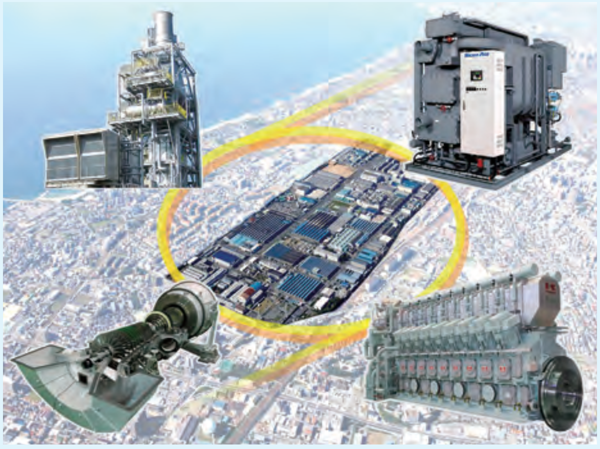
Distributed power generation systems that meet energy needs —Cogeneration system solutions



After the Great East Japan Earthquake, growing interest in energy has been motivated not only by energy conservation but also by power supply security, as Japan's energy and environment policies now mention the widespread use of cogeneration. To promote the introduction of cogeneration, we are making an effort to strengthen our ability to make proposals to customers about the configuration of the cogeneration system best suited to their demands for electric power, heat, air conditioning and the like, and about the manner of operating such a system. This article presents our approaches to cogeneration system solutions intended to maximize the customer's benefit.

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 the risks of power service interruptions after the Great East Japan Earthquake have created new needs such as "the reinforcement of power supply security."

With the government reviewing the energy basic plan, the Innovative Strategy for Energy and the Environment, which determines the future strategy on energy and the environment of the Cabinet (Energy and the Environment Council held on September 14, 2012), urges that cogeneration be spread as far and wide as possible to promote the effective use of energy, and that the energy generated by cogeneration be increased from the current 30 billion kWh to 150 billion kWh in 2030, which would account for 15% of the electricity demand then (Fig. 1). As a measure for promoting this strategic option, a business environment will be developed in which the electricity

