2004 Prize of the Chairman of ECCJ

Introduction of High-efficiency Energy System Utilizing Gas Turbine Combined System

Aisin AW Co., Ltd.
Facility Technology Group, Facilities Department

◎ **Keywords: Rationalization of heating, cooling and heat transfer (Heating equipment, etc.)**
Waste heat recovery and usage
Rationalization of conversion of heat to motive power, etc. (Cogeneration equipment)

◎ Outline of Theme

- This business establishment enforced fuel conversion from C heavy oil to LNG in 1991, earlier than other companies, and since then, we have worked on energy conservation improvement (Reduction of CO_2).
- In this case study, we have worked on building a comprehensive energy conservation system that covers both energy suppliers and users aiming at further energy conservation improvement. The supplier introduced an air-conditioning heat source system that combines steam turbines and steam driven refrigerators that utilize exhaust steam of cogeneration. In addition, the users replaced electric heaters, which are a heat source of the cleansing process, with steam heaters.

◎ Implementation Period of the said Example

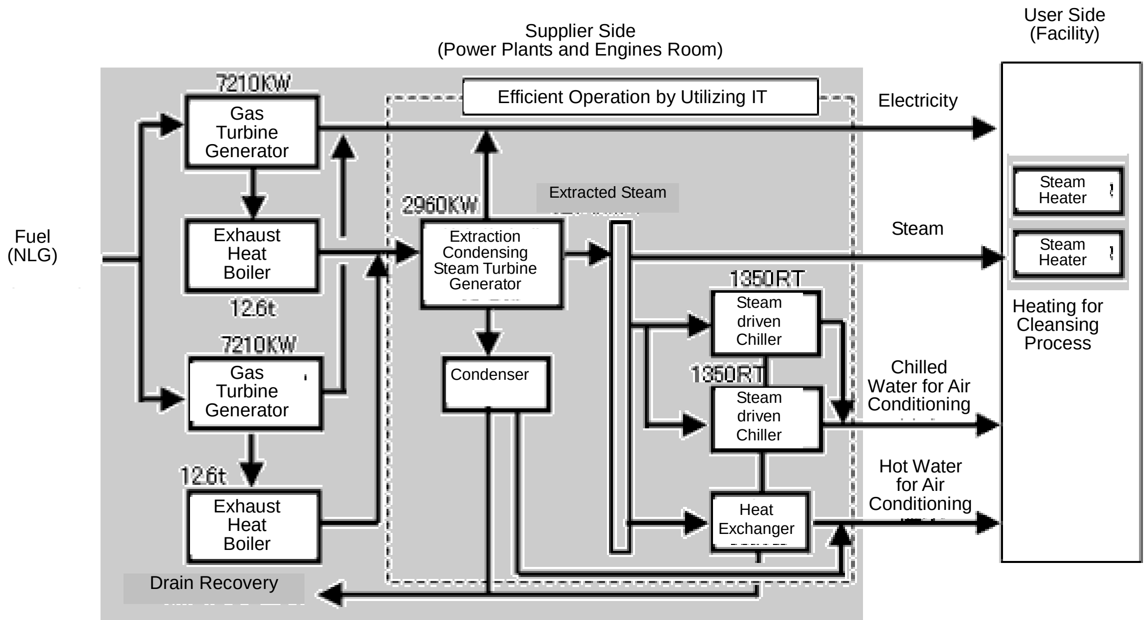
- Project Planning Period
  - First phase: January 1997 – December 1999 Total 24 months
  - Second phase: February 1999 – December 2001 Total 23 months
- Measures Implementation Period
  - First phase: January 2000 – August 2000 Total 8 months
  - Second phase: January 2002 – August 2002 Total 8 months
- Measures Effect Confirmation Period
  - First and second phases: September 2002 – August 2003 Total 12 months

◎ Outline of Business Establishment

- Detail of Business Manufacturing of automatic transmissions
- No. of Employees 5,086 (As of April, 2003)
- Annual Energy Usage Amount

