May 10, 2004
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Cases of Energy Saving Activity by Management System on the Web for Visualization Presentation of Energy Consumption

1. Introduction

The Fukuyama Works acquired certification of ISO14001 (environmental management system) in November 1997. In starting a series of activities aimed at acquiring the ISO14001 certification, the Fukuyama Works reflected upon its past energy saving activities that had tended to be concentrated on certain divisions in charge of environmental management, and introduced a system of objective management for each division. Also, the Fukuyama Works began promoting energy saving based on the "energy per unit production" management of each facility. This management system was designed to make intrinsically invisible energy consumption visible to everybody. The Fukuyama Works has incorporated energy saving activities in the system of ISO14001 to promote participatory energy saving activities, and has scored marvelous achievements. The following pages explain some of these energy saving activities in the Fukuyama Works.

2. Executing Organization and Approach

(1) Promotion of ISO14001

The works established the following three priority aspects (keywords) and promoted energy saving mainly in these three aspects.

- Quantitative definition of targets
- Promotion of activities by all concerned divisions at all levels
- Clear definition of the means and timetable to achieving the targets

(2) Nomination of persons responsible for energy saving of facilities according to substations in the works

The works defined responsibility and authority for energy saving for each of the sections tributary to 22 substations in the works' premises, and nominated person responsible for the sections, one for each.

(3) The works devised a system in which plans and performances of all divisions are visible for every person (or a system in which invisible energy is made visible).

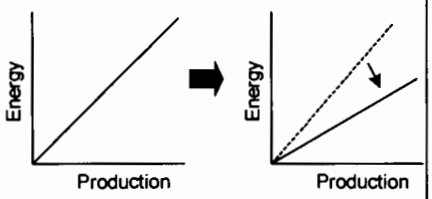
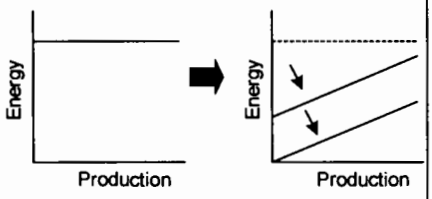
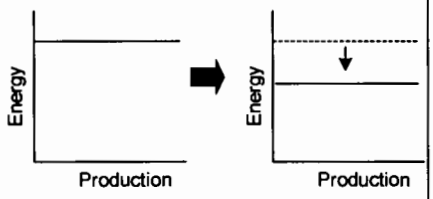
- The environmental management program of each division integrates quantitative targets of energy saving, means to achieve the targets, and schedules for achieving the targets.
- The electric power consumption is monitored at each level of distribution; namely, central receiving station, local substation, section (shop), manufacturing line (facility); thus, energy saving in electric power is grasped to the final end of distribution.
- The system for energy saving permits the intranet to graphically display the plan and performance in energy saving of each division on its 700 terminals. (This is also done on the state of reducing other environmental loads other than energy saving.)
- Regarding electric power consumption in particular, the planned daily consumption and actual daily consumption for one year are graphically shown on the intranet.

(4) Major viewpoints in energy saving

The 21st century is the century for improvement of resource productivity (while the 20th century was the century for improvement of labor productivity and output productivity). It is important from this standpoint that energy management in which energy consumption is proportional to production amount of products be realized. For this purpose, the "energy per unit production" management must be done individually for each production line. (In other words, the key point for the success in energy saving is establishment of a management system interlocked with the production amount.)

All incidents of energy consumption in the works are divided into production-related consumption and production-unrelated consumption, and the former incidents are further divided into variable consumption and fixed consumption with respect to production amount. The works endeavors to establish a system resistant to production variation by converting the fixed consumption into variable consumption to build an energy management interlocked with production amount. (In other words, the intended energy management system permits using just a required amount of energy when and where it is necessary.) The figure below shows the basic concept for reduction of electric power consumption.

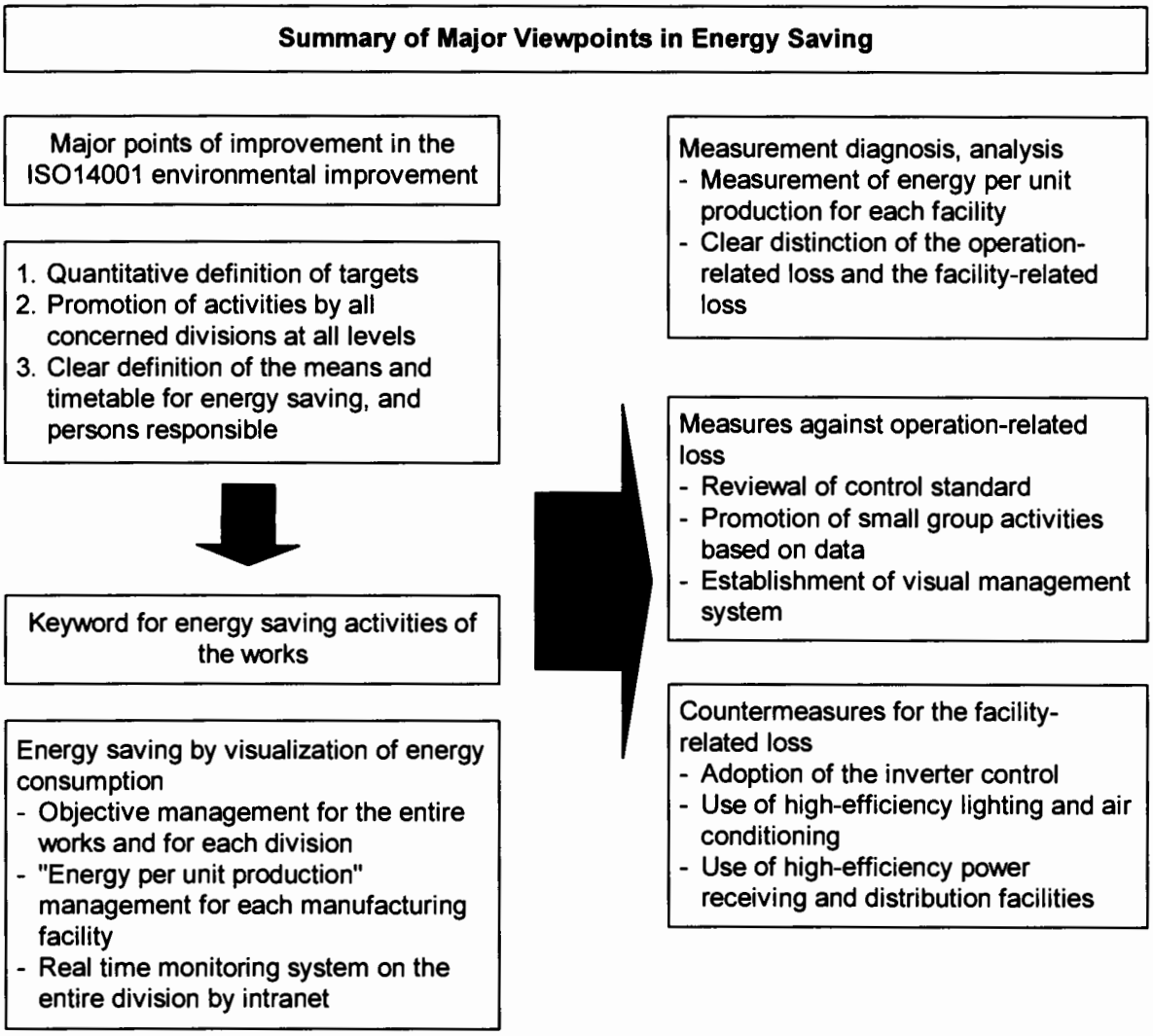
Basic Consideration for Energy Saving Approach

Reduction of electric power consumption	Production-related	Variable consumption		· Assembling facilities · Machine processing facilities · Plating and painting facilities	· Improvement of time efficiency in continuous production · Reduction of idling operation of facilities · Reduction of loss by TPM	· Introduction of high-efficiency facility · Reviewal of manufacturing process · Utilization of natural energy (adoption of natural lighting, photovoltaic power generation)
		Fixed consumption		· Peripheral auxiliary facilities (feed conveyer, discharge motor, etc.) · Air-conditioning machine for the facility · Lighting equipment for the facility · Plant air (compressor)	· Complete interlocking with operation for production · Reviewal of management standard	
	Production-unrelated consumption	Fixed consumption		· OA facility and equipment · General air conditioning · General lighting · General ventilation · Electric power for security purpose	· Operation interlocked with the manual work · Schedule control · Occupancy sensor · Electric power saving mode	

(5) Summary of major viewpoints for energy saving

It is important that everyone in the works can see realtime on the intranet the state of energy consumption and energy saving activities on a system based on the structure of the ISO14001 system (environmental management system).

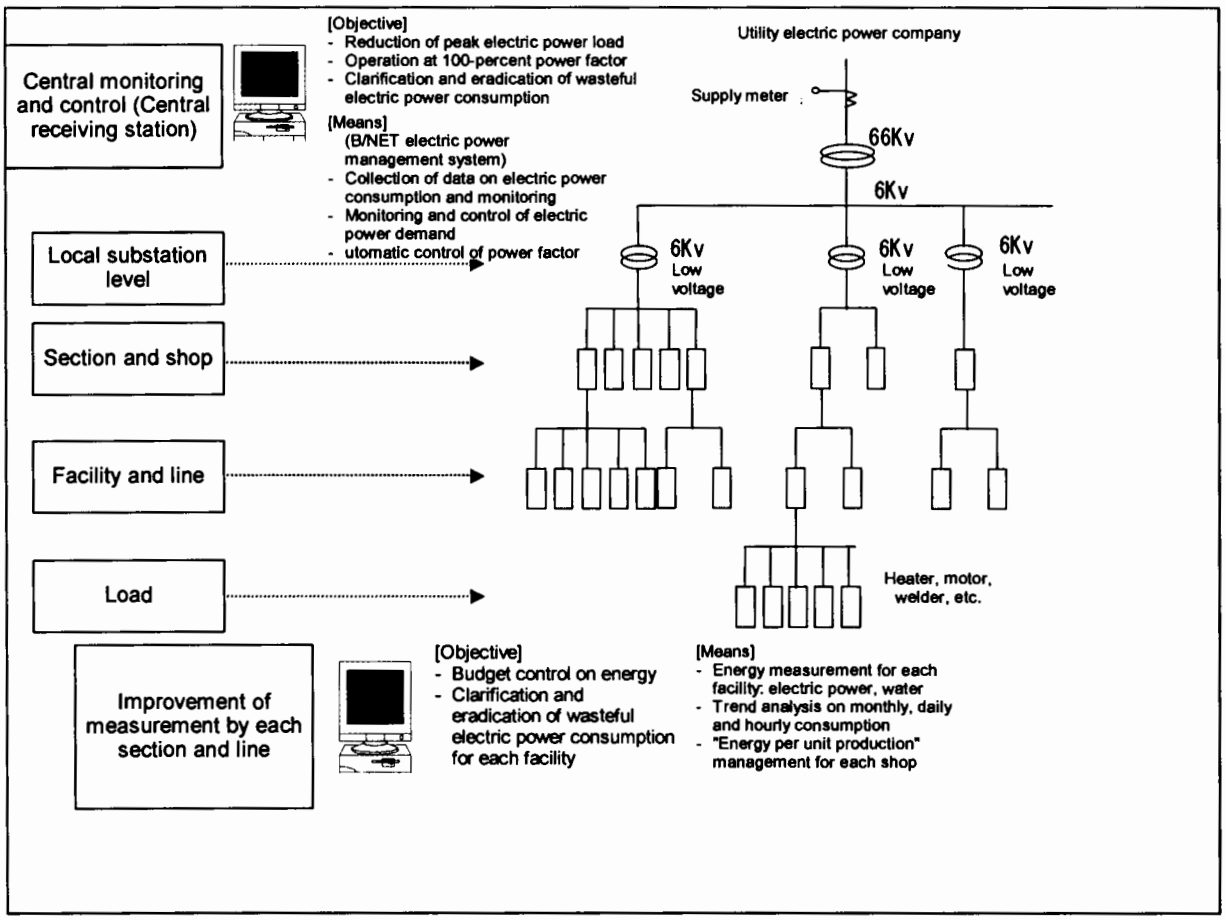
There are two keywords for energy saving. There are: 1) energy loss attributable to energy management (consumption of energy while the machine is not in operation to produce the products). 2) energy loss attributable to the conditions of facilities (energy loss caused by obsolescence of facilities). It is important that these losses be analyzed by means of energy saving measurement diagnosis. The outline of such operations is schematically shown in the figure below.