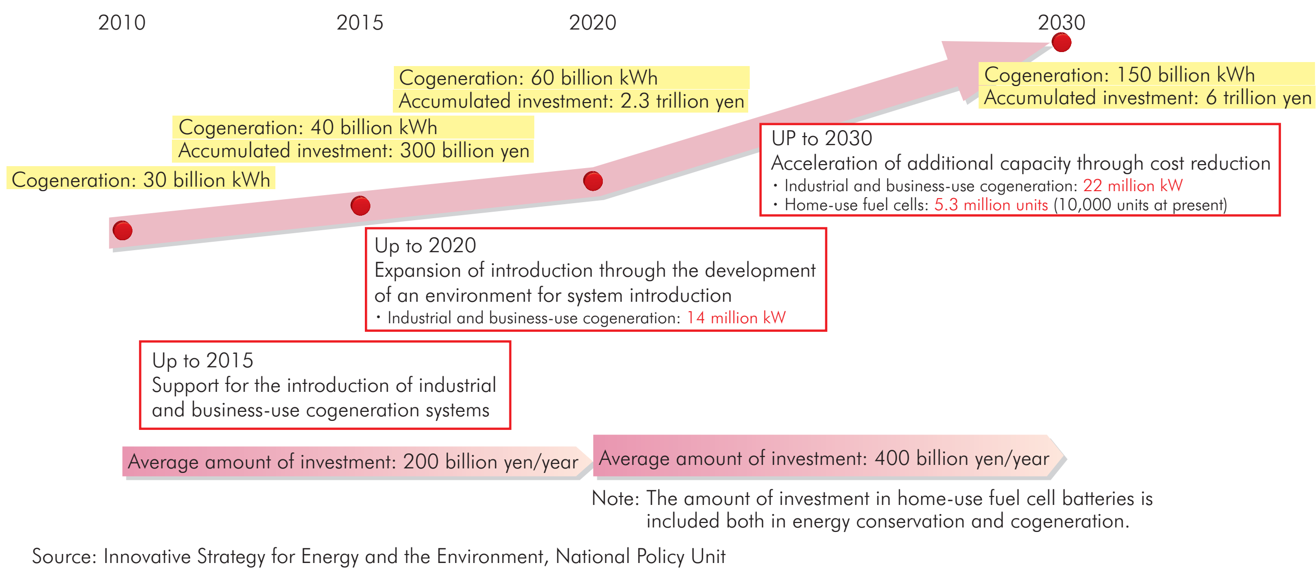


Fig. 1 Expansion of introduction of cogeneration toward 2030

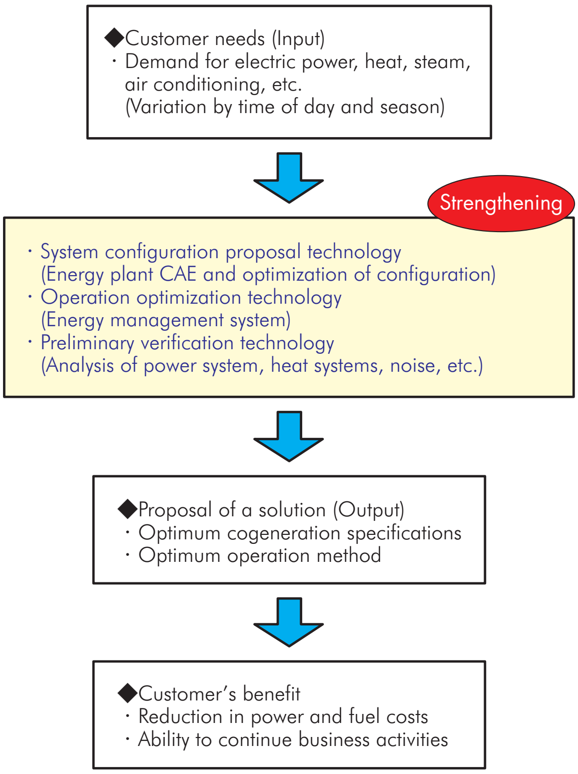


Fig. 2 Strengthening of ability to make proposals on introducing cogeneration

produced by cogeneration can be sold smoothly and measures for supporting the introduction of cogeneration will be reinforced.

Backed by such circumstances, we are strengthening (Fig. 2) our ability to propose cogeneration systems (Fig. 3), using a variety of energy supply machines (such as gas turbines, gas engines, boilers, and steam absorption chillers). In putting forward the suggestion to introduce cogeneration, it is particularly important to study the system configuration and the method of system operation so as to maximize the benefits of introducing such a system. In addition, selling the electricity from cogeneration or extending the range of utilization of waste heat from cogeneration requires that technologies verify beforehand how the variation in electricity and heat demand is followed (such as by power system analysis and steam system analysis). To achieve these goals, we are making efforts in the following ways.

1 Proposals on system configurations

In the early stages of cogeneration, too, we suggested to our customers the optimum system configuration based on energy plant computer aided engineering (energy plant CAE). However, since more complicated configurations are expected in the future due to the diversified needs of customers, it is necessary to strengthen our ability to propose system configurations.

