**2005 Prize of the Chairman of ECCJ**

# Challenging for the Top Runner of Factory Energy Conservation, Part II

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◎ **Keywords: Rationalization of heating, cooling and heat transfer (Air conditioning facilities, hot water supply facilities, etc.)**
**Rationalization of conversion to electricity motive power, heat, etc. (Electric power application equipment, electric heating equipment, etc.)**
**Rationalization of conversion to electricity motive power, heat, etc. (Lighting equipment, elevators, office equipment, consumer products)**

## ◎ Outline of Theme

This factory is engaged in the development, design and production of automobile related products such as car navigation systems, car audio products, etc. As the automobile industry has grown, the demand for these products has increased every year and we have faced the shortage of the production space in the existing factory buildings. To solve this problem, we, as identified above, were asked to build a new building for assembling the products in the existing premises. So we put together the energy management systems and energy conservation technologies which we had developed in this factory and the latest energy conservation technologies available in the market and completed a new production building as a “top runner of factory energy conservation”.
As a result, we could achieve the energy conservation of 23.8% compared with the conventional system.

## ◎ Implementation Period of the Said Example

October 2003 – July 2005

- Project Planning Period October 2003 – January 2004 Total of 4 months
- Measures Implementation Period February 2004 – July 2004 Total of 6 months
- Measures Effect Verification Period August 2004 – July 2005 Total of 12 months

## ◎ Outline of the Business Establishment

- Items Produced　Automobile accessories (AB), automobile multi media equipment, valves, etc.
- No. of Employees　2,141 (As of April 1, 2005)
- Annual Energy Usage Amount (Actual results for fiscal year 2004)
  Electricity　18,100 MWh

## ◎ Process Flow of Target Facility

New production building (Building facility) (Fig. 1)

1. Main usage: Product assembly
2. Size: 60m x 40m x 16.7m
3. Structure: Iron frame, double folded insulation board roof, ALC insulation walls, 3 stories, semi fire-proof
4. Conditions for building
   (1) Low cost
   (2) Adoption of energy conservation structure
   (3) Adoption of energy conservation facilities
   (4) Incorporation of energy management system (SA1)

Fig. 1 Target Facilities

# 1. Reasons for Theme Selection

This factory is engaged in the development, design and production of automobile related equipment. As the automobile industry has grown, the demand for our products has become bigger every year, so we faced the shortage of the production space in the existing buildings. To solve this problem, we needed to have a new production building for assembling the products in the existing premises.

This factory had actively engaged in the energy conservation activities aiming to be the “top runner of the factory energy conservation”. Meanwhile, the total floor area of the new production building was supposed to be as big as 7,200 $m^2$, necessitating the activities of energy conservation. So, in the initial planning phase, we put together the energy conservation technologies which we had steadily developed, the latest energy conservation technologies of the industry and the energy management system which we had established for this work place into the EM (Energy-Loss Minimum) activities to make our factory a top runner EM factory of energy conservation. So we chose the “challenging for the top runner of the factory energy management, Part II” as our theme and started the activities.

# 2. Understanding and Analysis of Current Situation

## (1) Understanding of Current Situation

[1] By building a new production building of 7,200 $m^2$, the existing area 47,234 $m^2$ is expanded by 15.2%.

[2] The production output is estimated to increase by approximately 7% in FY2004 compared with the level of FY2003.

[3] The electricity consumed by the new building is estimated to be around 2,700 MWh if the existing building method, building scale and energy usage are used.

[4] The electricity consumed by the factory before building the new building was 18,000 MWh in FY2003, and it is now estimated to increase by 15% by the having the new building.

[5] Therefore, if calculated simply, the electricity production intensity is likely to worsen by 7.5% as 1.15/1.07 x 100 = 107.5%.

## (2) Analysis of Current Situation

[1] The electricity accounts for 100% of the total energy of the factory.

[2] The electricity used by the new production building is estimated to be 2,700 MWh, greatly

increasing the entire electricity consumption.

[3] As we started the energy management system (SA1) in FY2003, it became possible to watch the energy consumption of the production lines or other facilities in real time from the office.