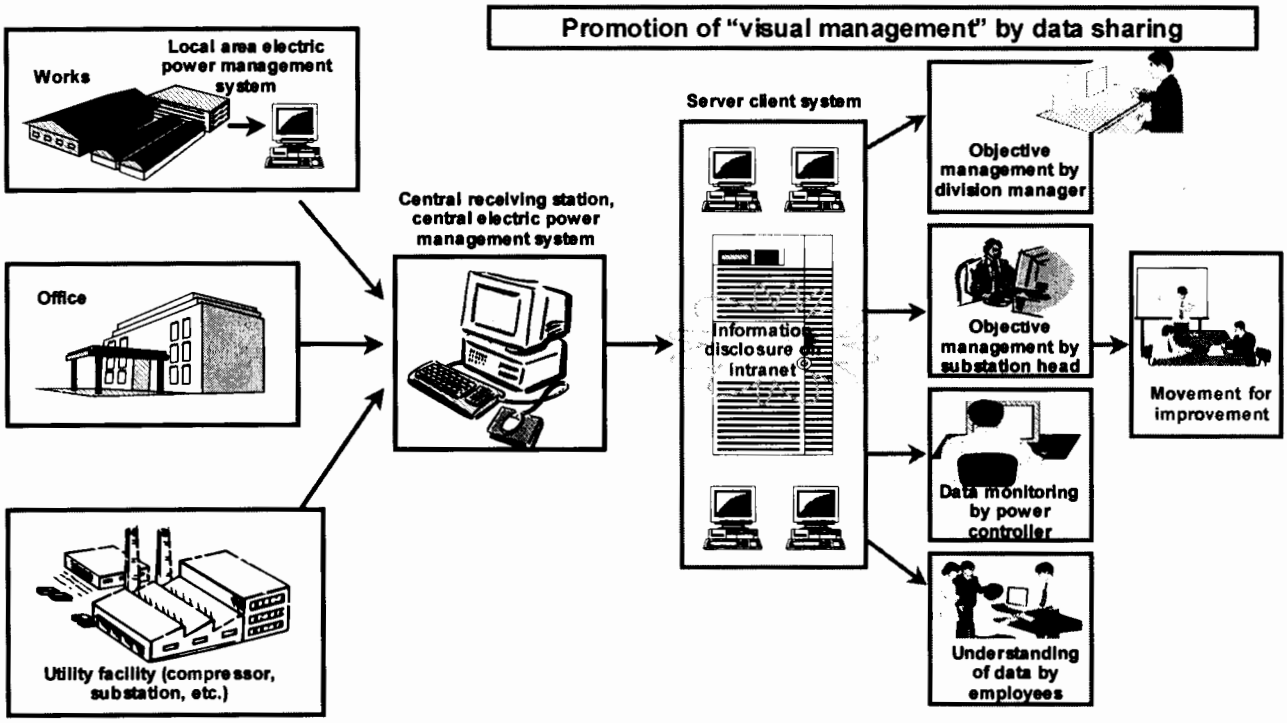
3. Establishment of Electric Power Management System in the Works (Establishment of Management and Monitoring System)

The electric power management system conducts measurements and monitorings at the following levels in the hierarchy; namely, central receiving station, substations, sections (shops), production lines (facilities). The central receiving station conducts overall management and monitoring of the works, and the sections and shops conduct "energy per unit production" measurement by their respective facilities and lines, using simple PC-controlled measuring systems, and improve energy consumption at their levels. The subsequent page shows a representative example of monitoring energy saving and electric power consumption management, outline of the electric power management system, and control graphs, being done on the works' intranet.

Example of Energy Saving Monitoring and Electric Power Management



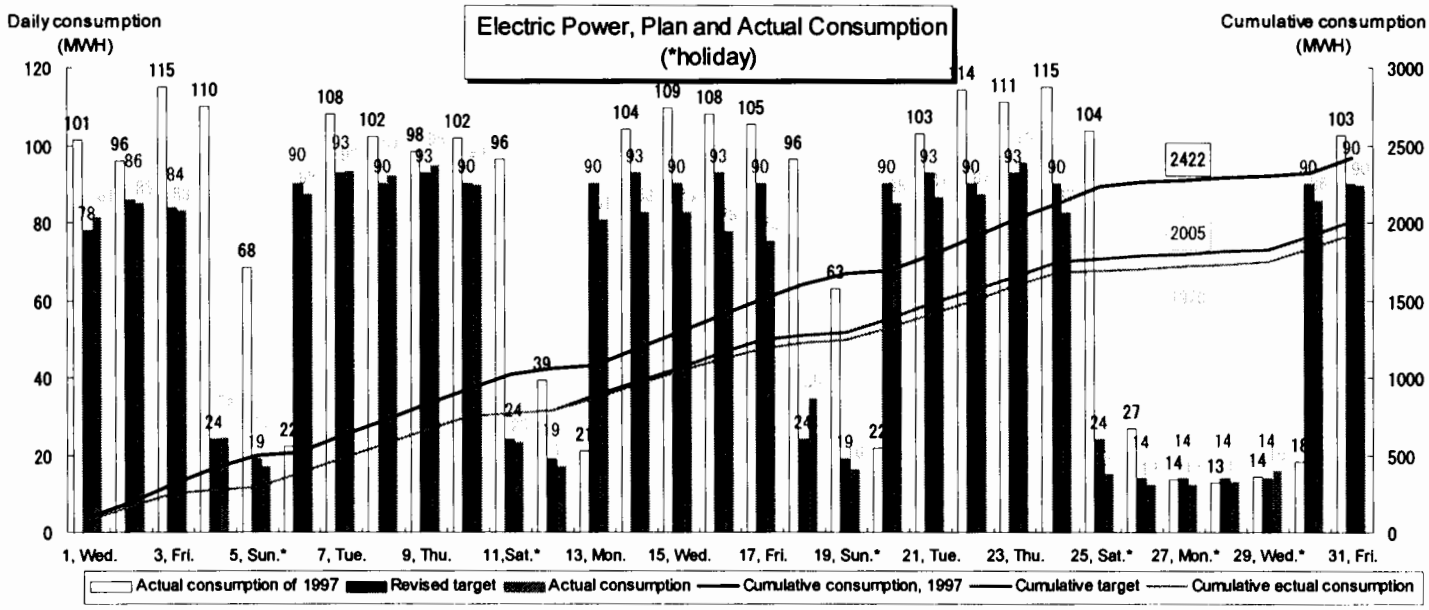
Schematic Diagram for Electric Power Management of Fukuyama Works



Daily Electric Power Consumption Graph (plan / actual consumption), Example

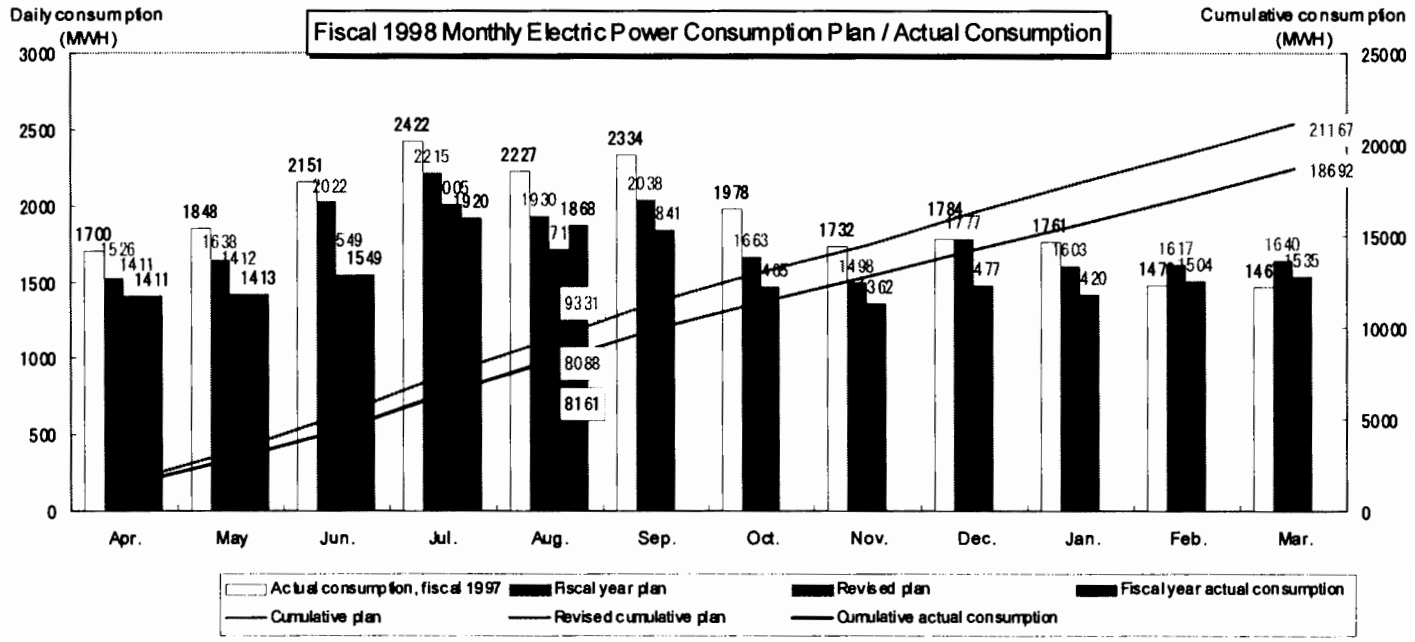
Monthly Electric Power Control Data for July

Electric power (MWh)	Jul-97	Jul-98		Comparison with the same day of the preceding year		
	Preceding year's record	Revised target	Reduction	Actual consumption	Actual reduction	Effect of reduction
	2422	2005	-417	1920	-502	9,035 (thousand yen)



Monthly Electric Power Consumption Graph (plan / actual consumption)

		MWH/year	Comparison with fiscal 1997 record	
Fiscal 1997 record		22880	Planned reduction	Actual reduction for the month
Fiscal 1998	Plan	21167	-1713	
	Revised plan	18692	-4188	-2187



4. Establishment of Energy Saving Improvement System by Means of Model Energy Saving Shop Activity

(1) Keyword for energy saving

It is important to promote activities focused on the manufacturing facilities in the workplaces, which together consume a greater portion of the works' energy, regarding the works' energy saving activities as an aspect of workplace improvement activities.

