Introduction

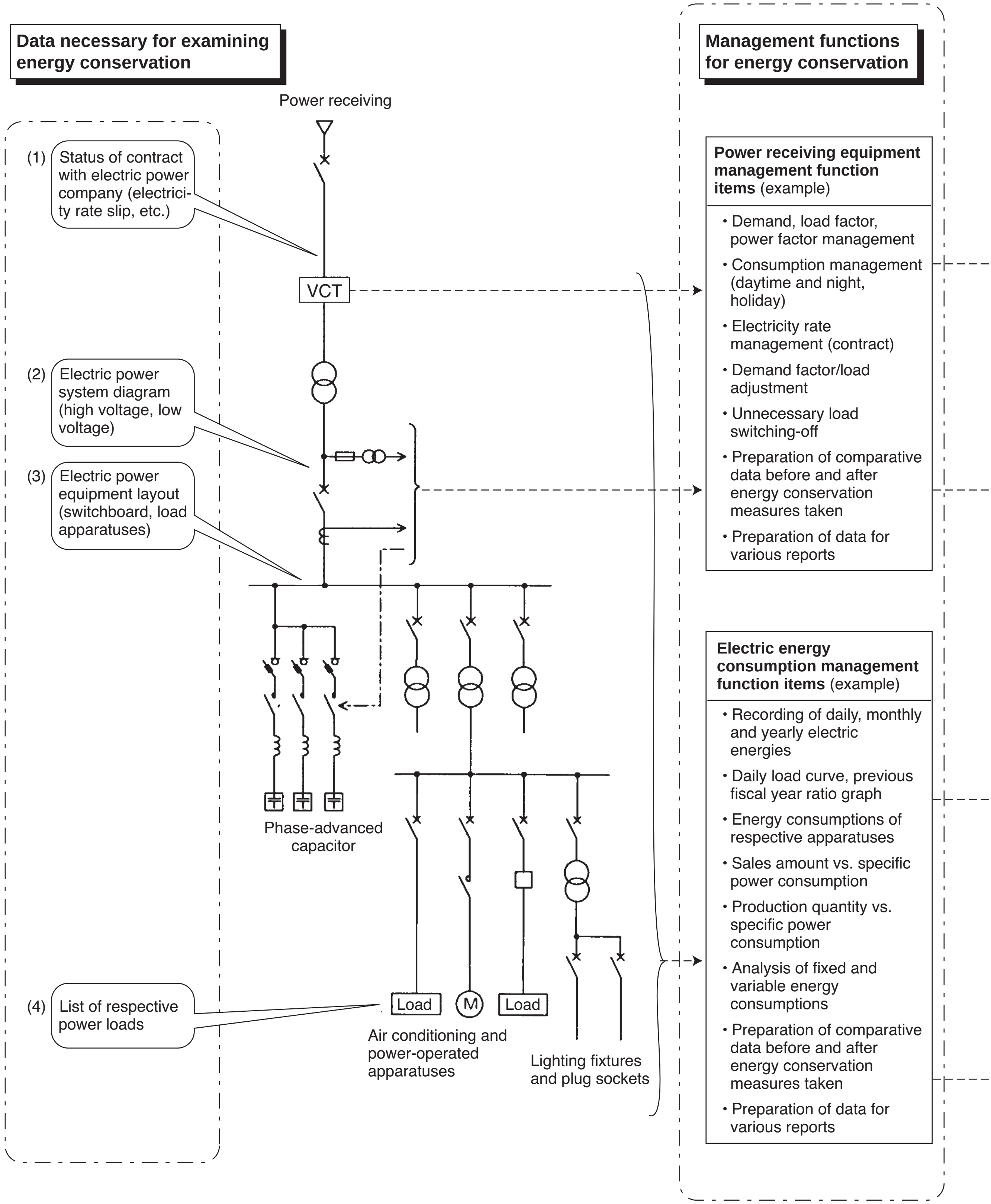
For effective utilization of electric energy to promote energy conservation, it is necessary to identify and manage the states of energy use by means of measurement, and further to analyze for carrying out improvement.

So, this guide presents cases where systems for measuring, monitoring, recording, controlling and data-analyzing the electric energy consumptions are introduced in respective plants, and also presents apparatuses relevant to such systems, for support of energy conservation. Since this guide mainly covers the power cost reduction methods such as reduction of electric energy consumption, peak-cut and power factor improvement, it does not include the instruments for measuring and improving the power source quality.

CONTENTS

Factories

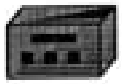
1. A guide for selection of systems relating to electric energy consumption for support of energy conservation



Application cases and relevant apparatuses for realizing the management functions

< Not including power source quality improving apparatuses (SVC, active filter, etc. >

1. Demand monitoring system

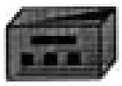


Demand controller mainly for saving contract demand

Type	Functions: Measurement	Monitoring and alarm	Recording	Control	Others
A					
B					
C					
D					
	(Data can be transferred to personal computer.)				
E					
	(Dedicated radio transmission apparatus)				

Application case	Relevant apparatus
Case1-A	Monitor
Case1-B	Monitor/recorder
Case1-C	Demand controller
Case1-D	Remotely connected demand controller
Case1-E	Transmission apparatus

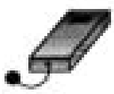
2. Power factor monitoring system



Type	Functions: Measurement	Control
A		
B		

Application case	Relevant apparatus
Case 2-A	Indicating instrument
Case 2-B	Automatic power factor adjuster

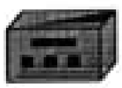
3. Power and electric energy monitoring system



For temporary installation

Type	Functions: Measurement	Recording	Others
A			
B			
	(Data can be transferred to personal computer.)		

Application case	Relevant apparatus
Case 3-A	Watt-hour meter
Case 3-B	Remotely connected watt-hour meter

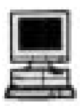


For permanent installation

Type	Functions: Measurement	Recording	Others
C			
D			
E			
	(Data can be transferred to personal computer.)		

Application case	Relevant apparatus
Case 3-C	Watt-hour meter
Case 3-D	Watt-hour recorder
Case 3-E	Remotely connected watt-hour recorder

4. Comprehensive demand management system



(Personal computer system)

Type	Functions: Documents and records	Data analysis	Others
A			
	(Standard package system)		
B			
	(Standard package system)		
C			
	(System including functions of measurement, control, etc.)		

Application case	Relevant apparatus
Case 4-A	Data collection system
Case 4-B	Data management system
Case 4-C	Comprehensive demand management system

2. Cases

2.1 Demand monitoring systems

Case 1-A **A demand controller with monitoring and alarm functions is used to reduce the contract demand.**

(1) General

Since a refrigerating compressor was replaced for a compressor with a larger capacity, the maximum demand increased and exceeded the contract demand, and an excess rate was paid. Furthermore, the contract demand was changed. The monthly electric energy consumption did not change so much, but the peak demand increased in August and September, being large also in October. If the peak demand can be lowered, it is expected that the contract demand can be lowered. At present, since no demand controller is used, the maximum demand occurring states cannot be identified, and peak-cut measures are also insufficient.

So, it is decided to install a demand controller with monitoring and alarm functions, for identifying the timings when the maximum demand occurs, in order to take peak-cut measures.

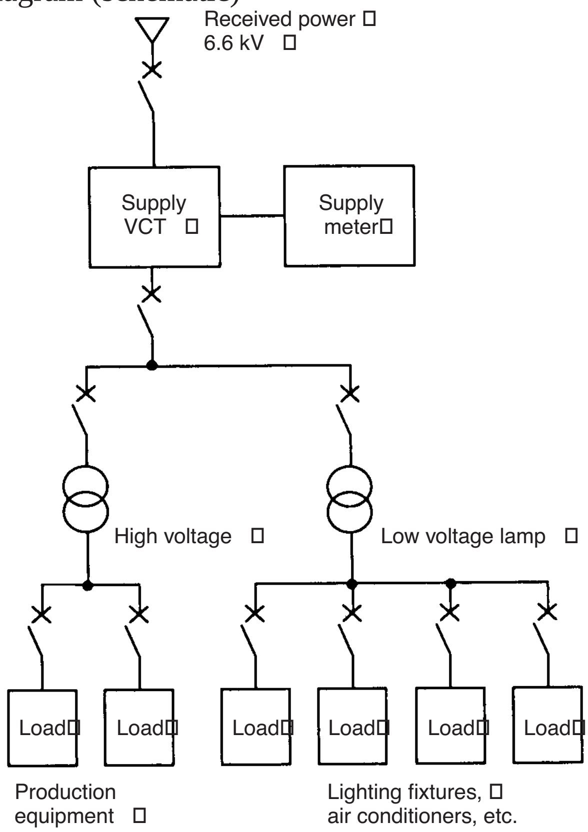
(2) Outline of equipment to be covered

(1) Business category: Manufacture of petroleum products and coal products

(2) Main products of the business establishment: LPG and petroleum products

(3) Contract demand: 840 kW

(4) Distribution system diagram (schematic)



(3) Proposed system

(1) Apparatuses to be introduced and outline of their functions

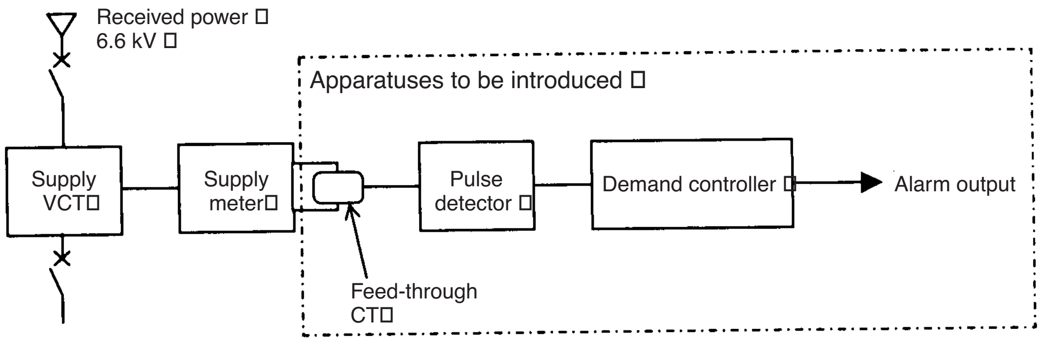
1) Demand controller (with monitoring and alarm functions)

a. Pulse signals transmitted from the supply meter are received to measure the demand values.

b. The demand values are monitored, and in the case where there is a possibility of exceeding a target demand, an alarm is issued with buzzing and a contact signal, etc.

2) Pulse detector: The pulses generated from the supply meter of the electric power company are supplied to the demand controller

(2) Connection method



(3) Usage

Since an alarm is issued when a target demand (a value lower than the contract demand) preset in the demand controller is going to be exceeded, the power source of, for example, air conditioning equipment unlikely to directly affect the production is switched off, to cut the peak. If the timings when the peak demand occurs can be identified, whether or not apparatuses with a large capacity can be operated according to a schedule is examined, and if it is concluded that the peak can be cut, the target demand is lowered to positively inhibit the occurrences of the maximum demand.

(4) Expected effect

If the contract demand can be reduced from 840 kW to 800 kW with the peak demand lowered, the effect is as follows. The basic electricity rate for calculation is ¥1,650/kW/month.

1) Contract demand decrement = 840 – 800 = 40 kW

2) Electricity rate decrement

= 40 kW × ¥1,650/kW/month × 85% × 12 months × 1.05 = ¥707,000/year

(5) Introduction cost, etc.

(1) Price of apparatuses (approximate)

Demand controller and pulse detector: About ¥300,000

(2) Construction cost (reference)

The construction cost is mainly the wiring cost, and greatly depends on the wiring length and wiring method (pit, piping, etc.), but is mostly about ¥300,000.

Case 1-B **A demand controller with measuring, recording, monitoring and alarm functions is used to identify and analyze the electric energy consumption states, for reduction of contract demand.**

In a foundry where most of electric apparatuses are electric furnaces, the electricity had been used almost at the very limit of contract demand. In this situation, sometimes peaks occurred and the contract demand was exceeded.

For the purpose of preventing it and reducing the contract demand by way of promoting energy conservation, a demand monitor has been introduced for constant monitoring, and its alarm function is utilized for manual on/off control of electric furnaces when an alarm occurs, to avoid that peaks occur and that the contract demand is exceeded.

Case 1-C **A demand controller with monitoring, alarm and control functions is used to reduce the contract demand.**

In a senior high school, on a cultural festival day of September, the contract demand was exceeded, and it was necessary to take any countermeasure. Usually since the school is closed in July and August for summer vacation, no peak occurred, but since electricity was used all at once on the cultural festival day, a peak in excess of the contract demand occurred.

Also in winter, a load peak occurred. So, a demand controller was introduced, to automatically control the loads, and the demand could be kept lower, and furthermore, the contract demand could be lowered.

Case 1-D-1 **A demand controller with monitoring, alarm, recording and control functions is used to identify and analyze the electric energy consumption states, for reducing the contract demand.**

In summer (July, August and September), the demand was 1,200 kW due to air conditioning equipment (installed capacity 600 kW), and the demand in winter was about 800 kW. The demand had been controlled with the loads controlled manually by a person in charge of electricity monitoring the demand meter. So, the contract demand was rather high, and a worker was also necessary for the demand control.

So, it was decided to install a demand controller with monitoring, alarm, control and recording functions. The demand controller generates a load control signal in the case where the predicted demand exceeds a target demand, and the load control signal is used to carry out peak-cut actions. Furthermore, since the electric room is apart from the office of the person in charge of electricity, the signals transmitted from the demand controller are received by a personal computer installed in the office, for remote display of demand data.

Case 1-D-2 **A demand controller with measuring, recording, monitoring, alarm and control functions that can be connected with a host processor is used to identify and analyze the electric energy consumption states, for reducing the contract demand.**

In a plant manufacturing machines and instruments, the daily electric energy consumptions of loads had been large, and the load variations were also large. In the past, the contract demand was exceeded several times.

Especially more than half of the power loads were concerned with air conditioning, and the demand for lighting fixtures had been little managed.

So, it was decided to introduce a demand monitor, and to use the data processing results of a personal computer as enlightening materials for grappling with energy conservation.

Furthermore, the brightness is investigated using an illumination meter in efforts to reduce the power consumption.

Case 1-E **A radio transmission apparatus is attached to a demand controller with measuring, recording, monitoring, alarm and control functions, for automatically reducing the contract demand.**

In a yarn-manufacturing plant where most of electric apparatuses are yarn-making machines, electricity had been used at the very limit of the contract demand. So, for the purpose of preventing the excess of the contract demand and reducing the contract demand by way of promoting energy conservation, a demand monitor was introduced for constant monitoring and control in efforts to avoid that peaks occurred and that the actual demand exceeded the contract demand. However, apparatuses have increased and electric rooms are dispersed in the plant. So, all the apparatuses cannot be covered while dedicated workers cannot be stationed in the electric rooms.

2.2 Power factor monitoring and controlling system

Case 2-A **The power factor is measured and managed for energy conservation.**

(1) General

The data such as voltages, currents, powers, electric energies, frequencies and power factors of the power receiving equipment and respective power-operated apparatuses are measured and monitored for identifying and analyzing the detailed consumption states of power and electric energy for energy conservation. Especially in the production lines of the plant, many electric machines such as motors and compressors are used to lower the power factor. So, the power factor of the power receiving equipment is measured for management. Furthermore, a phase-advanced capacitor is connected to enhance the power factor.

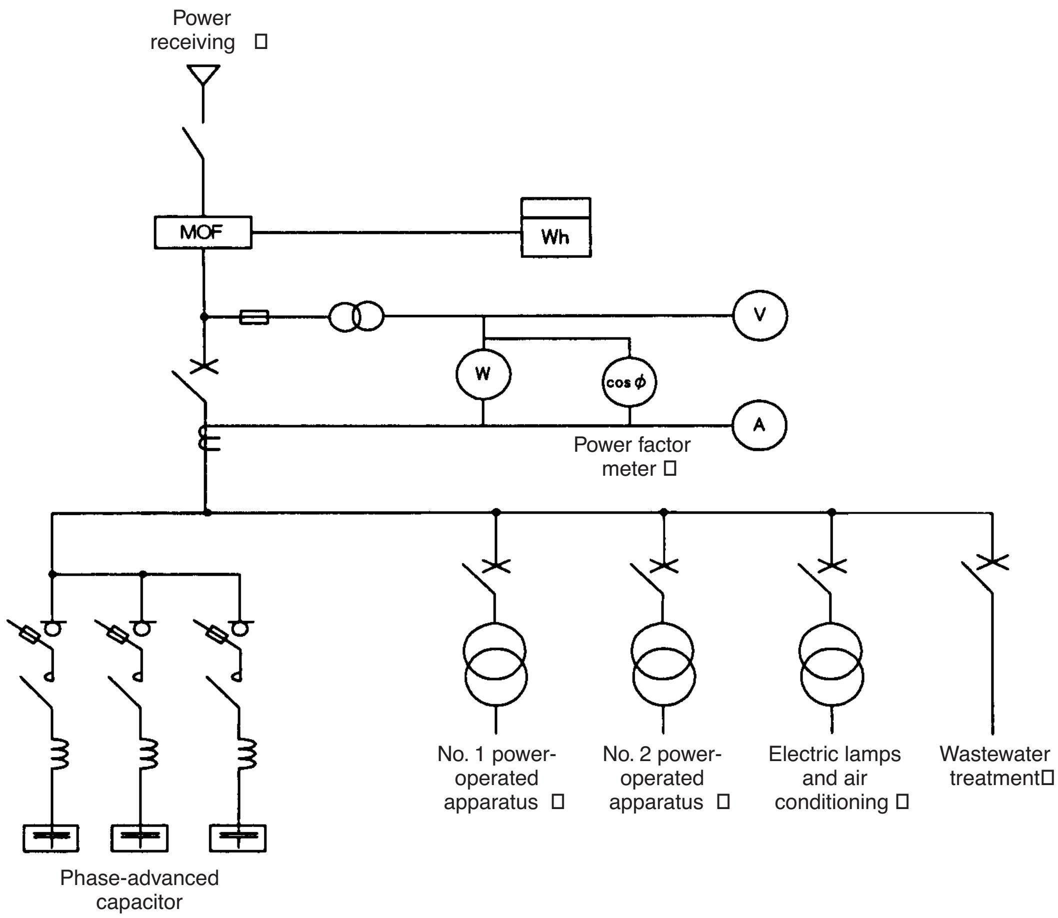
(2) Outline of equipment to be covered

(1) Business category: Manufacture of foods

(2) Main product of the business establishment: Soft drinks

(3) Contract demand: 1,000 kW

(4) Distribution system diagram (schematic)



(3) Proposed system

(1) Apparatus to be introduced, and outline of its function

1) Power factor meter (integral with converter)

a. Power factor meter: The AC voltage and current signals from PT and CT are used to indicate the value of power factor.

2) Power factor meter (separate from converter)

a. Power factor converter: The AC voltage and current signals from PT and CT are applied to this converter and converted into a unified output signal proportional to the power factor of loads.

b. Indicator: This indicator receives the signal from the power factor converter and indicates the power factor value.

(2) Usage

The power factor is connected to the trunk circuit of the power receiving equipment for power factor measurement. A worker visits the site periodically to record the data.
Since the electric power company offers a power factor discount (extra) scheme in their power rating system, the power factor should be improved by way of measuring and improving the power factor of the trunk circuit. The power factor can be improved by connecting a phase-advanced capacitor.

