Various Applications of High-efficiency H-25 Gas Turbine

Hidetaro Murata
Jinichiro Goto, Dr. Eng.
Norimasa Nakata
Satoshi Kusaka

OVERVIEW: Growing concern about environmental problems caused by thermal power plants is making the reduction of CO_2 through more efficient power generation and the reduction of NO_x and other emissions a top priority. The deregulation of the electric power industry, meanwhile, is helping to expand the demand for medium-capacity, high-efficiency thermal power plants geared toward IPP (independent power producer) and PPS (power producer and supplier) operations. At the same time, high-speed, broadband communications and security and encryption technologies are being used to deploy low-cost, multi-function monitoring services. Against this background, Hitachi has been working to increase the efficiency of its H-25 gas turbine while developing diverse applications and solution services about it, and has recently delivered three units of a power-generation plant to the Goi Power Plant of Goi Coast Energy, Ltd. This is a single-shaft type combined-cycle plant incorporating a 25-ppm-class low-NO_x combustor and applying a high-efficiency H-25 gas turbine. To operate and maintain this plant, Hitachi provides power-generation solution services using remote monitoring with high-speed Internet lines and a risk-management tool for power-generation businesses based on financial technology.

INTRODUCTION

CONSTRUCTION of the Goi Power Plant of Goi Coast Energy, Ltd. began in January 2003 and business operations commenced in June 2004. With this plant, Hitachi has successfully achieved a power-generation plant having the highest level of thermal efficiency in its class and high reliability. Hitachi continues to provide remote-monitoring services to operate and maintain the plant even after deployment and to respond effectively to customer needs. This report describes the features and application technologies of the H-25 gas turbine—the main component of this facility—as well as remote monitoring services and risk management technology for power-generation businesses.

Fig. 1—External View of the Goi Power Plant of Goi Coast Energy, Ltd.
Hitachi has completed three units of a single-shaft type combined-cycle power-generation plant on the premises of Chisso Petrochemical Corporation. Each plant consists of a gas turbine, generator, steam turbine, and heat recovery steam generator in a compact configuration.

PLANT OVERVIEW

The Goi Power Plant is a combined-cycle power-generation plant constructed on the premises of Chisso Petrochemical Corporation in Chiba prefecture, Japan. Table 1 lists the main specifications of this plant. Each single-shaft type combined-cycle plant interconnects a gas turbine, steam turbine, generator, and other equipment, and achieves a compact layout by adopting a vertical-type heat-recovery steam generator and arranging all of the above equipment along one shaft (see Figs. 2 and 3). Part of the electric power generated and some of the steam produced by the heat-recovery steam generator are supplied to Chisso Petrochemical Corporation on the same premises (see Fig. 4).

TABLE 1. Design Specifications of Power Plant

Item	Specification
Power generation system	Combined-cycle power generation
Type	Single shaft (steam turbine + generator + gas turbine)
Unit output	42,560 kW
Number of units	3
Plant output	112,200 kW
Fuel	Natural gas
Design thermal efficiency (based on lower heating value)	48.9%

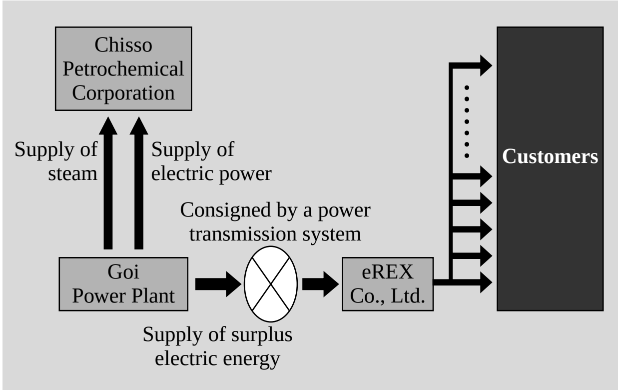

Fig. 4—Electric Power and Steam Supply Scheme.
Generated power and steam are supplied to Chisso Petrochemical Corporation and the surplus electrical power is supplied to eREX Co., Ltd.