Shown below are keywords for energy saving activities.

Action category	Viewpoint	Typical action
Abandon	Study the necessity of the facility and stop doing what is not necessary	Turn off unnecessary lights, shorten piping length, shorten warming operation time of machines
Discontinue	Discontinue unnecessary running	Execute air blowing when necessary instead of continuously, stop machine during recess, discontinue idle operation
Lower	Lower pressure, temperature, etc., after reviewing operation conditions	Lower pressures of air and steam, lower heated temperatures, lower discharge volumes of water and air of pumps and compressors
Correct	Inspect operations and correct irregularities	Stop air leaks, repair vacuum pipes, repair damaged insulators, clean lighting equipment
Recover	Recover waste heat, conduct recycling	Recover waste gas and waste hot water, use residual heat, conduct sorted collection of wastes, use easy-to-recycle structures
Change	Change to inexpensive energy or to more efficient equipment	Change from electricity to city gas, kerosene, or heavy fuel oil, adopt sodium-vapor lamp, adopt heat pumps, use servo motors instead of hydraulic drive for injection molding machine

(2) Setting up of a model shop for "energy per unit production" measurement by facility

One of the means to carry out energy saving keywords is "energy per unit production" measurement by facility. Measures for promoting energy saving include renewal of facilities and reduction of operating loss (idling loss of facilities), the "energy per unit production" measurement is an effective means for the latter route. This standpoint is effective in total participatory energy saving activities such as those for small group activities. This approach is not very costly but very effective in energy saving.

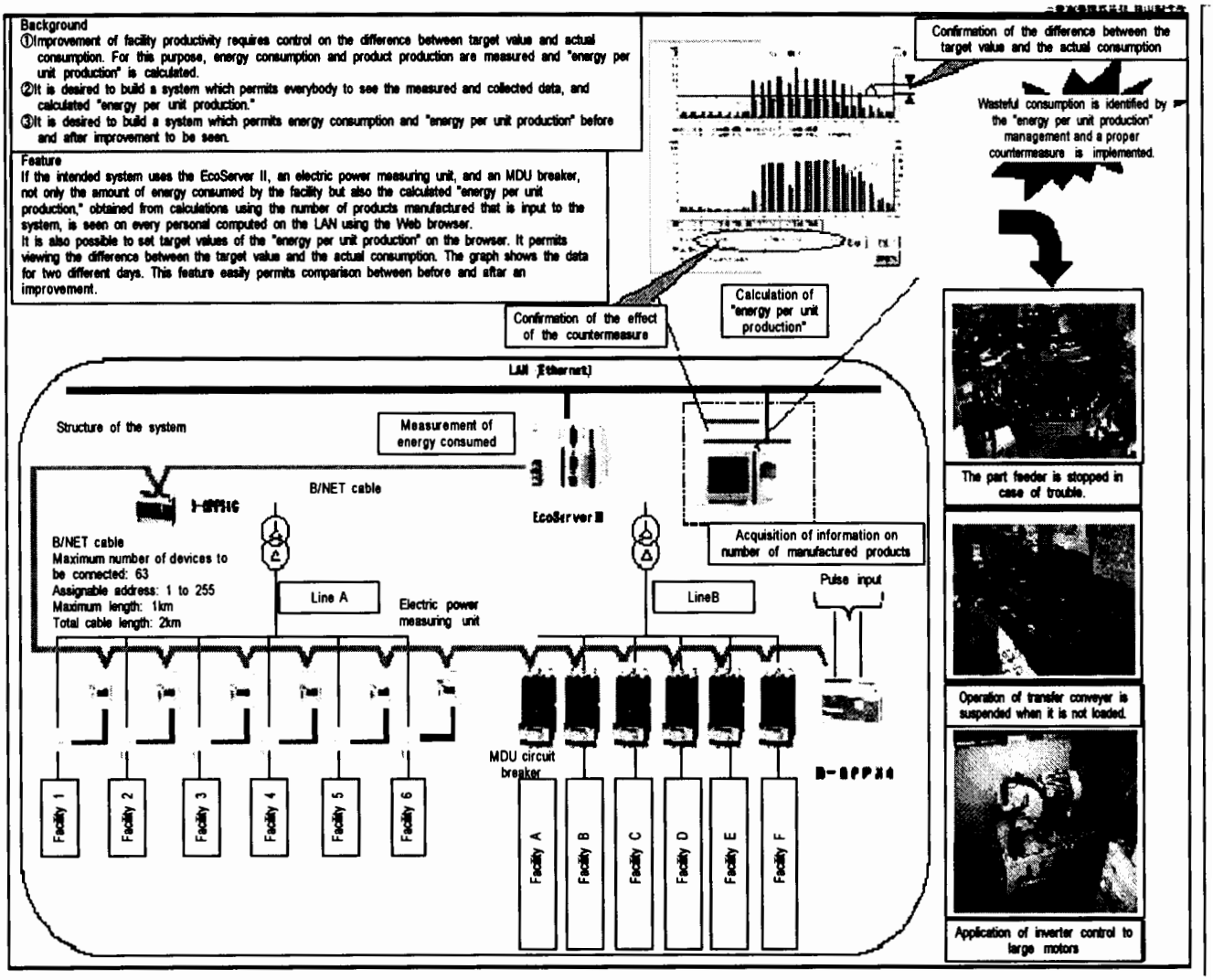
The "energy per unit production" measurement is done by measuring product production and electric power consumption, and to obtain energy consumption per unit production.

The keyword for analysis is that just a required amount of energy for production is used when and where it is necessary. Generally, by using graphical expression of

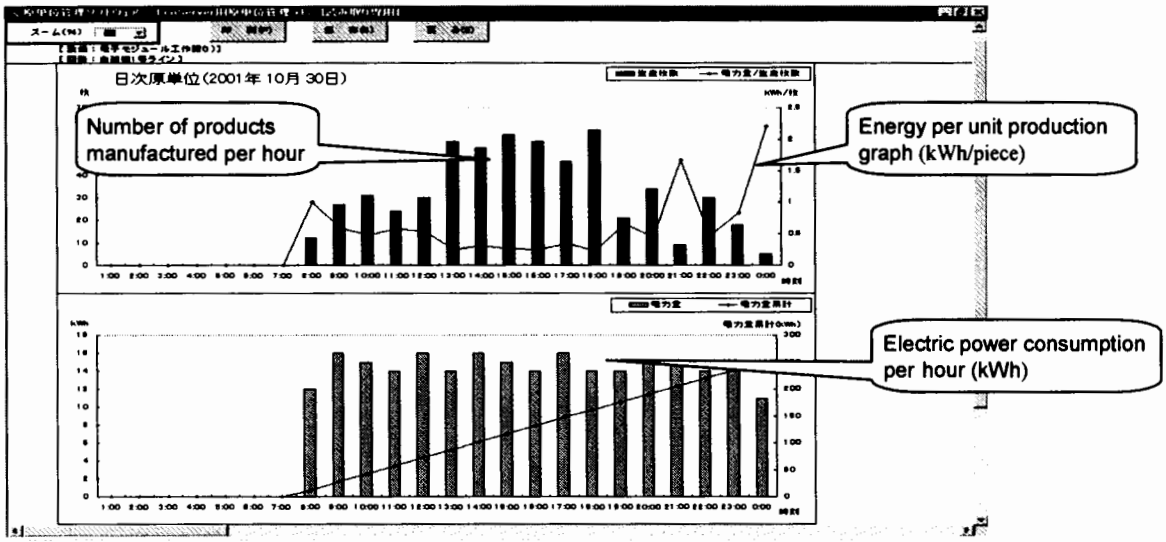
hourly measured electric power consumption per unit production, energy wasting of 10% to 30% becomes obvious.

The following figure shows an example of the systems for "energy per unit production" measurement and graphical presentations of measured results.

An Example of Model Shop for "Energy per Unit Production" Measurement of Machine Factory



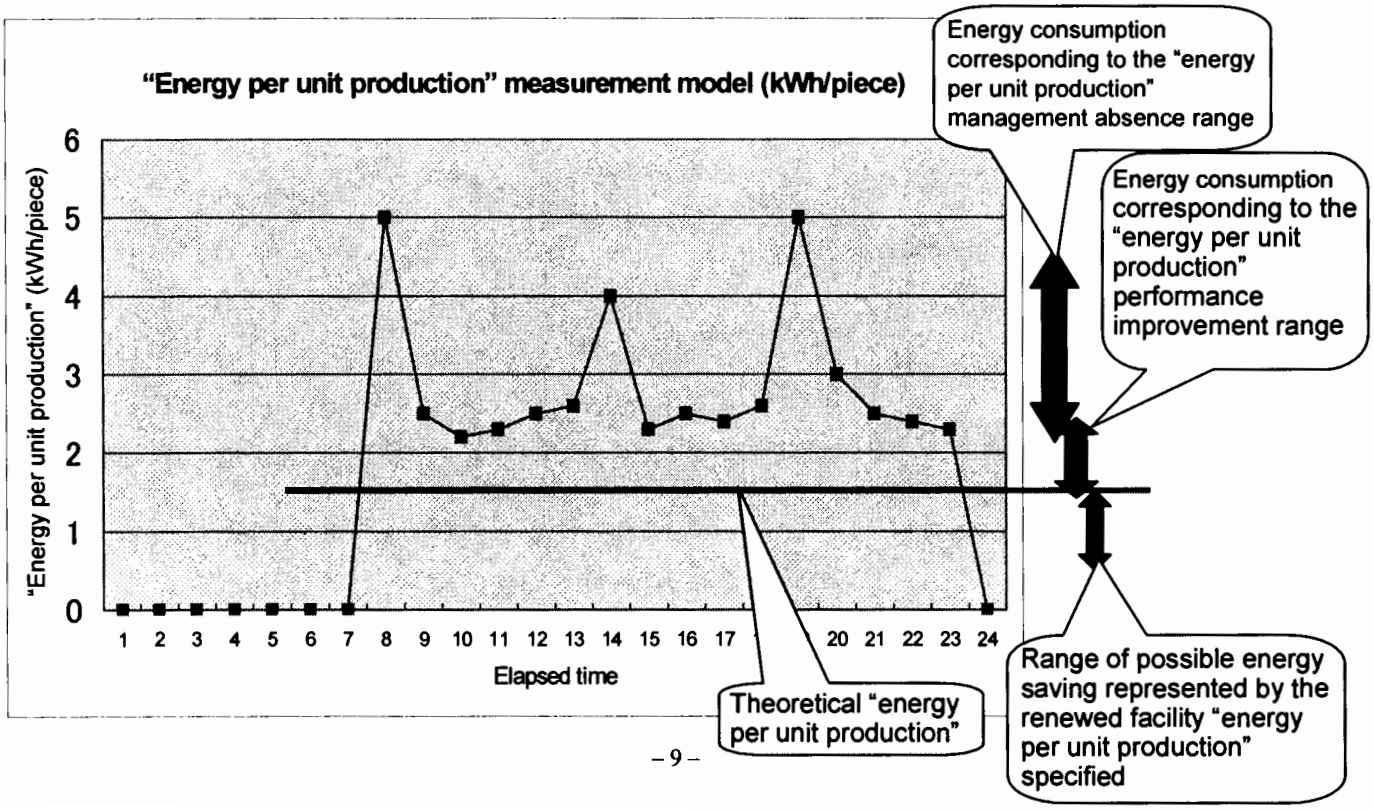
Graphical Expression of Measured "energy per unit production"
(Variation of Electric Power Consumption per Production per Hour)



(3) Model for "energy per unit production" measurement by facility

The method for analyzing the graphs for "energy per unit production" varies from one production facility to another. Here, an analytical model based on the concept that just a required amount of energy for production is used when and where it is necessary is presented.