Electricity:	159,378 MWh
LNG:	25,031,000 Nm^3

◎ Outline of Target Facilities

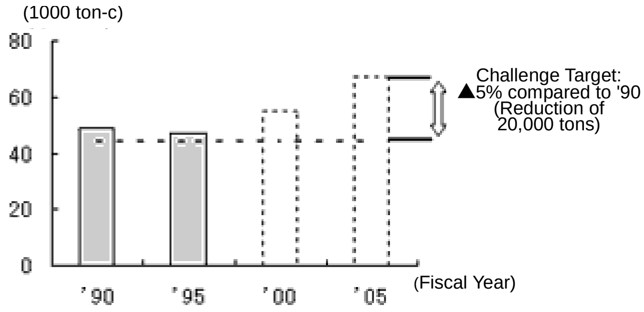


<Fig. 1 Flow of Gas Turbine Combined System>

1. Reasons for Theme Selection

It is expected that CO_2 emission increases with our production increases. Under these circumstances, companies have social responsibilities to enforce countermeasures against global warming, and reduction of CO_2 emission is essential.

We have set mid- and long-term energy strategies to promote energy conservation systematically. Especially, introduction of a co-generation system is an important item for reduction of CO_2 emission. This case study is an example of high efficiency system based on maximum utilization of exhaust heat.



<Fig. 2 Current Situation of Our CO_2 Emission and Mid-term Target>

2. Understanding of Current Situation

(1) Energy Environment that Surrounds Our Company

[Tougher Environmental Regulations]

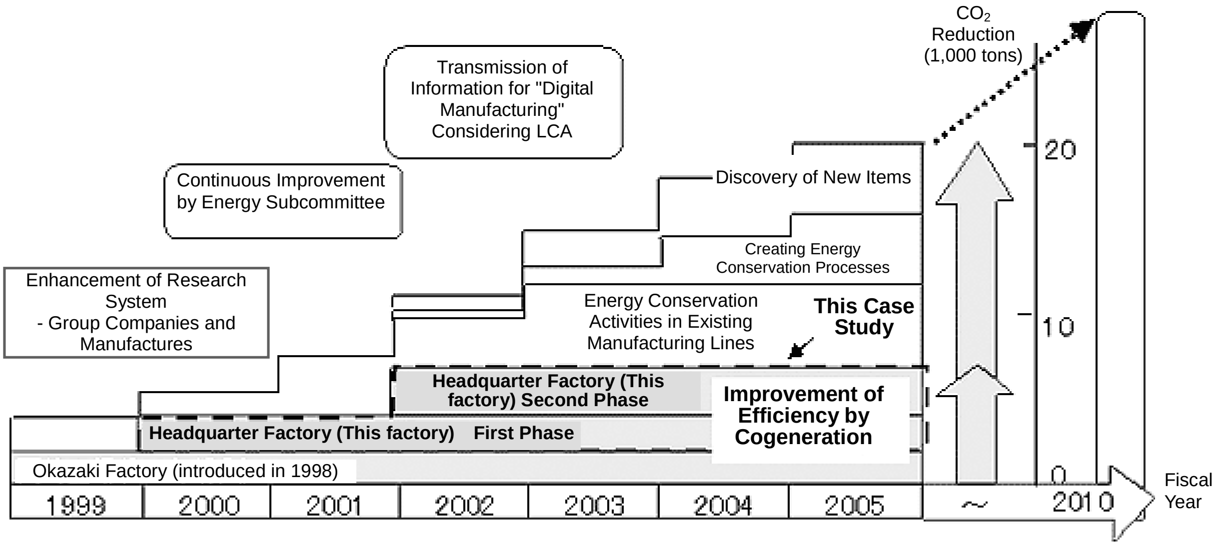
- Act concerning the Rational Use of Energy (Energy Conservation Act)
  - Obligation to reduce energy intensity by 1% compared to the previous fiscal year
  - On-site inspection of energy management situation by the government
- Nippon Keidanren, Japan Automobile Manufacturers Association, Inc. (All Toyota consolidated environmental management)
  - Reduction of CO_2 emission by 10% by 2010 compared to 1990 in the long term and by 5% by 2005 in the midterm.

* Energy conservation is essential. Discovery of energy conservation items and implementation according to mid- and long-term scenario are required.

