2006 Prize of the Chairman of ECCJ

Energy Conservation through Highly-Efficient Operations of Chillers

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Engineering Works Section, Production Planning Department
Energy Conservation Working Group for Air-Conditioning/Cold Energy Source

◎ **Keywords: Rationalization of heating, cooling, and heat transfer (Air conditioning facilities, hot water supply facilities, etc.)**

◎ Outline of Theme

Iwate Toshiba Electronics was facing large issues, such as energy losses due to aging of our chillers, which was producing chilled water to be used for internal purposes including air-conditioning of clean room, and growing electricity/fuel costs caused by soaring oil price. In order to solve the problems, we started studying energy efficiency of the 18 chillers we owned (11 turbo units and 7 absorption units), and changed their operation system based on the results. By implementing such measures, we successfully achieved energy and cost reductions.

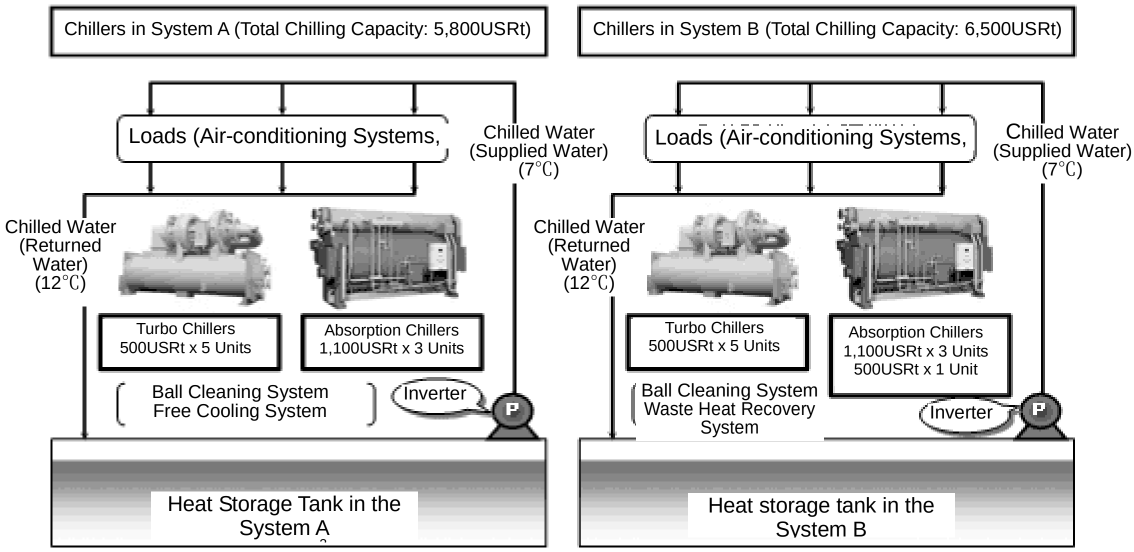
◎ Implementation Period for the Said Example

● Project Planning Period	May 2005 – June 2005	Total 0.7 month
● Measures Implementation Period	June 2005 – December 2005	Total 7.0 months
● Measures Effect Verification Period	July 2005 – January 2006	Total 6.5 months

◎ Outline of the Business Establishment

- Items Produced: Integrated circuit products (e.g. LSI, CCD, etc)
- No. of Employees: 1,798 (as of April 1, 2006)
- Annual Energy Usage Amount [Electricity] 272,299 MWh/year
  (Actual results for fiscal year 2005)[Type A heavy oil] 11,404 KL/year

◎ Target Facility



[Fig. 1] Outlined Flow of Chiller Equipment

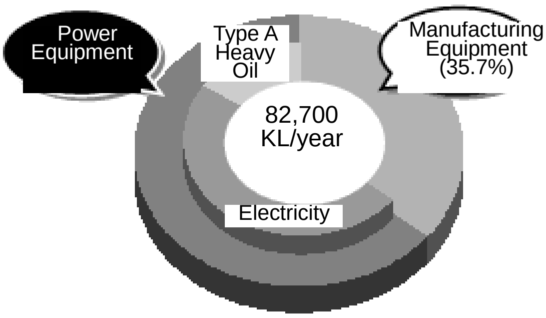
1. Reasons for Theme Selection

- Energy conservation, cost saving, and reduction of CO_2 emissions are important challenging issues for Iwate Toshiba Electronics.
- Energy consumption by the chillers accounts for almost 16% of total consumption by the company.
- Some of our chillers were installed over 20 years ago, and they are causing considerable energy losses due to aging. Since an effective method of “replacing of the equipment” requires considerable capital investments, implementation of immediately-effective measures are expected as a first step.