[4] The energy conservation measures we had implemented earlier were the measures to reform the existing equipment, so there was extra cost for modifying the existing equipment.

[5] As this factory has been designated as a model factory of energy conservation in our company, so, when making a new production building, the company expected the factory to implement measures which make it the top runner of the factory energy conservation.

# 3. Progress of Activities

## (1) Implementation Structure

When constructing our buildings or building our facilities, we used to ask construction companies or specialized facility makers to do everything from the study of the specifications to the completion of the construction. However, this time, the facility management group members in charge of the facility management and energy management participated in the construction from the initial planning phase as if they were going to do the construction themselves, so we decided to organize a project organization which can take up various energy conservation measures. Here, the facility management group also works as factory's energy conservation promotion secretariat (Fig. 2).

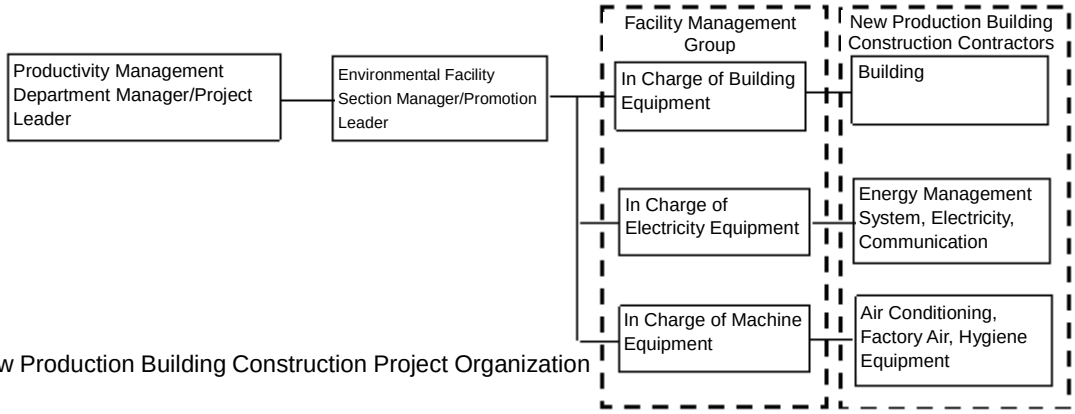


Fig. 2 New Production Building Construction Project Organization

## (2) Target Settings

To ease the increase of the electricity use due to the construction of the new production building by the EM (Energy-Loss Minimum) activities, we set the following values as the targets.

[1] Target reduction rate of the new production building: 20%

[2] Target reduction of electricity of the new production building: 540 MWh/year

## (3) Problem Points and their Investigation

### 1) Problem Points

[1] As the production expanded, it became necessary to build a new production building to secure the production area.

[2] Once the new production building is completed, the electricity consumption was likely to increase and the intensity was likely to worsen.

[3] If we ask the construction contractors to do everything about the construction of the new production building, from the study of the specifications to the completion of the construction, it may raise the cost and the energy conservation technologies we have developed so far may not be fully reflected in the construction.

### 2) Review and Discussions on Measures

[1] To have the facility management group members in charge of construction, electricity and machines participate in the new production building project from the initial planning phase.

[2] To implement the EM (Energy-Loss Minimum) activities suited for the “top runner of factory energy conservation”, incorporating as much as possible the energy conservation technologies and energy conservation measures which we have developed so far, to prevent the intensity from worsening.

[3] To have the facility management group members make the specifications of the new production building themselves and work with the specialized contractors (construction, electricity, machines, communication, fire fighting, etc.) to construct the energy conservation building, introduce the energy conservation equipment and horizontally deploy the energy management system.

[4] To have the new production building construction project members gather every week and check the progress of the energy conservation measures to achieve these objectives.

## 4. Details of Measures

The energy conservation technologies and measures adopted for the new production building are as follows.

### 1) Case 1: Construction related

#### a Building structure

The building was made of iron frames and the energy conservation specifications were applied to its roof, walls, ceiling height and windows (Table 1).

