2005 Prize of Director General of Regional Bureau of Economy, Trade and Industry

Energy Conservation Activities for Utility Facilities in the Semi conductor Assembly Factory

DENSO CORPORATION, Kouta Plant
Utilities

◎ **Key words: Others (Improvement of facility, change of energy source)**

◎ Outline of Theme

This factory is a post-process factory for semi conductors, having clean rooms and ultra-pure water generators while continuously operating air conditioning systems to maintain constant temperature, humidity and cleanness of the factory throughout a year. Therefore, the factory consumes a great deal of energy. So we reviewed the energy use of our facilities from the viewpoint of designing and maintenance without being bound by already-existing ideas. We worked with divisions concerned and, as a result, we could make great achievement. We hereby introduce 2 improvements we made, i.e. (1) improvement of the ultra-pure water generator and (2) improvement of the gas absorption freezer by using steam.

◎ Implementation Period of the said Example

- Project Planning Period: January, 2001 to November, 2004
- Measures Implementation Period: June, 2001 to May, 2005
- Measures Effect Verification Period: December, 2001 to July, 2005

◎ Outline of the Business Establishment

- Production items: IC products (monolithic IC, hybrid IC), sensor products, control system electronic products.
- Employees: 3,800 (as of April 1, 2005)
- Yearly energy consumption (Actual of 2004)

Electricity	189,531MWh/year (Private generation 56,755MWh/year)
City gas	19.958 million m^3/year
A heavy oil	773KL/year

◎ Overview of Target Facilities

Figure-1 and Figure 2 show the outline of the facilities we studied. The ultra-pure water generator in Figure-1 is a system that generates ultra-pure water by removing impure substances as much as possible from industrial water through various processes.
Figure-2 shows the processes in which the gas absorption freezer makes cold water and the air conditioner adjusts the air in the clean room throughout a year.

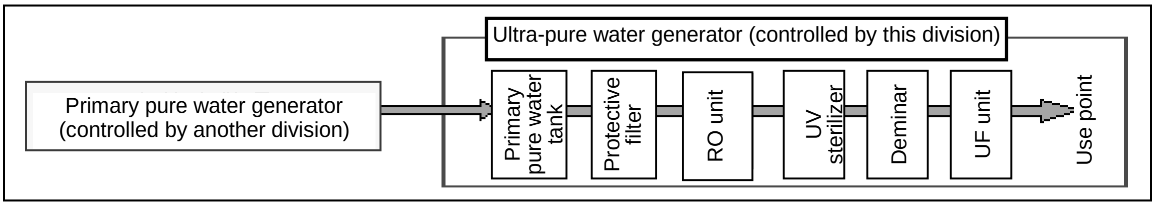


Figure-1 Flow of ultra-pure water generators

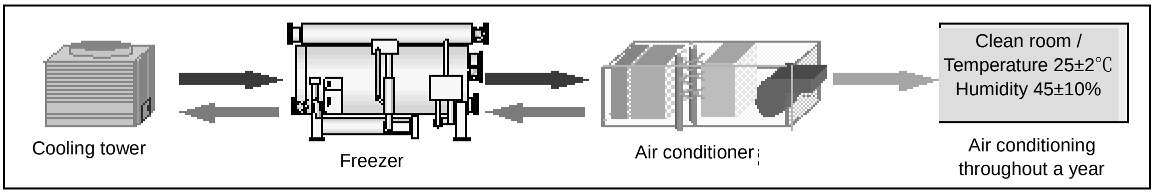
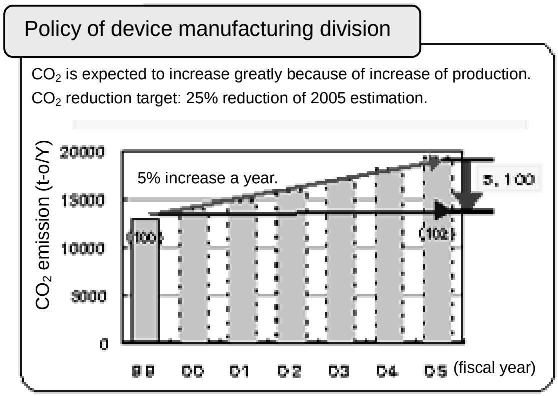


