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Energy conservation by tuning office building

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◎ **Keywords: Others (Energy conservation tuning of buildings)**
Others (Energy conservation tuning support tools)

◎ Outline of Theme

Setting a target to conserve 15% of energy, we continuously improved control and operation of the entire building and each system based on measurement of energy consumption for appropriate operation of lighting and air-conditioning facilities and environmental sustainability. In this energy conservation activity to which operators and outside specialists as designers and builders joined, we implemented efficient energy conservation tunings using a common visualized analytical tool and achieved energy conservation effect with high return on investment.

◎ Implementation Period for the Said Example

February, 2003 – March, 2006

● Planning period	February, 2003 - March, 2004	total 14 months
● Implementation period	April, 2004 – March, 2006	total 24 months
● Effect verification period	April, 2004 – March, 2006	total 24 months

◎ Outline of the Business Establishment

Produced items: Office buildings, show rooms
Number of employees: 2200
Annual energy consumption (Actual record in 2005)
Electricity: 7,400 MWh Gas: 18,200 m^3
Cool water: 14,900GJ Steam: 6,740GJ

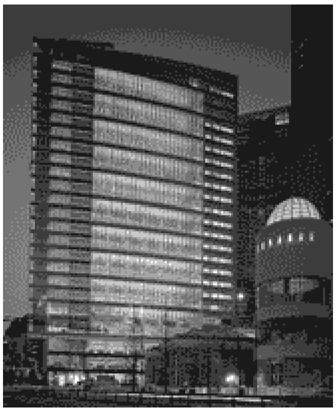

Fig.1 Overview of the target facility

◎ Process Flow of Target Facility

- Name: Matsushita Electric Works, Ltd Tokyo Headquarters building

  * Site area: 1,970m^2

- Total floor area: 47,274m^2

  * Number of stories: 24-stories above the ground and 4 underground stories

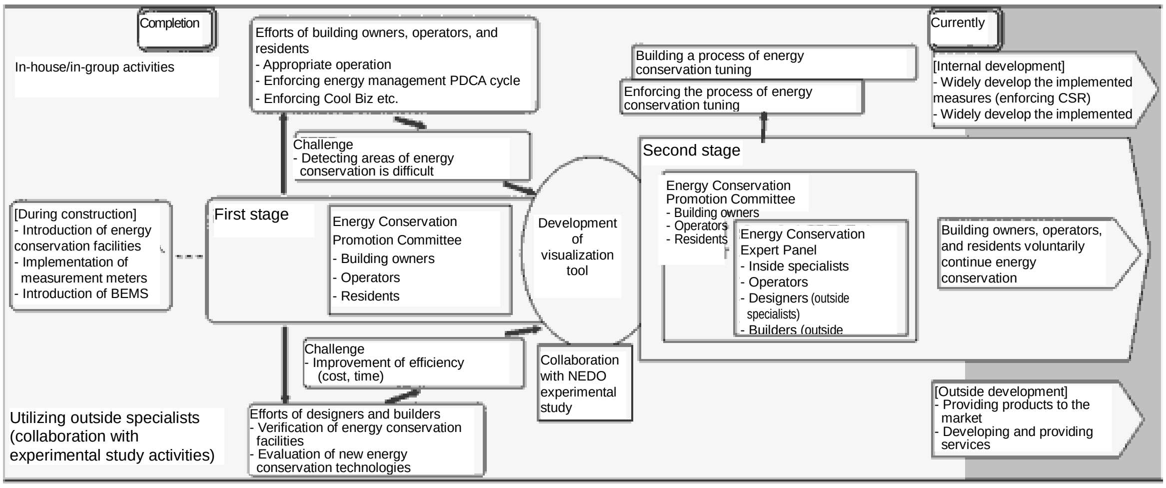

Fig.2 Process of the target facility

1. Reasons for Theme Selection

Matsushita Electric Works, Ltd Tokyo Headquarters building is an office building with a show room whose construction was completed in February 2003 and opened in April. It has a concept of a building that lasts for 100 years and proactively adopted new technology elements for energy conservation. From the construction phase, the plan considers energy management of introduced energy conservation facilities such as installing BEMS to grasp energy consumption status and measuring power consumption and calories at the end where energy is consumed. Using these BEMS and detailed energy measurement data, we had the following issues to enforce energy conservation:

[1] How to find the area where energy consumption can be reduced using the huge amounts of energy data

[2] How to establish a mechanism in which residents and operators can voluntarily and efficiently continue energy conservation activities within limited cost and time

We chose “energy conservation tunings” as a theme expecting the following effects:

1) To develop a tool that “visualizes” the status of facility operation and energy consumption to efficiently and continuously find areas of energy conservation as well as continuously improve operators skills based on the know-how obtained through the activities.