Table 1 Building Structure and Heat Flowing In

Conditions: Peak time in the summer

| | This Time (Energy Conservation Type) | Heat Amount Flowing In | Earlier Specifications | Heat Amount Flowing In (kW) |
|---|---|---|---|---|
| Roof Structure | Double Folded Board Insulation Glass Wool 10 kg/m$^3$ t100 + 9.5PB | 23.3 | Folded Board, Pef Applied + 9.5PB | 249.2 |
| Wall Structure | ALC Board t = 100 Insulation Structure | 41.7 | Slate Wall | 188.8 |
| Ceiling Height | 3.2m | 70.4 | 3.5m | 77.0 |
| Window Opening | 148.58m2 | 23.7 | 349.8m2 | 32.2 |
| Smoke Ventilation Window | Light Shielding Insulation Material | 3.9 | Figured Glass | 10.2 |
| Building Layout | Eastside Outer Wall | 40.1 | Westside Outer Wall | 42.7 |
| Total | | 203.1 | | 600.1 |

- The roof had been folded board pef structure before. We changed it to the boltless double folded board insulation material filled with glass wool 10 kg/m$^3$ t100 to enhance the insulation performance and reduce the air conditioning load.
- The wall which had been slate wall before was changed to ALC t100 insulation structure to reduce the air conditioning load. The story height was made taller as 6 m and the ceiling height was made lower as 3.2 m to make the building's inner volume smaller and reduce the air conditioning load.
- The windows were made as few as possible, and they were positioned near the story without window to block the direct sunlight coming in through the windows. As regards the smoke ventilation window, a light shielding insulation board was installed behind the glass to prevent the heat from coming in and reduce the air conditioning load (Fig. 3).

- Extra rooms were made in front of the entrance and exit of the building to keep the building inside away from the outside air (Fig. 4). Besides, a high-speed sheet shutter was installed behind the electric shutter at the place for carrying in/out goods on the 1st floor. Then, the high-speed sheet shutter alone was used usually to shorten the opening time and prevent the heat load from coming in (Fig. 5).

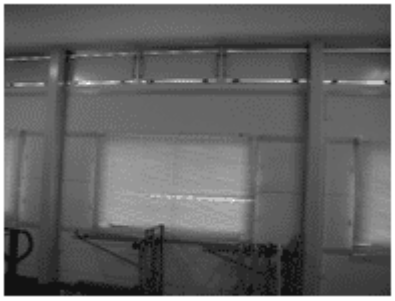

Fig. 3 Light Shielding and Heat Insulation of Smoke Ventilation Window

Fig. 4 Extra Room behind Entrance and Exist

Fig. 5 High-speed Sheet Shutter

**b. Positioning and layout of the building**

When determining the positioning of a building, we have to first consider the flow of the goods, but, in general, the heat load by the direct sunlight is greatest in the westward

direction. So we gathered the common-use areas such as stairs room, machine room, bathroom, rest room, etc. in the west side where the heat load was great to reduce the heat load by the direct sunlight in the production area and office area.

As regards the heat load generated in the durability test room or copying machine room in the building, we adopted the individual heat exhaust system which discharges individual waste heat outdoors by placing heat shielding partitions to reduce the heat load of the office area.

### 2) Case 2: Equipment related

#### a. Transformation equipment

We adopted high-efficiency transformers for the power transformation equipment to reduce the no-load loss and copper loss of the transformers (Table 2).

Table 2 Comparison of Transformer Loss

| | This Time (High-efficiency Type) /No-load Loss/Total Loss (W) | Before (Low Loss Type)/ No-load Loss/Total Loss (W) |
|---|---|---|
| 500kVA | 740／5,670 | 1,010／6,900 |

#### b. Lighting equipment

We adopted HF energy conservation type and LED type which consume less electricity (Table 3). As regards the ceiling lights, we not only adopted the HF energy conservation type but also attached strings to the lights so that they can be turned off individually. Meanwhile, we put motion sensors for the lights in common-use area such as rest rooms, bathrooms, entrance, etc.