Figure-2 Outline of air conditioning facility

1. Reasons for Theme Selection

Under our company's environment policy "Eco vision 2005", we set a major target that asked us to reduce our CO_2 emission by 10% compared with that of 1990 by 2010, so all people concerned in the company are working to achieve this.
This division is trying to reduce CO_2 emission by 25% by 2005 as shown in Figure-3 below. Meanwhile, in the long-term plan, it is asked to reduce the intermediate material cost by 5% every year in light of profitability.
As Figure-4 below shows, 24% of the intermediate material cost is the cost of energy, and 44% of the energy cost is spent for the utility equipment. Because of the high load production, it is forecast that holiday work will increase and there will be much energy loss due to diversified work. We are concerned about the profitability of the company and the target of the CO_2 reduction. So we decided to powerfully promote the energy conservation of the utility equipment.



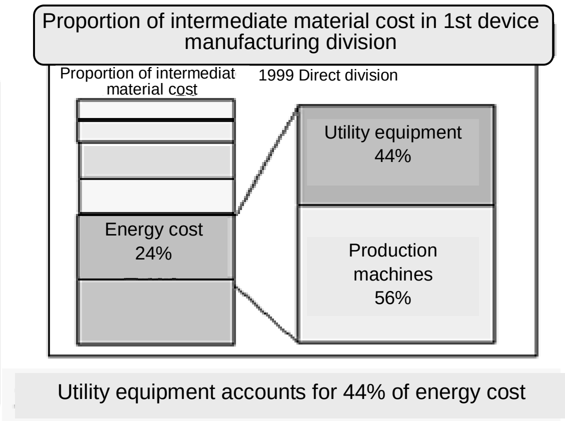


Figure-3 CO_2 reduction target of this division

Figure-4 Proportion of intermediate material cost of this division

2. Understanding and Analysis of Current Situation

(1) Understanding of Current Situation

Figure-5 shows the breakdown of the utility equipment energy cost of this division. As the figure shows, the air conditioning equipment accounts for 69% of the total. In the air conditioning equipment, the freezers account for the largest 47%, because they are operated throughout a year to control the temperature and humidity of the assembly factory. The ultra-pure water generators account for 21% and they are continuously operated throughout a year to maintain the water quality.

From this observation, we realized that we needed to reduce the fixed energy of these equipment and most important equipment for achieving the energy conservation was the ultra-pure water generators and freezers.

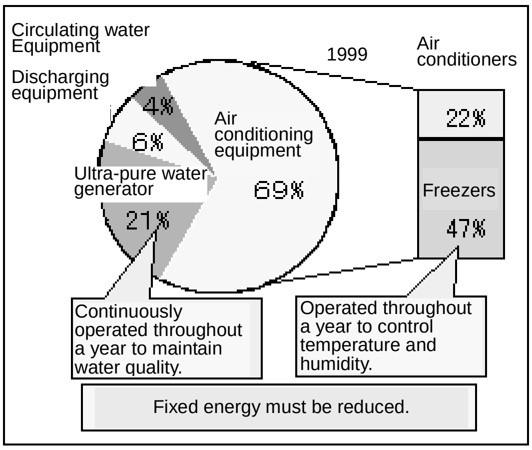


Figure-5 Breakdown of utility equipment's energy cost of this division

3. Progress of Activities

(1) Target Settings

Figure-6 shows the transition of CO_2 emission caused by the utility equipment of this division. When setting the target, we aimed to keep the CO_2 emission caused by the utility equipment to the level of 1999 in 2005 and to reduce CO_2 by 914t-c, i.e. 30%, by 2005.

(2) Implementation Structure

There were 2 people responsible for the utility. So we promoted the energy conservation within the section jointly with the special project activities and individual activities within the divisions which consumed much energy.