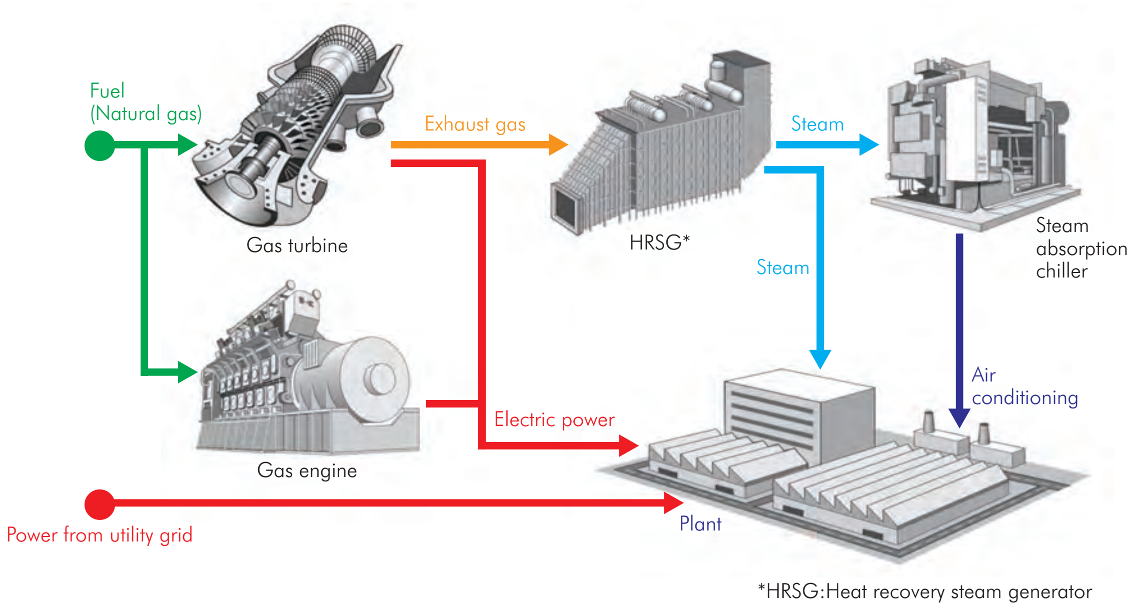


Fig. 3 Cogeneration system

The "configuration optimization technology" that we are developing aims at proposing a system configuration that will provide the customer introducing cogeneration with a minimized life cycle cost (i.e., reductions in facility maintenance expenses and fuel expenses; Fig. 4).

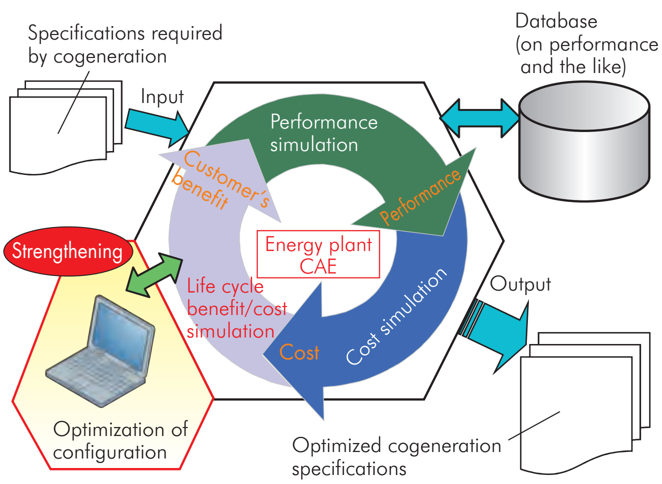


Fig. 4 Flow of proposal on cogeneration system configuration

Figure 5 shows an example of a study on fuel expenses using the configuration optimization technology. In this example, fuel consumption is simulated using plant demand patterns A and B for two different system configurations, ① and ②, in order to compare the integrated daily amounts. The following was learned. Under pattern A, in which the demand for heat is larger, configuration ①, which is equipped with more gas turbine cogeneration units thus exhibiting a higher overall efficiency inclusive of power generation and heat (steam), allows for lower fuel consumption. In contrast to the above, under pattern B, in which the same quantity of electricity is needed but the demand for heat is smaller, configuration ② with more gas engines of a higher power generation efficiency allows for lower fuel consumption.

We will focus our efforts on the combination of "energy plant CAE" and the "configuration optimization technology" so as to propose cogeneration system configurations more quickly and flexibly.

Configuration	Gas turbine cogeneration	Gas engine	Gas-fired boiler
① Gas turbine as the main component	3 units	1 unit	1 unit
② Gas engine as the main component	1 unit	3 units	3 units