[Concerns about deterioration of energy cost]

- Introduction of environmental tax
  - Full-scale debate on introduction of environmental tax

(2) Our Energy Conservation Scenario



<Fig. 3 Energy Conservation Scenario by 2005>

Fig. 3 shows our energy conservation scenario to achieve the target of CO_2 reduction by 2005. To reduce CO_2, we think there are three general areas: improvement on the supplier side, improvement on the user side, and discovery of new items for further improvement. Among these, we have introduced a cogeneration system to Okazaki Factory in 1998 with great success. Introduction of a cogeneration system with higher efficiency to the headquarter Factory is considered to be essential. Based on the timing of facility replacement on the supplier side and improvement of facilities on the user side, we introduce the system in 2000 and 2002 in a phased manner.

3. Progress of Activities

(1) Implementation Structure

In introducing the system, we considered that maximum utilization of exhaust heat and control of investment cost are important points. The supplier side promoted introduction of new technologies working together with manufacturers with a view to utilize the national subsidy system, while the user side (factory) promoted effective utilization of exhaust steam through our energy subcommittee.

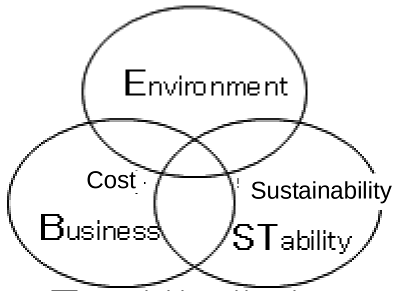
(2) Target Settings (the second introduction phase)

- Reduction of energy cost: 280 million yen/year or more

(Payout period: within 5 years)

- Reduction of CO_2 emission: 5,000 ton/year or more

(25% of the company-wide target)



<Fig.4 Our Concept>

Pursuit of "BEST Energy" for Stable Supply of Cheap and Clean Energy

(3) Problems and their Study

1) Investigation on the most appropriate capacity of the cogeneration system

We investigated the power machine, which is the core of the cogeneration system, and its most appropriate capacity.

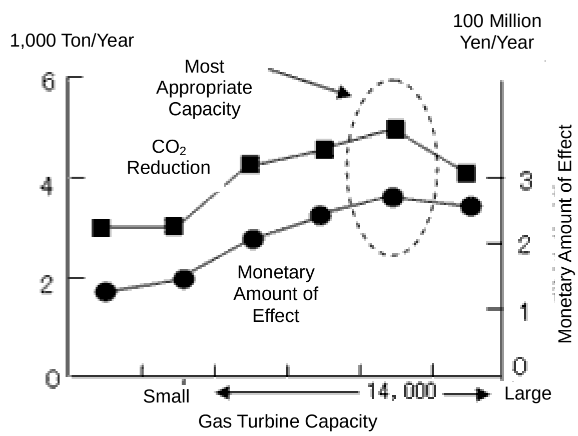
1) Investigation of Engines and Turbines for Cogeneration

	Diesel Engine	Gas Engine	Gas Turbine
Performance	○	○	○
Investment	○	△	○
Maintainability	△	△	○
Environment	△	○	○

<Table 1 Comparison of Engines and Turbines>

Focusing on cost and environment, gas turbine that is effective for both is adopted.

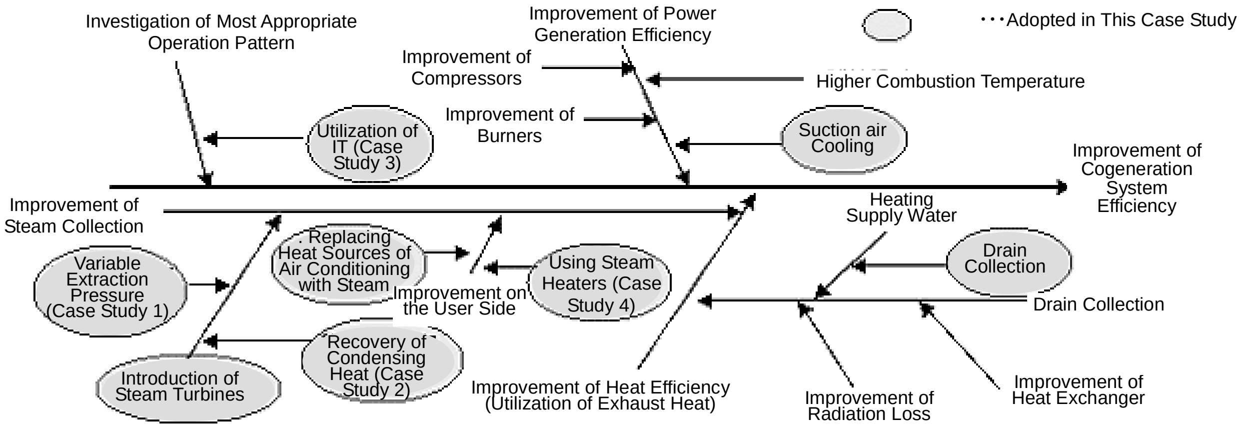
2) Investigation of Most Appropriate Capacity of Gas Turbine