Table 3 Comparison of Lighting Equipment

| | This Time (Energy Conservation Type) | Before | Note |
|---|---|---|---|
| Ceiling Lights | 32W x 2 Lights | 110W x 2 Lights | With Handy Strip |
| Night Lights | 32W x 1 Light | 40W x 2 Lights | Criterion is Necessary and Least Brightness Criteria. |
| Emergency Lights | 13W | 110W (Also used as ceiling light) | Criterion is Necessary and Least Brightness Criteria. |
| Evacuation Guiding Light | 2.4W | 20W x 1 Light | LED Type |
| Stairs Lights | 32W x 1 Light | 40W x 2 Lights | Dim lights |
| Entrance Hall Lights | 32W x 1 Light | 40W x 2 Lights | Motion sensor with Light detection |
| Vending Machine Lights | Always Off | 30W x 1 Light x 4 Shelves | Soft Drink, etc. |

**c. Air conditioning equipment**

The heat load of the air conditioning equipment varies depending on the building's organizational structure, equipment, production type, working type, etc., so we adopted the inverter system to minimize the energy loss. We also made it possible to do the air conditioning according to the purpose (Table 4). As regards the placement of the outdoor units, in order to shorten the length of the cooling medium pipe, we put the outdoor units on the ground for the indoor units on the 1st floor and put them on the 2nd floor for the units on the 2nd and 3rd floor (Fig. 6).

Table 4 Comparison of Air conditioning Equipment

| | This Time (Energy Conservation Type) | Before |
|---|---|---|
| Electricity Consumption (kW) | **474.47** | 749.88 |
| Average COP | **3.49** | 2.38 |

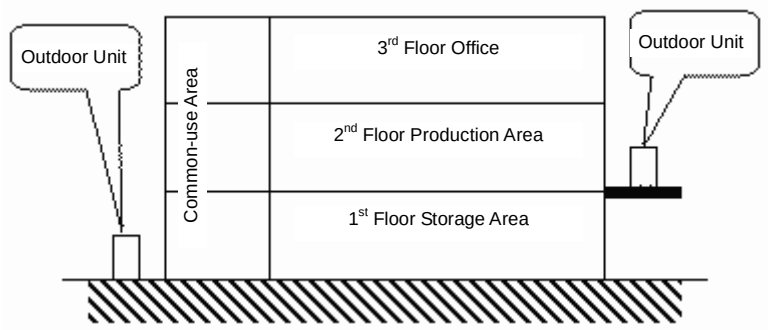


Fig. 6 Placement of Outdoor Units

**d. Exhaust heat equipment**

There is heat load discharged indoors from the soldering tank, production equipment such as vibration test room, large copying machines, vending machines. To reduce it, we came up with the way to directly discharge the exhaust heat outdoors through the exhaust heat equipment (dedicated duct) (Fig. 7). Especially, in case of the production exhaust heat, we visualized the exhaust heat by installing our original liquid tube indicator using differential pressure so that everybody could know if the exhaust fan is working or not (Fig. 8).

Fig. 7 Exhaust Heat of Vending Machine

Fig. 8 Exhaust Indicator

**e. Compressor equipment**

We introduced 2 units of the latest inverter compressors (37 kW). Then, we made it possible to control the 2 compressors according to the change of the load pressure by combining the yearly schedule timer and the inverter. By doing this, perfect unmanned operation was realized.

Meanwhile, although fixed blinds are installed generally to walls or windows as a measure for the compressor cooling, it does not create efficient cooling effect because it generates air resistance. So we adopted movable blinds to lower the air resistance and make the flow of the air, thus to cool the compressor more efficiently. As regards the exhaust heat from the compressor, we made it possible, by means of the inverter control, to turn ON/OFF the 3 exhaust heat fans and control the number of their revolution according to the compressor's indoor temperature (Fig. 9). As regards the indoor piping for the compressed air, we constructed loop piping with SGP-100A pipes for each of 1st floor, 2nd floor and 3rd floor to reduce the pressure loss at the terminal.

Meanwhile, to prevent the air leakage which may happen if somebody forgets to close the main valve of each line, we installed the electric valve (Fig. 11).

The switches for the electric valve were placed on the distribution board of each line to be interlocked with the valve's open/close state display lamps (Fig. 11).