The special activities aimed to make great effect by working with groups concerned and the individual activities aimed to make achievement in a short period of time having divisions concerned involved.

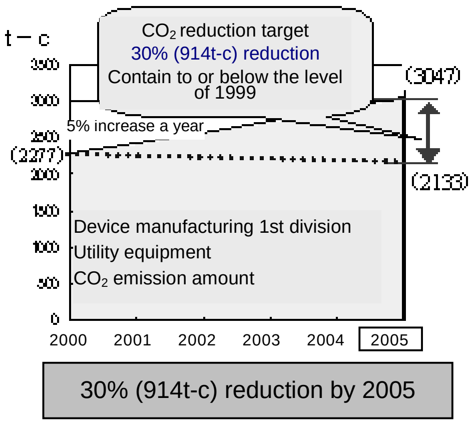


Figure-6 CO_2 emission of utility equipment of this division

(3)Methodology of Implementing Activities

I was transferred to this division from the facility division in 1999. Since then, I undertook the management of the utility equipment. The power equipment (air conditioners, etc.) was put under control of this division in April next year. So I worked with strong determination of a professional.

First, I studied the utility equipment as a whole and found out as follows.

[1] Energy conservation improvement of equipment is weak.

[2] Measures for equipment deterioration are late.

[3] Information on equipment is little and benchmarking is weak.

I thought that we needed to overcome these weaknesses. So, to determine the direction of the activities, I reviewed the utility equipment from “the professional viewpoint of an energy equipment” and with “the fresh eyes not being bound by already-made idea”. To be more specific, I acted as follows.

[1] To fully understand the equipment from the viewpoint of designing and manufacturing.

[2] To view the equipment from the perspective of the factory as a whole.

[3] To do benchmarking to be reflected on the improvement.

As a person specialized in designing and maintenance, I especially focused on the following issues.

[1] To recover capacity and function which may deteriorate.

[2] To optimize production which may make or deliver products too much.

[3] To make the flow of products slim watching it in total perspective.

[4] To change energy to cheaper one to realize high efficiency.

These issues were studied with priority in a short period of time to achieve the target.

(4) Activity Plan

I reviewed the utility equipment from the viewpoint of designing and maintenance and made the following plan.

Focal points	Theme	CO_2 reduction amount (t-c/Y)	Effect (Unit: 10 thousand yen)	Process FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
To recover capacity and function which may deteriorate.	701-4F air conditioning VAV renewal	62.1	583	⇨				
	General air conditioner function recovery	1.9	30				⇨	⇨
To optimize production which may make or deliver too much products.	701-4F integration of discharge equipment	1.0	9	⇨				
	Integration of ultra-pure water generators (701, 2 factory 4F)	63.9	2320	⇨				
	Renewal of 701-4F circulation water equipment	16.4	153	⇨				
	702 freezer cold water primary pump improvement	49.1	520			⇨	⇨	
To make the flow slim watching it totally.	Ultra-pure water generator system improvement (702 factory 4F) Case 1	77.3	2090	⇨	⇨			
	701-1F ultra-pure water generator system modification	13.2	435		⇨	⇨		
	701-1F ultra-pure water sensor installation improvement	3.4	98			⇨		
	702-4F Dicing water discharge equipment improvement	1.7	48			⇨		
To change energy to cheaper one to realize high efficiency.	Use of steam by Kouta 701 gas absorption freezers (4 units) Case 2	610	5330		2台	⇨ / 2台	⇨ / ⇨	⇨
Estimated total CO_2 reduction 922.2 t-c Monetary effect amount 116.16 million yen								

The case 1 below introduces system modification made to the ultra-pure water generator and case 2 introduces the use of steam for Kouta 701 gas absorption freezer.