(4) Expected effect

If the power factor can be improved from 85% to 90% at a contract demand of 1,000 kW, the effect can be calculated as follows. The basic rate for calculation is ¥1,650/kW/month.

1) Power factor increment = 90 – 85 = 5%

2) Electricity rate decrement

= (Contract demand value) × (Unit basic rate) × (Power factor discount)
× (12 months) × (Consumption tax)
= 1,000 kW × ¥1,650/kW/month × 0.05 × 12 months × 1.05
= ¥1,039,500/year

(5) Introduction cost, etc.

(1) Price of apparatus (approximate)

Power factor meter: ¥50,000 to ¥100,000

(2) Construction cost (reference)

The construction cost is mainly the wiring cost, and greatly depends on the wiring length and wiring method (pit, piping, etc.). The approximate cost is tens of thousands yen.

Case 2-B **The load current, power factor and reactive power are measured, and a phase-advanced capacitor suitable for the magnitude of the load current is connected to the circuit, for improving the power factor for energy conservation.**

The lagging reactive power caused by electric equipment such as motors is decreased by an installed phase-advanced capacitor. In this power factor improvement, the optimum capacitor suitable for the load variation is automatically selected and switched on and off, to keep the average power factor at about 100%.

The power factor improvement lowers the basic electricity rate, and simultaneously contributes to the increase in the allowance of the transformer and to the decrease in the loss of the transformer and the distribution lines.

2.3 Electric power and electric energy measuring systems

Case 3-A **A case where an electric power conservation measure has been taken based on the situation identified using a portable power-measuring instrument.**

(1) General

In the past, the demand had been monitored at the power receiving point only, and the demands of respective load apparatuses were not measured. It was planned to take positive measures for energy conservation, but it was not considered to be the best to install measuring instruments immediately in the situation where the actual power consumptions were not identified at all. So, at first, a portable measuring instrument was used to measure the demands at respective points.

In these efforts, attention was paid to the fact that the clean room was wasteful in air conditioning equipment, and an energy conservation measure was taken, to confirm the effect by comparing the data taken before and after the measure was taken.

(2) Outline of equipment to be covered

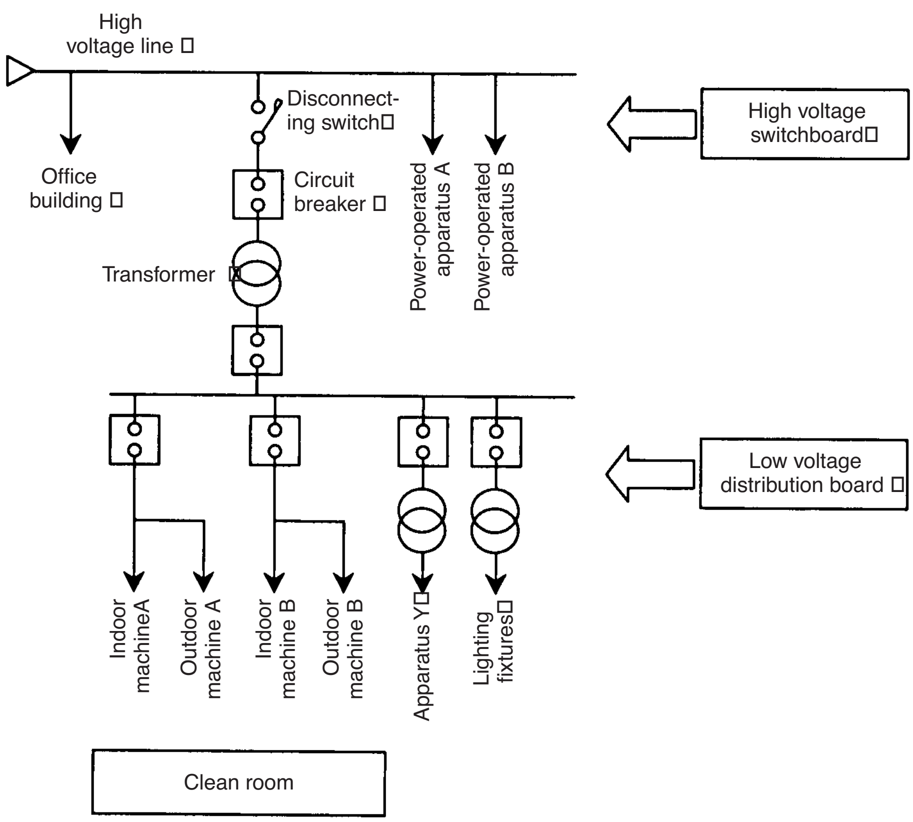
(1) Business category: Manufacture of electronic apparatuses

(2) Equipment concerned: Air conditioning equipment of clean room

(3) Contract demand: 1,100 kW

(4) Electric energy consumption: 3 million kWh/year

(5) Wiring system diagram (schematic)



(3) Proposed system

(1) Apparatus to be introduced and outline of its function

• Portable wattmeter

a. The meter can be simply connected by means of accessory clamps for current detection, or a voltage probe.

b. The meter can be used for various applications such as momentary value measurement, electric energy measurement, demand measurement and higher harmonic measurement.

c. The consumption during the operation of an apparatus can be identified if the on/off signals of the apparatus are applied to the meter.

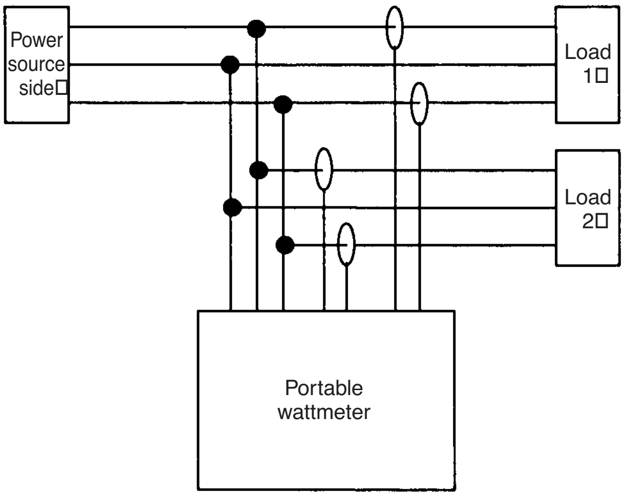
d. The data can be stored concurrently in the internal memory and a floppy disc. Furthermore, the meter can also be connected with a personal computer for serial communication.

e. The data can be printed if a printer is connected.

(2) Connection method

< In the case of single-phase 3-wire type >

The following drawing is a connection diagram for measuring two load systems (up to four clamps for current detection can be connected).



(3) Usage

· The meter is connected to a system to be measured for continuously measuring various power data for identification of present situation.

· Data can be stored in a floppy disc or personal computer connected.

· In the case where the system to be measured is intended to be stopped for power cutting, the data during operation only of the system can be collected to allow prediction of the situation where the system is stopped.

· If data are re-measured after taking an energy conservation measure, the effect of the measure taken can be qualitatively measured.

(4) Expected effect

If the electric energy in the clean room only can be reduced by about 3%, the electric energy cost decrement can be calculated as follows.

· Electric energy consumption decrement: 3 million kWh × 0.03 = 90,000 kWh
· Electric energy cost decrement: 90,000 kWh × ¥10/kWh = ¥900,000/year

(5) Introduction cost, etc.

(1) Price of apparatus (approximate)

· Portable wattmeter: Approx. ¥200,000 (price of meter proper)

(2) Construction cost (reference)

Zero because of simple connection

Case 3-B-1 Meters with a recording function that can be connected with a personal computer are used to identify and analyze the consumption states of power and electric energy, for reducing the electric energy consumption.

Generally the entire electric energy consumption including a high voltage and a low voltage is identified, but in unexpectedly many cases, the detailed electric energies of, for example, respective systems and respective blocks are not identified. So, it is important for the first stage of energy conservation, to investigate and identify the powers and electric energies consumed in respective electric apparatuses.

So, if simply mountable watt-hour meters are installed, data can be collected and analyzed, to allow the reduction of electric energy consumption.

Case 3-B-2 A temporarily installed compact power recorder with measuring and recording functions that can be connected with a host computer for data processing is used to identify and analyze the electric energy consumption states of individual apparatuses, for reducing the power consumption.

In a chemical business, the air conditioning equipment and the lighting fixtures for automation lines had not been managed, and the maximum demand had increased to sometimes exceed the contract demand. A demand controller was introduced, but the load management was not practiced, while the load cut-off order was not optimum either. So, the time zones in which the respective systems and loads consumed electricity were investigated to optimize the operation.

For a fact-finding survey of power consumptions of respective systems and loads, the respective electric energy consumptions were measured.

$\boxed{\text{Case 3-C-1}}$ An instrument with a measuring function only is used to identify and analyze the electric energy consumption states for energy conservation.

The efforts made for energy conservation were enlightenment activities for the workers only, and no particular measure had been taken. So, the electric energy consumption has increased year after year.

For the purpose of cost reduction, it is wished to investigate the actual electric energy consumptions states at a cost as low as possible.

$\boxed{\text{Case 3-C-2}}$ Permanently installed measuring instruments (watt-hour meters)

In an electric machine and instrument manufacturing business, the electric energy consumptions of respective systems had not been correctly identified, for the reduction of power consumption.

The overall electric energy consumption had been identified, and though the watt-hour meter used for the transaction with the electric power company measured the overall electric energy consumption of the trunk line, it was necessary to identify the detailed actual electric energy consumptions for achieving energy conservation.

So, it was decided to install watt-hour meters for management of respective systems, for identifying the electric energy consumptions of the respective systems in efforts for enlightenment, and also to review the operation plan for the reduction of power consumption.

$\boxed{\text{Case 3-D-1}}$ A system with a recording function is used to identify and analyze the states of power and electric energy for reducing the electric energy consumption.

Even in schools interested in environmental issues, the electric energy consumptions of respective buildings are not perfectly identified.

So, if a power measuring and display system is installed, the electric energies consumed in respective buildings in a school can be identified, and if the data are displayed on a permanently installed display, teachers and students can know the electric energy consumptions, to enhance the consciousness of energy conservation and to reduce the electric energy consumptions. At first, in the investigation stage, the apparatuses to be measured are selected, and how much power can be reduced actually is investigated by means of a system introduced.

Case 3-D-2 **An instrument with a measuring function only is used to identify and analyze the electric energy consumption states for energy conservation.**

The efforts made for energy conservation were enlightenment activities only for workers, and no particular measure had been taken. The electric energy consumptions had increased year after year.

For the purpose of cost reduction, it is wished to investigate the actual states of electric energy consumption at a cost as low as possible.

Case 3-D-3 **Permanently installed instruments with measuring and recording functions that can be connected with a host computer for data processing.**

In a precision machine and instrument manufacturing business, loads such as electric furnaces, pumps, air conditioners and lighting fixtures are used, and the contract demand was sometimes exceeded. A demand controller is also installed, but the power consumptions of the respective loads are not identified. Thus, the management of electric energy consumptions of loads as an energy conservation measure had not been established.

So, it was decided to install feeder power recorders for identifying and managing the electric energy consumption states of respective loads for the purposes of measurement, analysis and improvement, and to identify and analyze the actual states of energy consumptions in detail for energy conservation.

Case 3-E-1 **A power and electric energy measuring system with measuring and recording functions that can transfer data, for example, to a host personal computer is used to identify the electric energy consumption states, for energy conservation.**

This plant has been qualified for ISO 14001 since fiscal year 1997 and makes efforts for energy conservation. To comply with the qualification, it is necessary to identify electric energy consumptions and to prepare daily reports and monthly reports. The power and electric energy measuring system is introduced to make measurement tailored for the contract demand and the states of respective feeders and loads, and to automatically prepare documents such as daily reports and monthly reports. Furthermore, the data are transferred to a host personal computer to allow data analysis and control.

Case 3-E-2 **An energy management monitor with measuring, recording and data processing functions is used to identify and analyze the energy consumption states for contribution to energy conservation.**

In a ceramic and earth & rock product manufacturing business, especially many compressors are used, and further loads include industrial furnaces, air conditioning equipment and lighting fixtures. The plant is highly interested in energy conservation, but feels the necessity of demand management based on more detailed data collection and analysis.

It is intended to identify the energy consumption states of respective loads for use of electric energy without waste.

It was planned to introduce an energy management monitor, for highly accurately identifying the energy consumption states.

2.4 Comprehensive demand management system (application of personal computer)

Case 4-A **A comprehensive demand management system having package software is used to identify and analyze the electric energy consumption states for reducing the waste of electric energy.**

(1) General

Yearly 3 million kWh of electric energy had been used, and the energy consumption had been observed visually periodically every month for management. As electric equipment, two high voltage transformation stations and total ten transformers are installed. The values of 10 points had been observed and recorded periodically. The periodical visual observation had been made mainly for cost management of respective shops, and the energy consumption had been identified at a rough level for the entire plant. The periodical visual observation and the compilation of collected data had been manual.

So, if a personal computer is now loaded with a package system for collecting and recording demand data, the electric energy consumptions of respective divisions, respective purposes and respective time zones can be identified to clarify the waste of energy consumption and the matters to be improved.

(2) Outline of equipment to be covered

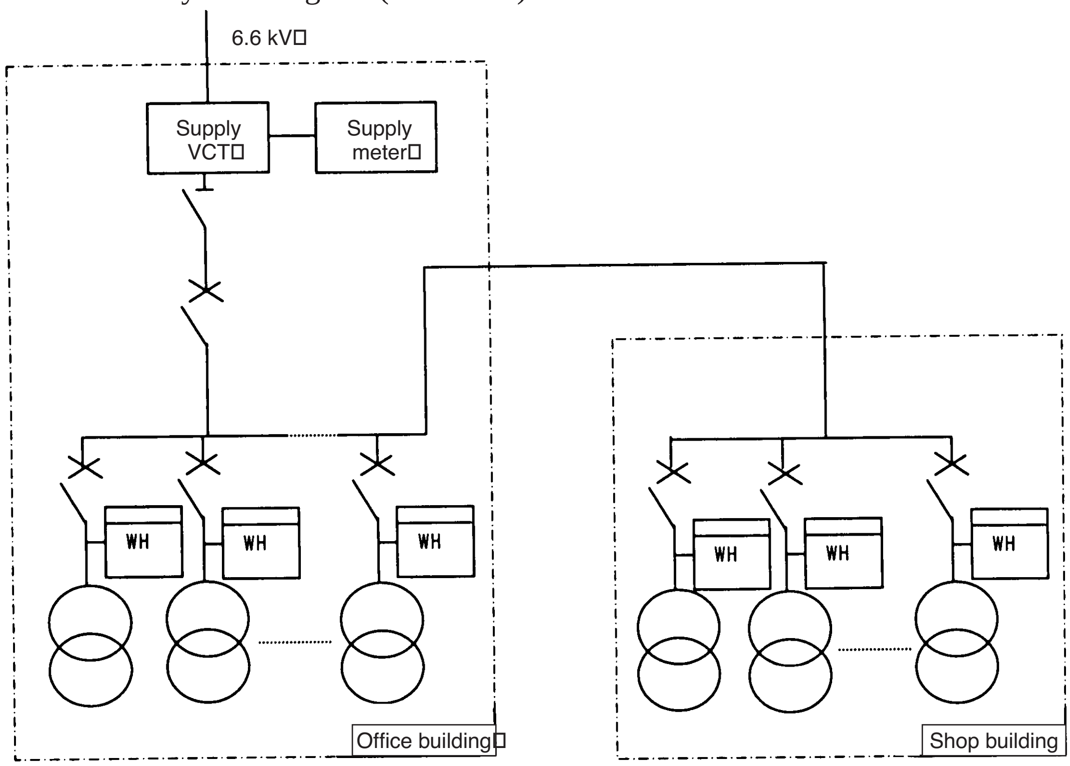
(1) Business category: Manufacture of electric machines and instruments

(2) Main product of the business establishment: Communication control equipment

(3) Contract demand: 1,000 kW

(4) Electric energy consumption: 3 million kWh/year

(5) Distribution system diagram (schematic)



(3) Proposal system

(1) Apparatuses to be installed and outline of their functions

1) Package software for data collection

As the hardware and OS, a general-purpose personal computer is used.

a. Demand data (electric energies, etc.) are collected as signals transmitted from respective measuring instruments. The data collection intervals are basically every hour. For specific apparatuses in need of more detailed energy conservation analysis, data can be collected at shorter time intervals, for example, every 5 minutes for a certain period of time.

b. The collected data are stored in a format to allow processing by means of commercially available tabulation software. For example, they are stored in CSV (Comma Separated Value) file format.

c. For documentation and graphical expression of data, commercially available tabulation software is used.

   A package software option for operation, documentation and graphical expression of collected data may be contained in a computer.

d. Present value data are observed on the screen of a personal computer.

2) Transmission interface

The signals transmitted from measuring instruments are applied to the personal computer. The interface may be contained in or provided separately from the personal computer, and usually consists of hardware and driver software.

3) Measuring instruments

The measuring instruments taken up in case 3 and containing a transmission function are used.

(2) Connection method

See Fig. 1.1 “Connection diagram of comprehensive demand management system using package software.”

(3) Usage

Electric energies had been measured at the respective transformers, but are now measured at respective low-voltage feeders. The number of measuring points has been increased from 10 to 48. A measuring instrument has been installed for each low-voltage feeder, and transmission lines have been installed for data collection. A personal computer is placed in the office of the person in charge of electricity for data collection. Data collection intervals are every hour.