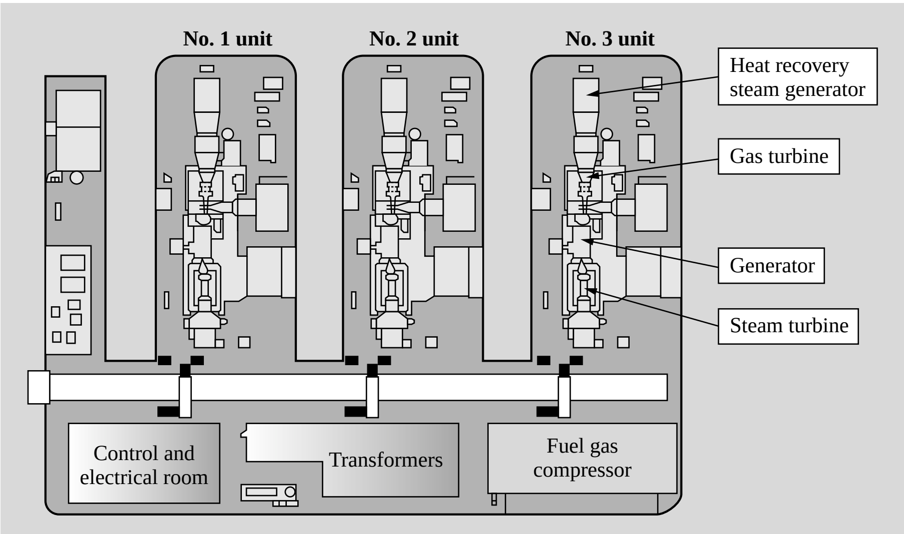

Fig. 2—Plant Floor Plan.
The plant consists of three units of a combined-cycle plant laid out in a compact configuration using vertical-type heat-recovery steam generators.

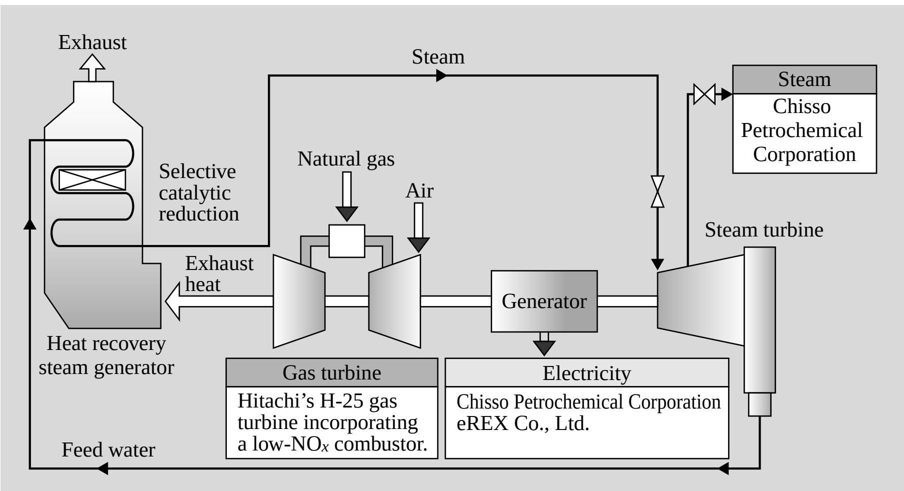

Fig. 3—Plant System.
Steam extracted from the steam turbine is supplied as process steam to Goi Factory of Chisso Petrochemical Corporation.

APPLICATION TECHNOLOGIES

H-25 Gas-turbine Specifications and Performance Enhancements

The H-25 gas turbine was independently developed by Hitachi to support combined-cycle power-generation systems and cogeneration systems. Since the completion of its first H-25 unit in 1988, Hitachi has delivered about 50 units to both Japanese and overseas customers. Each of these gas turbines is still running smoothly, and they have collectively logged more than 690,000 hours of operation. The upgrading of these turbines is an ongoing process, and recent enhancements have been made to achieve high-output and high-efficiency operation. The main features of these enhancements are as follows:

(1) Upgrade compressor blades, raise compressor efficiency, and increase compressor air flow

(2) Improve performance by reducing exhaust loss

(3) Reduce leak loss by optimizing the gap between compressor/turbine blade tips based on operation results of past machines.

(4) Raise efficiency by reducing cooling air by optimizing its distribution

Table 2 lists main specifications of the H-25 gas turbine.