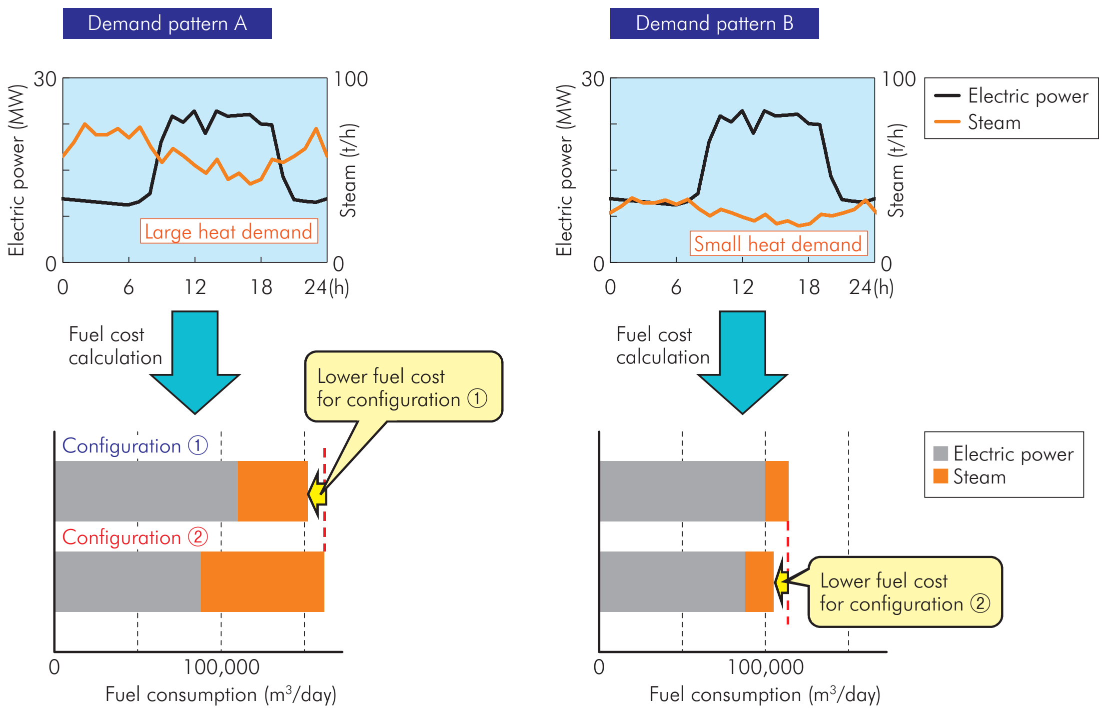


Fig. 5 Study on fuel cost based on configuration optimization technology

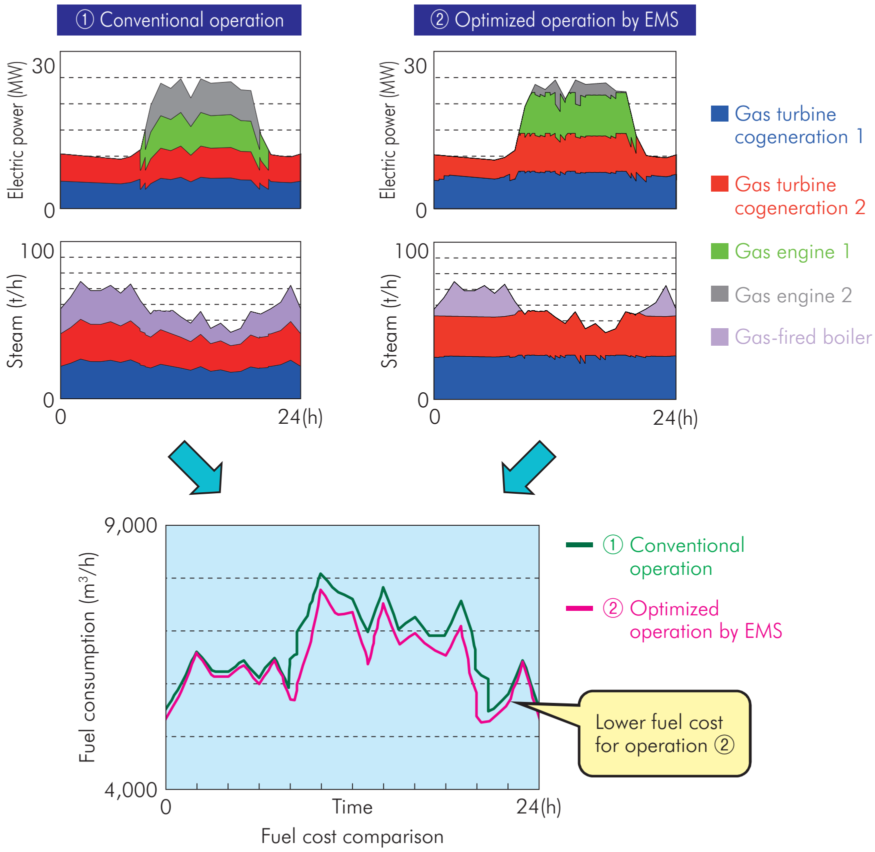


Fig. 6 EMS-based optimization of system operation

2 Optimization of operation

We have developed an energy management system (EMS) that optimizes the operation of cogeneration systems according to the variation in the customer's demand for electricity and heat. An EMS is a system that minimizes the fuel cost and the CO_2 emissions, while planning and implementing an energy distribution plan according to demand.