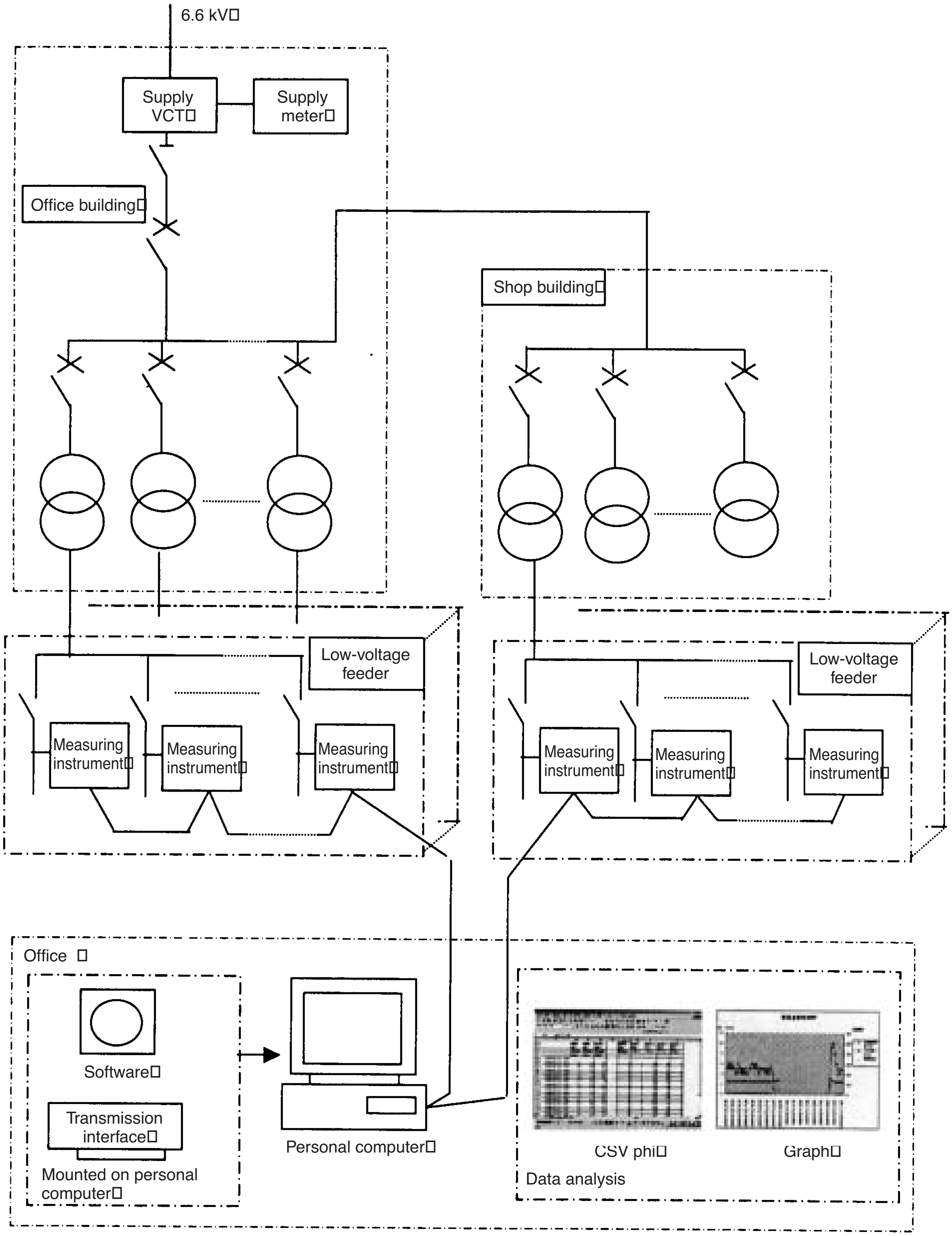


Fig. 1.1 Connection diagram of comprehensive demand management system using package software

At the 48 measuring points, daily load variations, monthly load variations and yearly (seasonal) load variations can be identified.

Quantitative energy conservation promotion activities can be practiced.

1) The waste of energy such as the energy consumption in an unnecessary time zone, the use of energy more than necessary at respective apparatuses and the revealing of the energy not contributing to production is clarified for reduction of energy consumption.
2) An energy use plan including energy conservation is worked out, considering the quantitative reductions based on measured data.
3) Since the results of energy conservation activities can be identified, the implementation of the energy conservation plan can be accurately identified and analyzed. Furthermore, if any possibility is found in failing to achieve the plan, a corrective action can be taken to accomplish the plan.

(4) Expected effect

The electric energy consumption can be reduced by 5% by means of quantitative management.

1) Electric energy consumption decrement = 3 million kWh × 0.05 = 150,000 kWh/year
2) Electricity rate decrement = 150,000 kWh × ¥10/kWh = ¥1,500,000/year

(5) Introduction cost, etc.

(1) Price of apparatuses (approximate)

- Personal computer and package software for data collection: Approx. ¥500,000
- Measuring instruments: Approx. 2 million yen (48 units)

(2) Construction cost (reference)

- Measuring instrument installation cost
  The construction cost depends on the places of installation, but approximately, the cost can be calculated by multiplying the construction cost per point by the number of installation points.
- Cable installation cost
  This greatly depends on the lengths of cables.

(6) Others (notes)

- Since the package software is of standard specifications, whether it has sufficient functions must be confirmed beforehand.
- For cost reduction, it is recommended to use standard functions without adding special functions.

Case 4-B **A comprehensive demand management system having a personal computer is used to collect and analyze the electric energy consumptions for realizing efficient energy conservation.**

Since the conventional demand management had covered the master power receiving and switchboard section only, the electric energies consumed in respective apparatuses could not be identified, and a specific improvement plan could not be formulated. There were also such problems that even if an energy conservation measure was taken for a certain apparatus, the effect could not be accurately judged since the working conditions of other apparatuses were not uniform.

So, a demand management system using a personal computer capable of collecting, storing and analyzing the electric energies consumed in the respective load apparatuses has been adopted. Using this system, the operation of respective load apparatuses can be adequately corrected, and medium- and long-term plans for energy conservation can be formulated. In addition, the man-hours needed for periodical site recording and manual calculation can be reduced.

Case 4-C-1 **A demand monitoring and controlling system using a personal computer is introduced for automatically collecting demand data, and for identifying and analyzing the electric energy consumption states (documented recording and graphical expression). Furthermore, demand control and power factor control are practiced for demand reduction.**

In the past, various data concerning electric power (voltage, current, power, electric energy, power factor, etc.) were observed and recorded by a worker visiting respective sites periodically. Furthermore, the demand management was mainly the management of received power, and the data of respective sections were not managed. Recently a demand monitoring system using a personal computer has been introduced to allow the detailed data of not only received power but also the electric energies consumed in the respective sections to be automatically collected. With this system, the detailed contents of the electric energies consumed in the entire plant can be identified and analyzed, and the wasteful demand can be reduced.

Furthermore, the demand control and the power factor control can be carried out automatically using the monitoring and controlling system to achieve the reduction of demand.

Case 4-C-2 **An energy management monitor with measuring, recording and data-analyzing functions is used to identify and analyze the energy consumption states for contribution to energy conservation.**

The actual states of electric energy consumptions have been manually periodically inspected in reference to meters, and daily reports and the like have been prepared. However, as efforts for energy conservation and for acquisition of ISO qualification, it is necessary to collect and analyze detailed data, and automation and labor saving were studied. If an energy management monitor is introduced, the actual energy consumption states of respective divisions can be identified, and data useful for eliminating unreasonableness and waste and for examining and planning the adoption of energy-conserving apparatuses can be collected.

3. Control Cases

3.1 Running machine quantity control

3.1.1 Gist and general

The operation method of compressors used as air sources of a plant is changed from the “loaded/unloaded run” method to the running machine quantity control method for running as many machines as suitable for the loads (pressure).

In the case where the compressor operation method is the “loaded/unloaded run” method, all the compressors are started when the operation of the plant starts, and are sequentially changed from the unloaded run to the loaded run according to the change of air supply pressure. So, the electric energy during the unloaded run is wastefully consumed. To reduce the unloaded run, the method is changed to the running machine quantity control method.

In the running machine quantity control method, a sequencer controls to run and stop compressors in response to the change of air supply pressure. The air supply pressure is detected by means of a pressure detector provided in a receiver tank, and the output signal is fed back to the sequencer, to be monitored. The sequencer starts, runs and stops the compressors, to keep the air supply pressure in a predetermined pressure range. Therefore, the unloaded run of compressors can be decreased. When the plant operation is started, predetermined compressors are run.

In order to eliminate the unloaded run, the capacity must be adjusted very accurately. So, at least one compressor must be a compressor made speed-controllable using an inverter.

3.1.2 System to be controlled

This method can be applied to all business categories having a compressed air supply source consisting of a plurality of compressors.

(1) Business category: Manufacture of foods

(2) Main product of the business establishment: Foods and dairy products

(3) Energy consumption: Received power 3,500 kW

(4) Problems

1) Compressors have been manually started and stopped, and have been operated with a capacity allowance.

2) The air supply pressure has been set at a higher level, considering sudden load pressure changes. Furthermore, to avoid the doubling in the loading and unloading pressure ranges of compressors, the discharge pressures of compressors have been set at higher levels.

3.1.3 Application of energy conservation control

Figure 3.1 shows an example of system constitution. One inverter-controlled 37 kW compressor is installed to eliminate the unloaded run. A pressure detector for detecting the air supply pressure is installed in a receiver tank. A sequencer accommodated in a quantity control panel controls the whole. The panel is provided with a touch-panel type control terminal for entering respective set values into the sequencer.

Figure 3.2 shows an operation pattern. The air supply pressure control range is 0.485 to 0.55 MPa, and to keep the air supply pressure in this range, the sequencer runs and stops compressors with an adequate capacity. The change in the number of compressors and the change of the load in this case are shown in Fig. 3.3. The No. 7 inverter-controlled compressor responds to the short-time changes of load capacities, and the sequencer controls the other compressors, to ensure that they are run in full load.

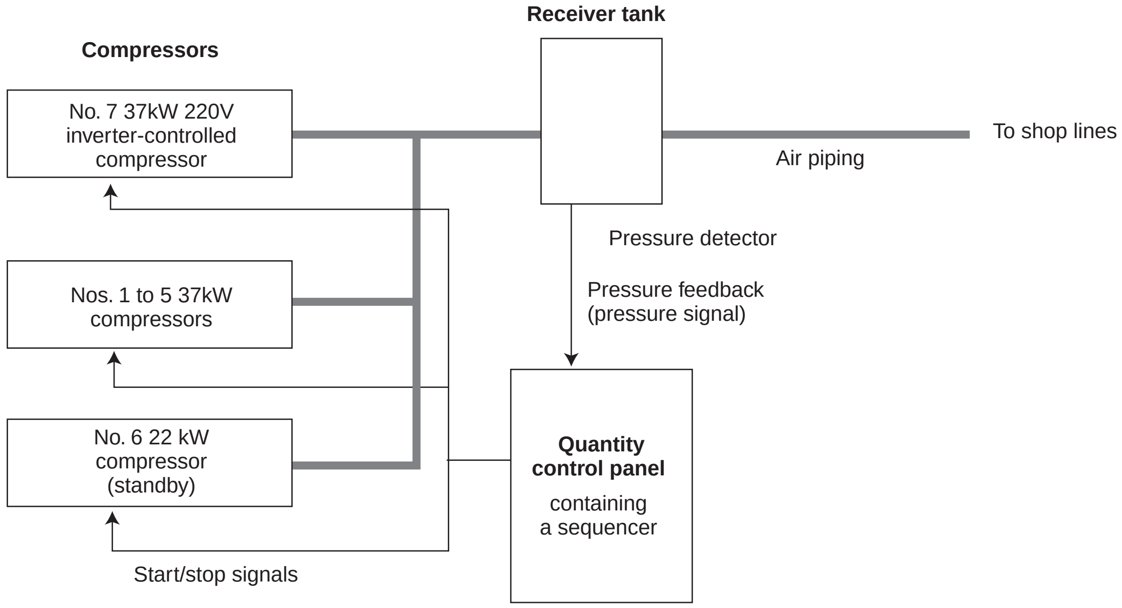


Fig. 3.1 System constitution

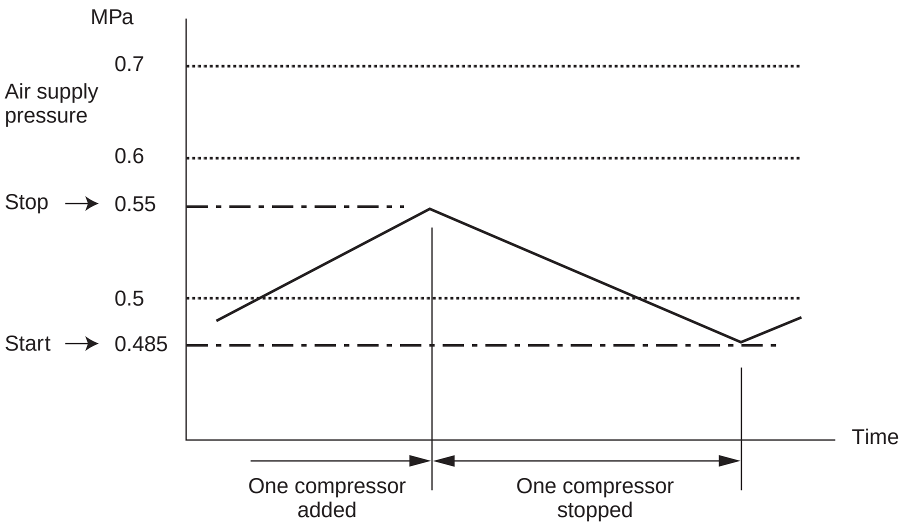


Fig. 3.2 Operation mode

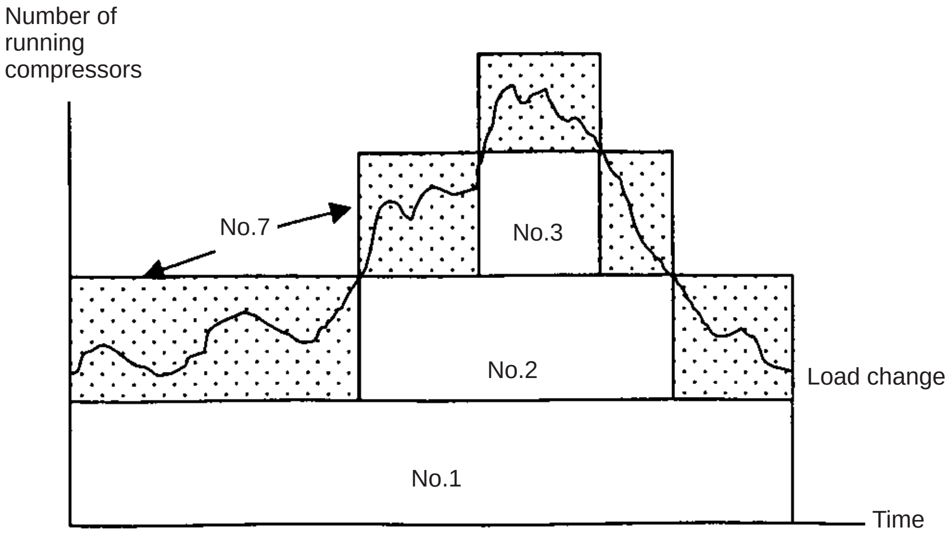


Fig. 3.3 Number of running compressors

3.1.4 Apparatuses

The following apparatuses are necessary.

No.	Name of apparatus
1	PLC sequencer
2	Display control panel
3	Pressure detector

3.1.5 Introduction effect

The unloaded run of compressors can be eliminated.

The following calculation is for the system constitution of Fig. 3.4.

In the unloaded run, a power consumption corresponding to 60% or more of that in the full load run occurs. The daily total unloaded running time is about 1 hour.

Power consumption P = 365 days × 1 hour x 6 units × 37 kW× 0.6 = 48,618 kWh

Electricity rate = 48,618 × ¥10/kWh = ¥486,180

3.1.6 Introduction cost

Since the cost of an inverter panel depends on the capacity of the inverter, it is not calculated here.

The cost of a quantity control panel depends on the number of controlled compressors to some extent, but is less than 2 million yen. The cost of one pressure detector is less than 200,000 yen.

3.2 Rotating speed control

3.2.1 Gist and general

To control the water level in a pump well of a sewage treatment plant within a set water level variation range, the rotating speeds of sanitary sewage pumps are controlled to smoothly feed the sewage influent to a downstream first settling tank. Rotating speed control is applied, for example, to pumps that transport a large quantity of a liquid for a long time. It is especially very effective in the case where the water level in a pump well greatly changes within a day to change the head difference. It is used for, for example, pumps that transfer cooling water or cold water to demanding equipment in a plant. For the sanitary sewage pumps in a large-scale sewage treatment plant or conveying pumps in a drinking water treatment plant, since the transferred flow rate is very large, quantity control and rotating speed control are combined for carefully thought-out control in many cases.

3.2.2 Outline of system to be controlled

(1) Business category: Sewage work

(2) Main product of the business establishment: Sewage treatment

(3) Energy consumption: Designated class 2 energy management plant

(4) Problem: The variation in the water level of a pump well has not been responded to sufficiently.

3.2.3 Application of energy conservation control

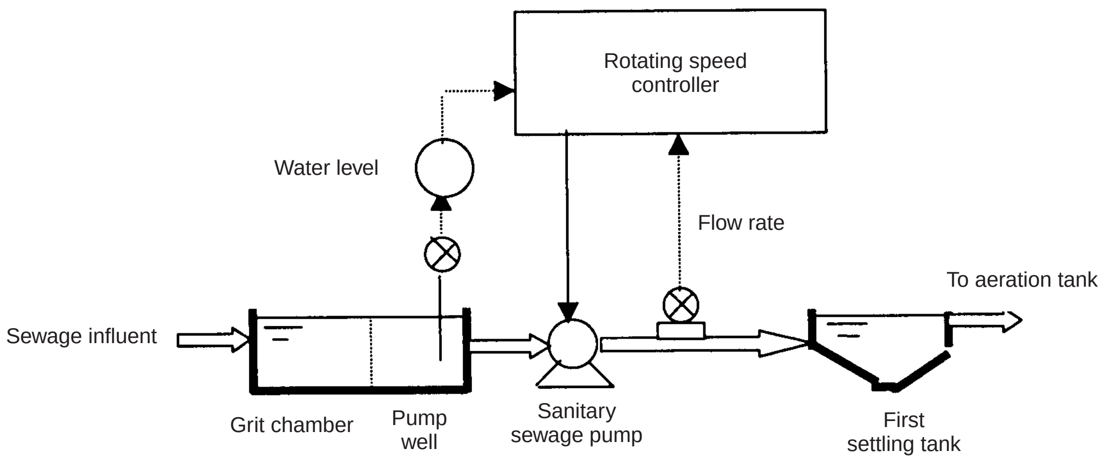


Fig. 3.4 Rotating speed control of sanitary sewage pump of sewage treatment plant

3.2.4 Necessary apparatuses

Necessary apparatuses	
Control apparatuses	One loop controller
	PLC (programmable logic controller, sequencer)
	PC (personal computer) (for monitoring and operation)
	Small-scale DCS (for control, monitoring and operation)
Sensors	Pump well water level gauge
	Conveying pump flow meter
Operation terminal	Control valve

3.2.5 Introduction effect

The calculated energy conservation effect with this system introduced is as shown below.

Control method	Rotating speed control	Discharge valve opening control
Discharge quantity	16 m^3/min (80%)	16 m^3/min (80%)
Required power of pump	83.3 kW	131.8 kW
Power consumption decrement	64.3 kW	15.8 kW
Annual power consumption decrement	563,268 kWh	138,408 kWh
Electricity rate decrement	¥5,632,000	¥1,384,000

3.2.6 Introduction cost

In this example, the cost of the rotating speed control apparatuses and sensors is about 6 million to about 10 million yen (not including the construction cost).

3.3 Air fuel ratio control (combustion control)

3.3.1 Gist and general

In a combustion system, air fuel ratio control is adopted for energy conservation (reduction of specific energy consumption). Irrespectively of the changes of combustion load (burning quantity), the ratio (μ: air fuel ratio, excess air factor) of combustion air flow rate to fuel flow rate is kept in a predetermined range, to maximize the combustion efficiency. If the combustion air becomes insufficient, incomplete combustion occurs, and the fuel per se is lost as an exhaust gas, to increase the heat loss and to generate black smoke. If the combustion air is excessive, the excessive air is heated and emitted as an exhaust gas, to cause heat loss and to start increasing NOx. Since the combustion efficiency is highest when the air fuel ratio is kept in a range of 1.02 to 1.10, strict air fuel ratio control is carried out to keep the air fuel ratio in the range, for maximizing the combustion efficiency.

At the same time, it is expected that the product quality is improved, and that, in the case of a furnace for iron or steel, the scale loss is reduced.