Fig. 9 Control Board of Exhaust Fan

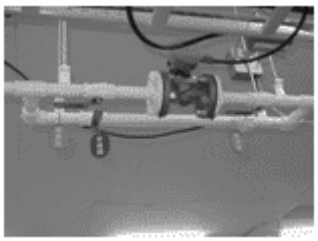

Fig. 10 Electric Valve

Fig. 11 Electric Valve Open/Close Switch

### 3) Case 3: Energy management system (SA1)

The energy management for the new production building incorporated the energy management system (SA1), as mandatory requirement, which we had started using in FY2003. So the energy use of the new production building is measured and monitored for 649 items at 188 places using various instruments including ampere meters, voltage meters, current meters, power factor meters, temperature gauges, humidity gauges, pressure gauges, etc. (Fig. 12) (Fig. 13).

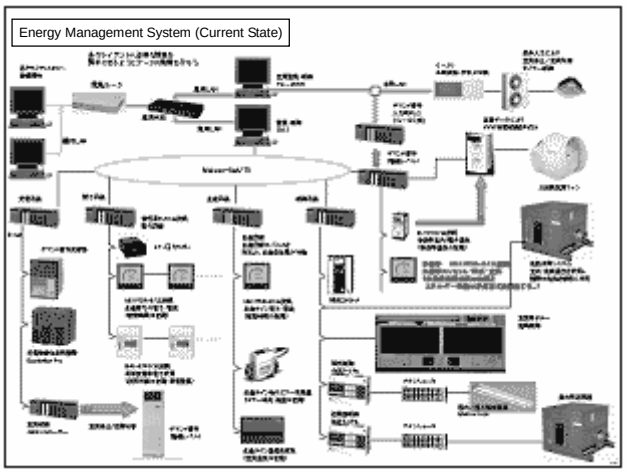


Fig. 12 SA1 System for the New Production Building

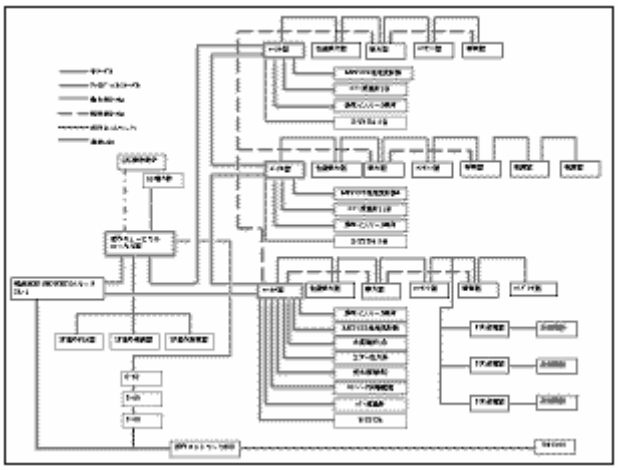

Fig. 13 Block Diagram of Monitoring and Controlling of New Production Building

**a. Monitoring function and control function of energy management system (SA1)**

The energy management system (SA1) can monitor in real-time the intensity of the production lines, electricity amount used, room temperature and lighting state. Besides, it can turn ON/OFF the lights, control the flow rate by the opening of the valves, control the time using the timer and control the room temperature by changing the setting temperature of the air conditioners.

**b. Control of air conditioning**

It became possible to control the air conditioning meticulously by managing the air conditioners with”TG2000” through the “air conditioning management system G50”. To manage the room temperature evenly which otherwise varies depending on the place, we

increased the number of temperature sensors and installed them almost 1 set every 100 $m^2$ and controlled the temperature by the unit of area.