<Fig. 5 Capacity and Effect>

Adopt gas turbines of 14,000 kW-class that is most effective for our company. => Cost and improvement of system efficiency are the challenge.

(2) Investigation to Improve the Efficiency of the Cogeneration System

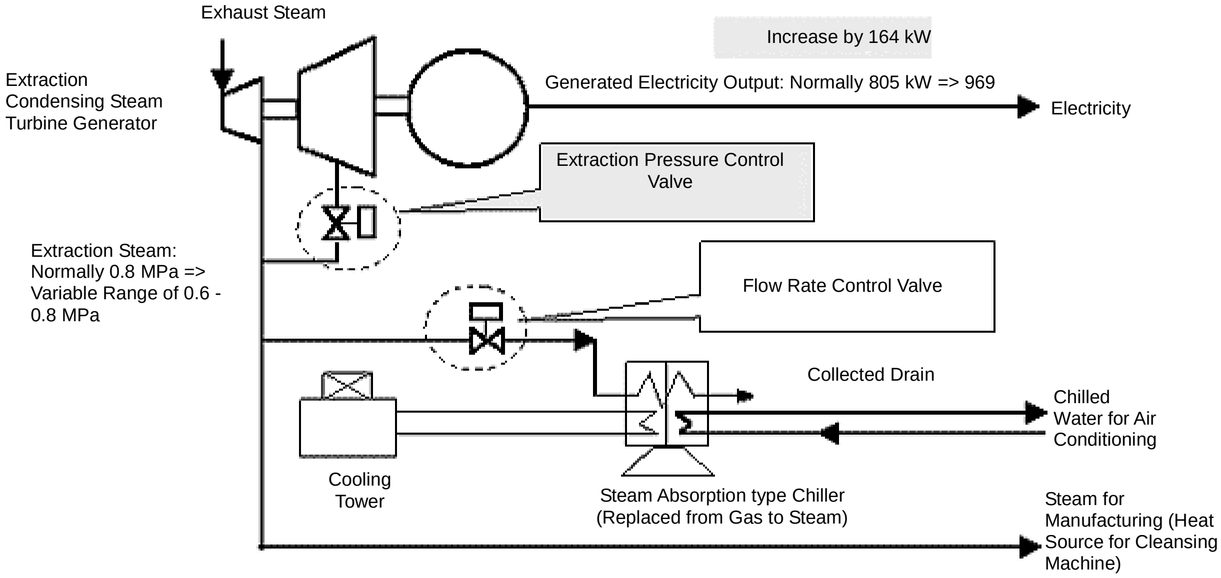


<Fig. 6 Investigation of Improvement of the Cogeneration System Efficiency>

4. Details of Measures

(1) Case Study 1 (New Technology 1): Control of optimum load of electric generators and chiller by introducing variable extraction pressure of the steam turbines (patent application)

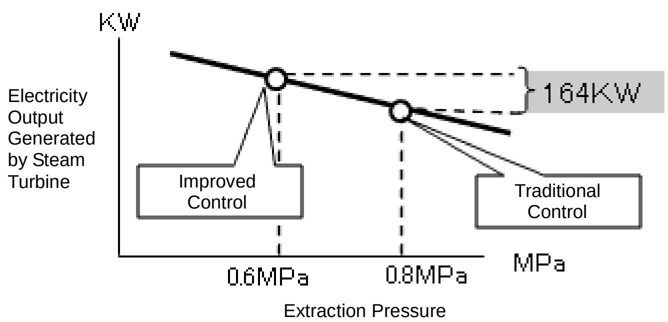
The pressure of the exhaust steam was 1.8 MPa, whereas the pressure required on the user side facility (steam driven chiller and production facility) was 0.6 MPa - 0.8 MPa. To effectively use this pressure difference, extraction condensing steam turbine electric generators were introduced. In addition, for further improvement of efficiency, we focused on fluctuation of the pressure required by the steam absorption type chiller and control the extraction pressure according to the load so that the maximum electricity is always generated.