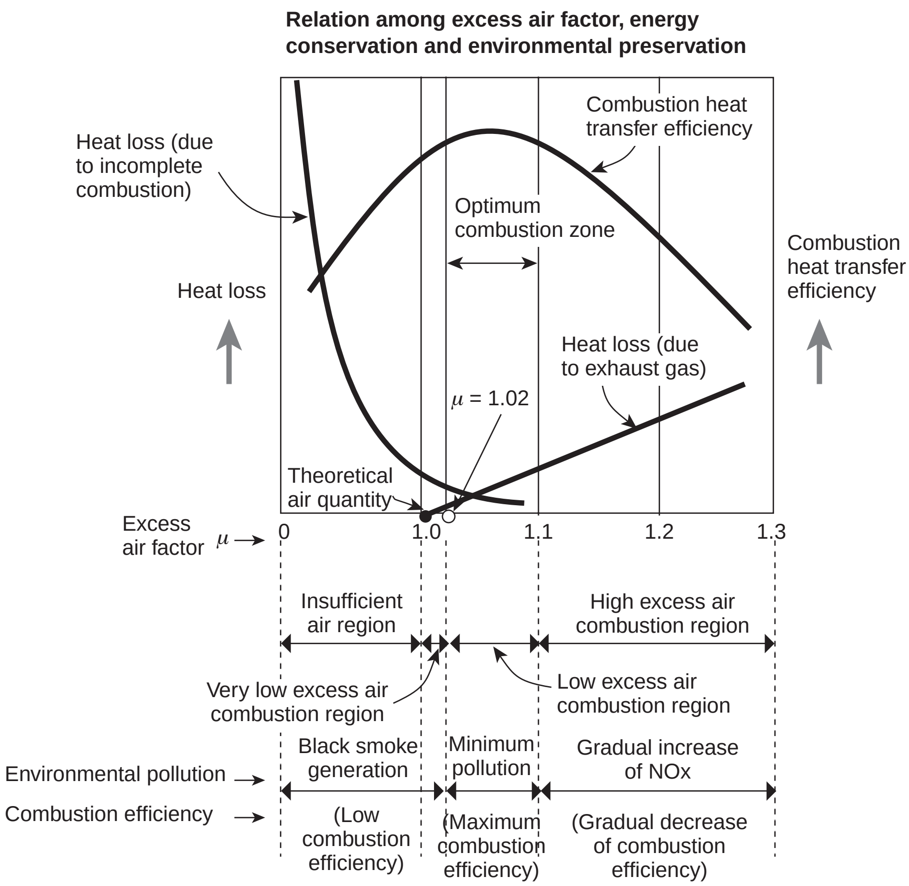


Fig. 3.5 Air fuel ratio (excess air factor) and energy conservation

3.3.2 Outline of system to be controlled

An example is shown below, but this control can be applied to all combustion systems irrespective of business categories and scales in boilers, industrial furnaces, glass melting furnaces, drying furnaces, etc.

(1) Business category: Manufacture of metallic products
(2) Main product of the business establishment: Galvanized stranded copper wires
(3) Energy consumption: About 3,800 kl in terms of crude oil
(4) Problem: The air fuel ratio control of a heating furnace of a plating shop is insufficient.

3.3.3 Application of energy conservation control

In the case where the outputs of a primary controller (furnace temperature control in the case of furnace control, or steam pressure control in the case of boiler control) are delivered in cascade as set values to a fuel flow controller and a combustion air flow controller, the cross limit processing is carried out to ensure that the air fuel ratio is kept in a certain range even in a transient state. The fuel flow controller and the combustion air flow controller have a fuel flow rate and a combustion air flow rate applied as process values, and deliver control signals to a fuel flow regulating valve and a combustion air flow regulating valve. In the case where the combustion air is heated by a recuperater (heat exchanger using an exhaust gas), temperature and pressure corrections are carried out for accurately measuring the flow rate. Also in the case where a gas fuel is heated, temperature and pressure corrections are carried out.

Furthermore, the CO concentration and O_2 concentration in the exhaust gas are measured for correction, to allow more highly accurate air fuel ratio control.

A schematic drawing of a case where a one loop controller is used as the controller is shown below.

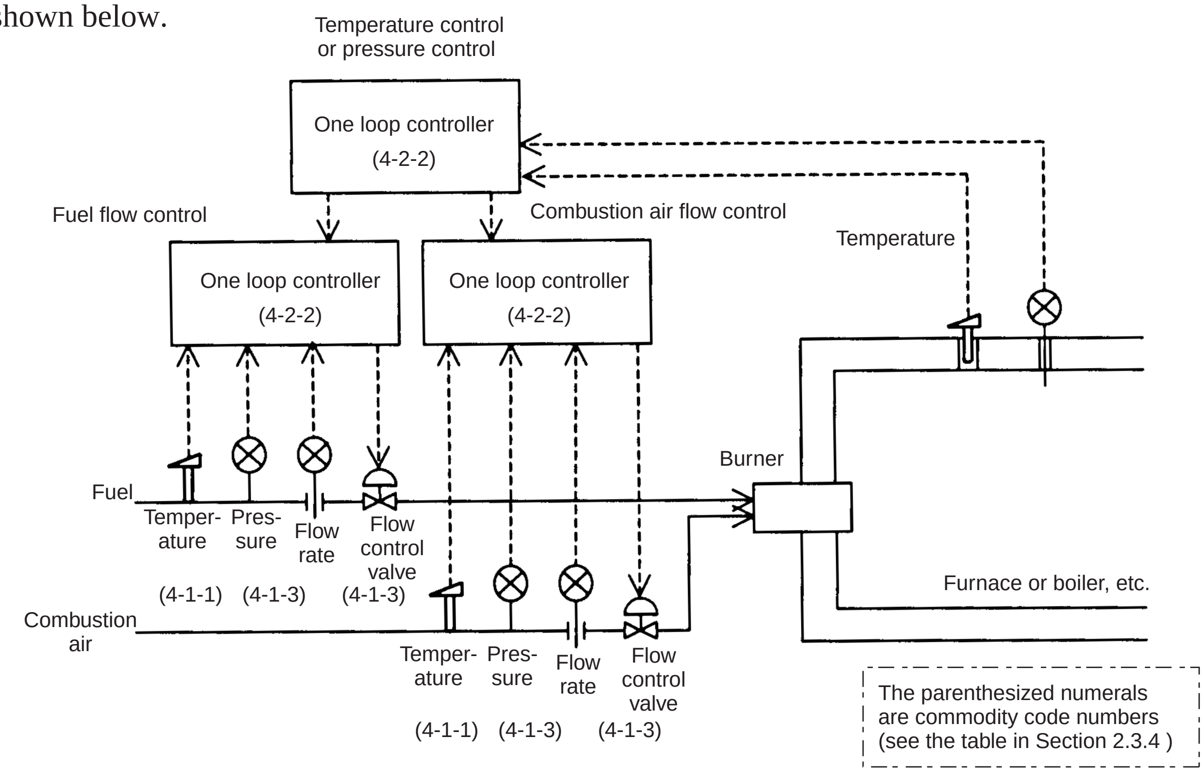


Fig. 3.6 Combustion control constitution (1)

A schematic drawing for a case where a personal computer is used as an HMI for general monitoring and operation is shown below. A bus is used to connect the HMI and the one loop controller, to allow the monitoring of data in the controller on the CRT, the changing of set values, the display of various trends, flow charts and alarms, etc.

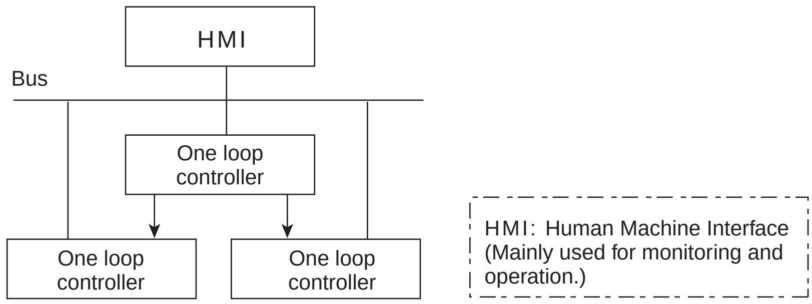


Fig. 3.7 Combustion control constitution (2)

The cross limit control refers to a method in which when the demanded combustion load suddenly changes, both the fuel control loop and the combustion air control loop follow the demanded combustion quantity while giving the upper and lower limits to the desired value of the self loop in response to the controlled variable of the other loop.

K1 (%): Smoke limit setting during load increase
K2 (%): Smoke limit setting during load decrease
K3 (%): Excess air limit setting during load decrease
K4 (%): Upper air limit setting during load increase

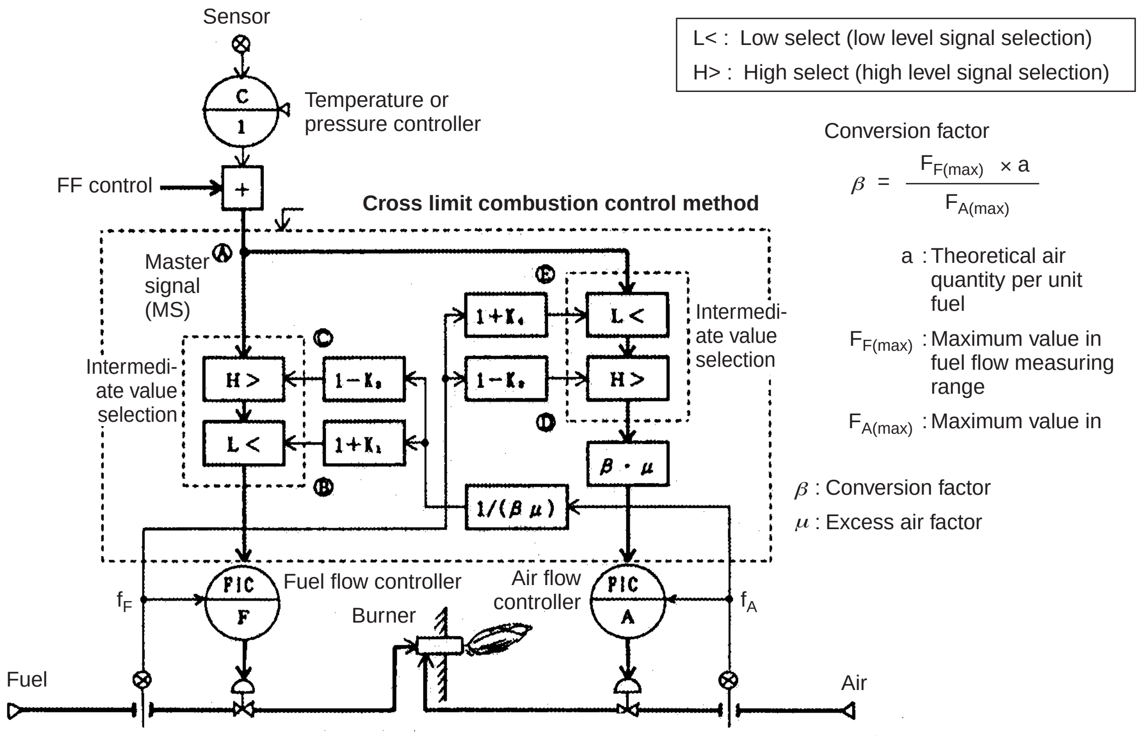


Fig. 3.8 Cross limit combustion control

3.3.4 Apparatuses

The following apparatuses are necessary, but the apparatuses installed in the existing equipment may be able to be used.

	Name of apparatus
Controllers	One loop controller (for control)
	PLC (programmable logic controller, sequencer) (for control)
	PC (personal computer) (for monitoring and operation)
	Small-scale DCS (for control, monitoring and operation)
Sensors	Orifice (used in combination with a differential pressure transmitter for gas fuel flow measurement)
	Differential pressure transmitter (used in combination with an orifice for gas fuel flow measurement)
	Positive displacement flow meter (for liquid fuel flow measurement)
	Pressure transmitter (for a case where the pressure correction of fuel flow rate is necessary, or for boiler pressure measurement)
	Resistance bulb (for a case where the temperature correction of fuel flow rate is necessary)
	Thermocouple (for furnace temperature measurement)
	Oxygen analyzer (O_2 analyzer, for a case where exhaust gas O_2 control is made)
	CO analyzer (for a case where exhaust gas CO control is made)
Operation terminal	Fuel flow regulating valve
	Combustion air flow regulating valve

3.3.5 Introduction effect

(1) An energy conservation case with a boiler

With a 200 ton/h boiler, the air fuel ratio was improved from 1.29 to 1.05, and the exhaust gas O_2 concentration declined from 4.8% to 1.0%. A heavy oil consumption of 1,034 kg/year could be saved as energy conservation. With the heavy oil price as ¥30/kg, ¥31,000/year could be saved. The annual consumption is 93,500 kg/year.

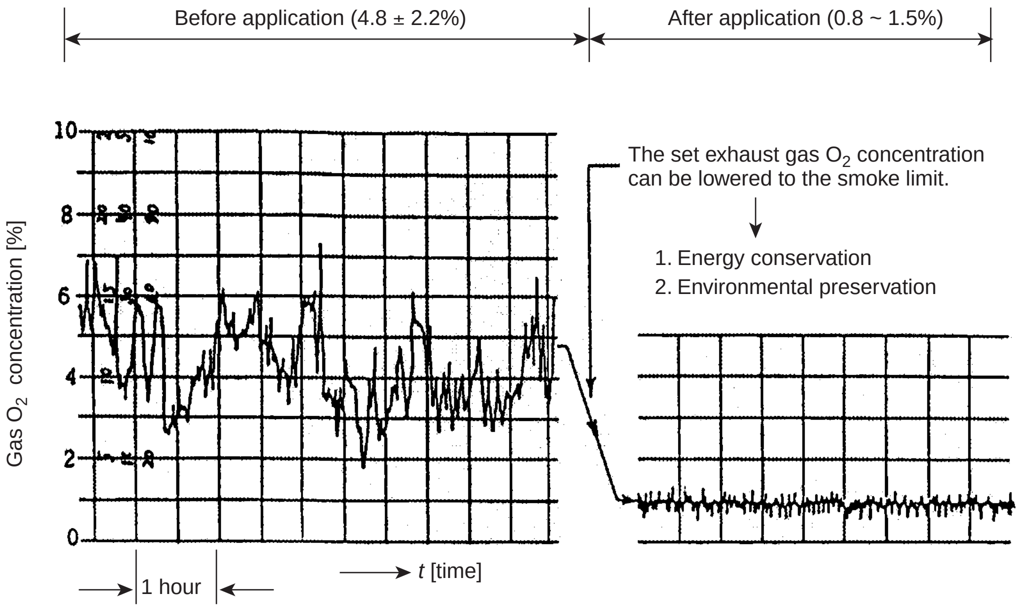


Fig. 3.9 An energy conservation case with a boiler

(2) An energy conservation case with a heating furnace (A)

Air fuel ratio control was carried out, and the specific energy consumption could be decreased from 1.7×10^6 J/ton (404×10^3 kcal/ton) to 1.5 × 106 J/ton (356×10^3 kcal/ton). Energy of 0.2×10^6 J/ton (48×10^3 kcal/ton) could be saved. The fuel was heavy oil. With the lower calorific value as 10,600 kcal/kg, about ¥140/ton could be saved. The saving rate was about 12%.

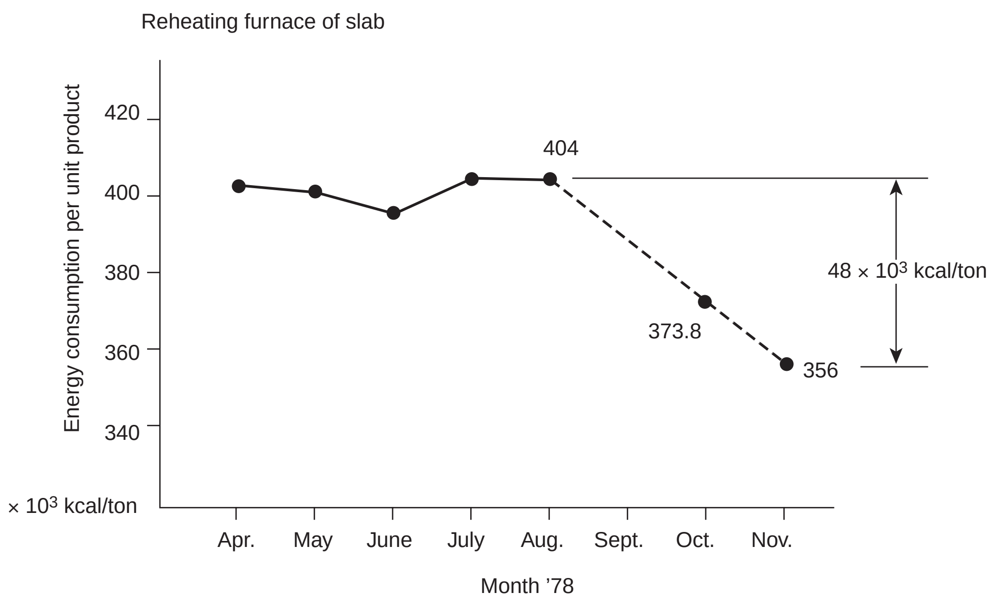


Fig. 3.10 An energy conservation case with a heating furnace (1)

(3) An energy conservation case with a heating furnace (B)

Air fuel ratio control was carried out, and the specific energy consumption could be decreased from 34.9 liters/ton to 32.4 liters/ton.

Energy of 2.5 liters/ton could be saved. The fuel was heavy oil. With the specific gravity of heavy oil as 0.9, about ¥70/ton could be saved. The saving rate was 7.2%. The lower portion of the following graph expresses this case of measurement.

(4) An energy conservation case with a heating furnace (C)

Air fuel ratio control was carried out, and the specific energy consumption could be decreased from 38.9 liters/ton to 37.6 liters/ton.

Energy of 1.35 liters/ton could be saved. The fuel was heavy oil.

About ¥40/ton could be saved. The saving rate was 3.3%. The upper portion of the following graph expresses this case of measurement.

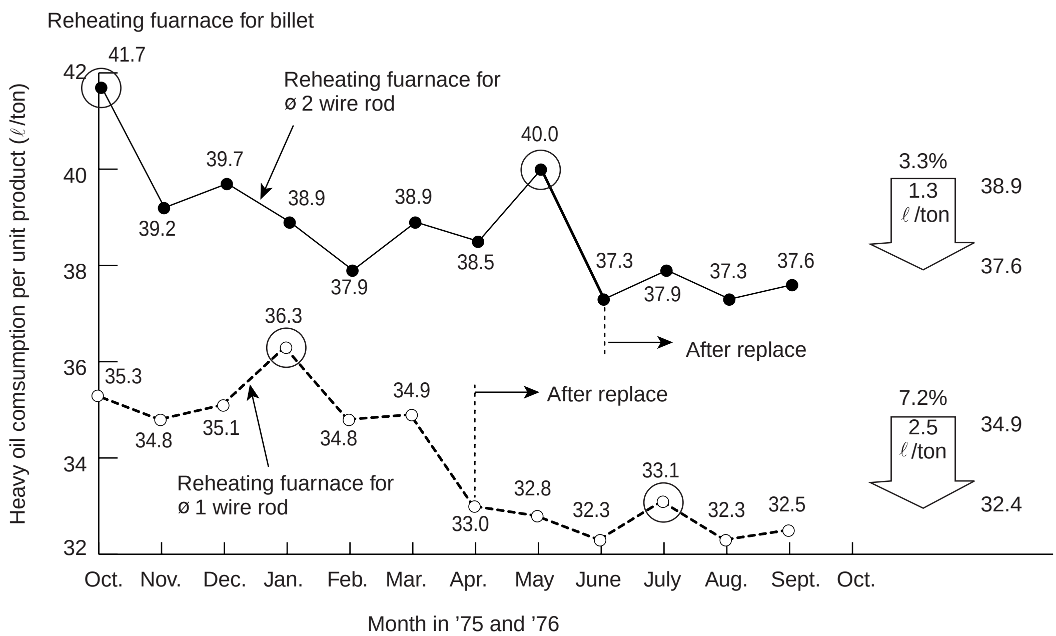


Fig. 3.11 Energy conservation cases with heating furnaces (2)

(5) An energy saving case with a glass melting furnace

The air fuel ratio was improved from 1.24 to 1.08, and the exhaust gas O_2 concentration declined from 4.0% to 1.5%. The heavy oil consumption decreased by 57.5×10^3 kg/year, and ¥1,725,000/year could be saved.