4. Details of Measures

(1) Case 1 Modification of Ultra-pure Water Generator

1) Focal points and study of ultra-pure water generator

First, important points of the ultra-pure water generator and the study made for them are as follows. The basic concept of the improvement is to look at the ultra-pure water generator totally, to find out a possibility of streamlining it or a presence of excessive equipment.
Ultra-pure water is extremely pure water made by eliminating impure substances as much as possible. Figure-7 shows the equipment flow. In the equipment flow, the pure water made in the primary pure water generator is sent to the RO unit (reverse osmosis membrane) of the ultra-pure water generator to remove TOC (total organic carbon), then it is made purer when going through each process and sent to the factory for circulation.
The features are:

[1] The RO unit accounts for approximately 90% of the energy cost.

[2]Pure water is discharged away to heighten the pure water level.

[3]It runs throughout a year to maintain the water quality. The running cost is high.

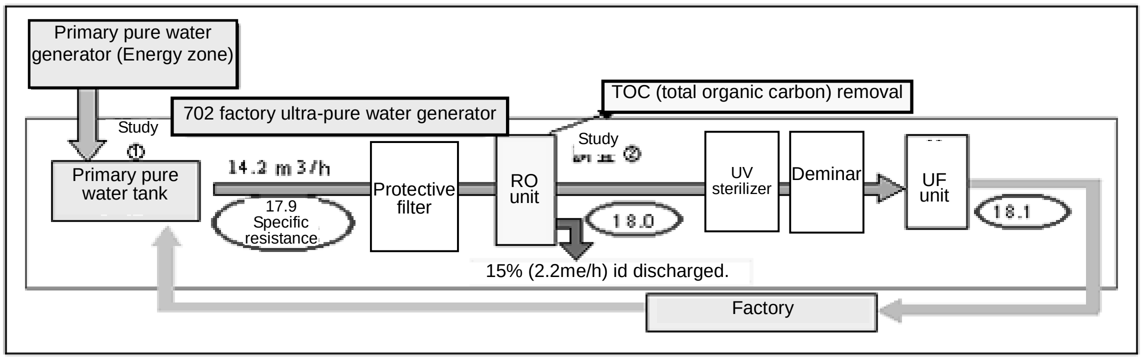


Figure-7 Flow of ultra-pure water generator

We wanted to know why the specific resistance (index indicating pureness of the water) does not change much in each process, so we looked into the ultra-pure water generator. As a result of our water quality examination (Table-1) and on-site study, we found out as follows:

[1] TOC 30ppb of the primary pure water is much better than the ultra-pure water warranty standard 1000ppb (1ppm).

[2] There are 2 RO units, at the primary pure water generator and at the ultra-pure water generator.

So we thought we could achieve great energy conservation if we could stop the RO unit of the ultra-pure water generator.

We asked the wafer production technology division about the quality conditions of the water used for product processing, but the reply was that the effect of the water quality to product was not known so the current water quality level should be maintained.

So I studied if the water quality of the primary pure water could be maintained.

Table-1 Results of water quality examination

		Specific resistance MΩ・cm	Fine particle Pieces/mL	Live bacteria Pieces/mL	TOC Ppb
Primary pure water warranty water quality standard		10 or above	200 or less	0.6 or less	2000 or below
①	Primary pure water outlet	17.9	> 20	0.04	30
Ultra-pure water warranty water quality standard		16 or above	30 or less	0.5 or less	1000 or below
②	RO unit outlet	18.0	> 20	0.04	40

2) Study, improvement of ultra-pure water generator

I asked a maker of the RO unit if we could stop the RO unit of the ultra-pure water, and the maker replied that the RO unit was installed from the beginning and it was necessary to maintain the water quality. I was not satisfied with this reply, so I conducted benchmarking to know how ultra-pure water RO units provided by other makers were installed. As a result I found that the installation of RO unit varied depending on the designing conditions.

So I focused my examination and analysis on the designing conditions and capacity. To do this, I studied the ultra-pure water generator myself and collected information from manufacturers to improve myself.

Then, I went back to pre-processes (controlled by another division) and checked the construction documents for the primary pure water generator.

I discovered that the actual value of the primary pure water generator was better than the ultra-pure water generator's warranty value, so I asked the manufacturers to cooperate and they accepted my request.

Study 1: Why is the actual value of the primary pure water good?

Study 2: Can that value be maintained in the operation during holidays (TOC melts out from the pipes during circulation operation)?