2) To benefit from outside specialists to newly find more detailed energy conservation activities and continue improvement to establish the process of efficient energy conservation tunings.

3) To summarize the experience of energy conservation tunings as case examples and processes to widely deploy throughout the company and groups and promote energy conservation. In addition, to contribute to promotion of energy conservation by reflecting the effects of the activities to our energy conservation products and services.

2. Understanding and Analysis of Current Situation

(1) Understanding of Current Situation

For many of the latest energy conservation systems that require verification of performance during the operation phase (VWV control, VAV control, cooling with outdoor air, natural ventilation, air flow window, day light interlock dimming control system + blind control, lighting and air-conditioning control using human detection sensors, etc.) among various energy conservation control systems introduced in the building, we have verified using data of BENS and entire building measuring that their performance expected in the design phase are almost brought out. On the other hand, as this is a large-scale building with double atrium space on the west side, energy consumption may rise if the operation is not appropriate.

(2) Analysis of Current Situation

As described above, energy conservation facilities shows expected performance, and energy conservation is promoted with cooperation of residents. To promote further energy conservation every year, however, detailed energy conservation efforts are required within a scope that does not affect business environment adding knowledge and innovation of facility engineers. Especially, this building has a distinguishing air-conditioning system including adoption of new energy conservation facilities with experimental elements and establishing the environment of a space using more than one air-conditioning device, so we expected that there still are energy conservation areas. Actual analysis of operations revealed areas of energy conservation tunings such as mixing loss that is characteristic of four-tube air-conditioning system.

3. Progress of Activities

(1) Implementation Structure

Adding to the Energy Conservation Promotion Committee, which is a normal operation organization to operate energy conservation of buildings, we have established a supporting system to propose advanced “energy conservation tunings” based on evaluation and verification by Energy Conservation Expert Panel. In addition, as one theme of NEDO experimental study *1, we share information with other facilities.

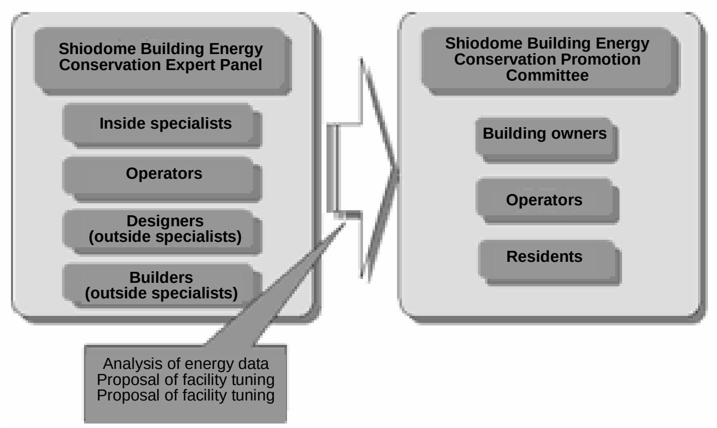

Fig.3 Organization

(2) Target Settings

Using the actual record of energy consumption in the initial year as the reference of "energy conservation tunings", we set the goal to reduce primary energy consumption by 15% in three years (96,137GJ/ year 2,033MJ/ m^2 year). The target when the building was constructed was reduction of 20% to the baseline assumed in the design phase including other energy conservation functions (100,072GJ/ year 2,117MJ/m^2 year)