<Fig. 7 Flow of Steam Turbines and Absorption Type Chiller>

The pressure of the extracted steam of the absorption type chiller was controlled high using the extraction pressure control valve when the cooling load is high and when the load is low or the temperature of the cooling water is low, it was controlled low so that the generated electricity is the maximum. (Fig.7)

As shown in Fig. 8, for example, when the chiller load is 80%, extraction pressure was traditionally 0.8 MPa, but it was lowered to 0.6 MPa, and we succeeded to increase the output electricity of steam turbines by 164 kW.

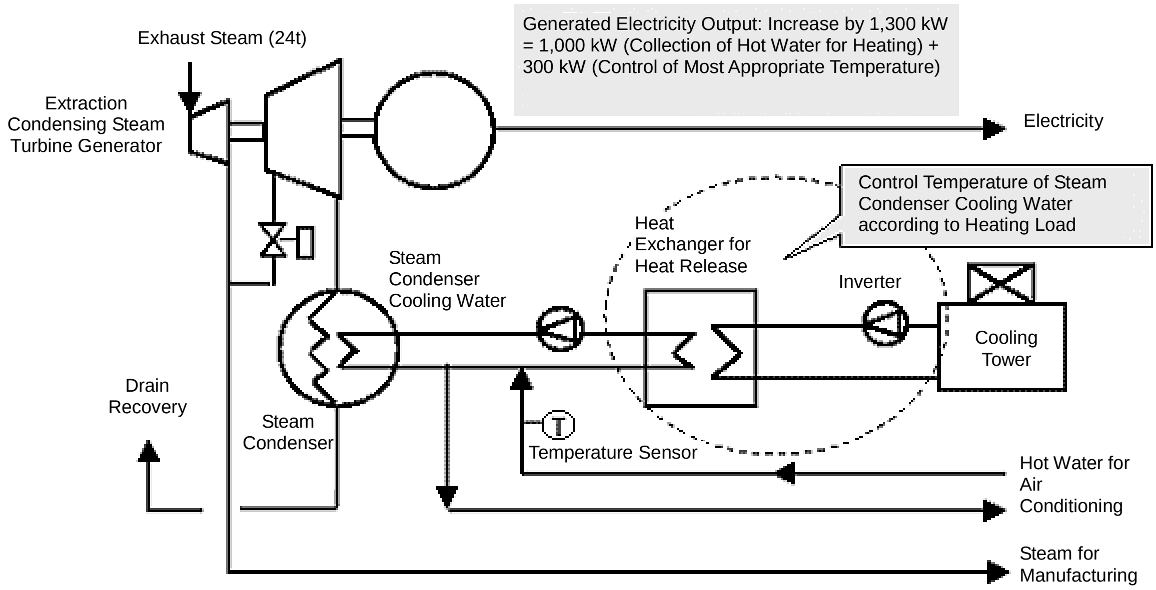


<Fig. 8 Extraction Pressure and Characteristics of Generated Electricity>

Effect of Introduction 1 (Gas Turbine + Steam Turbine + Variable Extraction Pressure)
Reduction of Energy Cost: 190 Million Yen/Year, Reduction of CO_2 emission: 3,600 ton/Year

(2) Case Study 2 (New Technology 2): Optimum control of temperature of the steam condenser cooling water (patent application)