In these studies, I had to look into the primary pure water generator controlled by another division.

3) Study, improvement of ultra-pure water generator

Figure-8 shows the flow from the primary pure water generator to the ultra-pure water generator.

In the course of the study, I examined from the primary pure water generator controlled by the other division to the ultra-pure water generator of my division.

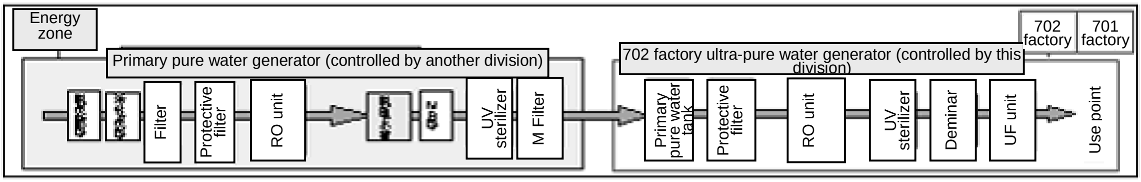


Figure-8 Flow from primary pure water generator to ultra-pure water generator

In study 1, I found that the RO unit's RO membranes used for the primary pure water generator and the ultra-pure water generator were same and the water quality was stable. So, working with the other division, I conducted a test run to see if it was possible to stop the RO unit in the ultra-pure water generator.

The water quality was the same before and after the improvement in each item (Table-2) so there was no problem.

In study 2, I checked the TOC transition of circulation operation during a long period of holidays (10 days).

As Figure-9 shows the water quality, there was no problem with TOC because it was within the standard value.

From these studies, I found that it was possible to maintain the water quality of the ultra-pure water, so I stopped the RO unit in the ultra-pure water generator.

	Specific resistance MΩ・cm	Fine particle Pieces/mL	Live bacteria Pieces/mL	TOC Ppb
Before improvement	18.0	> 20	0.04	40
After improvement	18.1	> 9	0	40
Evaluation	○	○	○	○

Table-2 Water quality after improvement

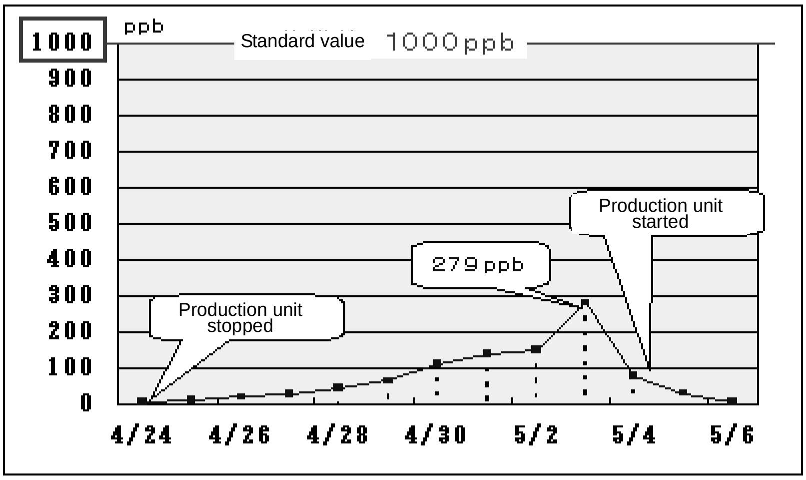


Figure-9 TOC transition

4) Effect of improvement, ultra-pure water generator

The effect of the improvement mentioned above is that CO_2 reduction is 77.5t-c/year, monetary effect amount is 20.90 million yen/year (Reduction of maintenance cost is 490 thousand yen/year) and the period for recovering the investment is 0.03 years.
There was additional effect that the primary pure water consumption controlled by the other division (wafer facility maintenance 2) was reduced greatly and the energy conservation was achieved by reducing the number of primary pure water RO units (CO_2 reduction 38.7t-c/year, effect amount 6.25 million yen/year).