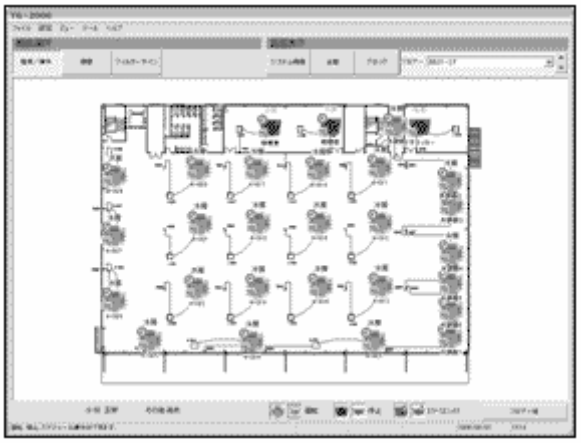

Fig. 14 Placement of Air Conditioners in New Production Building

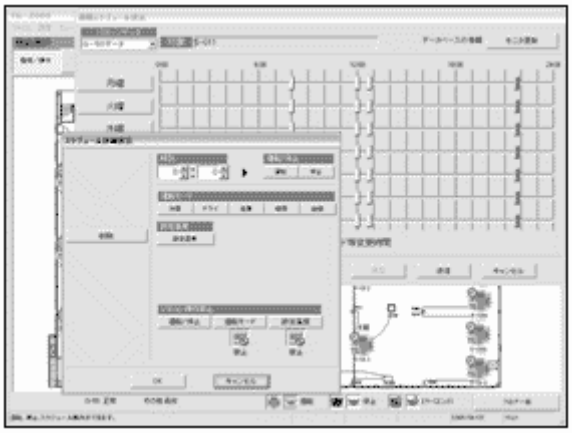

Fig. 15 Air Conditioning Control TG-2000

**c. Energy management of production lines**

We made it possible to monitor the production lines by installing dedicated measurement instruments to each line and taking the data concerning the production equipment including electricity, current, production pulse and operating hours and inputting it into the energy management system. As regards the air, we measured it by making the main valve of each line electric and installing the flow meter and pressure gauge.

**d. Energy management of office**

We made it possible to automatically monitor and measure the outlets and lights of the office

and the temperature and humidity in and out of the office. And using the lighting controller, it also became possible to control the ON/OFF of lights, control the ventilating fans by inverters and automatically turn off all of the lights during lunch time and after work (Fig. 6) (Fig. 7).

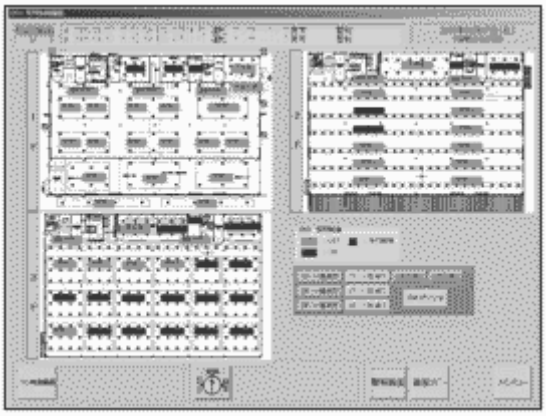

Fig. 16 Lighting Control

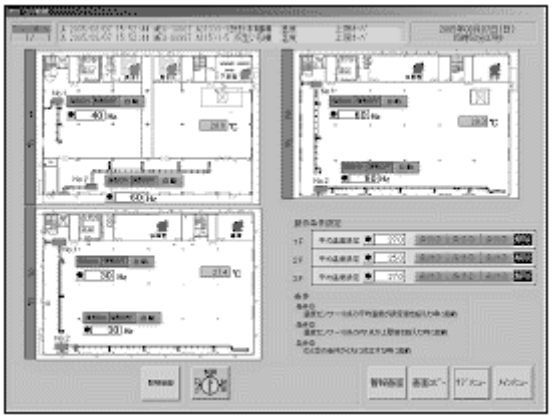

Fig. 17 Inverter Control of Ventilating Fans

＜Actual electricity use＞

The actual use of electricity of the new production building in a year from August, 2004 to July, 2005 was 2057 MWh against the estimation of 2700 MWh, showing the reduction of 643 MWh (23.8% reduction) by the energy conservation measures (Table 5) (Fig. 8).

Table 5 Actual Use of Electricity

| Period August, 2004 to July, 2005 | Actual Use of Electricity |
|---|---|
| Production Power | 644 |
| Air Conditioning | 354 |
| Lighting | 234 |
| N2 Generators | 181 |
| Others | 180 |
| Vacuum Pumps | 175 |
| Compressors | 152 |
| OQ Equipment | 98 |
| Common-Use Power | 40 |
| Total | 2,057 |

(The total may not tally with each number because each number was rounded.)