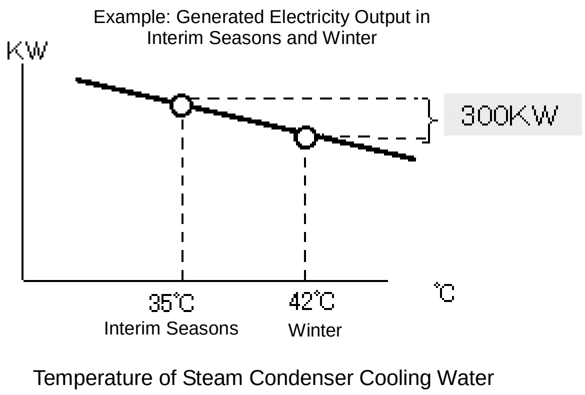
Traditionally, hot water for air conditioning was generated by heat exchanger using steam. In this system, the temperature of the steam condenser cooling water was controlled according to the heating load so that it can be used for air conditioning. This eliminates extracted steam for heating and increases generated electricity. In seasons when heating load is low or none, we adopted the operation that the temperature of the steam condenser cooling water was controlled lower and vacuum of the steam condenser was raised.



<Fig. 9 Flow of Steam Condenser and Hot Water for Air Conditioning>

As shown in Fig. 9, the temperature of the steam condenser cooling water of was controlled according to operation in each season. In winter, the temperature of the cooling water was raised so that it can be used as hot water for air conditioning. In other seasons, the temperature of the cooling water was lowered to increase vacuum of the steam condenser so that more electricity can be generated.

For example, as shown in Fig. 10, by lowering the temperature of the steam condenser cooling water from 42℃ to 35℃, vacuum of the steam condenser was increased and 300 kW of electricity was more generated.



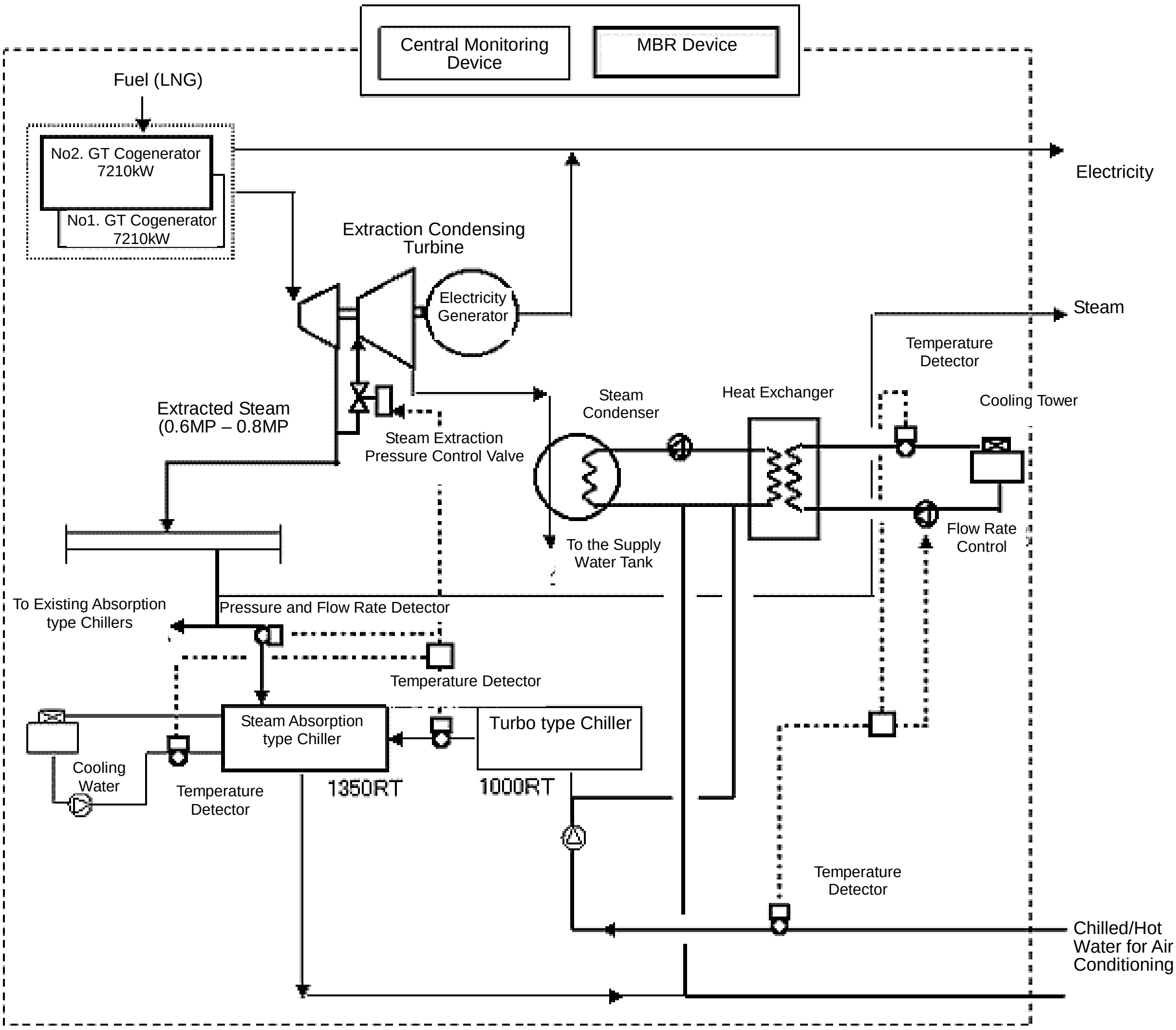
<Fig. 10 Temperature of Steam Condenser Cooling Water and Characteristics of Generated lectricity>