Figure 6 shows the results of a simulated case in which the system operation was optimized by EMS for the example cogeneration system configuration shown in Fig. 7. Under the existing operation pattern, it is common practice to keep the ratio of allotted output of individual units constant even if the demand for electricity or steam changes. In contrast, optimized operation based on EMS allows the ratio of allotted output to change from time to time so that the fuel cost is minimized. In other words, fuel consumption can be minimized by increasing the overall efficiency, inclusive of electricity and heat (steam), through an increase in the output allotment of the gas turbine cogeneration unit during the daytime when the demand for electricity and steam is high.

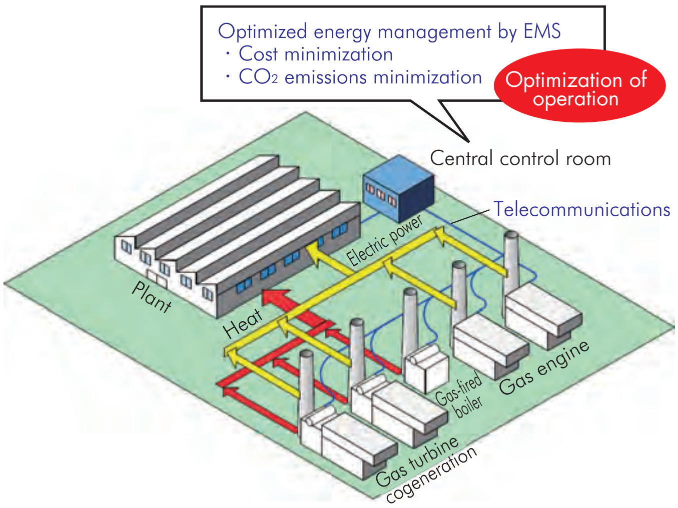


Fig. 7 Example configuration of cogeneration system

In this way, the EMS-based optimized operation can lower fuel consumption in comparison with the conventional operation mode, allowing the life cycle cost to the customer to be minimized.

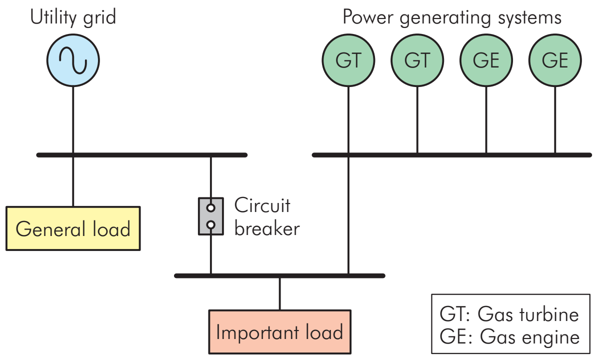


Fig. 8 Power system

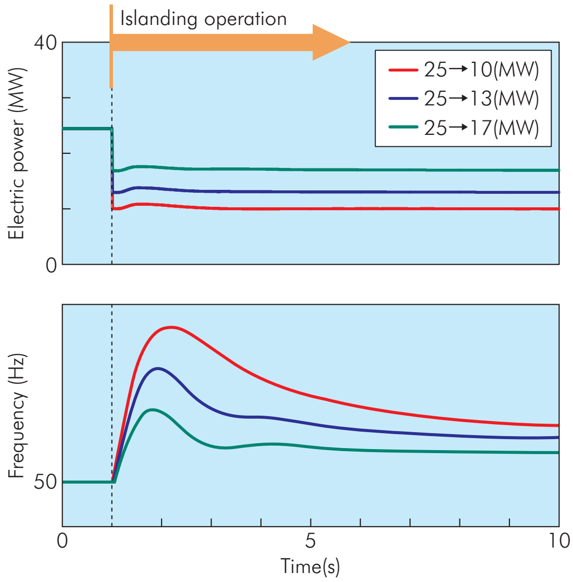


Fig. 9 Analysis of power system

3 Preliminary verification

In the planning and design stage following the proposal of a new cogeneration system configuration, it is necessary to verify, in advance, how the system follows electricity and steam load variations, the impact of faults in the utility grid, the behavior of electricity and steam at the time of equipment failure, and similar events. Among the technologies for verifying these factors, power system analysis, steam system analysis and noise analysis are presented in the following.