2. Understanding and Analysis of Current Situation

(1) Understanding of Current Situation

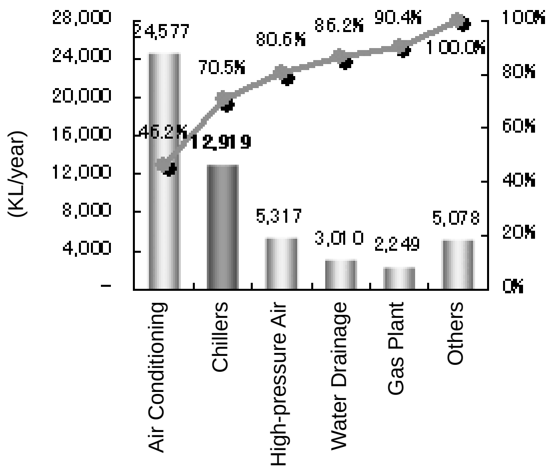
Before starting discussions over how to make energy conservation/cost savings, we made a study on breakdown of our energy usage in FY2004. It found that 64.3% of total energy in the plant was consumed by power equipment, as shown in the Fig. 2 below.



[Fig. 2] Breakdown of Energy Consumption

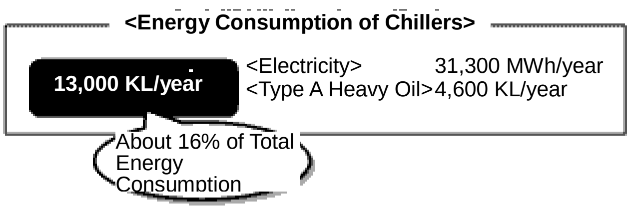
(2) Analysis of Current Situation

Fig. 3 shows a Pareto chart of energy consumption by the power equipments. The most energy-consuming application is air-conditioning, followed by chillers, and the two applications account for 70.5% of total energy required by power equipment.



[Fig. 3] Pareto Chart of Energy for Motive Power Equipment

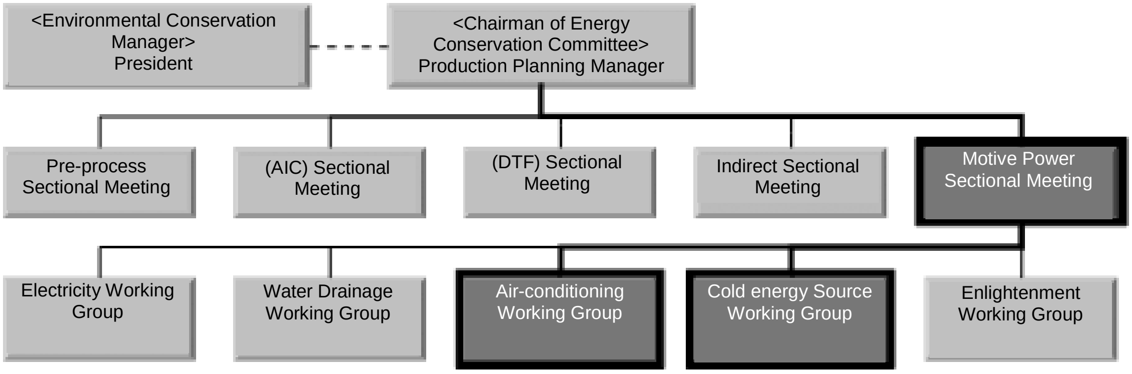
As to energy for air-conditioning, various energy-conserving and cost-saving measures have been developed and implemented, including inverter-controlled air blower and optimized wind speed in the clean room. Therefore, we determined to drive our energy conservation and cost-saving efforts focusing on the second largest energy consumer of chilled water production, in other words, "energy consumed by chillers".



3. Progress of Activities

(1) Implementation Structure

Fig. 4 below shows an overall structure of our energy conservation activities carried out in this project. The activities were launched with initiatives driven by engineers responsible for air-conditioning units and cold energy source equipment and technicians engaged in actual operation of the chiller equipment.