The annual total consumption is 3×10^6 kg/year.

3.3.6 Introduction cost

The introduction cost ranges from about 2 million yen to about 10 million yen, though depending on many conditions such as the instrumentation scale (depending on the equipment to be controlled), number of control loops, and whether or not O_2 control or CO control is carried out. This cost does not include the equipment modification cost or the installation work cost.

3.4 Electric heating control

3.4.1 Gist and general

An energy conservation improving case based on the power factor improvement in thyristor phase control and the monitoring of heater deterioration is introduced below. In this case, a transformer tap is automatically switched and phase-controlled using thyristors, and the deterioration of a heater is monitored.

The heating of a heater such as an electric furnace is generally controlled by means of thyristor phase control. The improvement of thermal efficiency by way of improving the control method depends on the process, and it is difficult to generalize the practice. This particular case is not an energy conservation measure by means of thermal efficiency improvement such as preventing the radiation from furnace walls.

This improvement case is the power factor improvement of thyristor phase control viewed from the power source side.

The monitoring of heater deterioration is an indirect energy conservation measure that prevents product failure by monitoring heater deterioration with alarming, for eliminating wasteful power consumption.

(1) Power factor

The power factor is defined by formula (1).

Power factor = (Active power ∕ Apparent power) × 100 (%) ....(1)

Apparent power = $\sqrt{(\text{Active power})^2 + (\text{Reactive power})^2}$ ....(2)

If the conventional thyristor phase control is carried out, the power factor viewed from the power source side is 100 (%) or less. This is shown in Fig. 3.12.

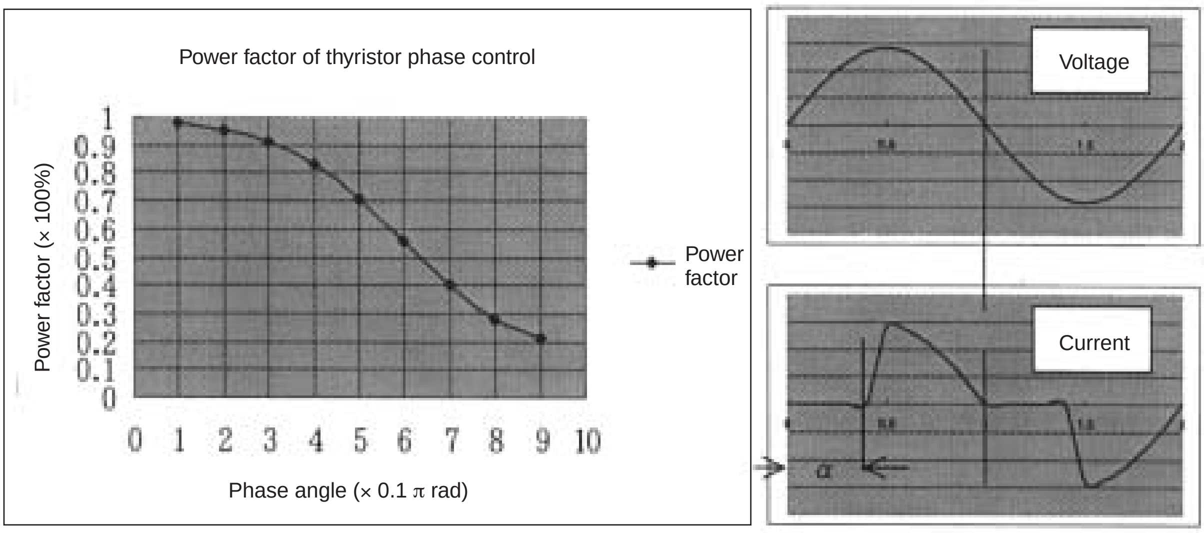


Fig. 3.12 Phase angle a and power factor of thyristor phase control

The AC power contains active power (power used for work) and reactive power (power not used for work), and the rate of the active power is called the power factor.
If the power factor is improved, the basic electricity rate is discounted, and this is an expected economic effect.

(2) Power factor discount

In the case of a contract of business use demand, high voltage demand A, high voltage demand B or extra high voltage demand, a discount (extra) rate is applied.
Since this depends on the contract pattern of electricity rate, this must be confirmed with the electric power company concerned. The calculation formula for the basic rate of The Tokyo Electric Power Co., Inc. is shown below for reference.

$$\text{Basic rate} = \text{Unit basic rate} \times \text{Contract demand} \times \frac{185 \pm \text{Powerfactor}}{100}$$

Example:

For a contract demand of 300 (kW), a high voltage demand A contract is applied.
The unit basic rate in this case is ¥1,175/kW.
If the power factor is improved by 10%, ¥35,250/month × 12 = ¥423,000/year can be saved.

(3) High power factor phase control

The high power factor phase control is simply described below.
As for the concept, the power factor is improved by controlling to eliminate the phase differences of voltage and current.
A thyristor phase controller and a tapped transformer are combined as shown in Fig. 3.13.

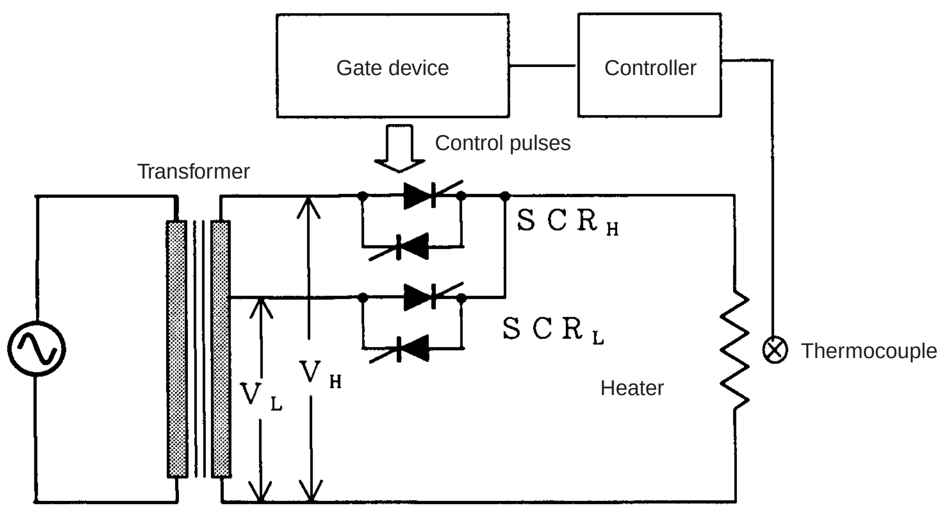


Fig. 3.13

In Fig. 3.13, at phase 0 (power source about 0 V), thyristor SCR_L is turned on, and phase α later, thyristor SCR_H is turned on.
Since SCR_L becomes in the reverse bias ($V_H - V_L$) state when SCR_H has been turned on, it is turned off at phase α. SCR_H is operated for conventional phase control.
With phase π to 0 (rad) control of α, the load voltage is continuously changed in a range of V_L and V_H, and the control waveform is as shown in Fig. 3.14, to improve the power factor.
If an adequate voltage tap is selected in this method, the power factor can be improved 90% or more. Compared with the conventional phase control, the high power factor phase control improves the power factor, and in addition, it can be expected that the higher harmonics can be decreased simultaneously due to waveform improvement.

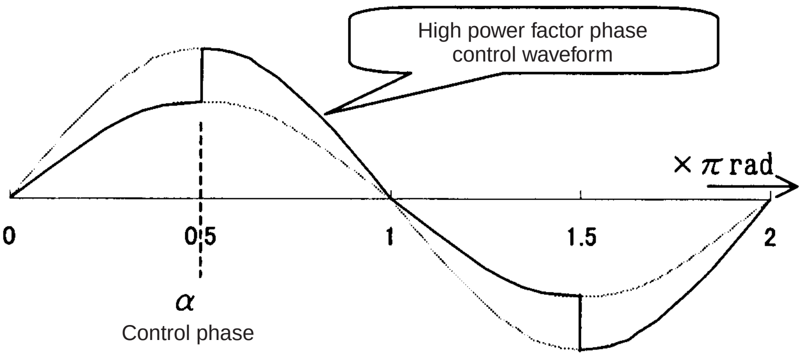


Fig. 3.14

(4) Monitoring of heater resistance

The monitoring of heater resistance is described below.
SiC that is the most popular non-metallic heater material is gradually deteriorated with use and increases in resistance.
Usually a heater is composed of a plurality of resistors, and the resistance value rise or wire breaking of some resistors affects the temperature balance of the process, to adversely affect the product. So, the heater must be exchanged in adequate cycles.
If the heater resistance is monitored, the heater can be exchanged before it is deteriorated, to allow positive preventive maintenance. So, the waste of energy can be prevented.
A heater monitoring unit refers to a unit for easily achieving the above purpose.
Figure 3.15 shows the basic method, and Fig. 3.16 shows the relation between the change of non-metallic heater resistance with lapse of time and alarms.

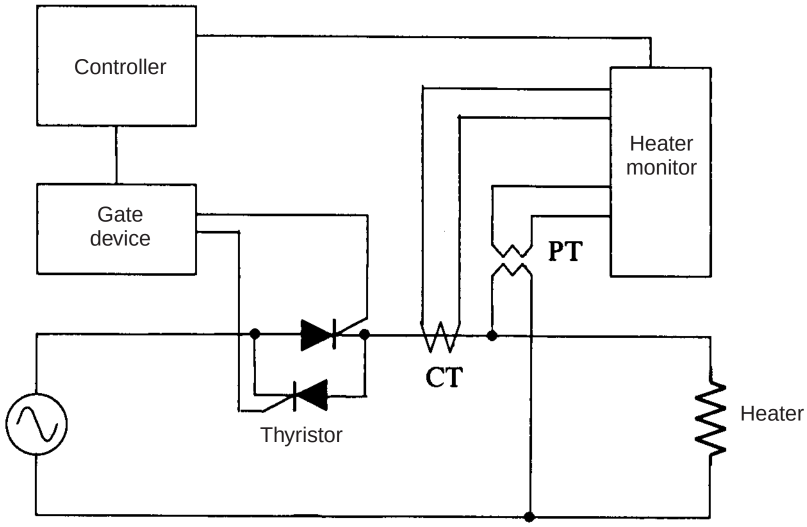


Fig. 3.15

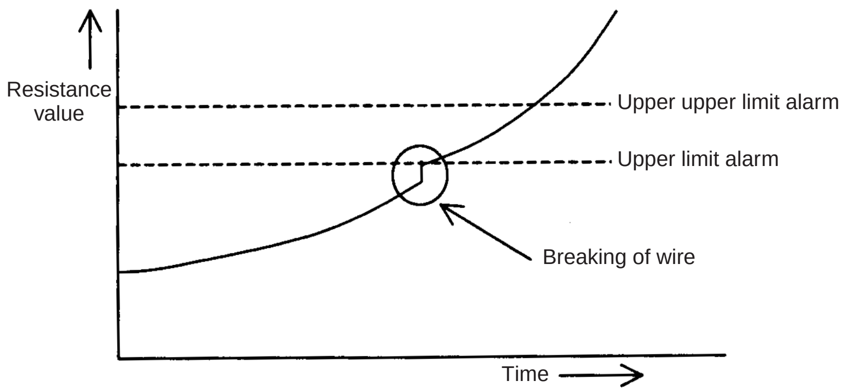


Fig. 3.16

3.4.2 Outline of system to be controlled

(1) Business category

Manufacture of electronic parts

(2) Main product of the business establishment

Chips to be mounted on surfaces

(3) Energy consumption

Contract demand 900 (kW) (high voltage demand B contract)
Approx. 2,500 (MWh/year)

(4) Effects and problems

High power factor phase control

This can be widely applied, for example, to electric furnaces and dimmers in which the temperature of the power-frequency source is controlled by means of thyristor phase control.

The control is effective in the case where the treatment temperature of an electric furnace is changed to a low, medium or high temperature, or in the case where a SiC heater is used.

Expected effects include the improvement of power factor, the increase of installed capacity under the same power receiving equipment, the reduction of feeder copper loss and the improvement of power source waveform (decrease of higher harmonics).

Since the numbers of thyristors and quick-acting fuses required for each heater are proportional to the number of taps, the equipment cost increases in proportion to the increase of taps as a disadvantage of this control.

Heater monitoring

This can be applied to the deterioration alarm and wire breaking alarm of a heater changing in resistance value with lapse of time and also to the partial disconnection of parallel or serial-parallel connection.

The temperature unbalance caused by heater wire breaking occurring when the power is switched on can be prevented, and preventive maintenance against the change with lapse of time can be ensured, to allow the product quality to be maintained.

In the case where the heater does not changes or little changes in resistance owing to the material used, this control cannot be used in view of principle. So, the characteristics of the heater must be confirmed beforehand.

3.4.3 Application of energy conservation control

A high power factor phase control gate device and a heater monitoring alarm unit are combined and applied to the temperature control of an electric furnace. A constitution for one furnace (model) is shown in Fig. 3.17.

The business establishment uses 16 electric furnaces as shown in Fig. 3.17, and their power consumption is 500 kW (about 1/2 of the total power consumption of the business establishment) on the average.

In the case where the electric furnaces were subjected to ordinary phase control, the average power factor was 82%, and the adoption of high power factor control could improve the average power factor to 92%.

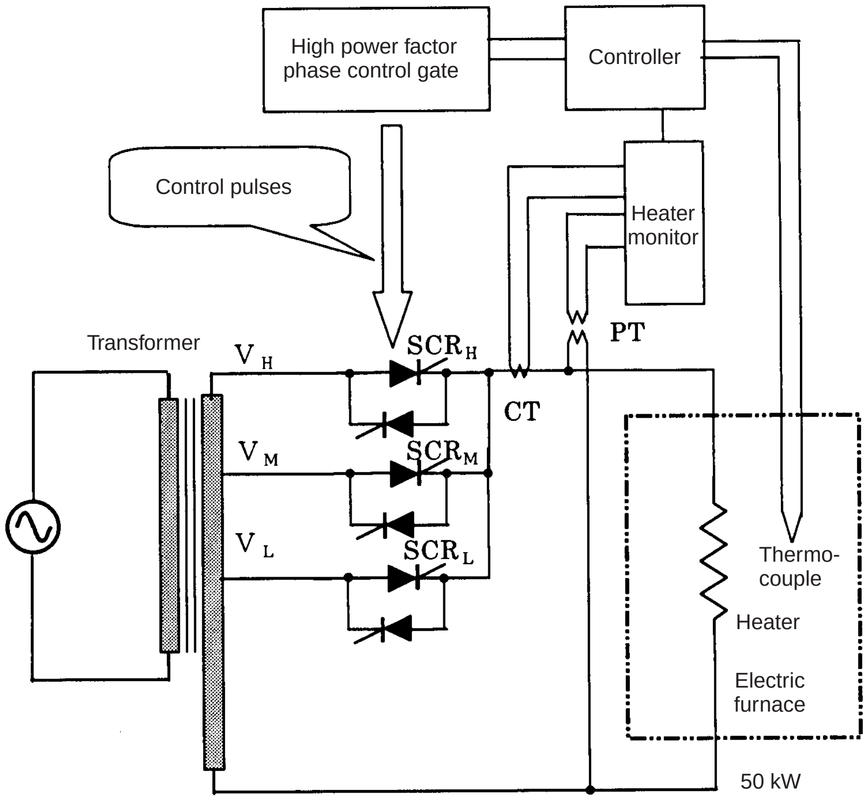


Fig. 3.17

3.4.4 Apparatuses

The following apparatuses are necessary.

Name of apparatus	Remark
Controller	
High power factor gate device	
Heater monitoring unit	
Tapped transformer	To be adapted to load specifications.
Thyristor	To be adapted to load specifications.
Instrument current transformer (CT)	
Instrument potential transformer (PT)	
Thermocouple	

3.4.5 Introduction effects

(1) Power factor discount (in the case of The Tokyo Electric Power Co., Inc.)

The discount of high voltage demand B contract is applied.

· Unit basic rate of high voltage demand B contract: ¥1,650/kW
· Contract demand: 900 kW
· Power factor: 10% improvement

· Covering rate: Rate of covered equipment demand in total demand of the business establishment (supposed to be about 1/2 = 0.5)

· Saved amount

$$= \text{Unit basic rate} \times \text{Contract demand} \times \frac{\text{Power factor improvement (\%)}}{100} \times \text{Covering rate}$$

· Saved amount = 1,650 × 900 × (10/1 00) × 0.5 = ¥74,250/month

· Annual saved amount = ¥74,250/month × 12 = ¥891,000/year

(2) Others

The capacity of the power receiving equipment can have an allowance.

The power receiving equipment for the electric furnaces has a capacity of 1,000 kVA, and at a power factor of 82% before improvement, the capacity is 820 kW (1,000 kVA × 0.82), having no allowance against the installed capacity of 800 kW (50 kW × 16 units).
The high power factor control improved the power factor to 92%, and the capacity of 920 kW (1,000 kVA × 0.92) has an allowance against the installed capacity. So, the existing power receiving equipment allows further two furnaces (50 kW × 2) to be additionally installed.

In addition, the copper loss of the power wiring can be decreased though slightly.

Since phase advancing equipment may be burned by higher harmonics, for example, it is said to be necessary to take any measure for decreasing the higher harmonics.

This system also allows the higher harmonics to be decreased though this advantage does not have direct relation with energy conservation.

(3) Heater monitoring

Heater monitoring allows heaters to be exchanged in adequate cycles for assuring quality preservation and preventive maintenance, to prevent the waste of energy.

In this application case, heater monitoring is combined with high power factor control, but it can also be combined with ordinary phase control.

The cost effect of the application case is calculated below based on some assumptions.

· MTTF of heater: 4 years (assumed, since it depends on the heater using method)
· Wasteful operation time: 24 hours (assumed to be one day)
· Average demand of furnace: 35 kW
· Unit electricity rate: ¥10/kWh

In the case where 16 electric furnaces are operated for one year, four furnaces (16/4) fail (wasteful operation) judging from the MTTF of heaters. (MTTF: Mean time to failure)

The electricity rate is $35 \times 24 \times 10 \times 4$ = ¥33,600/year.

Though the amount of money is small, the cost effect for quality preservation is not included since it is difficult to calculate the quality preservation. The expected effect of quality preservation and preventive maintenance is large.

3.4.6 Introduction cost

(1) Phase control cost

Gate device: Approx ¥250,000 ~
Tapped transformers and thyristors suitable for load conditions are arranged separately.