(1) Power system analysis

Power system analysis is a technology for verifying the ability of a power system to maintain the required quality of power supply under various circumstances such as operation interconnected with a utility grid or islanding operation of a cogeneration system.

Figure 8 shows a power system diagram for the example cogeneration system configuration shown in Fig. 7, and Fig. 9 the result of the power system analysis. In this example, the behavior of the power grid frequency in the process of transition from grid-interconnected operation to islanding operation as a result of a fault in the utility grid, for example, is verified under various load conditions.

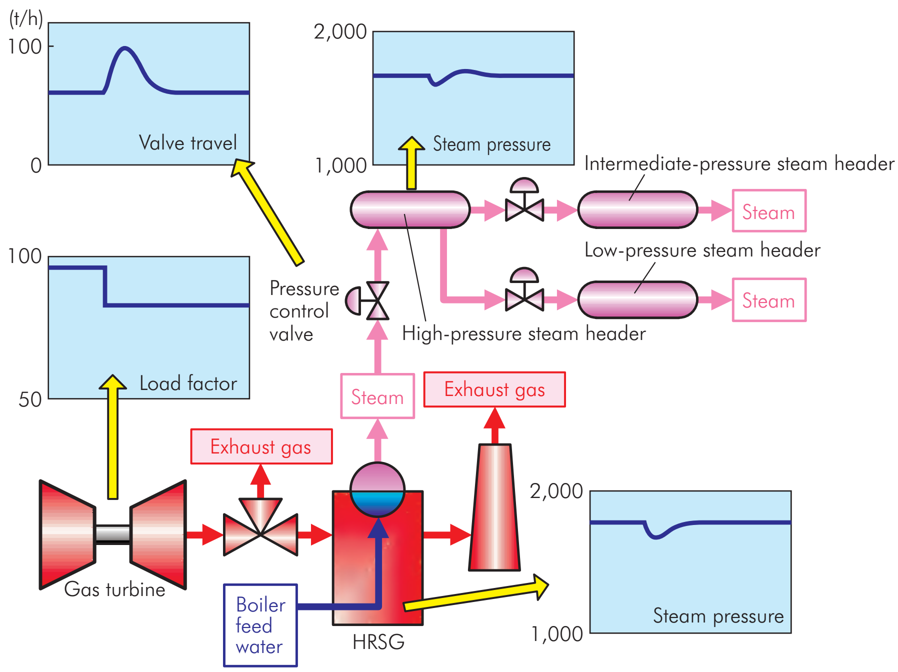


Fig. 10 Analysis of steam system

In this way, using power system analysis makes it possible to verify preliminarily the power (voltage, current, and frequency) behavior at the time of an accident or equipment failure, thereby increasing the possibility of continuing business activities on the customer side in an emergency.

(2) Steam system analysis

Steam system analysis allows steam behavior to be verified preliminarily under various operating conditions of a cogeneration system, thereby providing suggestions as to the method of effective operation.

Figure 10 shows the steam system of a gas turbine cogeneration system and the result of a simulation test. Verified in this example are the behavior of the steam pressure at the HRSG (heat recovery steam generator) and at the high-pressure steam header, and the manipulation of the pressure control valve in response to a variation in loading from the gas turbine.

In this way, using steam system analysis makes it possible to optimize the use of steam or extend its scope of use, thereby increasing the benefit of introducing cogeneration on the customer side.

(3) Noise analysis

With cogeneration facilities often installed near the boundaries of a customer's plant, it is necessary, in the planning stage, to ensure that the noise level at the premise boundaries is below the regulated level. With cogeneration facilities that contain a number of noise sources, optimization between the noise prevention performance of individual devices and machines, and the costs for this purpose is a particularly important issue.

We estimate the amount of noise at the boundaries using an environment noise analysis program that is based on accumulated data from noise sources, and examines noise prevention measures for individual devices and machines, and the necessity of installing noise barriers, before presenting overall noise prevention specifications.

Concluding remarks

The nuclear accident at the Tokyo Electric Power Company's Fukushima Daiich Nuclear Power Station has cast great doubt on the way the conventional energy-based society exists, and thus greatly changed market needs for cogeneration. In response to this change, we will enhance our ability to make system solution proposals on the strengths of individual products such as gas turbines and gas engines, in order to meet diverse customer needs.

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