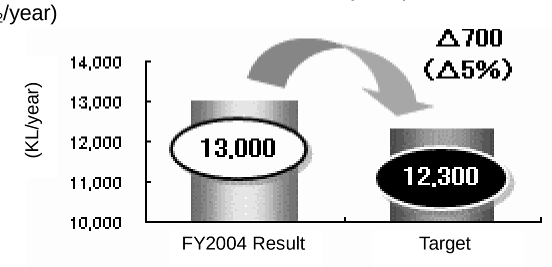
[Fig. 4] Overall Structure of Energy Conservation Activities

(2) Target Settings

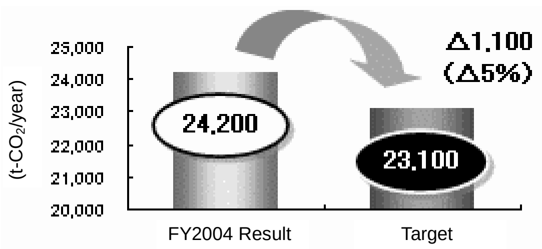
Target "5% Reduction" of Energy Consumption and CO_2 Emissions by Chillers

<Energy> 13,000 -> 12,300 KL/year (Reduction of 700 KL/year)
<CO_2 Emissions> 24,200 -> 23,100 t-CO_2/year (Reduction of 1,100 t-CO_2/year)

Cost Saving Saving of Approx. 20,000,000 yen per Year



[Fig. 5] Energy Conservation Target



[Fig. 6] CO2 Emission Reduction Target

(3) Problem Points and Their Investigation

As we move the activities forward, we tried to identify problems in operation control method of the chillers. As a result of the discussions, the following two problems were selected as focus points among various issues. Our next step was to develop measures for them.

Problem 1 Selection of Chillers and their Operation Method

Is each chiller operated and used taking account of individual energy efficiency (COP)?

Problem 2 Number of Chillers to be Operated

Is chilled water supply well balanced? (Balance between number of operated chillers against amount of chilled water required by the load equipment)?

Through seeking to and implementing immediately-effective measures, we aim at early contribution to energy conservation and cost saving.

4. Details of Measures

Measure 1 Study on Energy Efficiency (COP) of Individual Chiller and Change of Operation System Based on the Findings

Table 1 shows the results of our actual study on “energy efficiency (COP)” and “cost intensity” of all 18 chillers.

[Table 1] COP and Cost Intensity of Chillers

Since this information is classified, index numbers are provided instead of actual values. The intensity of the best performing chiller is translated into an index of "1.00".

	Chiller Unit Code	Type	Chilling Capacity	Electric Consumption	Amount of Steam	COP	Cost Intensity (Index)	
[System A]	R-1	Turbo	242	374		2.3	1.99	
	R-2	〃	290	356		2.9	1.59	
	R-3	〃	289	355		2.9	1.63	
	R-11	Absorption	1,100	226	3.9	1.2	1.59	Replaced in 2004
	R-12	〃	1,100	226	3.9	1.2	1.59	Replaced in 2003
	R-13	〃	570	249	4.7	0.5	3.66	
	R-18	Turbo	476	359		4.5	1.00	
	R-19	Subtotal	437	373		4.1	1.10	
		小 計	4,504	2,537	12.4	1.3	–	
[System B]	R-4	Turbo	396	324		4.3	1.24	
	R-5	〃	463	315		5.2	1.03	
	R-6	〃	463	306		5.3	1.00	
	R-7	〃	417	297		4.9	1.09	
	R-8	〃	395	333		4.1	1.31	
	R-9	〃	216	333		2.3	2.33	
	R-14	Absorption	663	212	4.7	0.6	3.61	
	R-15	〃	794	212	4.7	0.7	3.01	
	R-16	〃	744	131	4.7	0.7	3.05	
	R-17	〃	505	91	2.9	0.9	2.69	
		Subtotal	5,046	2,544	16.9	1.1	–	
			9,550	5,091	29.3	1.2	–	
Summary per Type	<Turbo>		4,074	3,745	0	3.9	1.00	
	< Absorption >		5,476	1,336	29.3	0.9	1.96	

<Chilling Capacity> (chilled water flow rate X thermal difference) ÷ 3,024 Kcal/USRt