"Energy per Unit Production" Management Absence Range and Energy per Unit Production Improvement Model



The "energy per unit production" measurement helps define the following three ranges. These are: 1) "energy per unit production" management absence range, 2) "energy per unit production" performance improvement range, and 3) renewed facility "energy per unit production" specified range. The energy saving in the "energy per unit production" management absence range, or 1), represents energy saving of the workplace when production is not done, or prevention of wasting of energy. Facilities that are running when no production is done and auxiliary facilities concerned with cooling water, for example, should be examined to find clues for energy saving. The "energy per unit production" performance improvement range, or 2), is a range where ideal energy consumption should be considered to be the theoretical "energy per unit production," and the difference between the theoretical "energy per unit production" and the actual one is studied for possible improvement. This is the range where facility engineers assume the major responsibility for improvement. For this reason, this range is named "energy per unit production performance improvement range." The renewed facility "energy per unit production" specified range, or 3), represents a range where the theoretical "energy per unit production" is to be improved. When a facility is renewed, target "energy per unit production" is defined in the equipment specifications to the equipment manufacturer. The target unit energy consumption is the value at which energy consumption should be managed for the sake of subsequent facility renewal.

Execution of medium- and long-range "energy per unit production" measurement enables continual improvement in energy saving.

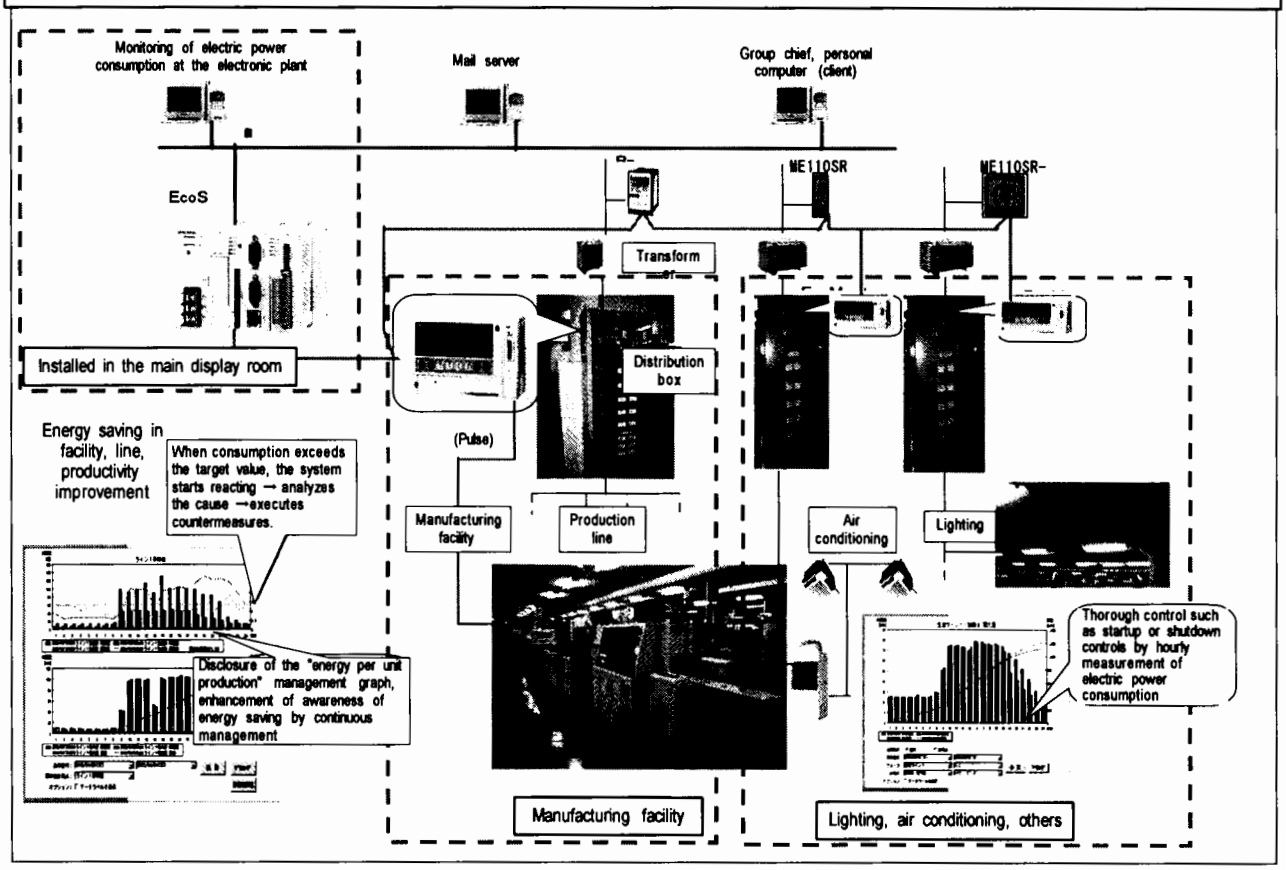
5. Achievement

(1) The works has achieved much by incorporating energy saving promotion in its activities of the ISO14001 environmental management system. At the same time, Fukuyama Works has been able to make an energy-saving plant out of itself which conducts minutely controlled energy management at facility level, facility group level and process level, which constitute one of criteria for evaluation of plants under the Law concerning Rational Use of Energy. The "energy per unit production" measurement management for each division and for each facility has proved to be very effective in promoting energy saving.

(2) An energy saving model shop of electronic module plant

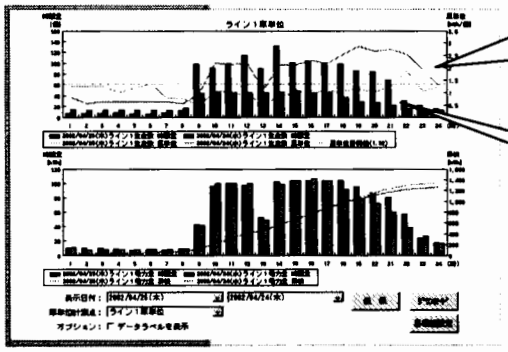
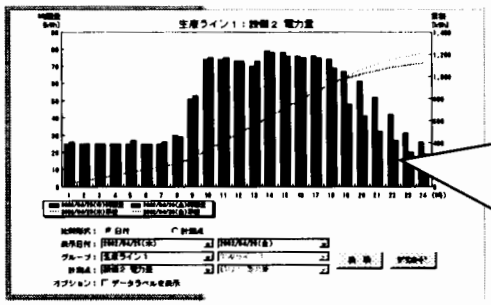
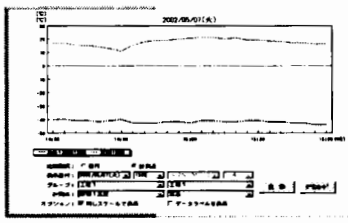
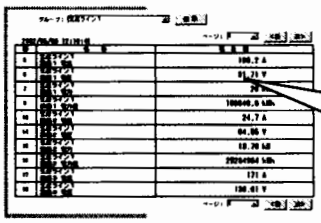
1) Outline of the system

Model Shop — Energy Saving System of Electronic Module Plant



Everyone can access the shop server (EcoServer) from the terminal (client) of the intranet to see in real time graphical representation of "energy per unit production" of any manufacturing facility, electric power consumption of lighting equipment, or air-conditioning facility. From the analysis of these graphs, the shop explores electric power consumed in waste and uses such information for improvement.

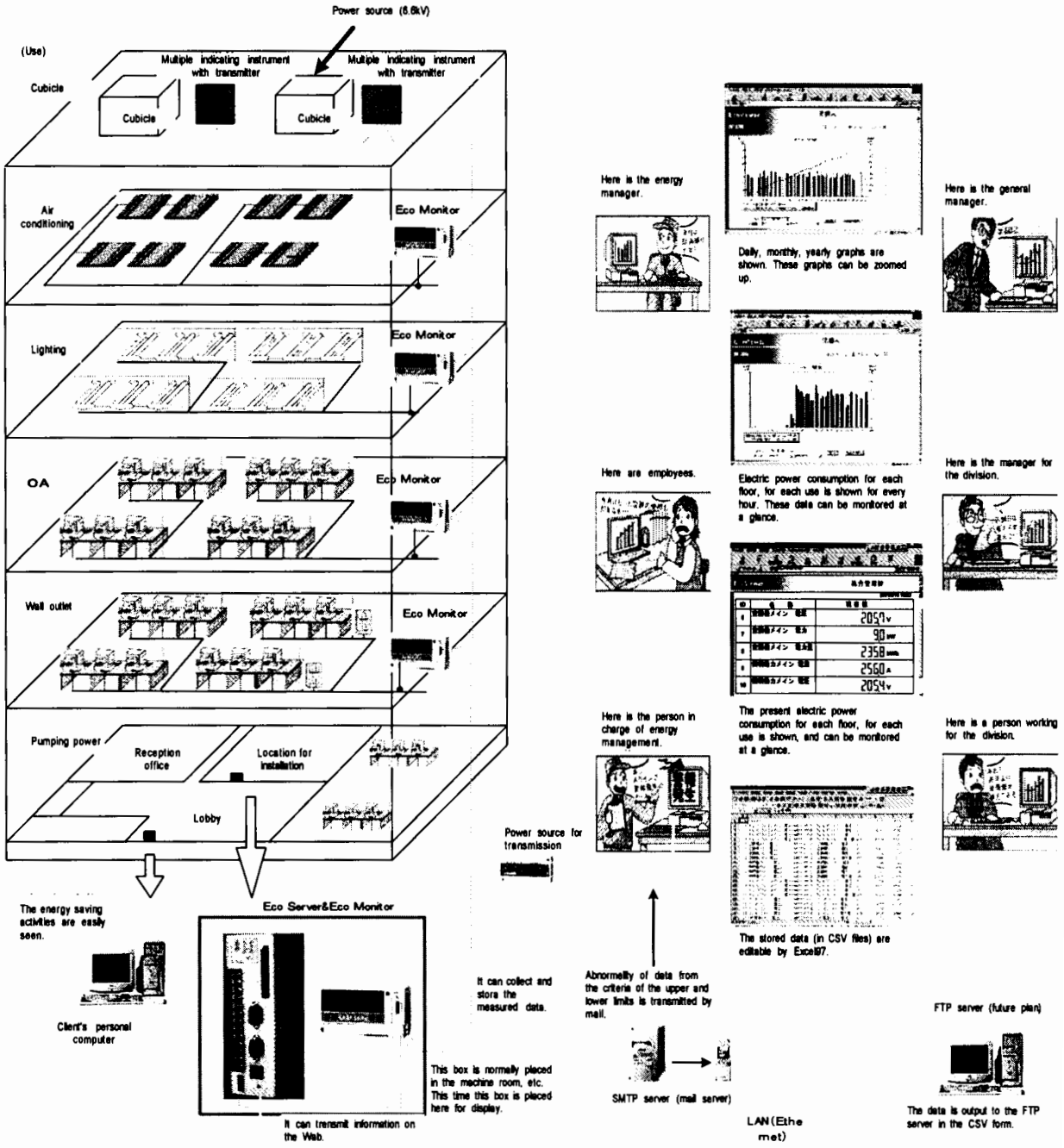
2) Achievement by the activities at the electronic module plant