(2) Temperature control and heater monitoring

Temperature controller: Approx. ¥50,000 to ¥500,000
Heater monitor: Approx. ¥70,000
The above are approximate amounts, and do not include the instrumentation cost, etc.

3.5 Pressure reduction control and schedule control

3.5.1 Gist

(1) Air leak countermeasure

If the air supply in the area where air is not used when the production equipment is not operated during holidays and nighttime is stopped using valves, the air leak at piping ends can be decreased. This can be remotely controlled or can also be combined with the following schedule control.

(2) Schedule control

In many cases, the set header pressure remains constant even during lunch time/rest time and holidays/nighttime. If the header pressure is set at the required minimum level under schedule control, the energy can be reduced.

(3) Pressure reduction control

Since the necessary pressure is different from system to system, system-wise pressure control allows stable pressures to be supplied. Furthermore, if regulating valve openings, air flow rates and system-wise pressures are integrally managed, the required minimum header pressure to be set can be always identified.

Pressure gauges are installed on the main pipelines in the shop, so that pressure control can be performed to change the openings of regulating valves, for lessening the pressure variations at the ends. Hitherto the pressure variation was large and wasteful air was used. However, with this arrangement, the pressure variation can be made smaller and the required pressure can be reduced. So, wasteful air can be decreased, and the air consumption can be reduced.

Furthermore, if this control is combined also with machine quantity control, the compressors can also be stopped, allowing also the electric energy to be reduced.

3.5.2 Outline of system to be controlled

(1) Business category: Manufacture of electric machines and instruments

(2) Main product of the business establishment: Molded parts

(3) Energy consumption: 8.5 million kWh/year

(4) Problem

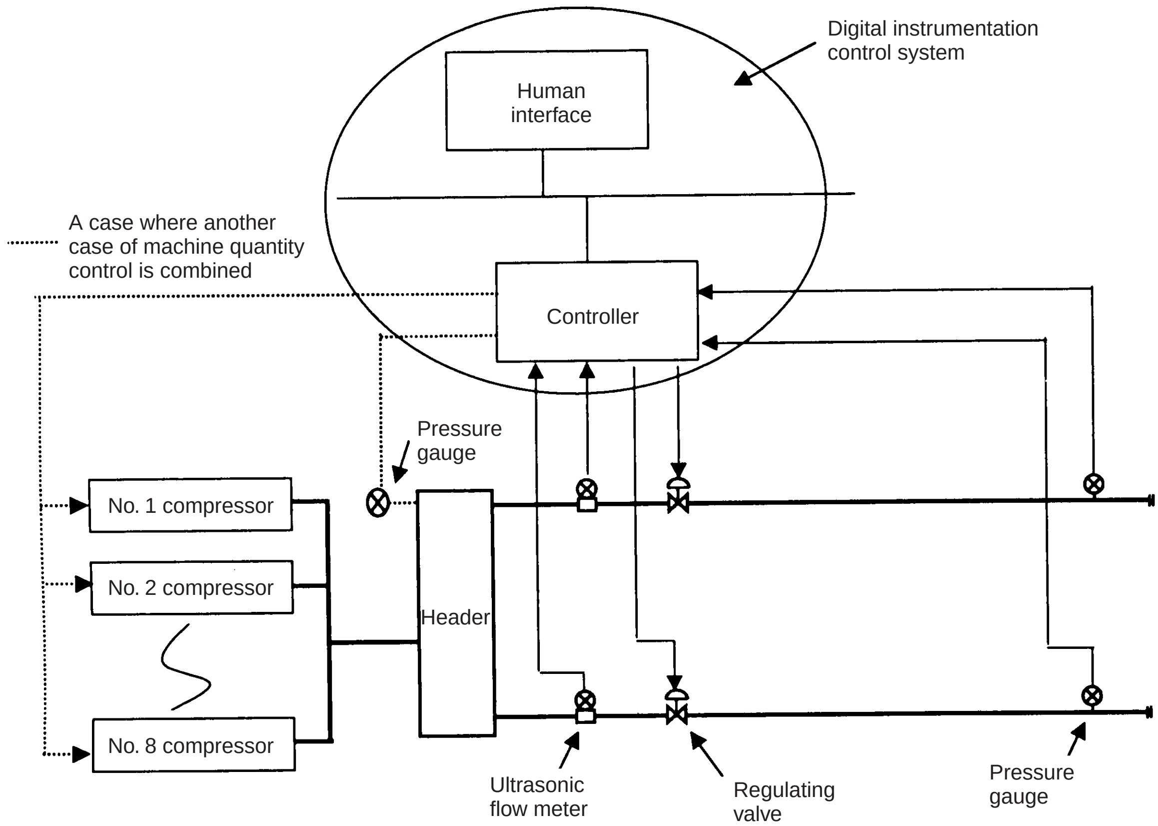
Six 37 kW compressors and two 22 kW compressors are being operated in two systems. At present, since the compressor control is unstable, the header pressure is set at 690 kPa. The pressures measured at site showed pressure variations of 696 kPa to 590 kPa. Therefore, if the pressures are stabilized, the header pressure can be lowered by 100 kPa.

Lowering the pressure by 100 kPa allows the energy to be saved by about 10%.

3.5.3 Application of energy conservation control

A system constitution is shown below. At first, ultrasonic flow meters wide in measuring range are installed on respective main pipelines, to identify consumptions and leaking air quantities. During holidays and nighttime when the production equipment is not used, the air supply in the area where air is not used is stopped using regulating valves, to decrease the air leak at the piping ends.

Furthermore, pressure gauges are installed at the ends of respective main pipelines, to control the pressures of the ends at the set levels, and the openings of regulating valves are changed. Furthermore, since actions automatically rise and fall according to the schedule, happening of forgetting can be prevented.



3.5.4 Apparatuses

Apparatus
Digital instrumentation control system
Ultrasonic flow meter
Pressure gauge
Regulating valve

3.5.5 Introduction effect

In this case, air consumes 20% of the entire electric energy, and in the amount of money, it costs about 25 million yen/year. In the above pressure reduction control, lowering by 100 kPa results in 10% energy conservation, and energy in the amount of about 2.5 million yen/year can be saved.

Furthermore, since the air leak during lunchtime, nighttime and holidays is prevented, energy in the amount of about one million yen/year can be saved.

3.5.6 Introduction cost

The cost for introduction is about 7 million yen to 15 million yen (including construction cost for two systems) (pay-back years are 2 to 4 years).

Buildings

4. A guide for selection of systems relating to electric energy consumption for support of energy conservation

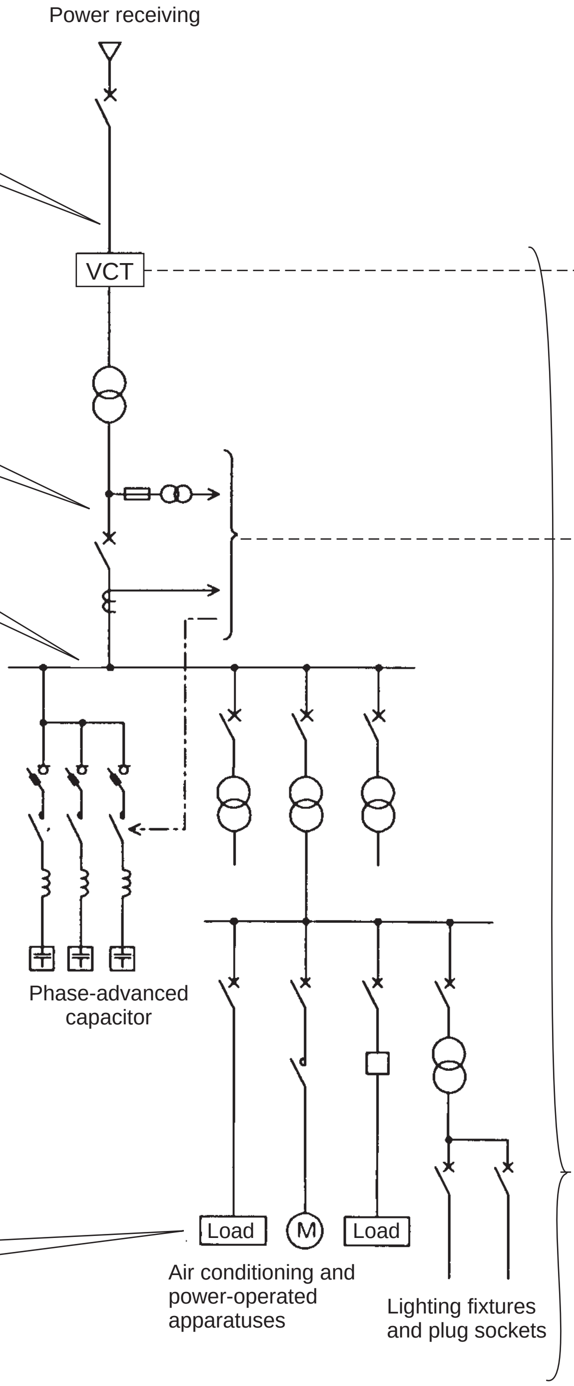
Data necessary for examining energy conservation

(1) Status of contract with electric power company (electricity rate slip, etc.)

(2) Electric power system diagram (high voltage, low voltage)

(3) Electric power equipment layout (switchboard, load apparatuses)

(4) List of respective power loads



Management functions for energy conservation

Power receiving equipment management function items (example)

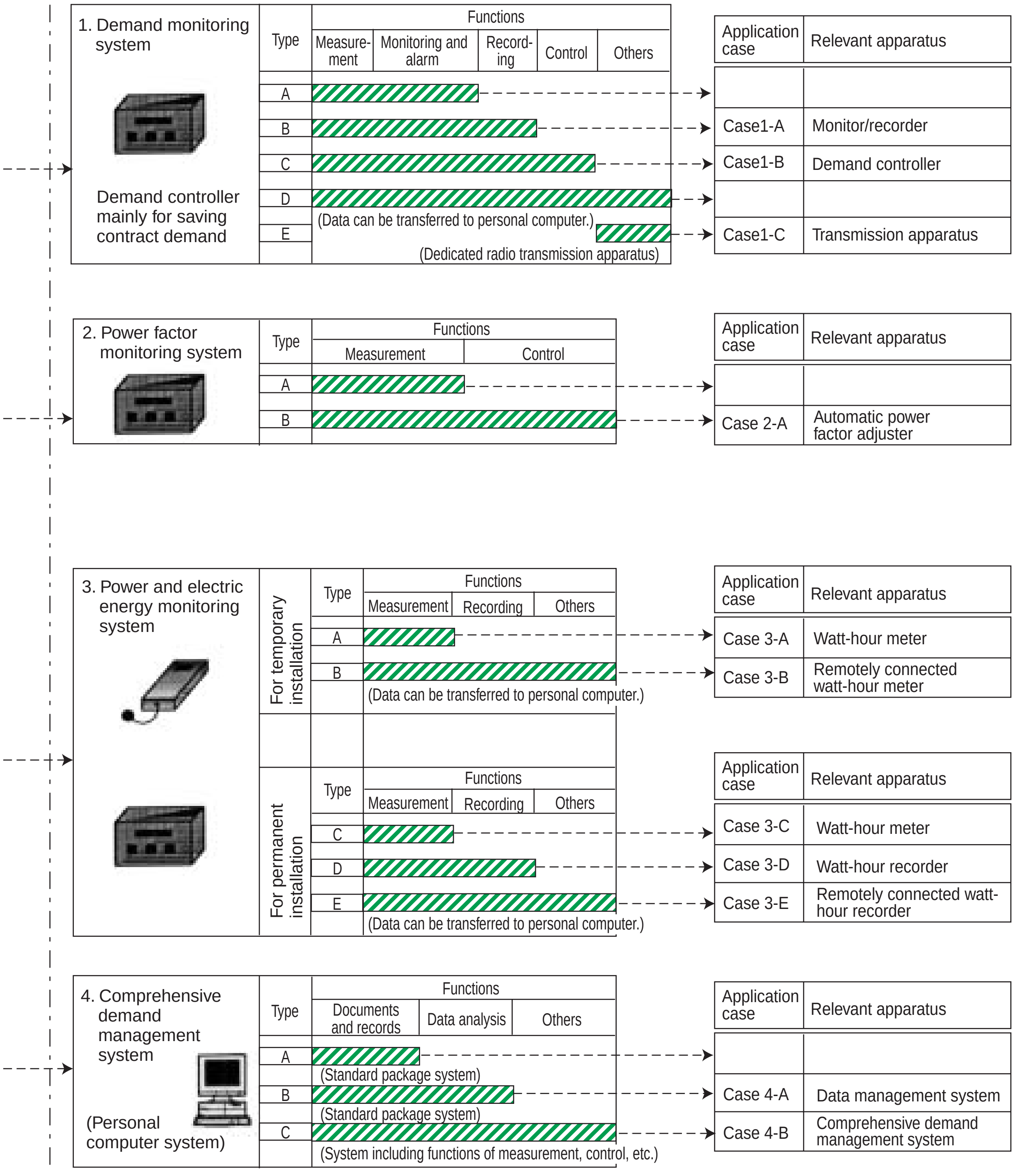
- Demand, load factor, power factor management
- Consumption management (daytime and night, holiday)
- Electricity rate management (contract)
- Demand factor/load adjustment
- Unnecessary load switching-off
- Preparation of comparative data before and after energy conservation measures taken
- Preparation of data for various reports

Electric energy consumption management function items (example)

- Recording of daily, monthly and yearly electric energies
- Daily load curve, previous fiscal year ratio graph
- Energy consumptions of respective apparatuses
- Sales amount vs. specific power consumption
- Production quantity vs. specific power consumption
- Analysis of fixed and variable energy consumptions
- Preparation of comparative data before and after energy conservation measures taken
- Preparation of data for various reports

Application cases and relevant apparatuses for realizing the management functions

< Not including power source quality improving apparatuses (SVC, active filter, etc. >



5. Cases

5.1 Demand monitoring systems

Case 1-A **Understand and analyze electric power usage conditions using a demand controller with measurement, recording, monitoring, and alarm functions, and reduce contract electric power**

1. Outline

A supermarket is operated in a commercial building. Because all the air conditioning is electrically powered, summer power consumption is markedly high. In contrast to winter, when power consumption is about 60% of the contract amount, in July and August, power consumption is very close to the contract amount. This time, in July, the amount of energy used exceeded the contract power on some occasions.

In order to prevent such occurrences, and to reduce the contract power by promoting energy conservation, a demand controller was introduced. By setting loads for adjustment using a demand alarm function, through manual on/off control of loads when an alarm has occurred, the system is operated without exceeding the maximum power.

2. Outline of subject facility

(1) Type of business: Retail (supermarket)

(2) Main products: Sale of food and clothing

(3) Contract power: 1,000 kW

3. Proposed system

(1) Outline of equipment introduced and its functions

1) Demand controller (with monitoring, alarm, and recording functions)

a. Demand value is measured by receiving a pulse signal emitted from the service meter

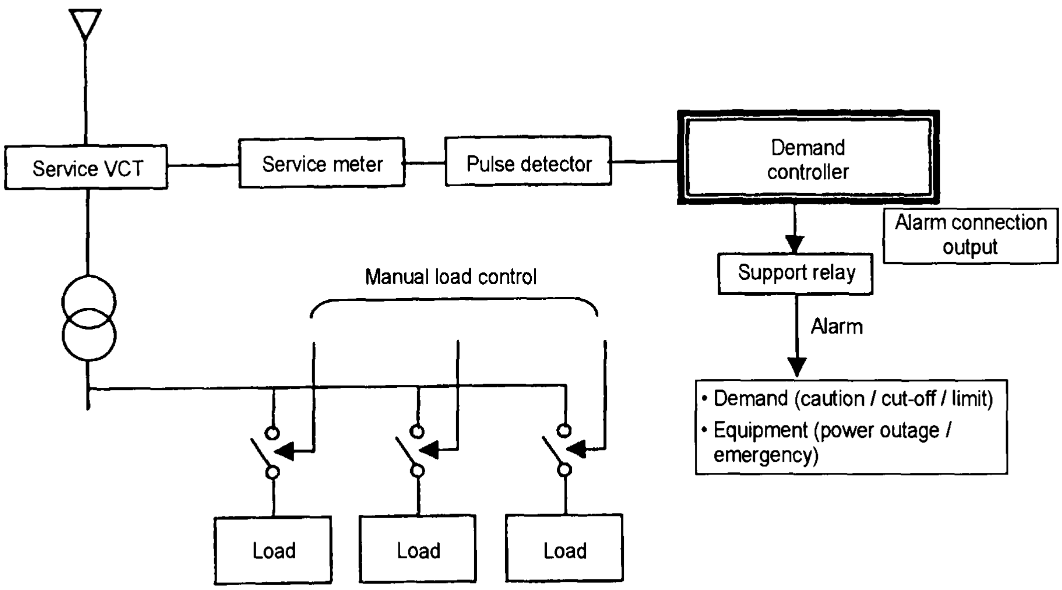
b. Demand value is monitored, and if it is possible that the target power will be exceeded, an alarm is issued via a buzzer and connection signal

c. Data (demand value, power) is recorded and results compiled (daily reports, monthly reports, yearly reports, peak demand, load curve, etc.)

2) Pulse detector

Supplies a pulse emitted from the power company's service meter to the demand controller.

(2) Connection method



(3) Usage method

If power consumption appears likely to exceed the target power set in advance for the demand controller (a value less than the contract power is set), an alarm is issued, and peak load is cut by switching off items of power supply equipment, in a sequence decided in advance. (Air conditioning, unnecessary lighting, etc. are switched off.)

Subsequently, if the data obtained can be analyzed to specify peak timing, consider scheduled operation of high-capacity equipment. If the peak can be cut, reduce target power and positively control the occurrence of peak demand, and if possible, reduce the contract power.

4. Expected effects

If peak power can be restrained and the contract power reduced from 1,000 kW to 930 kW, the results are as follows.

1) Reduction in contract power = 1,000 kW – 930 kW = 70 kW

2) Reduction in electricity charges
= 70 kW x ¥1,650/kW/month × 85% × 12 months/year × 1.05 = ¥1,237,000

5. Introduction costs

(1) Equipment costs (outline calculation)

Demand controller and pulse detector: About ¥220,000

(2) Engineering work expenses (reference)

The work expenses are mainly wiring costs, which depend on wiring length and method (pit/duct), but are about ¥300,000.

Case 1-B Use of a demand controller with monitoring, alarm, and control functions to reduce contract power.

1. Outline

Looking at electricity usage conditions in a laboratory, peak power (demand) exceeds 900 kW in summer in June and August, and in winter in February and March, but at other times of year, it is substantially less than 900 kW. Monthly energy usage also varies seasonally in line with demand, but does not change as much as demand. At present, because no demand controller is used, peak occurrence conditions are not understood, and measures for cutting the peak are also insufficient.

Regarding electricity uses, heat sources, air conditioning, lighting, and power outlets account for 80%, and major peak-cut measures are not possible. However, by installing a demand controller with monitoring, alarm, and control functions to determine peak timing, it will be possible to reduce the current contract power, through short-term cut-off for air conditioners, cold-water pumps, etc.