(2) Case 2: Use of Steam for Gas Absorption Freezer

1) Study of focal points, gas absorption freezer

The use of steam for gas absorption freezers is as follows. Figure-10 shows the outline of the air conditioning equipment. The concept of the improvement is the study of high efficiency machines and the focus is on the cheaper energy that can realize high efficiency.
The cold water made by the freezer is sent to the air conditioners installed in the factory and those air conditioners maintains the air of the clean room throughout a year.

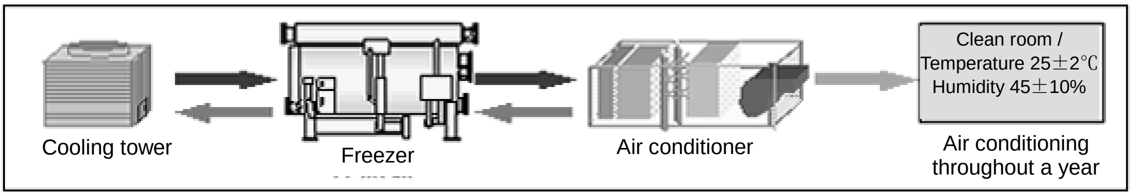


Figure-10 Outline of air conditioning equipment

Figure-11 shows the maintenance cost and the number of failures of the freezer. Both of the maintenance cost and the number of failures of the freezer tend to increase as time passes. So measures to deal with aging deterioration and reduce the maintenance cost are needed.
In the study of the aging deterioration, the performance of the gas absorption freezers (4 units) was measured and compared with the rated performance. Figure-12 shows the results.
In this study, the deterioration of the performance was noticed with all equipment and it was approximately 21% in average. Accordingly, there was energy loss caused by the deterioration.
From the findings above, it seemed to be the time to study the renewal.

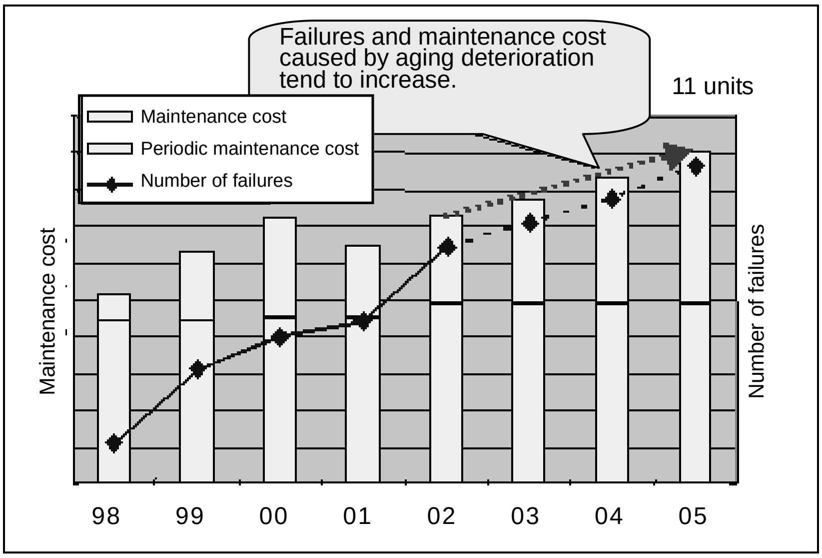
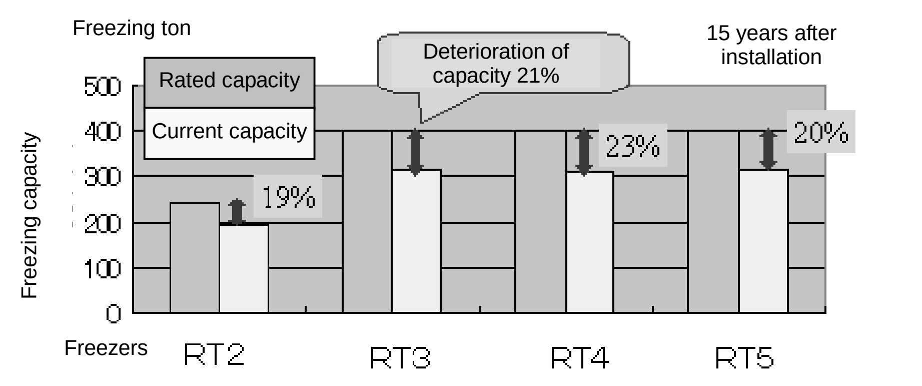


Figure-11 Maintenance cost and number of failures of freezers



Deterioration of capacity is approx. 21% in average. There is energy loss.