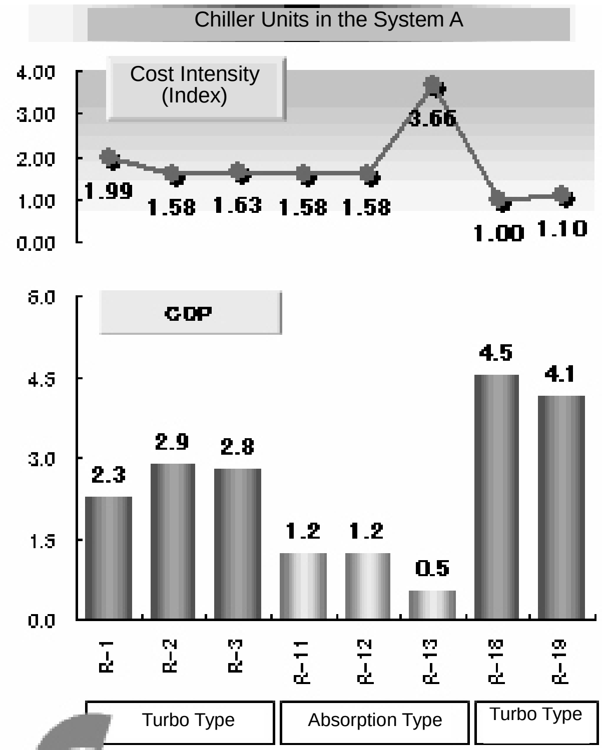
COP ; Coefficient of performance

<COP Calculation formula>

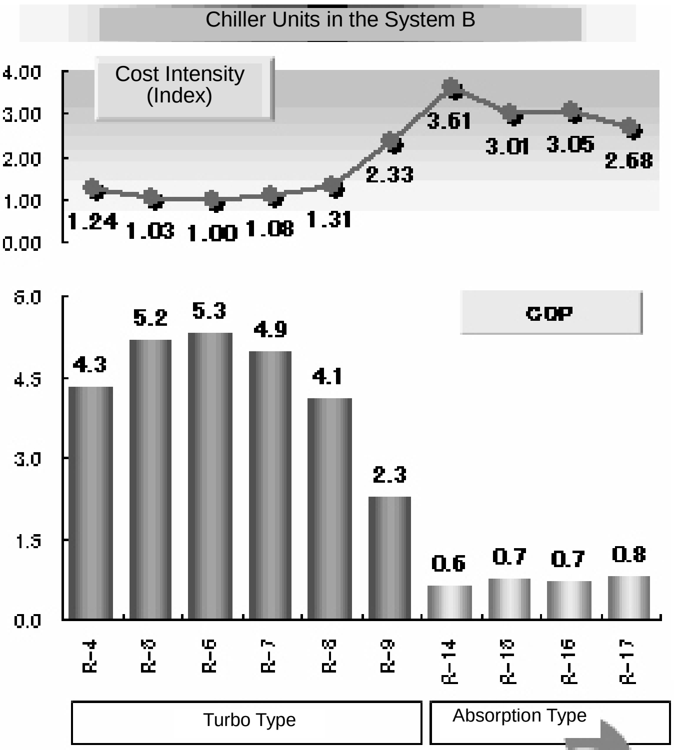
$$\frac{\text{Output Energy}}{\text{Input Energy}}$$

【Comparison among chiller units (COP and cost intensity)】

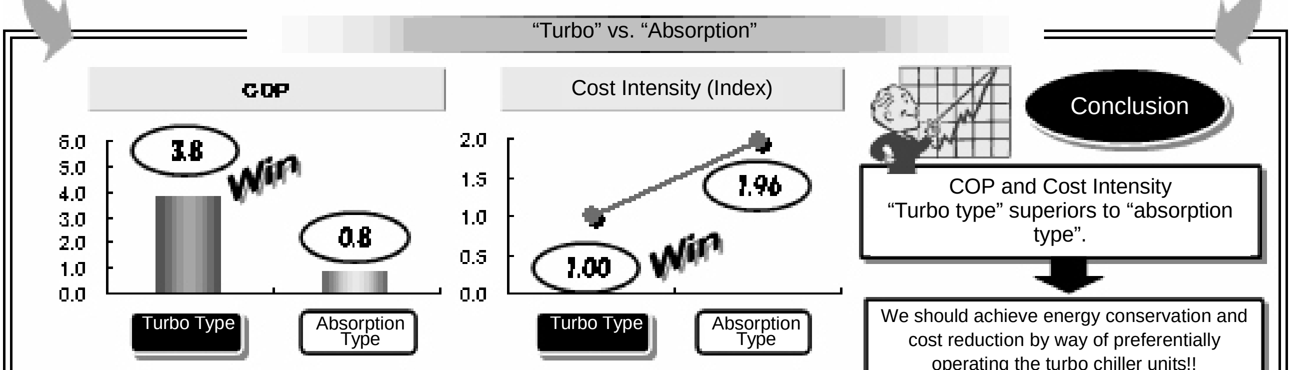
Fig. 7 and Fig. 8 show the results of our analysis on the COP and cost intensity. In both Systems A and B, turbo units superior to absorptions in both indexes, and the difference is more obvious when they are compared using weighted average values (See Fig. 9).