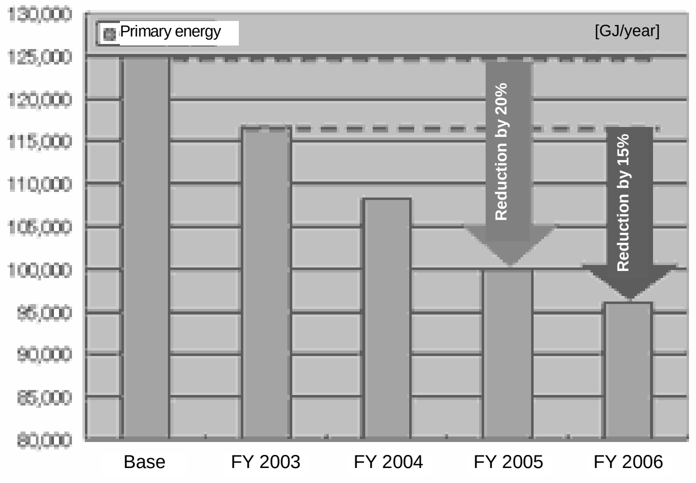

Fig.4 Steps of reduction target

(3) Problem Points and Their Investigation

Whether effective energy conservation can be promoted or not depends on how quickly we can find areas of energy conservation that were unknown and take appropriate measures. Therefore, we established Energy Conservation Expert Panel to utilize outside specialists who were involved in design and construction of this building. However, we realized that "visualizing" of operations (associating and sorting data and putting it into graphs etc.) requires a significant amount of time and it was not cost-effective. Therefore, we decided to develop a tool that facilitates visualization of operation and build a process to perform continuous energy conservation tunings using that tool.

*1: Strategic development of rationalization of energy consumption in fiscal years 2003 - 2005, "Experimental study on network agent type building total cooperative control"

4. Details of Measures

(1) Development of Analysis Tool and Building a Process to Utilize It

In developing the analysis tool, we considered that the tool should be available not only for tuning work but also for visualizing operations in every facet of energy conservation activities such as Energy Conservation Promotion Committee. Because the concept of analysis tool is that anyone can visualize energy consumption status any time any where quickly (“satto” in Japanese”), we named it “SatTool". Major features of SatTool are shown in Table 1. SatTool can be connected to BA system to collect operation data and distribute it as attachment to e-mails, so outside specialists can get operation data from anywhere and analyze it any time as far as they have mail connection, which is an existing infrastructure. SatTool enabled to effectively utilize outside specialists and find seeds of energy conservation efforts that were missed.

Table 1 Major features of SatTool

Function	Description
Data collection	Collect operation data of facilities from CSV files and central monitoring for unified management
Data analysis	Visualize data by flexibly combining points and graph styles
Energy management	Compare energy consumption statuses with target values and data in the previous year
Data distribution	Distribute operation data as attachments to e-mails (PC function)

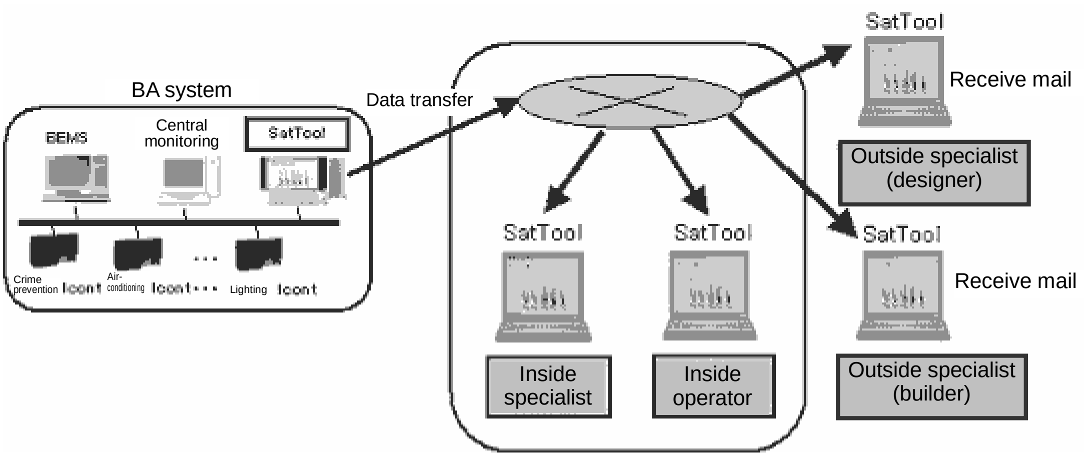

Fig.5 SatTool system architecture

With a core of SatTool, we build a process of energy conservation tunings to maximize the performance of facilities.

1) Daily energy management

Building operators grasp the operation status using SatTool to perform improvement cycle daily. However, for difficult and urgent problem solving, SatTool is used as a shared tool for collaboration work with outside specialists to appropriately implement temporary measures to prevent energy loss. Early detection and early measures enabled to minimize energy loss.

2) Utilizing Energy Conservation Expert Panel

As a special committee of Energy Conservation Promotion Committee, we have established Energy Conservation Expert Panel that is comprised of facility management personnel in our group and outside specialists. Energy Conservation Expert Panel supports activities of Energy Conservation Promotion Committee by discovering new areas of energy conservation and technical review of energy conservation tunings to maximize the facility performance, as well as making proposals of permanent measures to replace the above mentioned temporary measures. Activities of Energy Conservation Expert Panel also contribute to reduction of burden of Energy Conservation Promotion Committee.