Loss of approx. 4.84 million yen (81t-c/Y) a year.

Figure-12 Study of freezer’s deterioration

2) Study-1, renewal of gas absorption freezer

So I conducted benchmarking to see the renewal state of the absorption freezers. Figure-13 shows the results. The absorption freezers of Nishio factory have been renewed in 24 to 31 years after the installation, while those of Kouta 701 factory have passed only 15 years. Considering the fact that they are used only for cooling in Nishio factory while they are used for air conditioning throughout a year in Kouta factory, I checked their operating time and compared them using durability conversion years. As a result, I found that the freezers of Kouta factory have operated longer than those of Nishio factory, and it was time to renew the freezers of Kouta factory.

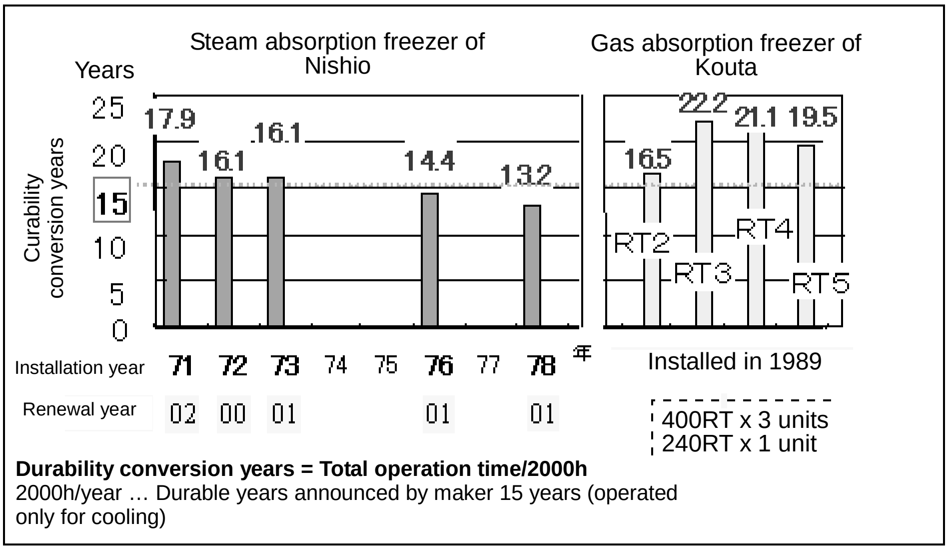


Figure-13 Benchmarking of absorption freezer

As a staff member of the special project Assy air conditioning working group, I studied the possibility of renewing Kouta 701 gas absorption freezers to the latest model, but I found that the investment recovery period was as long as 13 years. The investment recovery period had to be shortened. Meanwhile, the No.2 cogeneration introduction plan proposed by the wafer cogeneration working group was not making progress because steam demand had to be increased in light of investment efficiency. So I thought of the way of using steam for the absorption freezers to solve both problems at once. Working with relevant divisions, I continued to study (cogeneration is a generation system generating steam together with electricity – it is important to use steam if we are to enhance the investment efficiency).

3) Study-2, renewal of gas absorption freezer

In studying the use of steam, I focused on the way to increase the use of cogeneration steam by the freezers. In the operation, the energy for the base machine was changed from electricity (turbo freezer) to cogeneration steam (steam absorption freezer) in order to greatly increase the use of steam. Figure-14 shows the steam use estimated if the steam is used for the freezers.