This gas turbine has also been deployed at the SaskPower's Queen Elizabeth Power Station in Canada along with a low-NO_x combustor having a proven record of low NO_x levels and stable combustion (see Fig. 5).

The Goi Power Plant began test runs in November 2003 and went online in June 2004 after successfully completing those tests. A performance test revealed a high level of performance significantly exceeding design specifications (see Table 3).

TABLE 2. Specifications of the H-25 Gas Turbine Delivered to the Goi Power Plant
Main specifications are listed.

Item	Specification
Output	29,300 kW
Efficiency	34.6% (LHV)
Rated speed	7,275 min^{-1}
Airflow	92 kg/s
Exhaust temperature	564°C
Compressor	Axial-flow type, 17 stages
Turbine	Axial flow, 3 stages
Combustor	Multi-can type, 10 cans
Exhaust direction	Axial exhaust

LHV: lower heating valve

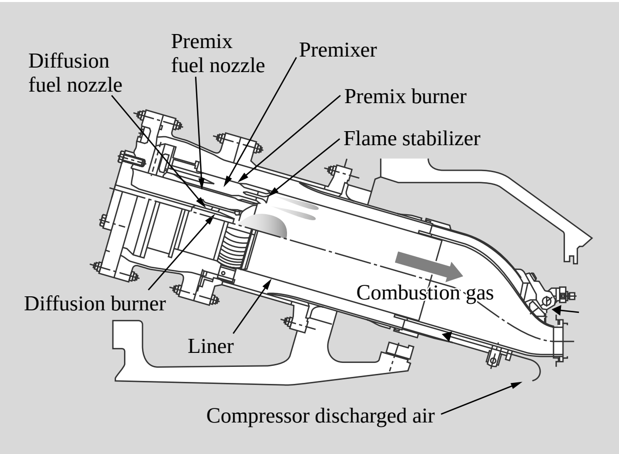

Fig. 5—Basic Structure of Low-NO_x Combustor.
A low-NO_x combustor with proven results is adopted for the sake of the environment.

TABLE 3. Plant Performance Results (relative comparison)
The use of high-efficiency gas turbines makes for a high level of performance exceeding design specifications.

	Unit 1	Unit 2	Unit 3
Plant output (kW)	+5.6%	+6.2%	+8.0%
Plant efficiency	+4.6%	+4.9%	+4.6%

Remote Monitoring Technology

The combined-cycle power-generation facilities of the Goi Power Plant have been provided with remote monitoring services since the time of test runs. The remote monitoring system consists of a monitoring system installed in the plant and a monitoring system installed in the remote monitoring center (see Fig. 6).

The system on the plant is connected to the center through a broadband Internet line to achieve high speed communications while reducing communication costs. And to ensure secure communications, a firewall is adopted on both the power-plant side and the monitoring center side to establish a pseudo leased line through a VPN, and performs data encryption.

During normal operations of the plant, the monitoring data is transmitted to the monitoring center once per day, and the data is stored on a center server. In addition, an operator/engineer may request a direct connection to the power-plant site so that it can perform online monitoring of various process data, exhaust temperature distribution, and other parameters.

The monitoring system includes a soft-alarm function that automatically contacts the experts/engineers when a certain parameter exceeds a predetermined threshold. This enables an immediate response to be taken when a trouble occurs. Also, in