3) Activation of Energy Conservation Promotion Committee

Some members of Energy Conservation Promotion Committee are less involved in operation, but visualization by SatTool promoted understanding of members and facilitated consensus building. As a result, residents became more cooperative; it also contributes to continuation of energy conservation activities.

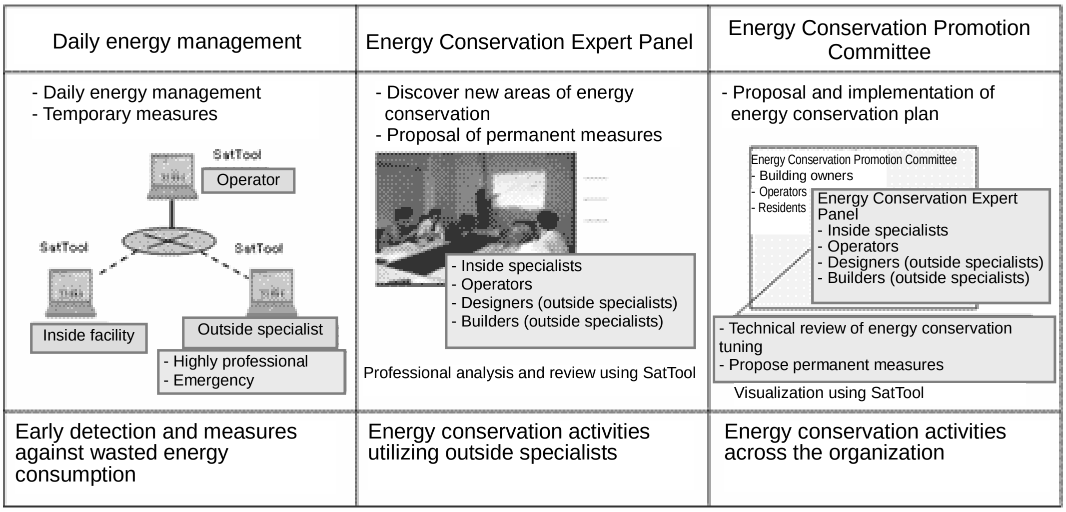

Fig.6 Mechanism to utilize the tool

(2) Implementation

The steps to implement energy conservation tunings are shown in Fig.7. They are mainly tunings of operation and parameters to follow change in usage pattern after the second year. Because Energy Conservation Expert Panel were able to work efficiently using the analysis tool and utilizing the detailed energy measurement data, many of the energy conservation tunings shown in Table 2 were implemented in a short period of time. Major 30 energy tuning case examples implemented in this building are shown in Table 2.