2. Outline of subject facility

(1) Type of building:	Laboratory
(2) Number of building users:	Weekdays 90 persons; Holidays 1 person
(3) Building outline:	Six floors above ground, total floor area approx. 9,000 m^2
(4) Contract power:	1,000 kW

3. Proposed system

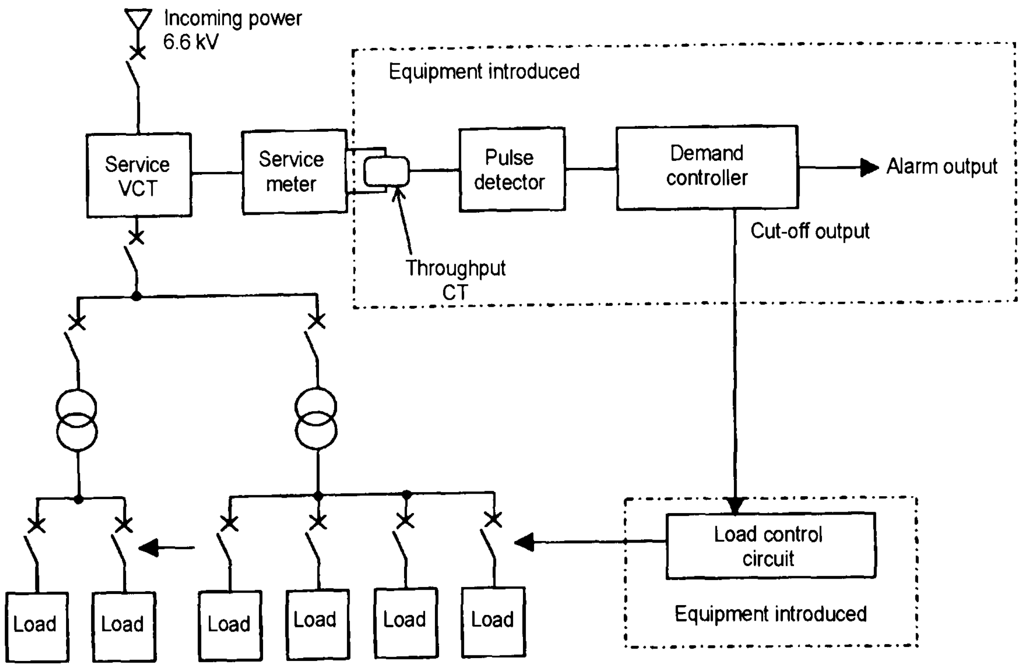
(1) Equipment introduced and its functions

1) Demand controller (with monitoring, alarm, and control functions)
   a. A pulse signal emitted from the service meter is received via a pulse detector and used to measure demand value.
   b. Demand value is monitored, and if it is possible that it will exceed the target power, an alarm is emitted via a buzzer, connection signal, etc, and a load control signal is output to control circuit breakers for air conditioners, etc.
   c. Data (demand value, power) is recorded and results such as daily reports, monthly reports, yearly reports, and peak demand are compiled.

2) Pulse detector: Supplies a pulse emitted from the power company's meter to the demand controller. In some cases, suitable types differ, depending on the power company.

3) Load control circuit: Receives signal from demand controller and controls load from air conditioners etc. (Introduced if necessary)

(2) Connection method



(3) Usage method

If the target power set in advance for the demand controller (set a value less than the contract power and less than previous actual values) appears likely to be exceeded, an alarm is issued, and the need for control with respect to the previously set load is automatically judged and a cut-off signal is emitted. By this means, it is possible to keep demand below the target value.

As the loads subject to control, items for which short-term cut-off is possible are chosen, such as air conditioners, cold-water pumps, and lighting. They are connected to the cut-off output circuit of the demand controller via the load control circuit. By setting the cut-off load capacity for the demand controller, electricity usage conditions are monitored and if it is possible that the target power will be exceeded, appropriate cut-off control is performed by comparing cut-off load capacity and excess power conditions. Because the cut-off sequence can also be set, it is also possible to cut off important loads last.

The cut-off load capacity set for the demand controller is, in principle, the power consumption value during operation of the loads subject to control, but at the time of introduction, appropriate control can be achieved by setting a slightly lower value and implementing early cut-off control, then looking at load operation conditions and adjusting the set value.

In addition, if the occurrence of peak power and load operation conditions can be specified by analyzing recorded data (demand value, power), it is also possible to consider scheduled operation of those loads, positively suppress peak occurrence, and reduce the contract power.

4. Expected effects

If peak power can be suppressed and contract power reduced from 1,000 kW to 900 kW, the effects are as follows. In the calculation, the basic electricity charge is ¥1,650/kW/month.

1) Reduction in contract power = 1,000 kW – 900 kW = 100 kW

2) Reduction in electricity charges
= 100 kW × ¥1,650/kW/month × 85% × 12 months/year × 1.05 = ¥1,767,000

5. Introduction costs, etc.

(1) Equipment costs (outline calculation)

1) Demand controller and pulse detector: About ¥400,000

2) Load control circuit: Configuration depends on the loads subject to control

(2) Engineering work expenses (reference)

1) Demand controller and pulse detector
The work expenses are mainly wiring costs, which vary largely, depending on wiring length and method (pit/duct). In most cases, the cost is about ¥300,000.

2) Load control work
Wiring work varies largely, depending on the installation locations of loads and control circuit

6. Other matters (points to bear in mind, etc.)

It is necessary to ensure that there is no discrepancy in demand time limit between the service meter and demand controller.

Case 1-C **Automatically reduce contract power by attaching a wireless transmitter to a demand controller with measurement, recording, monitoring, alarm, and control functions**

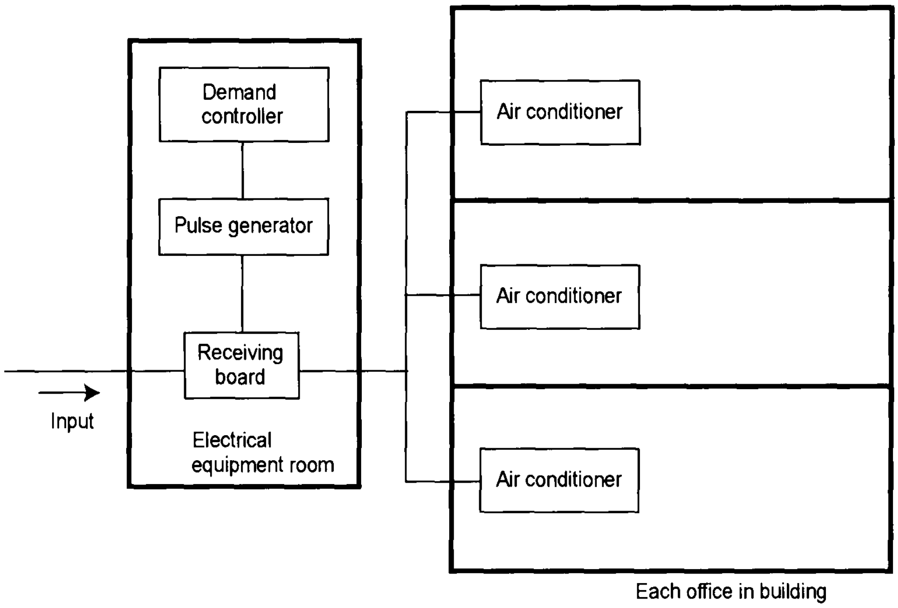
1. Outline

In electrical energy conservation as an energy conservation measure in a building, particularly as a measure for air conditioners, conditions with usage almost at the contract power limit have continued. Accordingly, in order to prevent demand exceeding the contract power, with the aim of reducing the contract power by promoting energy conservation, continuous monitoring and control through introduction of demand monitoring equipment, and operation in such a way as to avoid peaks and over-demand, have been adopted. However, as full-time staff could not be stationed in the electrical equipment room, the demand monitoring equipment is unable to display its capabilities.

2. Outline of subject facility

(1) Contract power: 1,500 kW

(2) Schematic wiring diagram (outline)



3. Proposed system

(1) Outline of equipment introduced and its functions

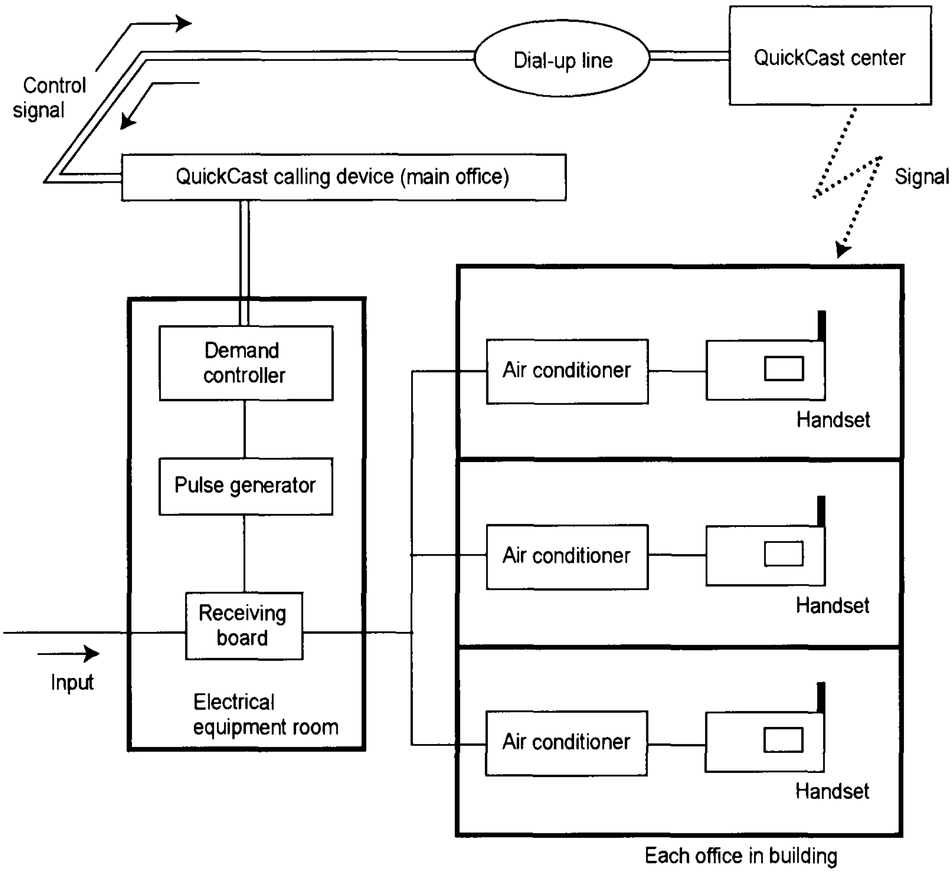
1) Remote control device incorporating QuickCast (main and sub units)

a. Receives pulse emitted from meter and measures demand value

b. Demand value is monitored and if it is possible that target power will be exceeded, a

QuickCast signal is sent to the sub unit to switch the power supply on or off. Consequently, there is no need for unnecessary wiring on the premises.

(2) Connection method



(3) Usage method

If it is predicted that the target power set in advance for the demand monitoring and control equipment (set a value less than the contract power) will be exceeded, a QuickCast signal from the main control unit is dialed out, and by switching off power supply equipment in a sequence decided in advance, a peak cut can be achieved. (For example, air conditioners not directly related to production and unnecessary lighting can be switched off, followed by machinery indirectly related to production.)

If it is predicted that subsequently, the target power will not be exceeded, revert to automatic operation.

4. Expected effects

If peak power can be suppressed and contract power reduced from 1,500 kW to 1,300 kW, the effects are as follows. If the basic electricity charge is ¥1,650/kW/month,

1) Reduction in contract power = 1,500 kW – 1,300 kW = 200 kW

2) Reduction in electricity charges
= 200 kW × ¥1,650/kW/month × 85% × 12 months/year × 1.05 = ¥3,534,000

5. Introduction costs

(1) Equipment costs (outline calculation)

Remote demand controller, main unit: ¥600,000

Remote demand controller, sub units: ¥60,000 per unit

*In addition, the QuickCast system itself and registration fee are needed.

(2) Engineering work expenses (reference)

Work expenses are mainly for internal wiring of air conditioners, and depend on wiring length and method, but are about ¥250,000.

5.2 Power factor monitoring and controlling system

Case 2-A **Conserve energy by measuring reactive power, power, and power factor, and improving power factor by connecting a phase-advancing capacitor, in accordance with load current magnitude, to the circuit.**

1. Outline

Aim to improve power factor by installing a phase-advancing capacitor to offset and reduce the lagging reactive power occurring with electrical equipment such as motors. To keep power factor close to 100%, it is necessary to adjust the capacitor input in accordance with load variation. An automatic power factor adjuster measures reactive power and automatically connects or disconnects the circuit to the phase-advancing capacitor.

By improving power factor, it is possible to

1) Reduce transformer loss

2) Reduce line loss

3) Improve de facto usage rate of equipment capacity

4) Reduce line voltage drop

5) Reduce electricity charges through a power factor discount system

Item 5) provides the biggest financial merit.

2. Example of subject equipment

(1) Contract power: Up to 1,000 kW

(2) Contract type: Commercial power

(3) Power factor (before measures): 0.90

3. Proposed system

(1) Outline of equipment introduced and its functions

(a) Automatic power factor adjuster

Measures reactive power, power, and power factor from alternating voltage and current from VT and CT, selects appropriate phase-advancing capacitor based on measured values, and outputs circuit making and breaking commands.

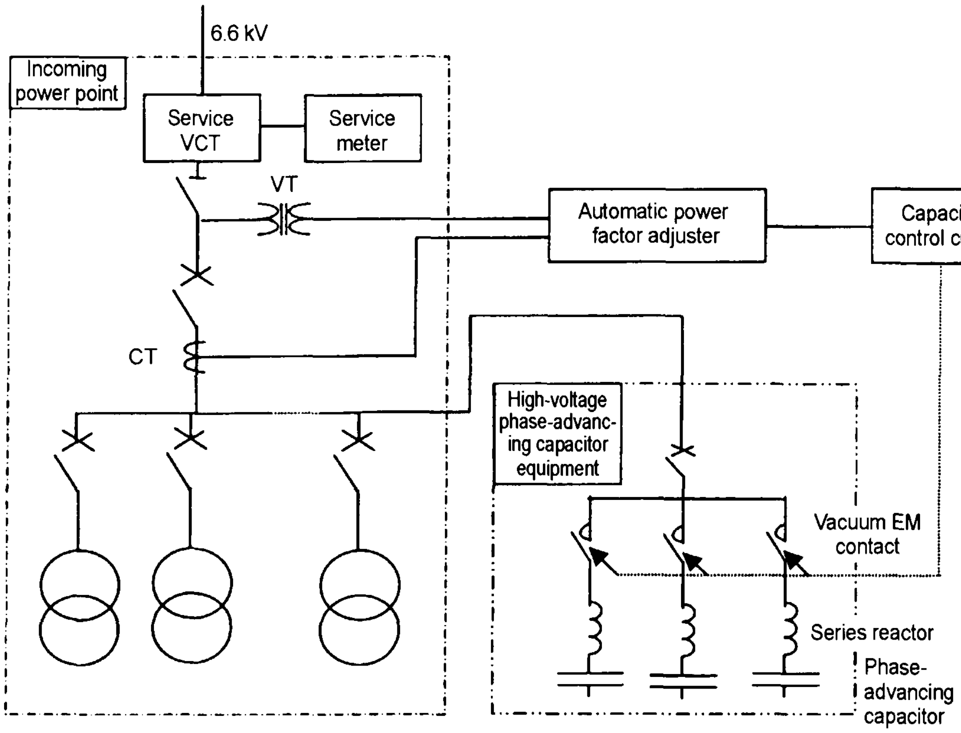
(b) High-voltage phase-advancing capacitor equipment

Consists of a high-voltage phase-advancing capacitor to improve power factor, a DC reactor to protect the capacitor, a discharge coil, and a vacuum EM contact to automatically connect and disconnect the circuit to the capacitor.

(c) Other items

The capacitor control circuit varies the signal from the automatic power factor adjuster and operates the vacuum EM contact.

(2) Connection method



(3) Usage method

Set primary current, secondary current, and target power factor for the automatic power factor adjuster. The automatic power factor adjuster continually measures reactive power and power factor, selects an optimal phase-advancing capacitor based on the measured values, and outputs circuit making and breaking commands for the installed capacitors.

The automatic power factor adjuster, to prevent power factor from advancing too far, prohibits input to the capacitor when load is light, and prohibits control until the disconnected capacitor is discharged. It has the ability to select the control method for capacitor input, from among cyclic control, priority control, and optimal control.

Through the display function of the automatic power factor adjuster, capacitor control status and measured power value can be monitored.

4. Expected effects

1) During peak power usage

   Power factor is improved from 90% to 98%

2) If contract power is 1,000 kW,

   Reduction in electricity charges

   = (contract power value) × (basic unit charge) × (improvement in power factor) × (12 months/year) × (consumption tax)

   = 1,000 kW × ¥1,650/kW/month × 0.08 × 12 months/year × 1.05 = ¥1,663,000/year

5. Introduction costs, etc.

(1) Equipment costs (outline calculation)

   Automatic power factor adjuster: ¥230,000 (ref.)

   Three banks of phase-advancing capacitors
   100 kvar (with 13% reactor): ¥3,600,000 (ref.)

   Three vacuum EM contacts: ¥360,000

(2) Engineering work expenses

   Panel costs and installation costs are required for high-voltage phase-advancing capacitor equipment

5.3 Electric power and electric energy measuring systems

Case 3-A Example of understanding current situation and energy conservation measures using portable power meter

1. Outline

In energy conservation initiatives, it is essential to not only monitor power at the incoming power point, but understand how much is currently consumed for each location and application. Accordingly, before introducing full-scale equipment such as continuous monitoring devices and demand controllers, measurements were made cheaply and easily at each point using portable measuring equipment.

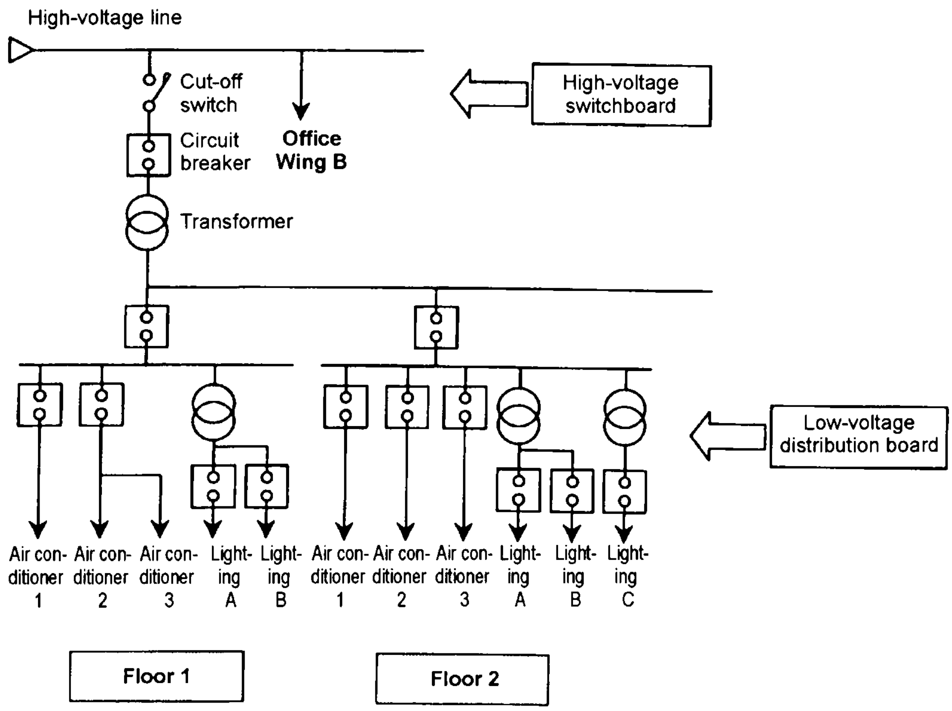
By understanding the current situation, it was possible to determine that wasteful usage occurred with air conditioners and lighting, and to propose measures such as cutting usage during periods when rooms were unoccupied. It was also possible to set specific figures as future targets.