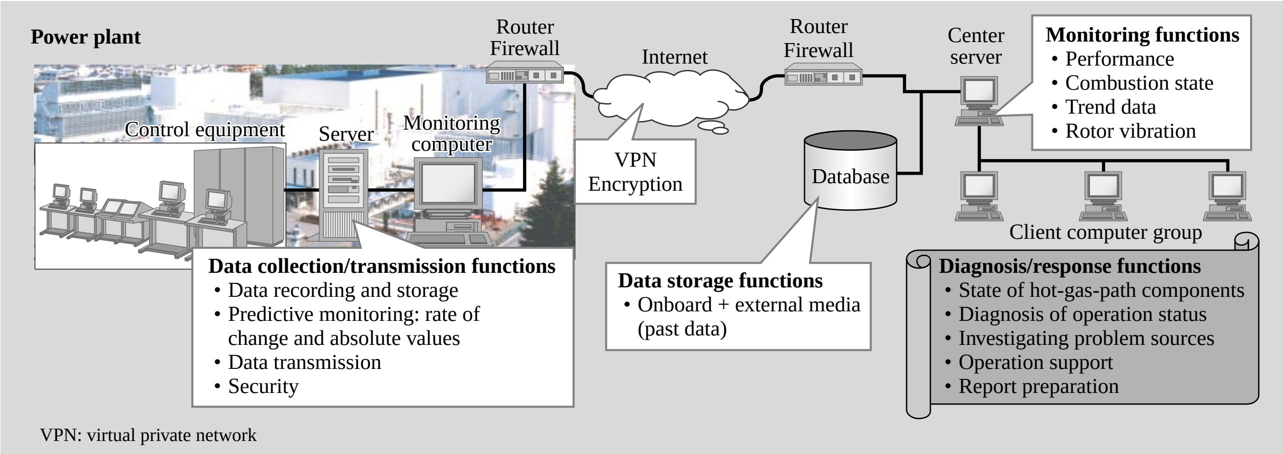

Fig. 6—Configuration of Remote Monitoring System.
A monitoring computer collects data from remotely located control panel in a power plant, and the operator/ engineer monitors this data in the monitoring center via high-speed Internet lines to perform diagnosis.

addition to the monitoring of plant status during normal operations, the monitoring system can be used to support test runs during power-plant construction and after maintenance and thereby streamline the testing process.

There are also diagnostic functions for evaluating the performance of main system components such as the gas turbine, steam turbine, and heat recovery steam generator and to check for degradation or damage to hot-gas-path components. These diagnostic functions can be used to support optimal plant operations and maintenance.

For the future, a satellite-based monitoring system is under development considering a scenario in which no terrestrial communications platform exists between a power plant and monitoring center (see Fig. 7).

Profit-variation Risk-management Technology for a Power-generation Business

The operations performed at the Goi Power Plant include a power-generation business that supplies at wholesale part of the generated electric power to a PPS (power producer and supplier). In particular, this power plant supplies electric power and steam to Goi Factory of Chisso Petrochemical Corporation on the same premises and sells at wholesale surplus electric energy to eREX Co., Ltd., which, in turn, sells that power at retail to utility customers. Here, the main risk factors affecting the profit of a power-generation business are fuel costs, electric energy price, transmission volume, and backup capacity purchased by a PPS.

Hitachi is developing a risk-management tool applying financial technology to enable the assessment

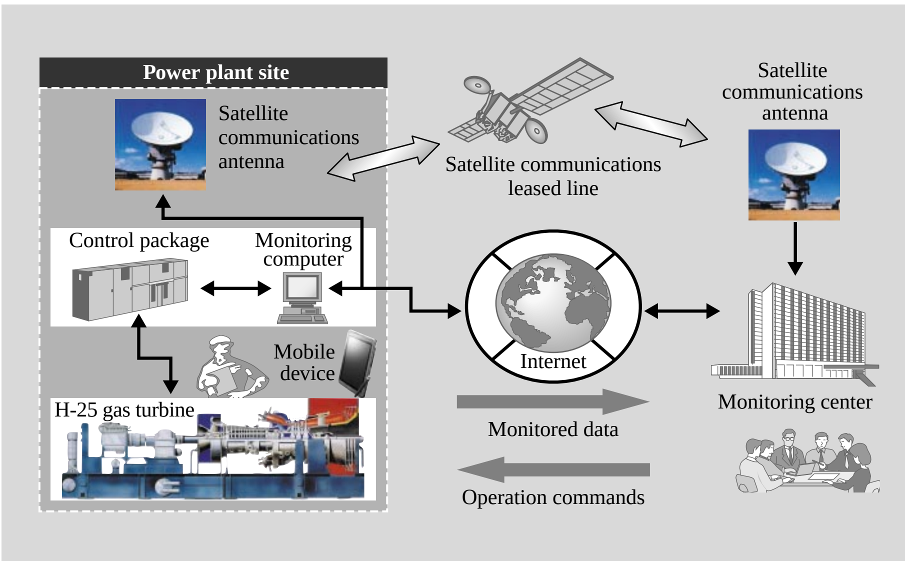

Fig. 7—Outline of Satellite Monitoring System.
Satellite communication can be used to monitor the operations status of a remotely located power plant from a monitoring center and to support system construction, testing, and inspections.