Items for energy saving endeavor	Energy saving effect
1. Productivity improvement of the line and facility · Identification of energy loss by the "energy per unit production" management graph and reduction of the identified loss · Enhancement of employee's awareness by continuous management (1) Production facility  When consumption exceeds the target value, the system starts reacting → analyzes the cause → executes countermeasures. Disclosure of the "energy per unit consumption" management graph. Enhancement of awareness by continuous management	23.5%
2. Energy saving in air conditioning and lighting · Thorough control such as startup or shutdown controls by hourly measurement of electric power consumption (2) Air conditioning facility (3) Lighting facility (4) Others  ①Thorough control such as startup or shutdown controls by hourly measurement of electric power consumption ②A switch left on in waste is seen. ③Change in the electric power consumption graph is seen when the air conditioner set temperature is varied. All these lead to enhancement of awareness.	8.0%
3. Compliance with the Law concerning the Rational Use of Energy · Reinforcing the energy management by preparation of the summary table and the management standard   Now, this amount of electric power is used. The condition is OK.	Improvement of energy management
Total	31.5%

The electronic module plant realized energy saving of 23.5% by the improvement of the manufacturing facilities and 8% by the improvement of lighting and air-conditioning facilities. Most of such saving was realized by reduction of wasteful energy consumption occurring when manufacturing activities are not done, and is the result of visualization of energy consumption associated with production activities. In this sense, the "energy per unit production" management is particularly important.

(3) Activities at a model shop of general management building

1) Outline of installation of a shop server and an eco monitor



The shop server (EcoServer) automatically collects in real time information on electric power consumption for each floor and for each use (lighting circuit, air-conditioning circuit, OA circuit, wall outlet circuit) from the Eco Monitor, which is a terminal equipped with a function of multi-circuit electric power measurement and transmission, installed in the distribution box on each floor. Everybody can see the data in the shop server in real time on the intranet indicating the state of electric power consumption (in the forms of time graph, five-minute graph, etc.).

2) Steps of activities and example of improvement

Measurement
Collection of energy saving data by the Eco Server.

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Visible management
① Enhancement of employees' awareness of energy saving by data disclosure
② Promotion of energy saving by means of numerical target control

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Representative measures
1. Lighting
   ① Not turning on the light before business hour begins at (8:45)
   ② Turning off the light during the lunch break (12:15 to 13:00)
   ③ Turning off lights during the overtime work hours
2. Air conditioning
   ① Not starting air conditioner until the business hour begins at (8:45)
   ② Thorough enforcement of controlled temperatures (cooling at 28°C and heating at 18°C)
3. Thorough enforcement of work regulation
   ① Establishment of general holidays (Wednesday and Friday)
   ② Thorough enforcement of the special permission rule on midnight work (yellow card)

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Energy saving effect
24% achieved

(4) Other model shops

Other energy saving model shops (machine part processing factory, surface treatment factory, assembly plant, etc.) have been able to achieve 10 to 30 percent energy saving on their respective entire shops by introducing the energy saving measurement system on the web.

(5) Examples of operation-related improvement and facility-related improvement in energy saving

Representative items for energy saving by "energy per unit production" measurement diagnosis for manufacturing facility:

	Orientation of operation improvement	Orientation of facility improvement
Manufacturing facility	1. Operating only when products are manufactured: reviewal of the operation standard 2. Clear definition of facility operation schedule 3. Setting of the energy saving schedule timer (production starting up, production slowing down, operation setup change, operators' break) 4. Strengthening of control on insulation of facilities, on exhaust gas treatment 5. Minimization of short-time operation suspensions when operation setup is changed 6. Reviewal of operation standards on turning off electricity when the facility is down 7. Minimizing material and product inventories in the holding furnace and refrigerator when operation is not done, and strengthening of thermal insulation 8. Reviewal of energy standards for production of versatile products in small lots	1. "Energy per unit production" management system for manufacturing shop, for manufacturing line, for facility 2. Control system of the facility operation schedule 3. Application of inverter control to transportation facilities such as conveyer 4. Operation control interlocked with variation in production (application of inverter control) 5. Application of thermal insulation to facilities (thermal insulating material, thermal insulating wall) 6. Strengthening of thermal insulation of electric furnace
Compressor	1. Strengthening of inspection on air leakage 2. Use of proper air pressures (discharge pressure, pressure used for works) 3. Lowering control of the suction temperature in the summer season 4. Thorough execution of right opening and shutting of air valves at each workplace and on each facility 5. Reviewal of air blower pressure and operation time 6. Thorough control on cooling water temperature	1. Reviewal of pipe pressure drops 2. Loop pipes 3. Machine number operation control 4. Replacement of the existing compressor with one equipped with inverter control 5. Selection of receiver tank capacity suited to load variation 6. Reviewal of root blowers, etc.
Auxiliary facility	1. Suspension of hydraulic pump operation when the production is not done 2. Suspension of dust collector operation when the production is not done 3. Reviewal of control standards for auxiliary facilities for the startup time, set up change time, maintenance time 4. Reviewal of operation standards for auxiliary facilities for the time when the production is not done	1. Application of inverter control to the exhaust fan, roof fan, draft fan 2. Application of inverter control to the hydraulic pump 3. Application of inverter control to pumps operated during the holiday (painting plant, wastewater treatment facility)
Others	1. Energy saving achievable by improvement of yields 2. Reviewal of facility operation standard during the maintenance time 3. Improvement of "energy per unit production" by rapid increase of production rate after startup 4. Energy saving by increasing the operation rates of facilities	

Representative items for energy saving for the power distribution, lighting and air conditioning facility:

	Orientation of reduction of the operation-related energy loss	Orientation of facility improvement
Power distribution facility	1. Improvement of the demand factor of distribution transformer 2. Shutting down of idle transformers when under medium load 3. Thorough execution of shutting down of specified transformers when the production is low 4. Reviewal of demand management standards 5. Implementation of positive demand reduction measures, etc. during the summer peak period (shift of production from 13:00 to 16:00 to another time period) 6. Establishment of management standards for power factor at 95%	1. Integration of the electric power management system and the "energy per unit production" management system for facility 2. Replacement of the existing transformers with high-efficiency transformers 3. Installation of the demand controller and adoption of automatic load control 4. Additional installation of phase advance capacitors and installation of automatic power factor regulators
Lighting	1. Establishment of the illuminance control standards and workplace patrolling 2. Thorough and minute execution of turning off the light in the non-working places and times (lunch break, etc.) 3. Thorough execution of turning off the light in the natural daylight areas (guard room of the front entrance, porch, lobby, areas by the windows, goods disposal area, etc.) 4. Reviewal of balance between the ceiling area lighting and local lighting 5. Thorough executing of turning off the internal lights of automatic vending machines 6. Cleaning of skylights 7. Reviewal of uses of the timer for outdoor lights, and illuminance sensors	1. Installation of occupancy sensors, illuminance sensors, timers 2. Installation of skylights 3. High-efficiency lighting equipment 4. Use of system lighting with light controlling system, automatic scheduling control, illuminated area control
Air conditioning	1. Thorough enforcement of heating and cooling control temperatures (18°C, 28°C) 2. Clear indication of the air conditioning time control standard and thorough enforcement 3. Strict control of air conditioning for holidays and overtime working hours when a smaller number of people are working 4. Clear definition of the cooling water temperature, cooling water temperature control standard, and efficient operation 5. Reviewal of cooling tower control for the winter season	1. Adoption of cooling by ice thermal storage system (eco ice) 2. High-efficiency air conditioning system 3. Demand management system by air conditioning control 4. Adoption of demand leveling system by controlling demands of multiple outdoor machines

5. Conclusion

In the 21st century, prevention of the global warming presents a serious challenge to business enterprises. Of a number of measures against the global warming issue, the energy saving will be the core measure.

Energy saving measures by business enterprises have tended to be concentrated on introduction of high-efficiency facilities or replacing the old machines with new and more efficient ones in their utility systems (such common facilities as air-conditioning facility, refrigerating facility, compressor, duct collector, lighting facilities).

Recently, increasing attention is being paid to manufacturing facilities, or improvement of electric power consumption per unit production in relation to in the operation-related energy loss in the production line of each production facility, the latter being more important players in energy consumption. This tendency also means development of participatory energy saving activities focused on improvement of workplaces. A significant energy saving may be expected by establishing an effective system on the web whereby energy, intrinsically invisible, is made visible to everybody.