[Fig. 7] Comparison of Chillers in the System A



[Fig. 8] Comparison of Chillers in the System B



[Fig. 9] Comparison between Turbo Type and Absorption Type

【Operation system of chillers before and after implementing the measures】

In relation to our contract with a power company, Iwate Toshiba Electronics is required to maintain power consumption rate above a certain level during nights. In order to fulfill the requirement, turbo or absorption units are selected and used as necessary.

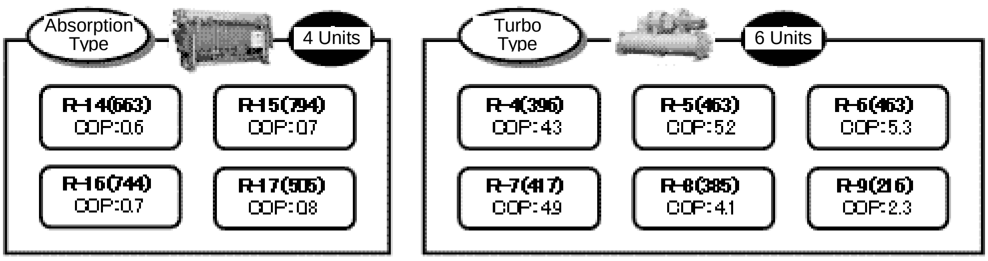
However, since cost intensity of the absorption units is lower as described above, we determined to have the operation system shifted to more turbo type units, minimizing operation of absorption units, while maintaining the conditions required by the power utility contract.

<◎: Main Machines △: Sub Machines> <Before Implementing Measures>				<After Implementing Measures>	
	Energy Efficiency	Daytime	Night	Daytime	Night
Turbo Chillers	Good	△	◎	◎	◎
Absorption Chillers	Bad	◎	△	△	△