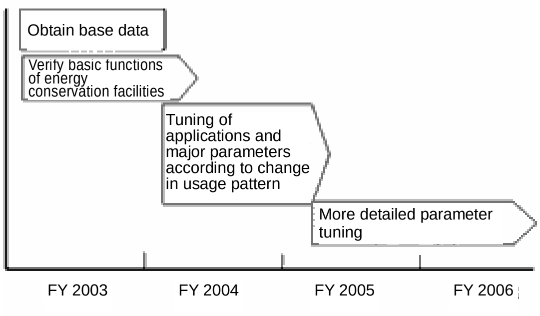

Fig.7 Steps of energy conservation tunings

Table 2 List of implemented energy conservation tunings

Major item	Medium item	Implemented energy conservation tuning items	Viewpoint	Type of reduction effect
Reduction of load	Temperature	1 Adjust preset temperatures of air-conditioning in the entrance hall	[3]	Electricity, cold energy
		2 Adjust preset temperatures of air-conditioning in elevator hall in each floor		Electricity, cold energy
		3 Adjust preset temperatures of air-conditioning in meeting rooms on reference floors		Electricity, cold energy
		4 Adjust preset temperatures of air-conditioning in the restaurant		Electricity, cold energy, thermal
	Outdoor air volume	5 Review air volume in the restrooms system of the air-conditioning machines on the reference floors		Electricity, cold energy, thermal
		6 Adjust air balance of the air-conditioning machines on the reference floors to appropriately take in outdoor air	[2]	Indoor environment
		7 Enforce control of cooling with outdoor air in the common lobbies	[1]	Electricity, cold energy
	Mixing loss	8 Add mode to forcibly stop using warm water of the air-conditioning machines	[3]	Thermal
		9 Grasp calories of each air-conditioning machine and change setting of period to supply warm water		Thermal
		10 Stop hot water pumps in summer season		Thermal
Efficient operation of facilities	Appropriate control	11 Identify sensors that are affected by insolation and change their control logic	[2]	Electricity, cold energy, thermal
		12 Adjust positions of the room temperature sensors on the west side of the reference floor		Electricity, cold energy, thermal
		13 Review the positions of the heat exchanger control sensor		Electricity
		14 Apply automatic preset temperature shift control to common areas (such as restaurant)	[3]	Electricity, cold energy, thermal
		15 Add VAV full close control of meeting room system on the reference floors		Electricity, cold energy, thermal
		16 Add VAV full close control of elevator hall system on the reference floors		Electricity, cold energy, thermal
		17 Parameter tuning of various air-conditioning machines	[4]	Electricity, cold energy, thermal
		18 Ensure gap between room temperature sensors and copiers	[2]	Electricity, cold energy, thermal
		19 Add upper and lower limit to preset temperatures of meeting rooms	[3]	Electricity, cold energy, thermal
Reduction of feeding power	Pumps (water system)	20 Tuning of control of assumed terminatory pressure of the heat source cool and warm water secondary pump	[4]	Electricity
	Air-conditioners etc. (air system)	21 Change the air-conditioning operation mode of the west side of the reference floors from air-conditioning machines to FOU.	[3]	Electricity, cold energy, thermal
Operation	Operation management	22 Change the system so that the calculation initial value of supply air temperature of the air-conditioning machines on the reference floors can be set from the central monitoring		Cold energy, thermal

		23 Exclude elevator hall in each floor from calculation of supply air temperature		Cold energy, thermal
		24 Optimization of start time of air-conditioning		Electricity, cold energy, thermal
		25 Stop machine out of adjustment of the communication machine room system during night. Stop cool water pump during night.		Electricity, cold energy
		26 Enforce operation of number control of package air-conditioners in the communication machine room		Electricity
		27 Review the time to start air-conditioning		Electricity, cold energy, thermal
	Maintenance management	28 Increase control points by energy conservation evaluation tool		Electricity, cold energy, thermal
	Ventilation facilities	29 Improve operation of air volume control of the outdoor air processing unit in the kitchen	[1]	Electricity, cold energy, thermal
	Construction	30 Shield the entrance hall using the east side roll screen	[1]	Electricity, cold energy, thermal

Items are classified according to the “Energy conservation tuning guidebook” published by “Energy Conservation Center, Japan”.

We sorted out the implemented measures and found that there are four viewpoints in performing energy conservation tunings. The four viewpoints and their case examples are described below. In addition, Table 2 is classified by those viewpoints.

[Four viewpoints of tuning]

[Viewpoint 1] Tuning for optimum operation based on the design intent

Large scale and complicated facilities are often operated with little understanding of design intent. First, intended energy conservation functions should be utilized and then optimum tuning according to the operation status should be done.

[Case example] Appropriate operation of outdoor air processing air-conditioning machine in the kitchen

Outdoor air processing air-conditioning machine in the kitchen can manually control its air volume in steps according to the condition of cooking. However, we found that the function was not utilized because the operation was left to the restaurant company. We instructed the energy conservation function of the outside air processing air-conditioner, and as a result, both power consumption and cool and hot heat consumption were reduced.

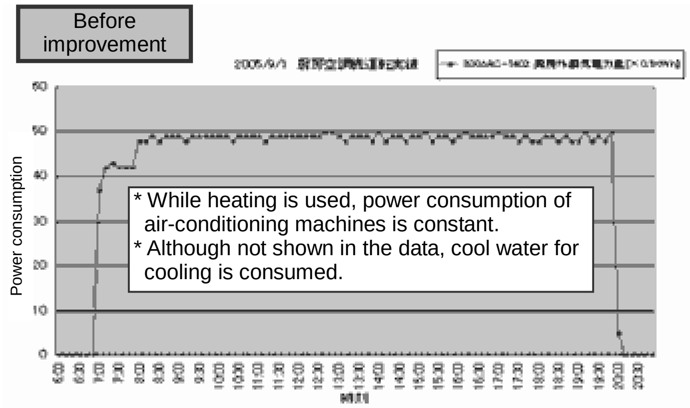

Fig.8 Improvement of how to operate outdoor air processing air-conditioning machine in the kitchen

[Viewpoint 2] Tuning to improve initial problems

Initial problems in new buildings are unavoidable; resolving these problems is a part of energy conservation tunings. If those problems are left unnoticed for a long period of time, it would be a significant amount of energy loss.