Effect of Introduction 2 (Collection of Hot Water for Heating + Control of Most Appropriate Temperature)

Reduction of Energy Cost: 54 Million Yen/Year, Reduction of CO_2 Emission: 980 ton/Year

(3) Case Study 3 (New Technology 3): Optimum operation by utilizing IT

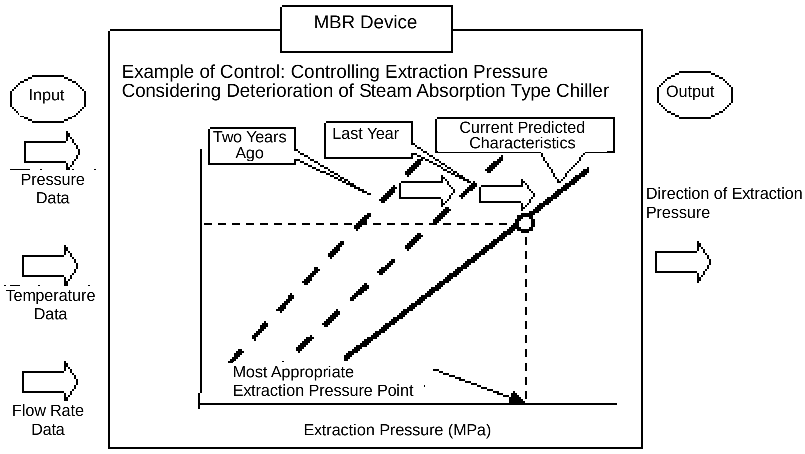
Systems that use heat exchangers such as chillers are affected by external factors, so the minimum point of operation cost is not constant. Even when each facility is affected by the weather, deterioration of facility, and load conditions etc., to realize a system that can determine the optimum operational condition at the moment based on the actual operation data (pressure, temperature, act.) and to provide optimum demand and supply operation as described above (New technologies 1 and 2)., we introduced memory-based reasoning (MBR) method.



<Fig. 11 Overall Flow of the Cogeneration System>

Fig. 12 shows an example of controlling using MBR unit, considering deterioration of the steam absorption type chiller. Even when the cooling load is the same, required extracted steam pressure (required pressure) may be different due to deterioration of the chiller, and extraction pressure that fits the deterioration is required.