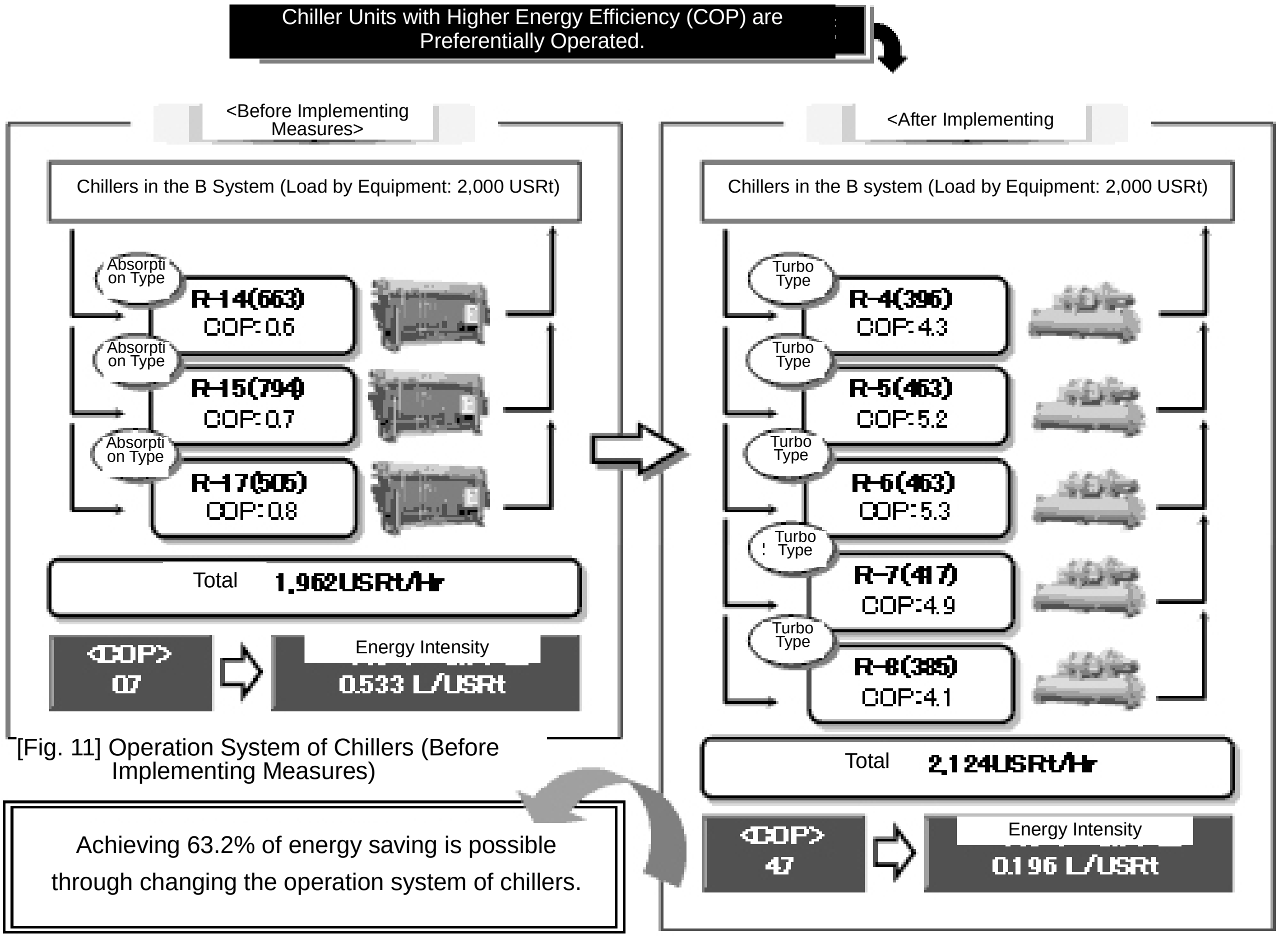
［Table 2］Operation System of Chillers

Outline of the Measures

Taking the group of chillers in the System B (4 absorption and 6 turbo units) as a sample, Fig. 11 and Fig. 12 show operation system of the chillers and their energy intensity before and after implementing the measures, with an assumption that cold energy required by the load equipment is 2,000 USRt.



［Fig. 10］ Chiller in the System B * ( ): Chilling Capacity (USRt)



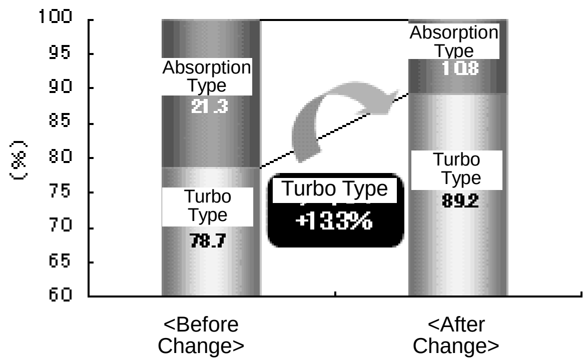
[Fig. 11] Operation System of Chillers (Before Implementing Measures)

[Fig. 12] Operation System of Chillers (After Implementing Measures)

【Ratio of chiller operating hours before and after implementing the measures】

The change in operation system has raised operating ratio of turbo chillers, which have higher energy efficiency, up to 13.3% while halving operating ratio of absorption chillers, which have lower efficiency, down to half.(See Fig. 13).

The shift to more turbo units kept fulfilling the “consumption level during night hours” required by the contract with the power company, and caused no particular problem.