[Case example] Improvement of the position of the control sensor in the heat source heat exchanger

This facility conserves energy by large temperature difference water feed, but we found that in low load level the control is unstable and the temperature difference is not obtained and the feeding power increased Detailed analysis of these two situations revealed that the sensor position was not appropriate. By improving the sensor position, the two problems were resolved at the same time.

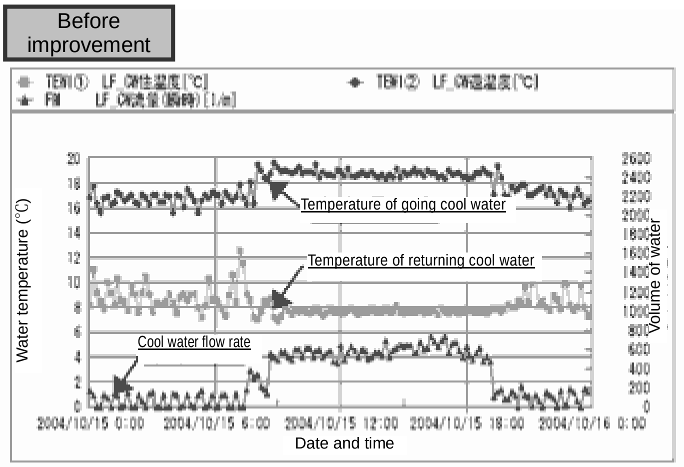

Fig.9 Stabilizing cool water circulation temperature

[Viewpoint 3] Tuning according to operation patterns

When the operation patterns change, tuning according to them is required. In addition, giving advice to operators bringing change of operation into view and to guide to the best operation is a part of energy conservation tuning.

[Case example] Setting function to automatically shift preset value according to business patterns

In operating air-conditioning system in shared areas such as restaurant and lounge, we set shift pattern of air conditioning machine's preset values according to the changing business pattern and reduced wasted air-conditioning energy.

[Viewpoint 4] Advanced tuning of facility

There are areas for tunings in places beyond the reach of operators such as PID values of automatic control. It requires time and cost to find the optimum setting values, but by comparing various data using the analysis tool to find the optimum parameter values etc. and enforce them at adjustment and maintenance work, efficient tuning can be done.

[Case example] Optimization of parameters to control air-conditioning machines

At initial adjustment, control parameters were set to a pattern so that the parameters become stable relatively early, but under current load, control response was too quick and mixing loss was caused. We modified the control parameters to eliminate loss.

5. Effects of the Countermeasures

(1) Primary Energy Reduction

The trend of primary energy intensity is shown in Table 3. Energy conservation is reliably promoted every year. In last year, which is the second year of this activity, the effect of energy conservation tuning was 97,665GJ/year and 2,066MJ/m^2 year, becoming close to the target value 15% compared to the initial year (2003).

Table 3 Trend of energy consumption record and intensity

Fiscal year	Primary energy (GJ/year)	Reduction rate to base (%)	Reduction rate compared to FY 2003 (%)	Intensity (MJ/m^2 year)
Base	125,093	–	–	2.646
2003'	113,103	9.6%	–	2.392
2004'	105,989	15.3%	6.3%	2.242
2005'	97,665	**21.9%**	**13.6%**	2.066

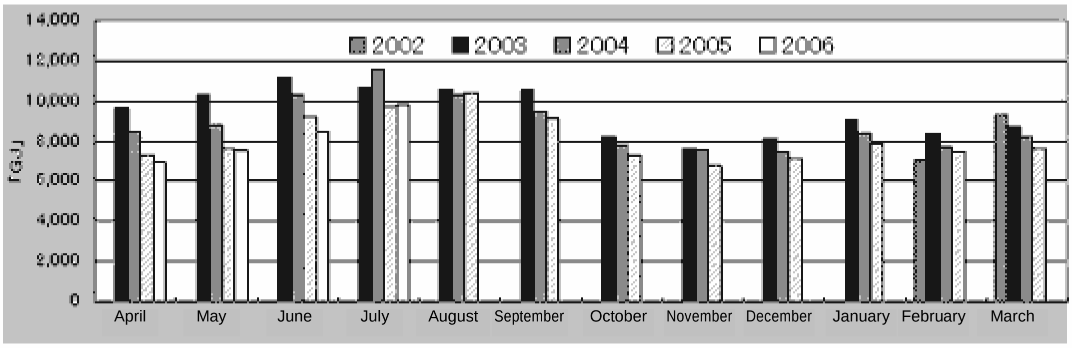

Fig.10 Trend of energy consumption

Energy consumption was significantly reduced not only during peak periods of air-conditioning, but also during interim periods. This can be attributed to energy conservation tunings such as reduction of fan power during partial load and elimination of mixing loss as well as effects of adjusting preset temperatures and reducing operation time etc.