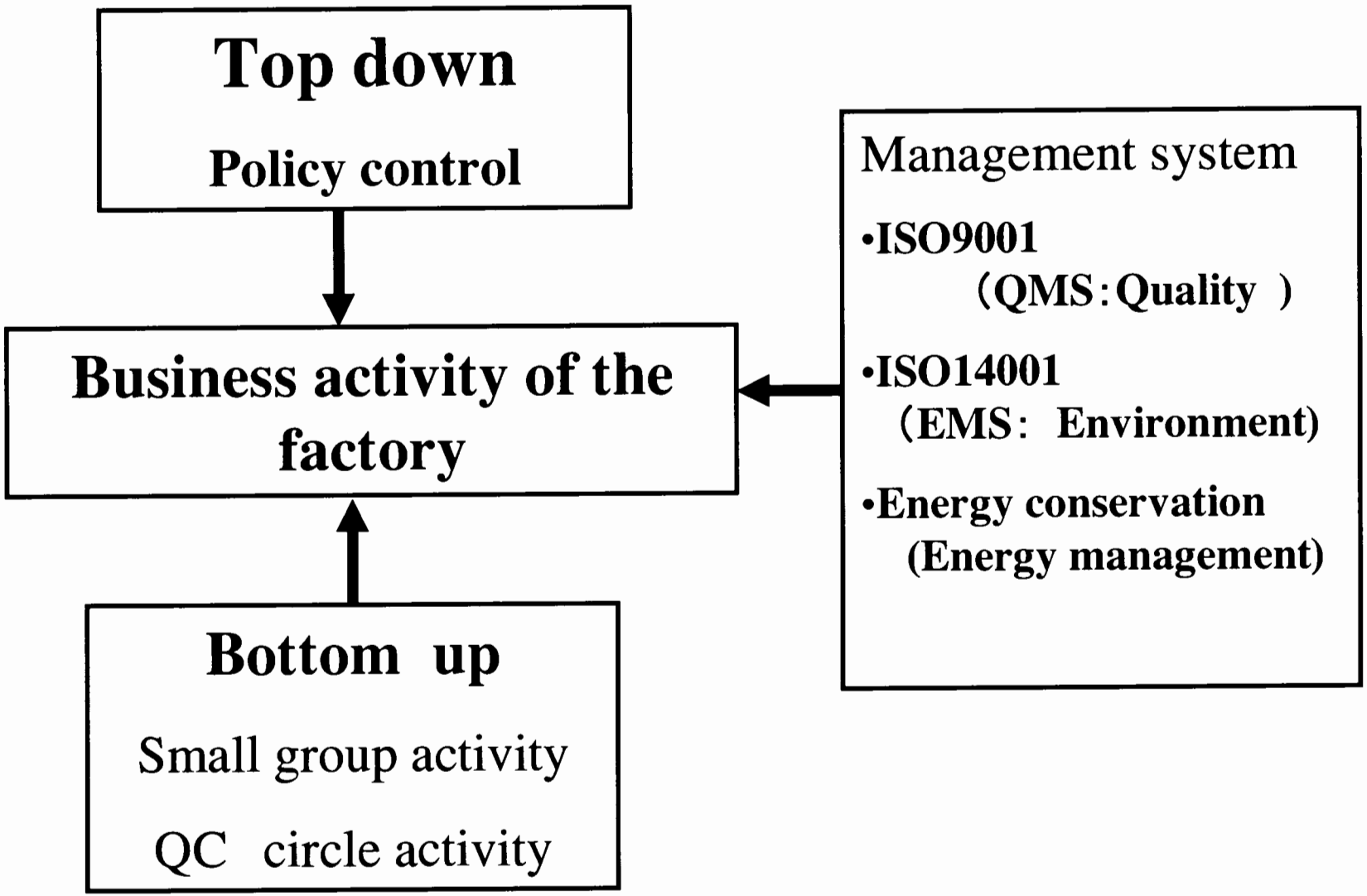
Even more effective energy saving may be expected if the system is incorporated in execution of the ISO14001 (environmental management system), the latter being increasingly adopted by business enterprises.

Concept of Energy Conservation Activities in the Factory

(Electric Energy Management System)

Fukuyama Works,
Mitsubishi Electric Corporation

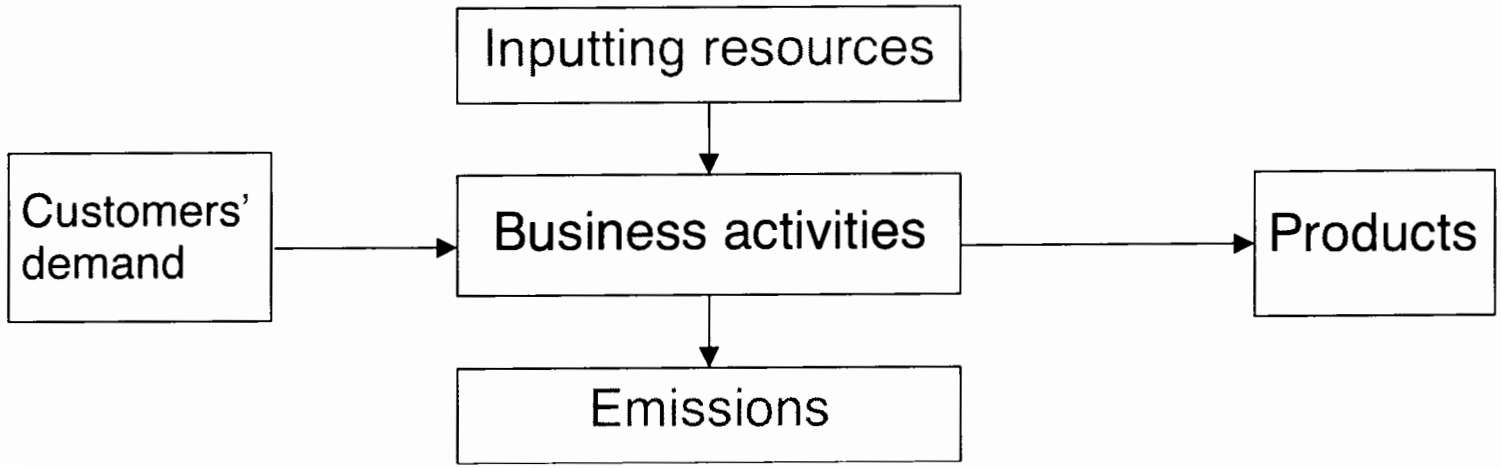
Japanese style TQM (Total Quality Manegement)