By introducing MBR unit to determine optimum extraction pressure according to the current predicted characteristics of the chiller obtained from the actual data, we succeeded to prevent excess operation of turbo (electric) chiller whose total efficiency is poor and predict the true values at earliest for efficient control. (Steam absorption type chillers are given priority for operation)



<Fig. 12 Example of Control by MBR Unit>

Effect of Introduction
Included in Case Studies 1 and 2

(4) Case Study 4: Using steam for heat source of the cleanser in manufacturing line

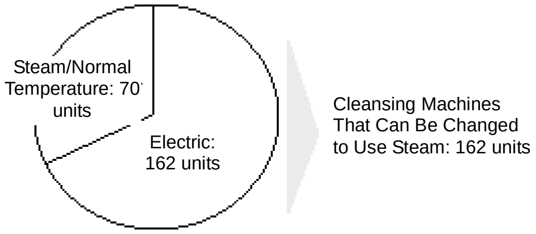
We replaced electric heaters that are used as heat source for cleansing process of the manufacturing lines with steam heaters to improve utilization according to TPO (time, place and occasion). In addition, to prevent deterioration of work environment due to use of steam for heating, all steam drain is recovered and used for heating supply water of exhaust heat boilers.

1) Facilities that can be replaced with steam in our company

Facility	Technology	Cost	Effect
Heat Source for Air Conditioning	○	○	○
Cleansing Machine	○	○	○
Oil Injection System	○	○	△

Heat source for air conditioning and cleansing machines that are effective in technology, cost, and effect (However, two heat sources for air conditioning are adopted on the premise that their lives are updated.)

2) Actual status of heat sources of cleansing machines



<Fig. 13 Actual Status of Heat Sources of Cleansing Machines>

Implemented in Three-Year Schedule (2001 - 2003)
Considering Number of Improvement etc.

Effect of Introduction

Reduction of Energy Cost: 34 Million Yen/Year, Reduction of CO_2 Emission : 670 ton/Year
(For 55 Units of Cleansing Machines That Were Changed to Use Steam during 2001 and August 2002)

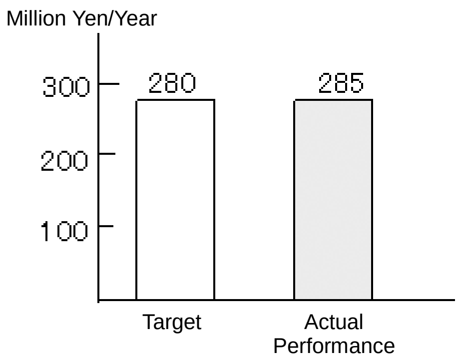
5. Effects achieved after Implementing Measures

(1) Summary of Improvement Effects

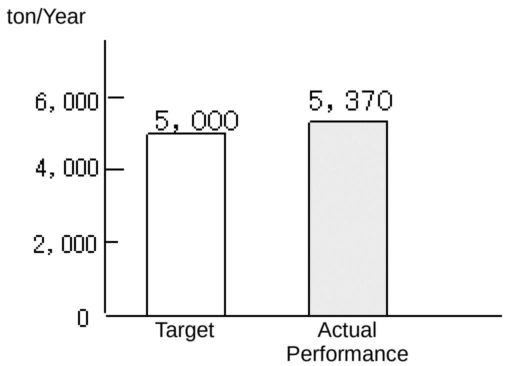
Improvement Items	Reduction of Energy Cost (Million Yen/Year)	Reduction of CO_2 Emission (ton/Year)
Gas Turbines + Steam Turbines + Variable Extraction Pressure	190	3,600
Control of Most Appropriate Temperature of Steam Condenser Cooling Water	54	980
Changing Heat Source of Cleansing Machines for Manufacturing to Steam	34	670
Recovery of Performance of Air Conditioner by changing Heat Source	7	120
Total	285	5,370

(2) Summery of Effects

[Reduction of Energy Cost]



[Reduction of CO_2 Emission]



Payout Period Target: within 5 Years => Actual: 4.7 Years
(Utilizing National Subsidy System)

6. Summary

In this case study, we have built a high efficiency energy system that covers both energy supplier side and user side introducing four new technologies to utilize exhaust heat at maximum. As a result, we have reduced investment by utilizing the national subsidy system and achieved the target for CO_2 reduction, so we significantly contributed to prevention of global warming.

7. Future Plans

We plan to continuously evaluate facilities that are introduced in this case study and aim further improvement of efficiency. We also plan to investigate optimum parameters based on the memory-based reasoning method utilizing IT, and investigate and implement horizontal spread to other engines and turbines including other plants. In addition, to achieve the company-wide target of CO_2 reduction, we would like to involve entire company to discover and enforce new specific items and become the top runner of energy management always assuming the best energy management.