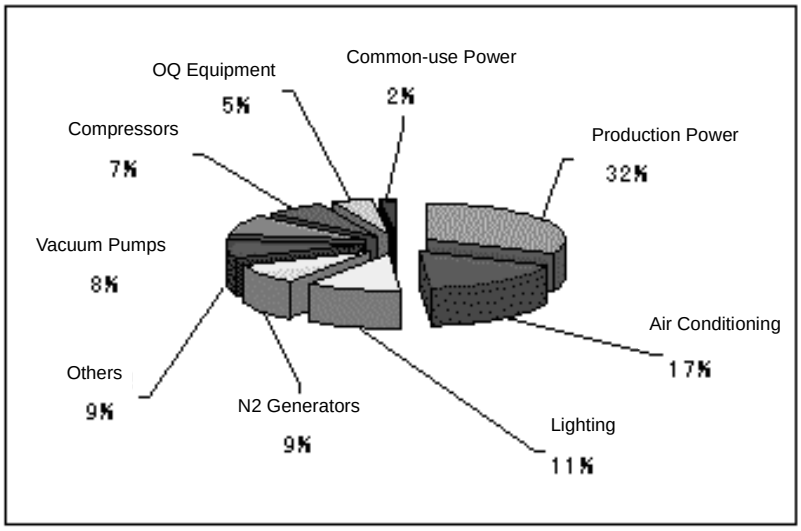


Fig. 18 Ratio of Each Electricity Use

## 5. Effects Achieved after Implementing Measures

As a result of the factory's energy conservation activities which were implemented from the construction designing phase of the new production building, we could achieve great energy conservation as shown in the actual use of the electricity in one year since the completion of the building (Fig. 19).

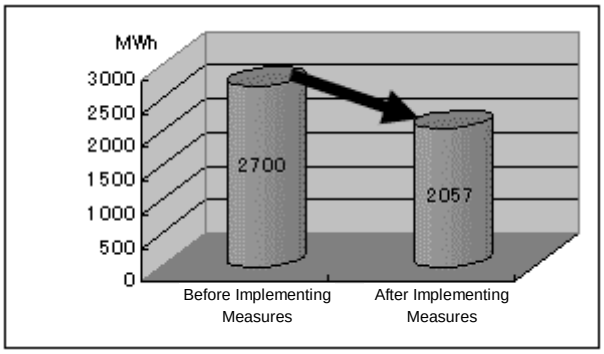


Fig. 19 Effect achieved after Implementing Measures

- Energy conservation ratio: 23.8%
- Energy conservation amount: 643 MWh
- Energy conservation effect: 228 t-$CO_2$ (0.356 kg-$CO_2$/kWh, the factor announced by The Kansai Electric Power Co., Inc. was used.)
- Monetary amount of effect: 9.645 million yen/year
- Investment recovery: 1.2 years (The investment amount was estimated to be 12 million yen as the cost for expanding the energy management system.)

## 6. Summary

When constructing a factory, it was customary to ask construction companies and equipment manufactures to do everything from the study of the specifications of the factory to be built to the performance of the construction. So if energy conservation measures other than the basic specifications were incorporated in the design, it would greatly raise the cost. However, in the activities we did this time, the facility management group members who were in charge of the management of the factory facilities and the energy management became the project members for constructing the new production building. They worked in their specialized fields using their own energy conservation know-how as much as possible within the limited budgetary frame from the beginning of the planning and, as a result, the energy conservation technologies were condensed and there was a great deal of energy conservation. So we could build a factory which deserves to be called a “top runner of the factory energy conservation”.

Meanwhile, by monitoring all of the energy used by the new production building with the “energy management system SA1”, it became possible for not only the energy management division but also for the managers and people of each division to visually confirm the operation of the lines, temperature and humidity of the room, factory air, etc. through the

intra-net.

As a result, it became possible to use various data of the “energy management system SA1” not only for each division’s energy management but also for the energy conservation training and campaigning for the employees.

## 7. Future Plans

We will make the new production building we made the model of the factory challenging for “the top runner of the factory energy conservation”, i.e. the factory purring priority on the energy management. We will make our activities widely known in the industry and horizontally deployed them in and out of the company to contribute to the reduction of $CO_2$ emission of the industry.