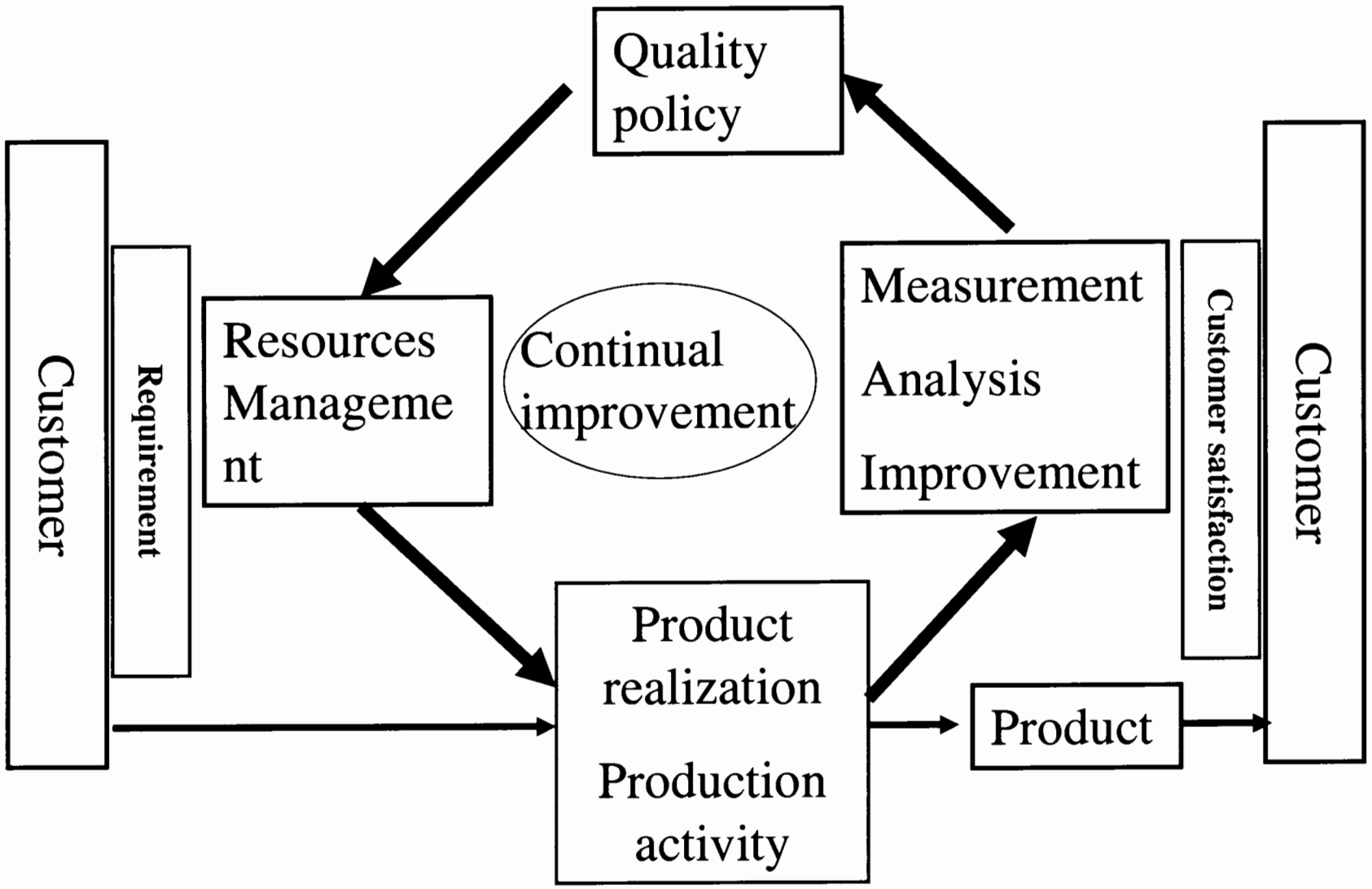
Improvement of Productivity

1. Key words in the 21st century
   Improvement of resource productivity

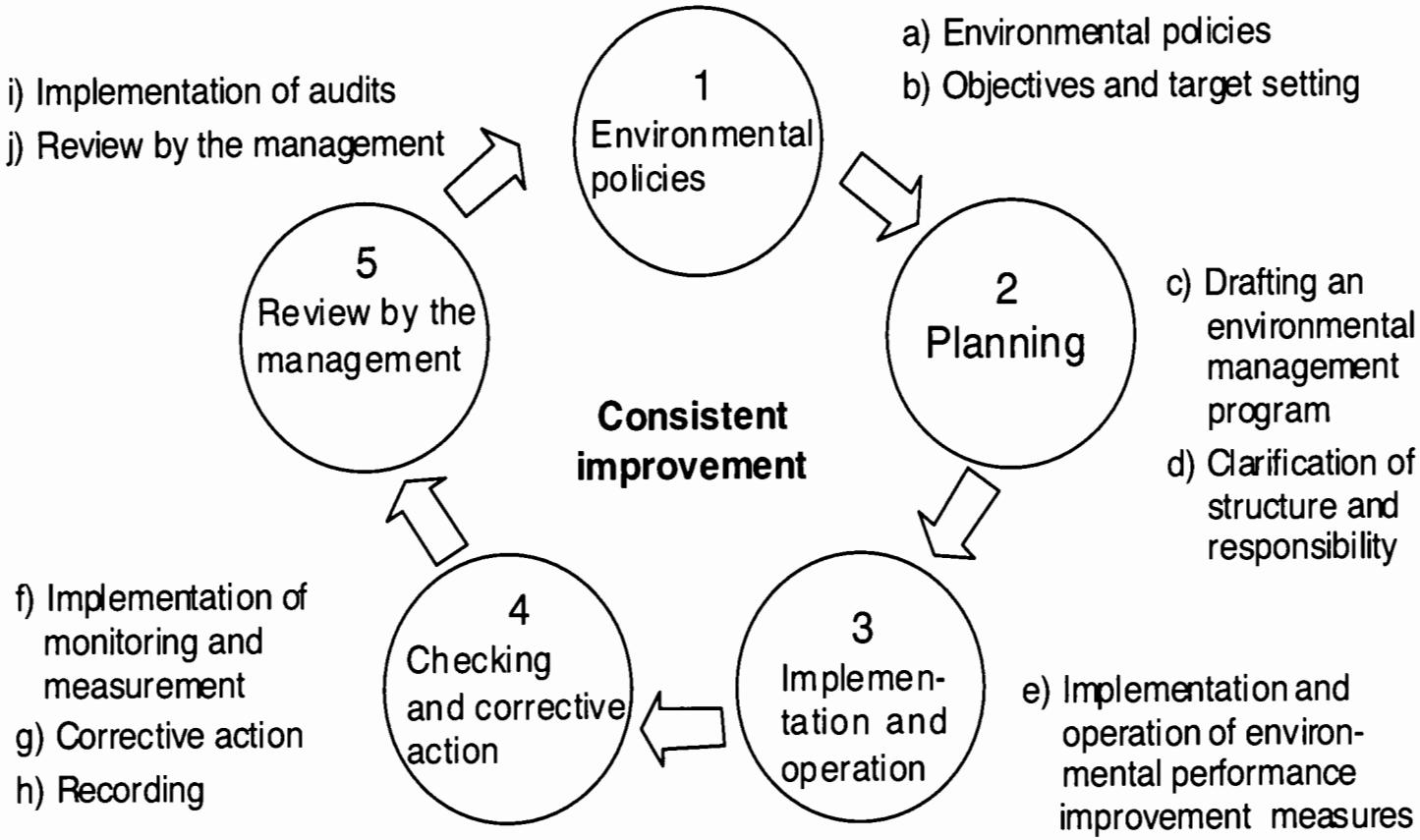
2. Key words in the 20th century
   Improvement of labor productivity (Improvement of output productivity)



ISO9001(QMS : Quality management system)