of risk factors in the power-generation business (see Fig. 8). This tool inputs various conditions related to the power plant in question plus fuel-price scenarios, electric energy price, generating pattern, and other factors to evaluate business operations. It can automatically determine the unit commitment of a generator based on plant conditions and on forecasted transmission volume and its range of fluctuation, and can compute hourly fuel expenses and revenue from sale of electric power and steam and other expenses as well. Such computations can be used to automatically prepare financial statements for business evaluation on a yearly or monthly basis. Similarly, the tool can be used to evaluate, from a profit perspective, the schedule for periodic inspections and business plans such as for purchased-fuel volume, and to easily determine how estimated fuel prices and fluctuation in transmission volume present a risk in terms of business profit.

In a power-generation business, the amount of power transmitted by a power plant must be adjusted in accordance with PPS demand. The key here is to determine how the plant can be operated at high load and high efficiency while observing the electric-power-selling balancing rule. If a PPS can appropriately determine the amount of backup power to purchase

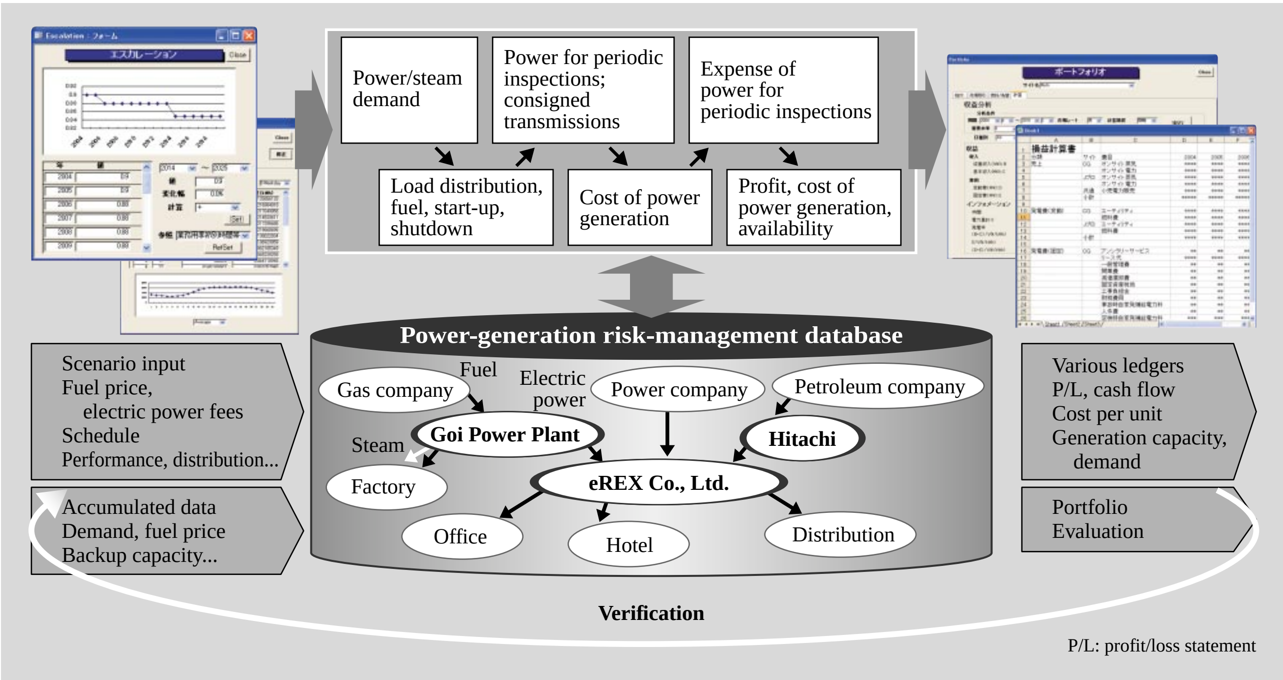

Fig. 8—Outline of Risk-management Tool for Power-generation Business.
Using estimates related to fuel, demand, plant conditions, etc., this tool reproduces plant-operation conditions on an hourly basis and calculates revenues and expenses to output financial statements for business assessment.