Then, at the steam freezer study meeting, I explained that we needed to renew the freezers, there were merits in having the cogeneration system if we could use steam (cogeneration investment recovery is shortened from 12.5 years to 4.1 years) and there was great energy conservation effect. My proposal was approved by the divisions concerned and it was decided to introduce the cogeneration system.

So 4 units of gas absorption freezers were renewed to the steam absorption freezers (using cogeneration steam).

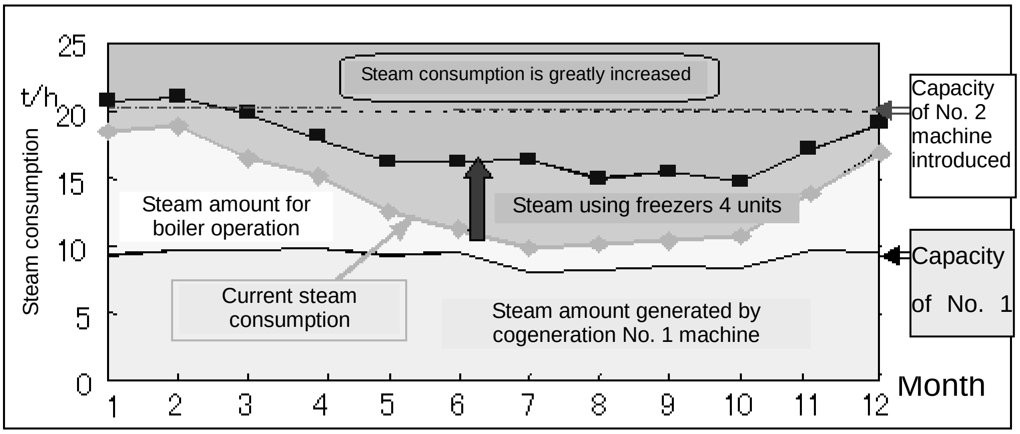


Figure-14 Estimation of steam consumption

4) Effect of steam used for absorption freezer

The effect generated by the use of steam for the freezers is expected to be CO_2 reduction of 838t-c/year, monetary effect amount of 77.99 million yen/year (reduction of maintenance cost of 23.71 million yen) and investment recovery of 1.8 years.

5. Summary

In doing the activities mentioned above, I reviewed the utility equipment from the viewpoint of designing and maintenance. In doing so, I worked with relevant working groups and divisions to activate the energy conservation activities within the organization. Figure-15 shows the achievements.

The activities are summarized that CO_2 reduction is 1150.2 t-c (38% reduction) against the target 914 t-c (30% reduction) and the monetary effect amount is as much as 140.85 million yen (reduction of maintenance cost is 27.27 million yen).

Energy conservation theme	CO_2 reduction (t-c/Y)	Monetary effect amount (ten thousand yen)
701-4P air conditioning VAV renewal	62.1	583
General air conditioner function recovery 10 units	1.9	30
701-4F integration of discharge equipment	1.0	9
Integration of ultra-pure water generators (701, 2 factory 4F)	85.9	2320
Renewal of 701-4F circulation water equipment	16.4	153

702 freezer cold water primary pump improvement (jointly by manufacturing and planning)	49.1	520
Ultra-pure water generator system improvement (702 factory 4F) Case 1	77.5	2090
701-1F ultra-pure water generator system modification	13.2	435
701-1F ultra-pure water sensor installation improvement	3.4	98
702-4F Dicing water discharge equipment improvement	1.7	48
Use of steam by Kouta 701 gas absorption freezers June, 2004 (2 units), June, 2005 (2 units) Case 2	838.0	7799
Total (As of August, 2005)	1150.2	14085

Figure-15 Summary of effect

6. Future Plans

Based on the importance of breaking fixed ideas and of co-working with relevant division which we came to know through the activities mentioned above, we will expand the improvement from the equipment we are in charge of to the entire factory and implement the energy conservation of production equipment from the viewpoint of the responsibility for the utility. As regards the old equipment, we will try to improve the investment efficiency based on the plan considering energy conservation such as changing to energy conservation machines or maintenance of current functions. We challenge further CO_2 reduction with all members of the organization.