(2) Cost-effectiveness

The cost spent on promotion of this theme was total 36,700,000 yen in the following four categories.

[1] Labor cost related to evaluation by experts: 8.49 million yen

[2] Cost of analysis tool: 3.4 million yen

[3] Additional measurement for tunings: 12.16 million yen

[4] Adjustment for tunings: 12.65 million yen

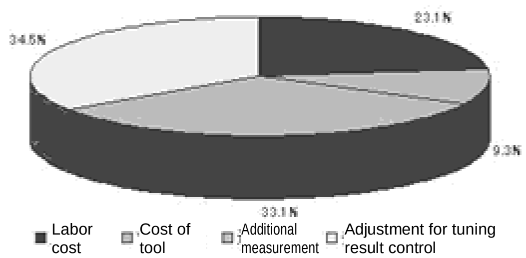

Fig.11 Breakdown of tuning cost

On the other hand, when we assume the total reduction of pure energy cost as the recovered amount, the reduced amount of energy cost in fiscal years 2004 and 2005 (April 2004 - March 2006) compared to the energy cost in fiscal year 2003 (April 2003 - March

2004) was 44.38 million yen.

Therefore, the simple payout time by the tuning effect is:

36.7 million yen / 44.38 million yen = 0.827 year

The average return on investment during the two years was less than one year. This is good enough.

However, the investment includes the following elements:

[1] Cost reduction effect is seen continuously, but the average was calculated based on the cost reduction amount in two years.

[2] Energy Conservation Expert Panel initially had 12 members, but currently, it is operated by 6 members as efficiency improves.

[3] Considering the continuous verification work in the future, we added experimental measurement points.

Therefore, we consider that investment was even lower and recovery was larger as the genuine achievement and the return on investment was even better. Compared to the construction investment (for facilities), this is less than 1 %. This is a model case in which the facility was made to energy conservation structure by considering energy conservation measures at construction stage.

6. Summary

By expanding the idea of “energy conservation tuning” to optimal operation based on the design intent, improvement of initial problems, tuning according to operation patterns, and advanced tuning of the facilities, we have achieved significant effects as shown below. Having verified the importance and effects of “energy conservation tuning” is a significant achievement that can be used as a model case for promotion of energy conservation activities in other facilities.

[1] From the viewpoint of “energy conservation tuning”, we obtained process and skills with which energy conservation can be continuously promoted.

[2] We established a mechanism to efficiently enforce experts participatory “energy conservation tuning” and verified its effectiveness.

[3] We developed (commercialized) "SatTool” that makes tunings more efficient and verified its effects.

[4] We kept energy conservation effect of about 6% annually, achieving reduction rate of 13.6% (97,665GJ/ year) in the second year.

[5] We verified “energy conservation tuning” with high return on investment (0.827 year).

[6] We identified many energy conservation improvement themes other than cooperation (patience) of facility users.

[7] We could share advanced knowledge about energy conservation by having people involved in facility operation join the activity.

As initial investment, we built infrastructure environment that is suitable energy conservation tunings; in the operation phase, we considered involving specialists as well as residents and operators (considering efficient investment with low cost) in promoting energy conservation promotion activities with the viewpoint of “energy conservation tuning”, which lead to significant energy conservation effect (in other words, detection and improvement of potential energy losses). While energy conservation activities promoted by cooperation of residents such as Cool Biz shows certain achievements, we believe that “energy conservation tunings” is one of beneficial methods that realize next stage energy conservation “continuously” and “developmentally”.

7. Future Plans

“Energy conservation tunings” in Shiodome Building is continuing. We think it is important to “maintain and continue the current energy conservation status” and make efforts to “continuously discover new energy conservation elements”. We keep the PDCA management cycle of “energy conservation tunings”. To further spread and expand these activities, we have started the following efforts:

- Horizontal development of these activities to our major facilities

  (Developing in major 7 facilities (buildings))
- Building method to share analysis know-how with building managers etc.