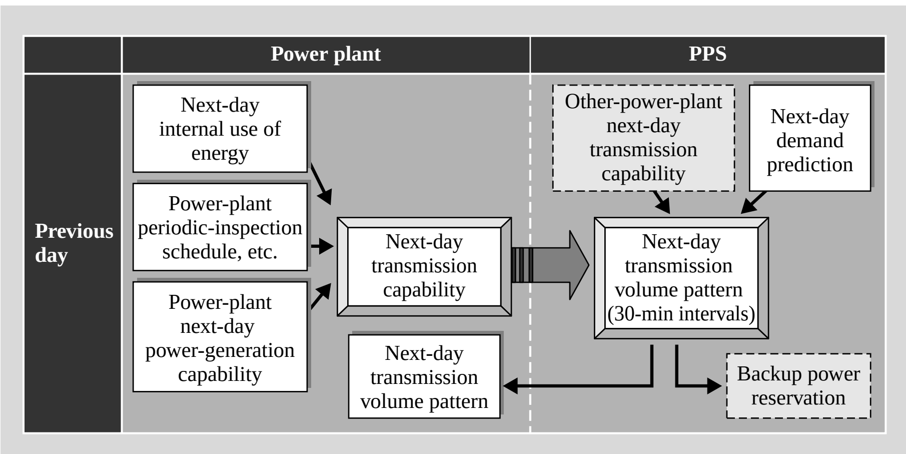

Fig. 9—Flow for Determining Next-day Transmission Volume Plan.
The following chart shows the process flow from the prediction of a power-plant's next-day transmission capability and next-day demand to the determination of a PPS next-day transmission volume pattern and reservation of backup power.

using supply and demand adjustments, the power plant can be operated at high load and high efficiency. Backup capacity must be reserved one day in advance in 30-minute units. But for the Goi Power Plant, output at the power-generating end fluctuates due to atmospheric conditions (temperature, air pressure, etc.) and internal use of energy (electricity and steam), which makes prediction of next-day's transmission volume in 30-minute units difficult. In response to this problem, Hitachi is developing a tool to simplify the task of determining next-day transmission capability (see Fig. 9).

CONCLUSIONS

This report described the features and technology of Hitachi's H-25 gas turbine now deployed at the Goi Power Plant of Goi Coast Energy, Ltd., plus remote monitoring services and risk-management technology for the power-generation business.

For the future, Hitachi plans to use the results of the Goi Power Plant as a basis for developing a gas turbine excelling in performance and reliability, and intends to expand the provision of services that are even easier to use.

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ABOUT THE AUTHORS

Hidetaro Murata

Joined Hitachi, Ltd. in 1991, and now works at the Gas Turbine Design Section of the Turbine Plant Design Department, Hitachi Works, the Power Systems. He is currently engaged in the development of gas turbine. Mr. Murata can be reached by e-mail at hidetaro_murata@pis.hitachi.co.jp.

Jinichiro Goto

Joined Hitachi, Ltd. in 2000, and now works at the Turbine Global Service Section, the Thermal Power Plant After Sales Service Department, Hitachi Works, the Power Systems. He is currently engaged in the development of power-plant preventive-maintenance services. Dr. Goto is a member of The Japan Society of Mechanical Engineers (JSME), Society for Experimental Mechanics (SEM), and The Society of Materials Science, Japan (JSMS), and can be reached by e-mail at jinichirou_gotou@pis.hitachi.co.jp.

Norimasa Nakata

Joined Hitachi, Ltd. in 1994, and now works at the Financial Engineering Unit, the 4th Department of Systems Research, Hitachi Research Laboratory. He is currently engaged in the research and development of the industrial application of financial technology to risk management of electric power business. Mr. Nakata is a member of The Japanese Association of Financial Econometrics & Engineering, and can be reached by e-mail at norimasa@gm.hrl.hitachi.co.jp.

Satoshi Kusaka

Joined Hitachi, Ltd. in 1980, and now works at the Power Business & System Planning Section, the Business Development Department, the Thermal & Hydroelectric System Division, the Power Systems. He is currently engaged in the development and management of thermal power plants for PPS. Mr. Kusaka can be reached by e-mail at satoshi_kusaka@pis.hitachi.co.jp.