[Fig. 13] Operating Ratio of Chillers

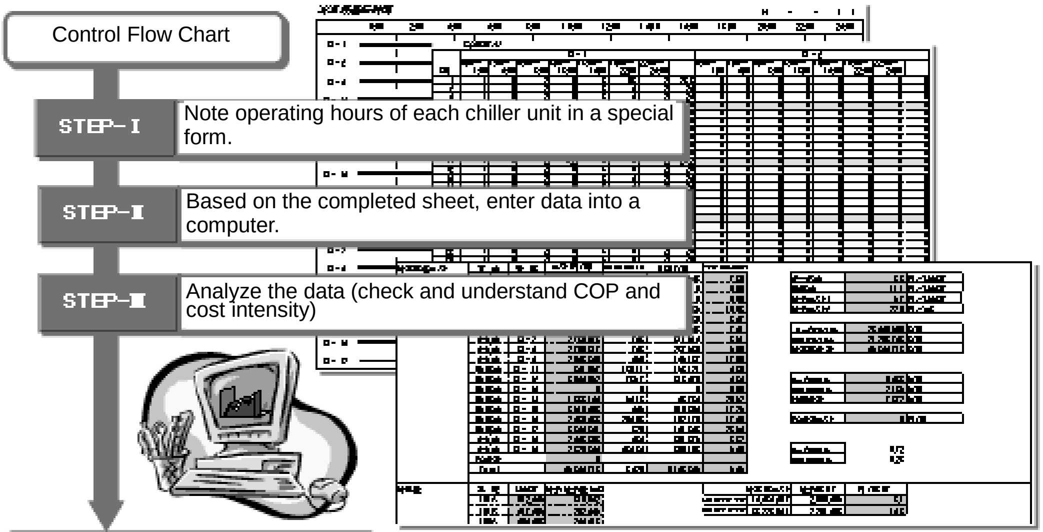
	Before Change	After Change	Increase/Decrease Compared to "Before Change"
Turbo	78.7%	89.2%	+ 13.3%
Absorption	21.3%	10.8%	△49.3%

[Table 3] Operating Ratio of Chillers

Measure 2	Reduction of Energy Losses by Controling Excess Operations of Chillers (Optimization of Number of Operated Units)

The chillers were stopped and restarted by operators depending on temperature of chilled water. But such control was not always made at the most appropriate timing due to differences among individuals, and causing some energy losses.

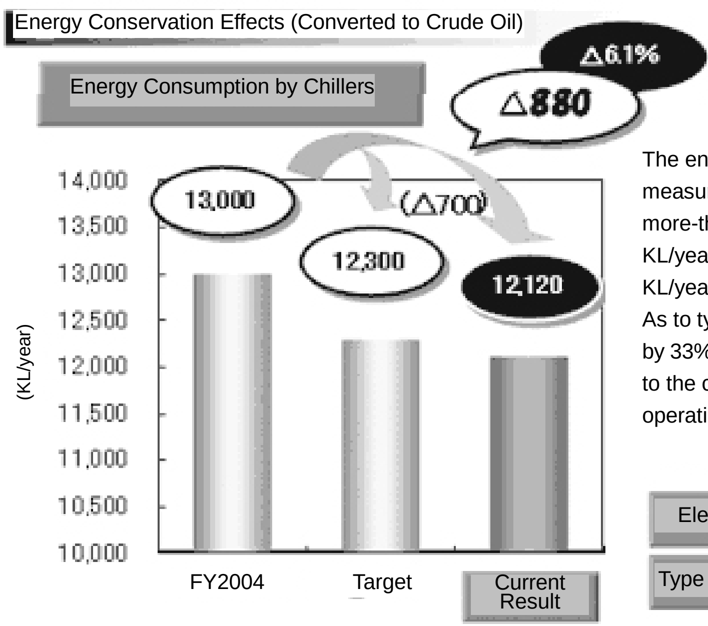
In order to control the losses, the following sheet (Fig. 14) was prepared for further enhanced control of the operations.



[Fig 14] Operation Control Sheet for Chiller Units

5. Effects achieved after Implementing Measures

Measure 1	Study on Energy Efficiency (COP) of Individual Chiller and Change of Operation System Based on the Findings.
Measure 2	Reduction of Energy Losses by Controling Excess Operations of Chillers (Optimization of Number of Operated Units)