  Building and sharing know-how database etc.)
- Training inside specialists

  Improve skills within the company and accelerate horizontal development)
- Utilize these efforts as a case example of utilizing energy conservation related products including “SatTool”.
- Achieving and accumulating the energy conservation target 15% as the result of “energy conservation tunings” of this building

We would like to keep promotion of energy conservation by “energy conservation tunings” in our facilities and utilize know-how obtained in our facilities to future products and services to contribute to energy conservation by “energy conservation tunings”.

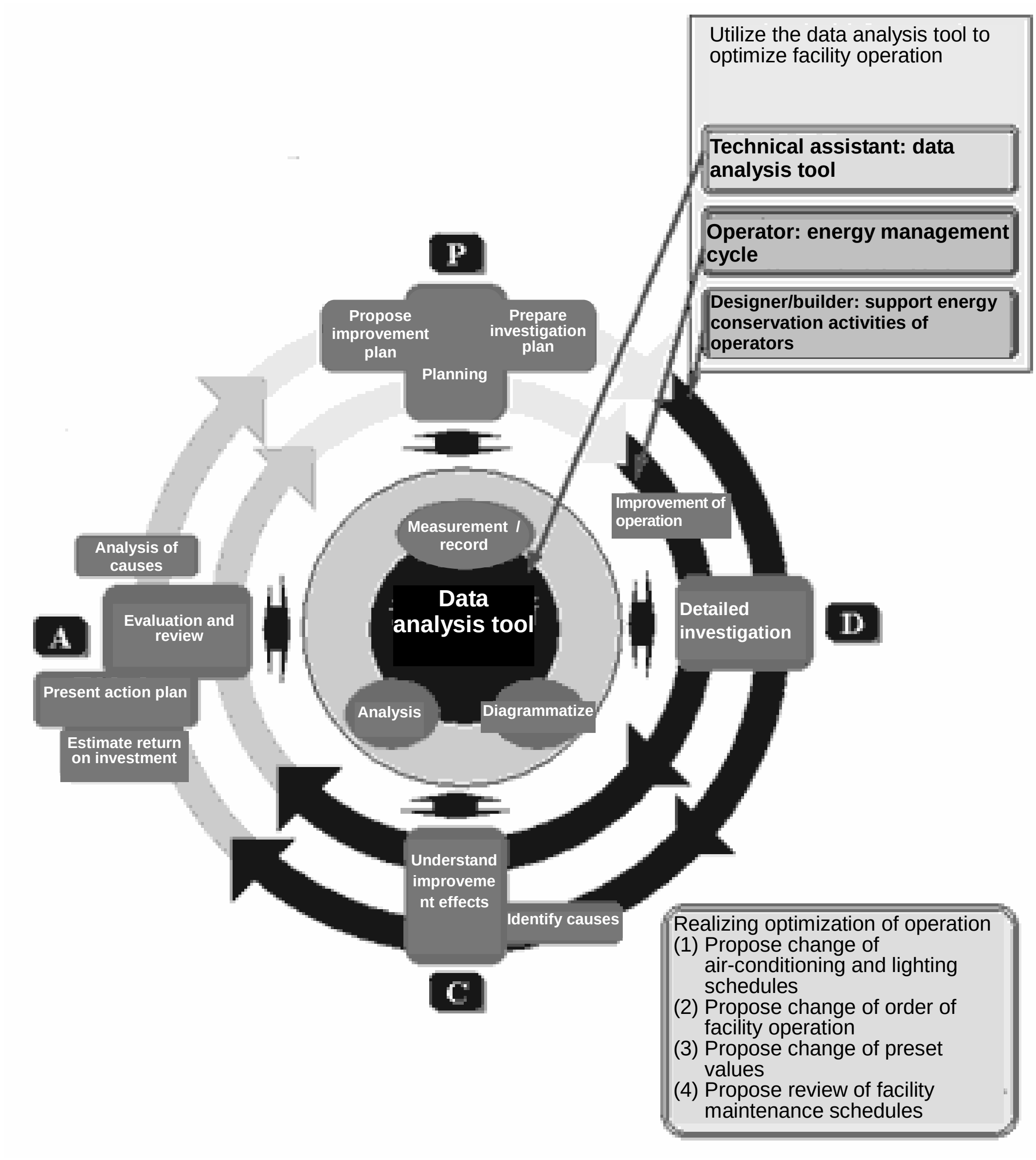

Fig.12 Management cycle of energy conservation tunings