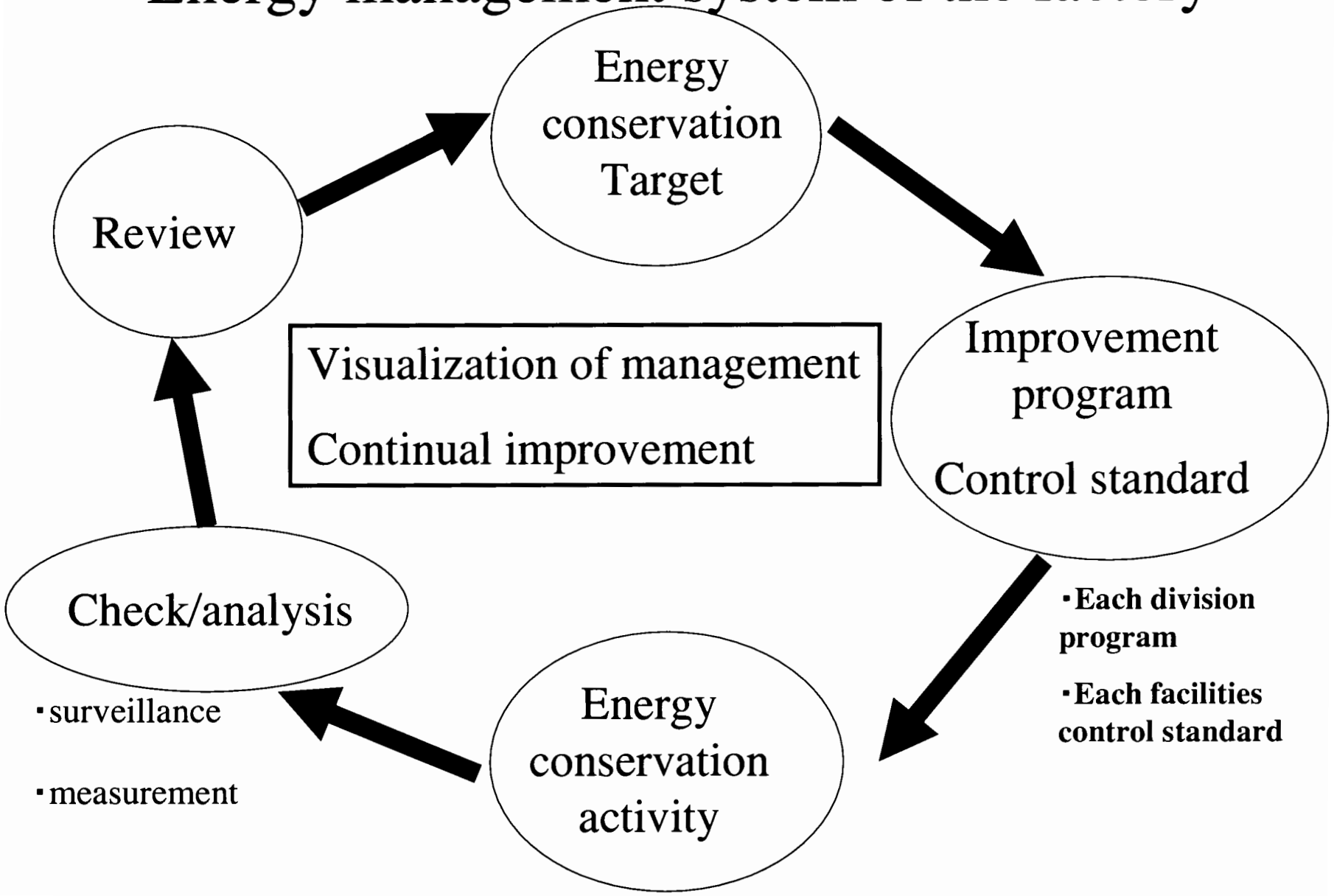


ISO's Requirements and Consistent Commitment to Improvement

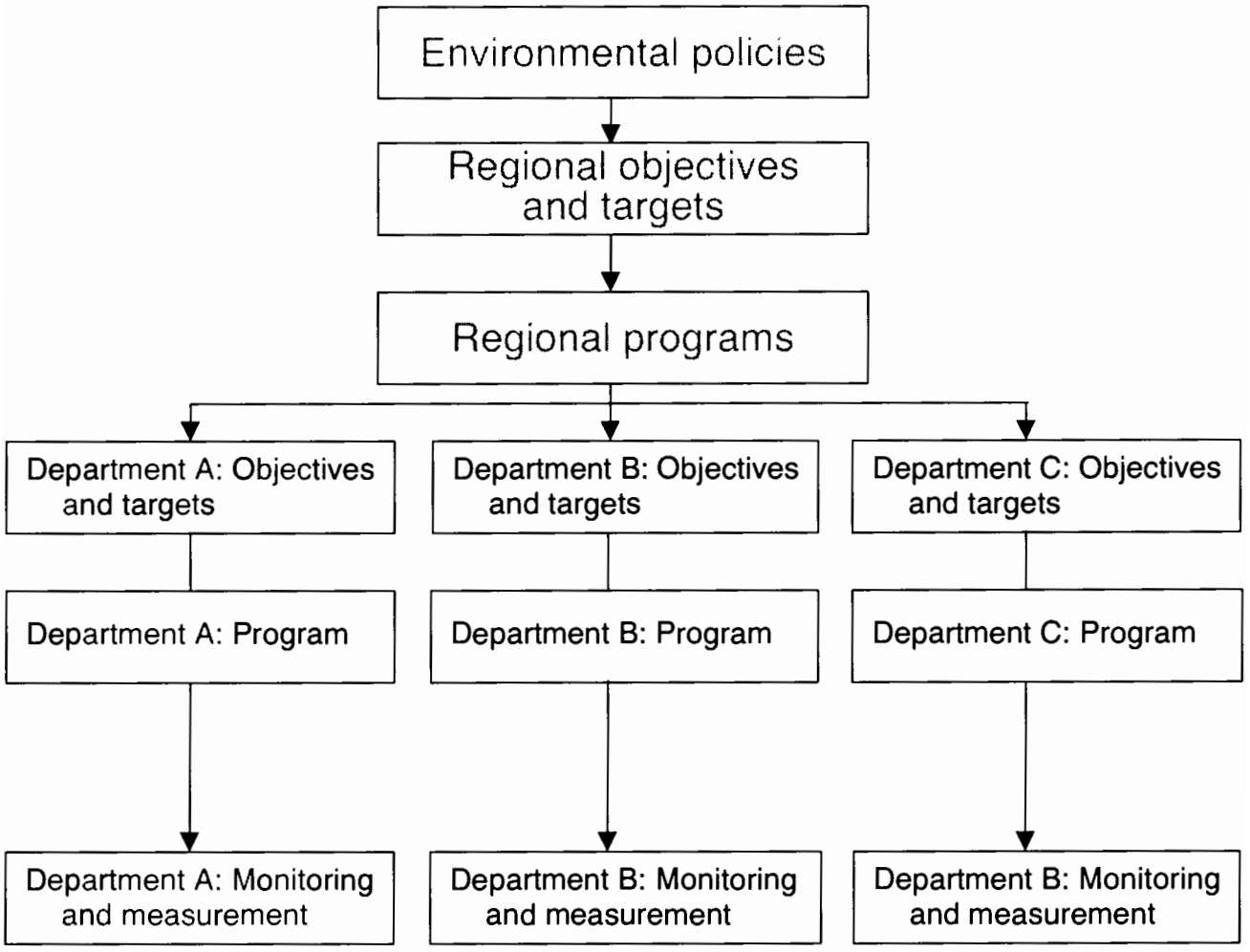


Environmental Management System under ISO14001

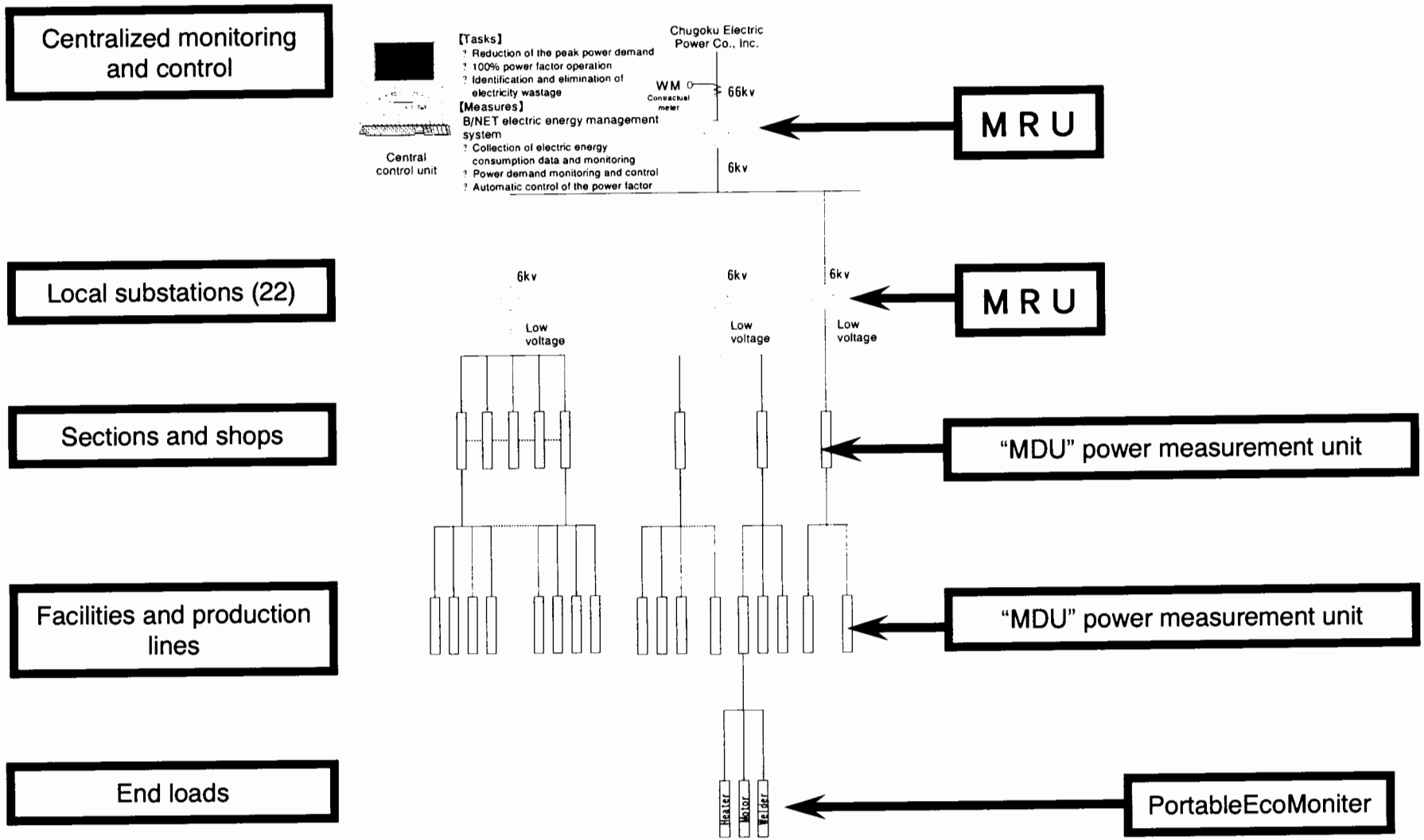
Energy management system of the factory



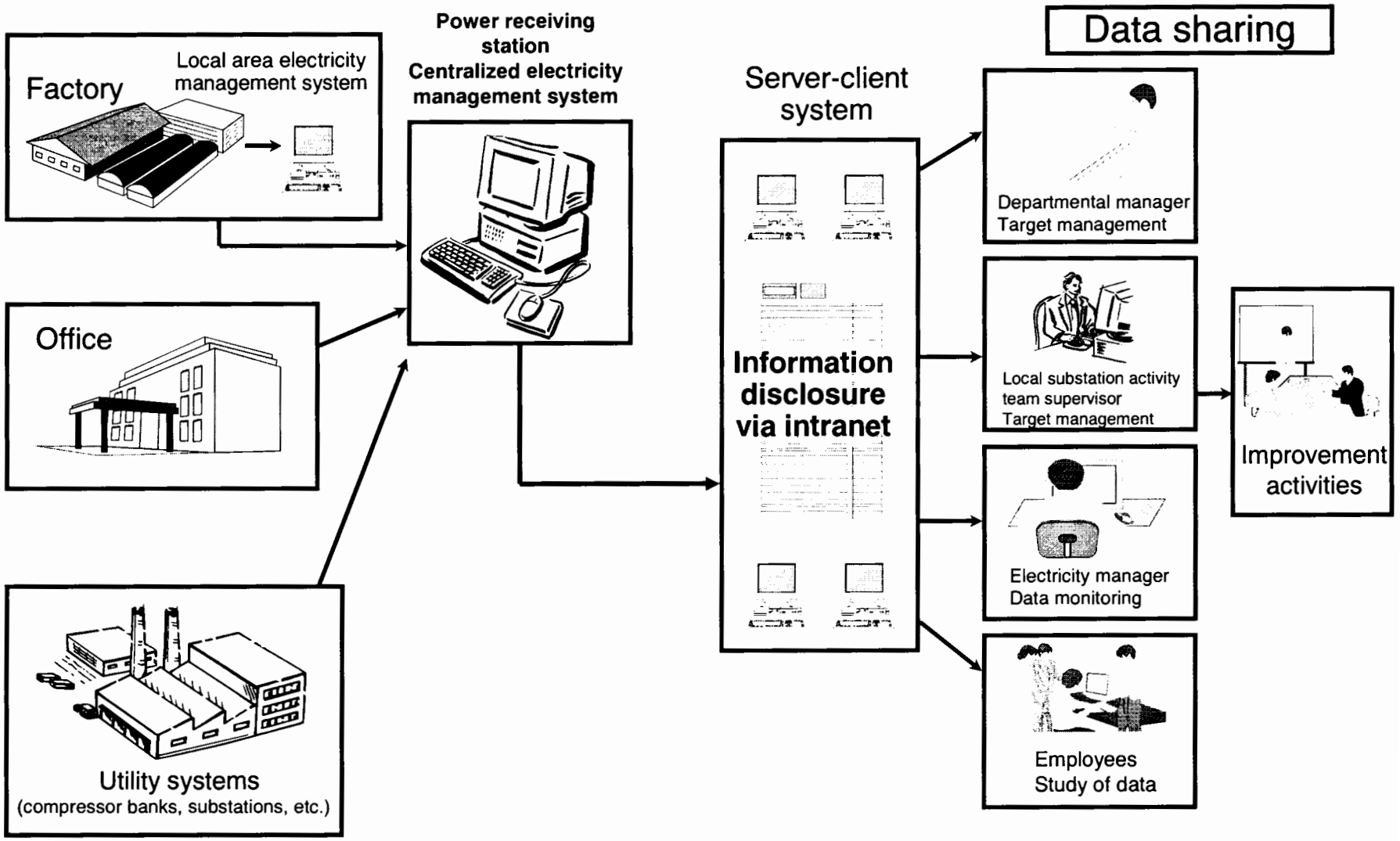
Plan Framework

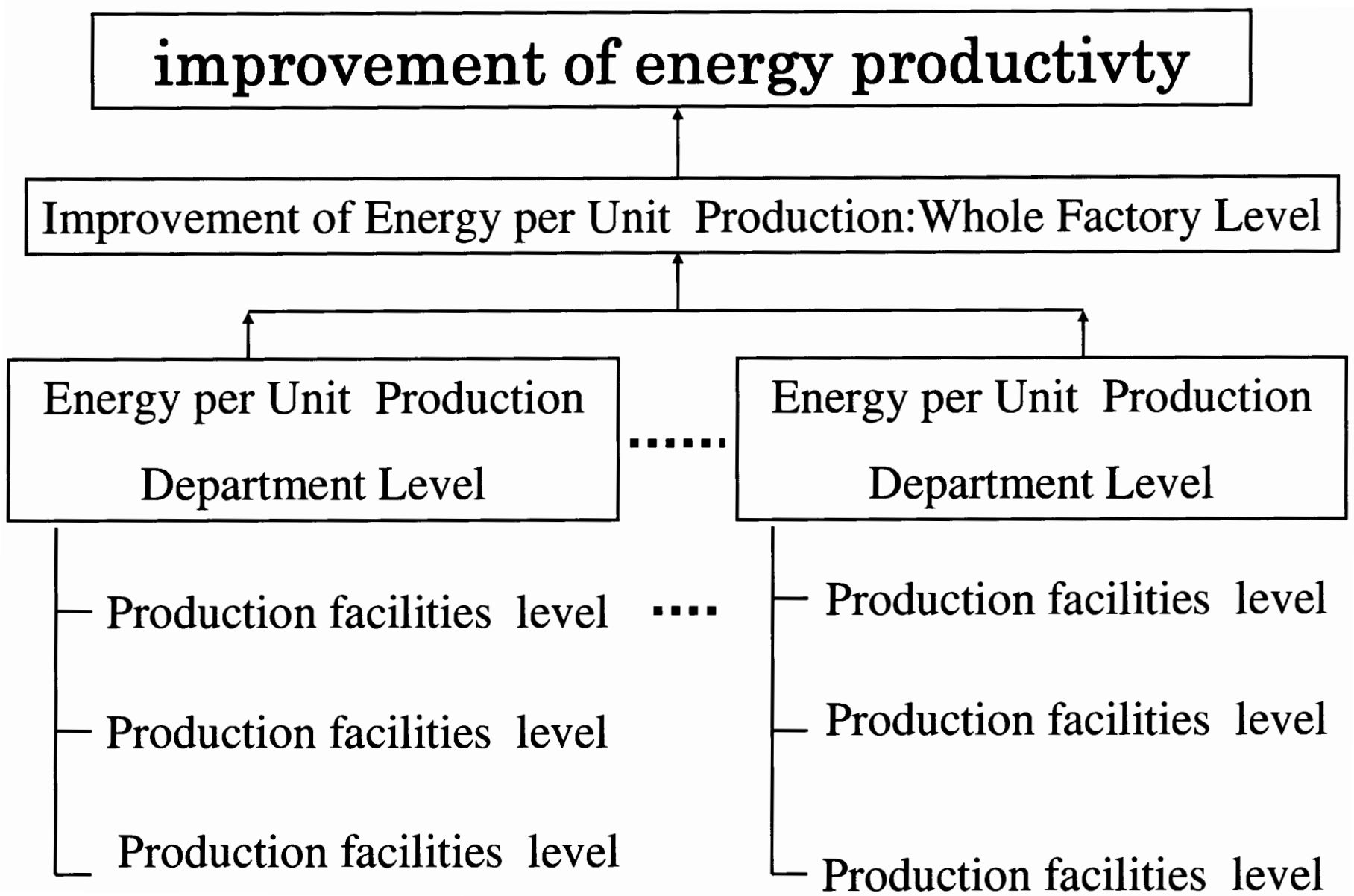


Electricity Management Structure (1)



Overview of Yamaden Electricity Management System




improvement of energy productivty
Improvement of Energy per Unit Production:Whole Factory Level
Energy per Unit Production Department Level
Energy per Unit Production Department Level
Production facilities level
Production facilities level
Production facilities level
Production facilities level
Production facilities level
Production facilities level

Key ward of the activity of the factory

1. **Visualization of management**

- Management by target of the factory and also each division
- Improvement of Energy per Unit Production
- Visualization of management system in the intranet

2. Energy needed for the production

- **Use Only when it is necessary** **(year, months, days, hour, minute etc.)**
- **Use Only a necessary place** **(whole, division, shops, facilities etc.)**
- **Use Only necessary quantity** **(use standard, application standard)**