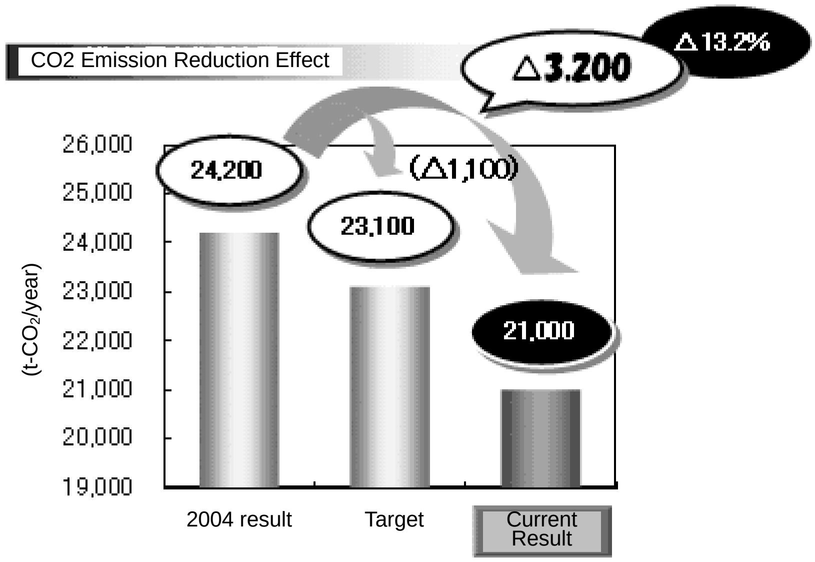


[Fig. 15] Energy Conservation Effect

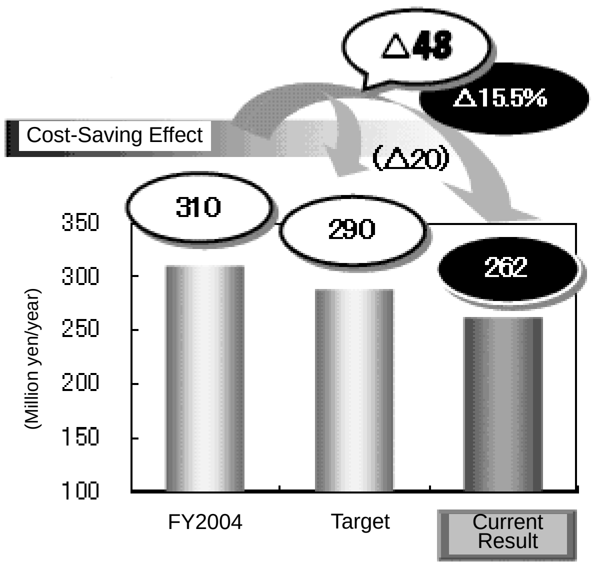
Energy conservation effect was confirmed.

The energy conservation effect obtained by the two measures is shown in Fig. 15. We have achieved more-than-expected energy-saving effect in reducing 880 KL/year, exceeding the initial target (reduction of 700 KL/year, or 5% of the previous year) by 25.7%.
As to type of energy, “fuel (Type A heavy oil)” was reduced by 33%, while “electricity” was increased by around 8% due to the change in chiller operation system (preferential operation of turbo units).

Electricity	31,300	⇒	33,700 MWH/year
Type A Heavy	4,600	⇒	3,100 KL/year



［Fig. 16］ CO2 Emissions Reduction Effect



［Fig. 17］ Cost-Saving Effect

Summary of Three Reduction Effects

Through both of the two measures improvement effects exceeding our targets have been achieved in each items.

Cost saving largely surpassing the target has also achieved, with some impact by certain factors such as price increase of Type A heavy oil led by soaring crude oil price.

	FY2004 Result	Target	Current Result	Increase/Decrease Compared to FY2004 Result
<Energy Consumption by Chillers> (KL/year)	13,000	12,300	12,120	△880
<CO_2 Emission by Chillers> (t-CO_2/year)	24,200	23,100	21,000	△3,200
<Operation Cost of Chillers> (million yen/year)	310	290	262	△48

[Table 4] Summary of Three Reduction Effects

6. Summary

Energy conservation as much as "880 KL reduction per year" has been achieved by way of studying energy efficiency (COP) and cost intensity for all of 18 chiller units we owned, preferentially operating chillers with higher efficiency, and enhancing controls to control energy losses caused by less efficient manual operation by operators to stop and restart equipment.

We understand that the fast launch, which required only one month after the program planning, also contributed to the very speedy and meaningful activities.

7. Future Plans

The measures we placed this time resulted in CO_2 reduction of 3,200 t/year. However, considering the fact that our equipment is considerably aged, we will drive the following measures forward in a planned manner, and make further efforts to achieve more energy conservation and cost savings.