki discover a different need for cogeneration than that of the past. A system that allows electric power and exhaust heat energy to be used efficiently on a regional basis can be said a small-scale example of a "smart energy network."

(2) Energy conservation and reduction in energy costs

Figure 4 shows an outline of the PUC180D gas turbine cogeneration unit, equipped with a reheating device and delivered to a factory in Shizuoka Prefecture. With the existing heavy-oil-fired boiler out of service and a natural-gas-fired gas turbine cogeneration unit working together with the customer's own waste heat reuse facility, a yearly reduction in crude oil consumption of about 19,000 kL was attained, contributing to a 34% energy-savings by the entire plant.

(3) Electric power conservation

The energy center of our Akashi Works is composed of a PUCS250 combined cycle generator set made up of a L20A gas turbine and a steam turbine, the PUC80D turbine cogeneration generator set, and a PUC17D mono-generation generator set. These are installed with the main objective of reducing plant electricity and steam costs, and conducting long-hour demonstration tests of model plants and newly developed gas turbine engines (Fig. 5).

In response to a request from Kansai Electric Power Co., Inc. for power conservation beginning in 2011 (in winter and in summer), these generator sets are operated to the maximum to reduce purchased power, and when a surplus occurs under this operating condition, it is sent back (transmitted) to the power utility by reversing power flow.

■ Plant performance

Gas turbine generator output : Approx. 17,000 kW
Quantity of steam supplied : Approx. 51 t/h

Fig. 4 PUC180D gas turbine cogeneration system

■ Plant performance

Generator set No. 4 (L20A)	: 18,000 kW
Generator set No. 6 (Steam turbine)	: 6,700 kW
Generator set No. 7 (PUC80D)	: 8,100 kW
Generator set No. 8 (PUC17D)	: 1,800 kW

Fig. 5 Akashi Works Energy Center

4 Technological readiness to the market needs after the Great East Japan Earthquake

(1) Dual fuel

"Dual fuel" is a specification by which an engine can run on either liquid or gas fuel. An engine with this capability can be operated for a long time if gas fuel can be supplied through gas conduits when a disaster or the like makes it difficult to procure liquid fuel. Also capable of starting up even under a service interruption, gas turbines made to dual fuel specification can be used as a standby power supply in an emergency. Many of them have been introduced for hospital and private building use (Fig. 6).

Fig. 6 Gas turbine of dual-fuel specification

(2) Isolated operation

Isolated operation refers to a mode of operation in which a cogeneration system parallels off the generator set from an interconnected commercial power supply to independently supply power to important loads, should an abnormality such as an instantaneous voltage drop occur in the interconnected commercial power supply. After the Great East Japan Earthquake, we executed a number of electrical construction projects to convert existing cogeneration systems to ones capable of isolated operation.

Figure 7 shows an example of measures against instantaneous voltage drops using a high-speed circuit breaker. When an instantaneous voltage drop occurs, the high-speed circuit breaker, using semiconductor switches, allows the bus-connected circuit breaker (52B) to be paralleled off, with power feeding to important loads continued.

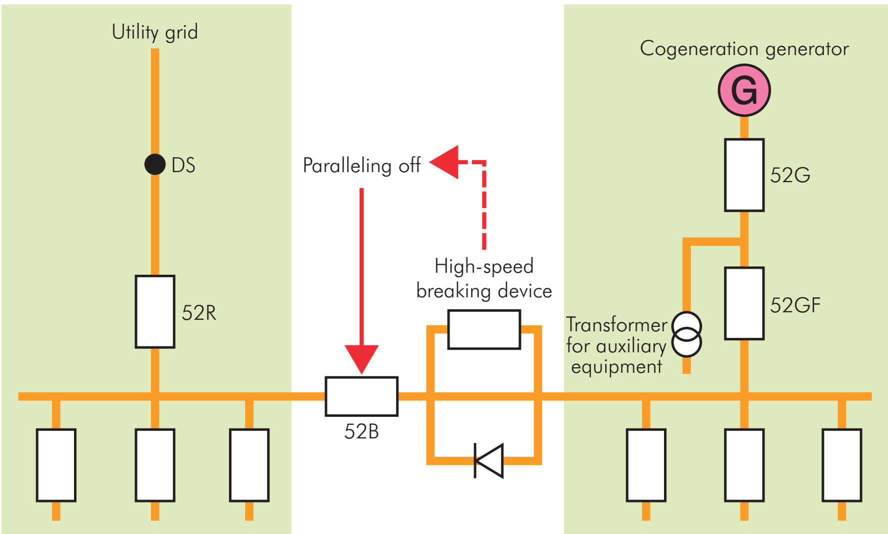


Fig. 7 Measure against instantaneous voltage drop using high-speed circuit breaker

(3) Power conservation by means of absorption chillers

Using steam generated by exhaust heat from a cogeneration system to make space-cooling cold water in an absorption chiller reduces electricity equivalent to that consumed by a turbo refrigerator.

Figure 8 shows the effect of the reduction in electricity achieved by an absorption chiller. To obtain a space-cooling capacity of about 500 USRT, an absorption chiller consumes about 2 t/h of steam, while a turbo refrigerator consumes about 260 kW of electricity.

For this reason, steam generated by 2 t/h of exhaust heat from a cogeneration system provides space-cooling equivalent to 500 USRT and simultaneously achieves about a 260 kW reduction in received power or peak cut.

Concluding remarks

With business environments relating to energy changing greatly day by day, we at Kawasaki hope to immediately catch wind of these changes in order to provide products that match market needs, thus contributing to society.

Reference

1) IEA, Combined Heat and Power, 2008.

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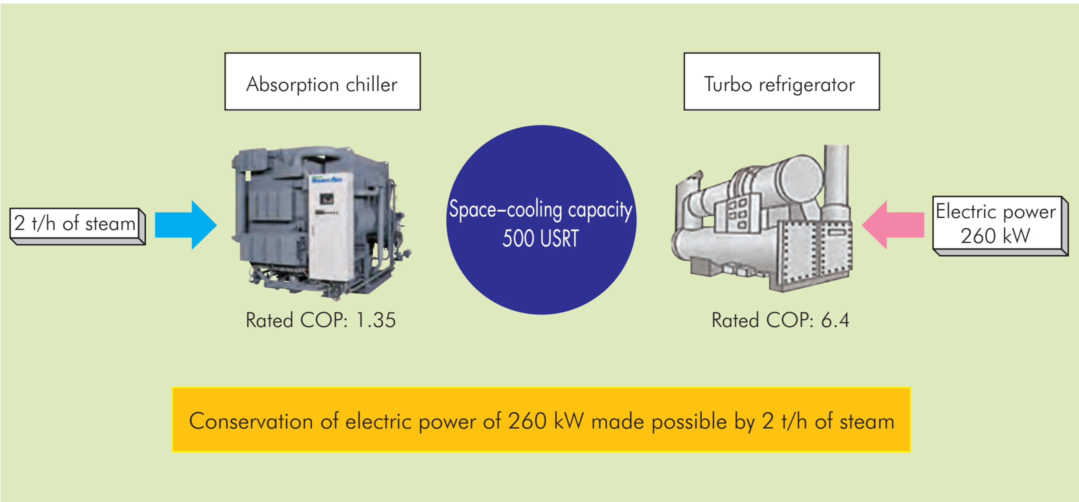

Fig. 8 Example of electricity conservation by means of absorption chiller