2. Outline of subject facility

(1) Subject equipment: Power used for air conditioning and lighting

(2) Contract power: 1,500 kW

(3) Schematic wiring diagram (outline)



3. Proposed system

(1) Outline of equipment introduced and its functions

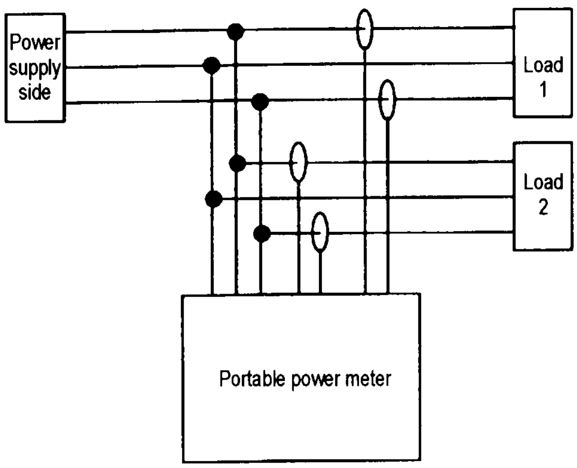
- Portable power meter

(a) Simple connection using attached current detection clamp and voltage probe
(b) Usable for various applications, including measurement of instantaneous values, electrical energy, demand, and higher harmonics
(c) Can determine usage capacity during operation, by incorporating start/stop signals for measured equipment
(d) Enables data to be saved simultaneously in internal memory and on floppy disk. Can also be connected to PC through serial port.
(e) Can be connected to a printer to print out data.

(2) Connection method

<For single-phase, three-wire system>

The figure shows connections for measuring two load systems (up to four current detection clamps can be connected)



(3) Usage method

- By connecting to the subject system and making sequential measurements of power data, understand current situation.
- To save data, use floppy disk or connect to PC.
- When considering a cut in power when subject equipment is not operating, results after the measure can be predicted by collecting data during operation.

- By making measurements again after implementing energy conservation measures, the effects of such measures can be measured quantitatively.

4. Expected effects

Assuming about 5% reduction in relation to air conditioning, ventilation, and lighting, the reduction in electricity charges is as follows.

Reduction in energy used: $3{,}000{,}000$ kWh × 0.05 = 150,000 kWh

Reduction in electricity charges: 150,000 kWh × ¥10/kWh = ¥1,500,000/year

Case 3-B **Conserve energy by using a meter with a recording function and connecting it to a PC to understand and analyze usage situation regarding power and energy.**

1. Outline

In a school, heighten awareness of energy conservation by measuring and displaying electrical energy details for each floor used by students and each classroom.

By installing a simply connectable watt-hour meter that can be easily attached, data can be collected and analyzed, helping with awareness regarding reduction in electrical energy usage and energy conservation education.

2. Outline of subject facility

(1) Type of business: Public elementary school

(2) Subject equipment: Distribution board for each floor (lighting, outlets, etc.)

(3) Contract power: 169 kVA (Commercial power)

3. Proposed system

(1) Outline of equipment introduced and its functions

Simply connectable watt-hour meter

a) Make measurements with meter, using CT, at breaker for each measured location (See Figure1)

b) Data can be collected and analyzed using a PC, and displayed using EXCEL.

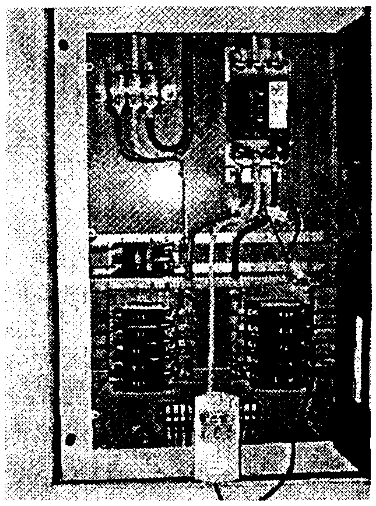


Figure 1 Example of attachment

(2) Connection method

See Figure 2

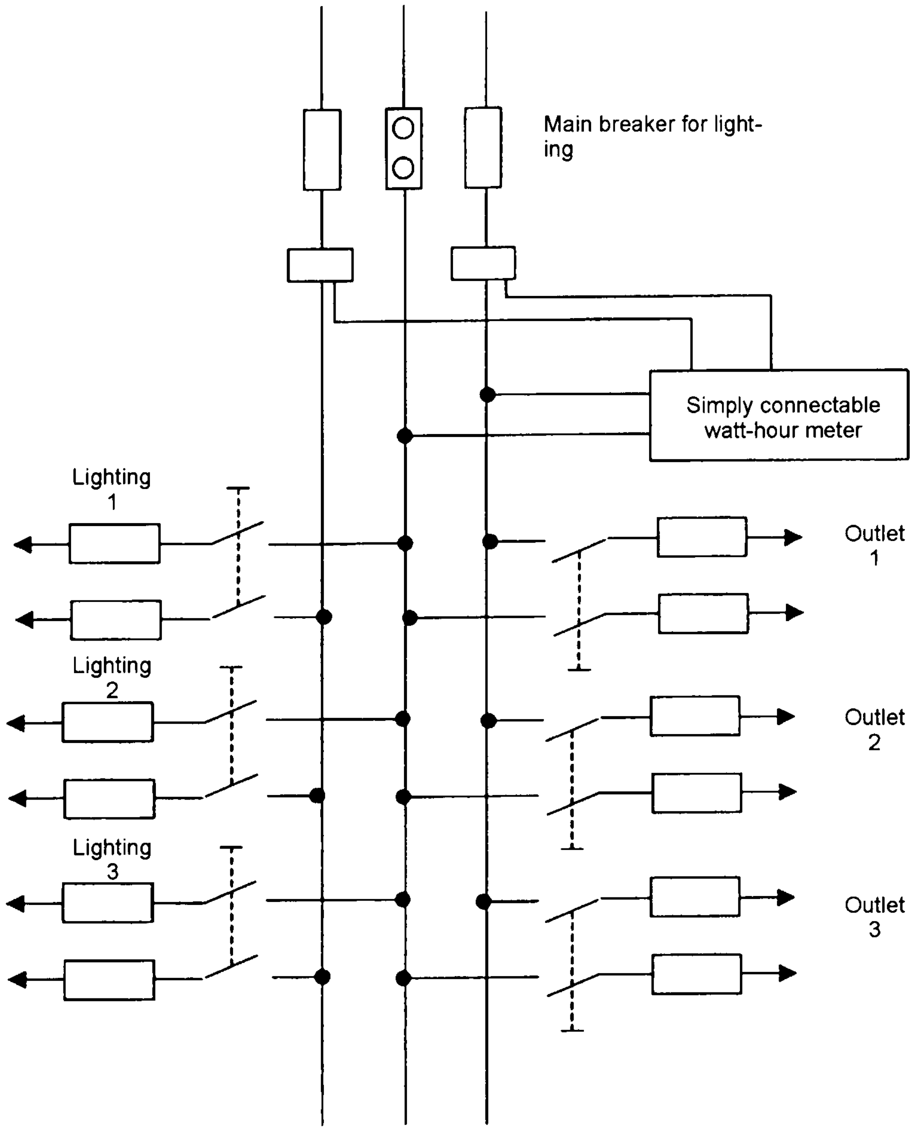


Figure 2 Connection method for simply connectable watt-hour meter

(3) Data analysis and examination

By attaching a simply connectable watt-hour meter for each floor and classroom, connecting it to a PC, and collecting and analyzing data, the usage situation for each floor and classroom can be understood. In addition, by considering usage methods, reductions in energy usage can be expected.

4. Expected effects

If a 10% reduction in energy consumption can be achieved after introducing the watt-hour meter, the following reduction effects can be expected.

1) Reduction in energy usage: 240,900 kWh × 0.1 = 24,090 kWh

2) Reduction in electricity charges: 24,090 kWh × ¥13.27 = ¥320,000/year (kWh = ¥13.2)

5. Introduction costs, etc.

(1) Cost of equipment (outline calculation)

Simply connectable watt-hour meter: ¥39,800

Data collection cables and software: ¥7,000

(2) Engineering work expenditure (reference)

Because the meter can be connected easily, no work expenses are necessary.

Case 3-C Conserving energy by determining and analyzing the electrical energy usage situation using a device with a recording function.

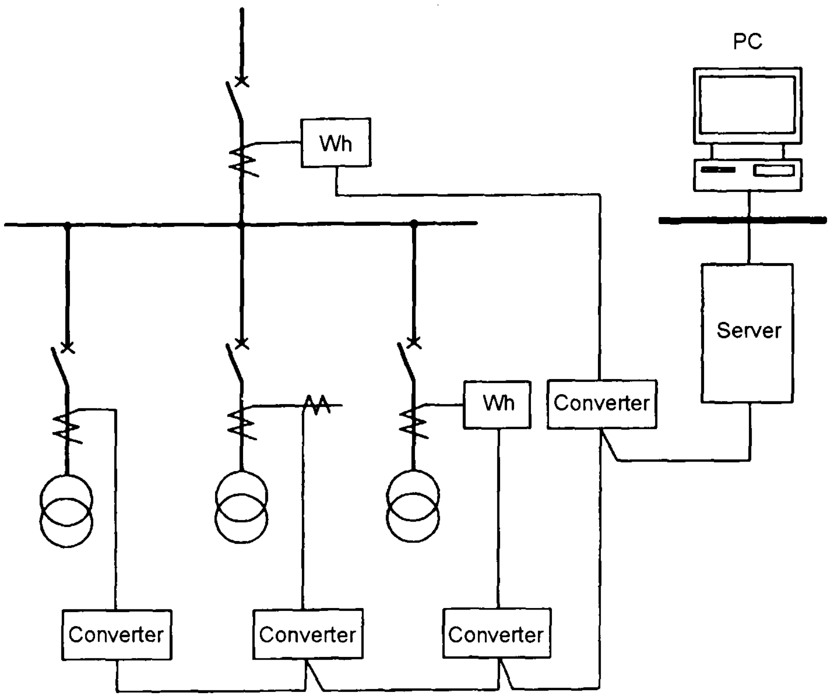
1. Outline

The energy usage situation in a building depends on the building's purpose, scale, structure, location, etc., but in general, air conditioning and lighting, and power outlets account for a high proportion of usage.

It is effective to emphasize these two types of equipment in energy conservation measures. For this reason, it is necessary to manage, in visible fashion, where and why energy is used in the building, and in what amounts.

2. Outline of subject facility

(1) Business type: Electric machinery manufacturing
(2) Main products handled: Software
(3) Contract power: 1,500 kW
(4) Distribution schematic and connection diagram (outline)



3. Proposed system

(1) Outline of equipment introduced and its functions

1) Energy converter (with transmission function)

a. The incoming power circuit uses a multi-transducer that enables measurement of electrical energy, reactive power, voltage, current, frequency, power factor, etc.

b. The feeder circuit uses an energy monitor with a function that converts the pulse signal from an existing watt-hour meter, and voltage and current, to energy values.

2) Energy management monitor and server

a. Signals from the converter are collected by the management server and various data (daily reports, monthly and other tables, graphs) are displayed.

(2) Connection method

See distribution schematic and connection diagram in 2.(4).

(3) Usage method

Using the power monitor, as well as creating tables such as daily reports and monthly reports from data collected by the converter and transducer, each type of data is put in graphical form and the energy usage situation is analyzed.

4. Expected effects

(1) Example calculation

For a user with 1,500 kW contract, if a 100 kW reduction is achieved by using the power monitor to assess day-to-day usage situation, the effects are as follows. The calculation assumes a basic charge of ¥1,650/kW/month.

1) Reduction in contract power
= 1,500 kW (before improvement) – 1,400 kW (after improvement) = 100 kW

2) Reduction in electricity charges
= 100 kW × ¥1,650/kW/month × 85% × 12 months/year × 1.05 = ¥1,767,000/year

5. Introduction costs, etc.

(1) Equipment costs (outline calculation)

1) Converter (with transmission function): About ¥50,000 ~ ¥80,000

2) Power monitor and server: About ¥1,500,000

(2) Engineering work expenditure (reference)

1) The installation fee for the converter depends on wiring length and method, but in general, is about ¥60,000 per location.

Case 3-D Energy conservation by recording electrical energy and understanding and analyzing the power usage situation. (Permanent facility)

1. Outline

In a hospital, the power usage situation is understood by looking at readings on the service meter, but only recording and management of daily and monthly values is carried out. In the future, to enable load smoothing through such means as demand management, understanding the usage situation for each application and time will be important for determining current status and proposing improvement measures.

Accordingly, readings on the service meter will be automatically recorded for each time, and daily and monthly usage amounts will be recorded. In addition, by introducing a system that automatically measures time-specific energy usage for each major circuit, detailed information will be collected to promote energy conservation.

2. Outline of subject facilities

(1) Building purpose:	Hospital
(2) Number of building users:	Weekdays 1,500 persons; Holidays 1,000 persons
(3) Building outline:	Nine floors above ground, total floor area approx. 23,000 m^2
(4) Contract power:	850 kW

3. Proposed system

(1) Outline of equipment introduced and its functions

1) Print-out recorder

a. Receives pulse signal from service meter via pulse detector and records energy, etc.
b. Receives pulse signal from watt-hour meter and records energy, etc. for each circuit.

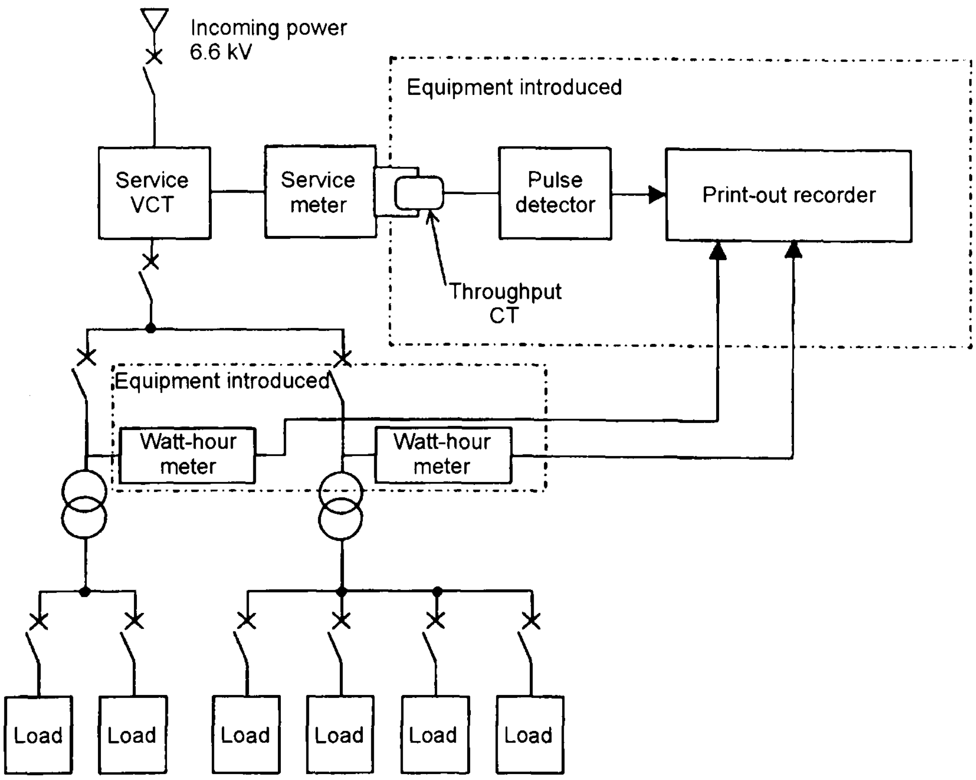
2) Pulse detector

Supplies pulse from power company's meter to print-out recorder. Suitable type may vary, depending on the power company.

3) Watt-hour meter with signal generator

Indicates energy and emits a pulse signal proportional to it.

(2) Connection method



(3) Usage method

Pulse signals from watt-hour meters installed in the service meter (main circuit) and each major circuit are received by the print-out recorder, and energy usage, demand, etc. are recorded for each time. In addition, data are compiled on a daily, monthly, etc. basis. Because collection of power usage data is automated, and it is easy to determine and analyze power usage conditions for each time, it is also easy to specify the timing of peak demand. If scheduled operation of major equipment is possible based on the results of data analysis, a peak cut is also possible, and the contract power can be suppressed.

4. Expected effects

It is possible to reduce the work involved in determining power usage situation. In addition, if a peak cut can be achieved based on the results of data analysis, and the contract power reduced from 850 kW to 800 kW, the results are as follows. The calculation assumes a basic charge of ¥1,560/kW/month.

1) Reduction in contract power = 850 – 800 = 50 kW

2) Reduction in electricity charges
= 50 kW × ¥1,650/kW/month × 0.85 × 12 months/year × 1.05 ≈ 884,000/year

5. Introduction costs, etc.

(1) Equipment costs (outline calculation)

1) Print-out recorder and pulse detector: About ¥500,000

2) Watt-hour meter with signal generator

Depends on specifications such as phase line type, voltage, and current, but about ¥30,000 ~ ¥60,000 per unit

(2) Engineering work expenses (ref.)

1) Print-out recorder and pulse detector

Work costs are mainly for wiring, and depend largely on wiring length and method (pit, duct, etc). About ¥300,000.

2) Installation of watt-hour meters

Depend largely on wiring length and method, but about ¥60,000 per location. Also, wiring work is needed to connect meters to print-out recorders, but varies largely, depending on locations of watt-hour meters and recorders.

6. Other matters (points to bear in mind, etc.)

Watt-hour meters must be selected after checking phase line type, voltage, and current in circuits to be measured.

Case 3-E **Using a power and energy measuring system that comprises measuring instruments with measuring and recording functions and the ability to send data to an upper-level PC, understand the energy usage situation in order to conserve energy.**

1. Outline

An office is located on one floor of a rental building. The amount of electrical energy used is 300,000 kWh per year, and the only information on energy usage has come from the monthly bill. Consequently, nobody working in the office knew how much electrical energy was being used.

Accordingly, the aim was to improve energy conservation awareness and clarify usage reduction targets and amounts actually used. For this reason, electrical energy usage was measured, and amounts of energy used for each work division, purpose, and time were communicated to all people working in the building.

2. Outline of subject facility

(1) Type of business: Rental building (lease contract for one floor)

(2) Floor area: 3,000 m^2

(3) Energy used: 300,000 kWh/year

(4) Wiring type: Supply from rental building's distribution board
(supplied to lighting and outlets, but for air conditioning, no supply, to enable focused management)

3. Proposed system

(1) Outline of equipment introduced and its functions

1) Multi-circuit power meter unit

a. Measures energy for each circuit
For voltage, the wiring is the same for all circuits, and for current, a current sensor is connected for each circuit. To enable the current sensors to be installed for existing equipment, a division type is used.

b. Sends data to a network
In response to requests from a data collection server using a central monitoring system or the Web, measured data are sent over a network. At the same time, data are displayed.

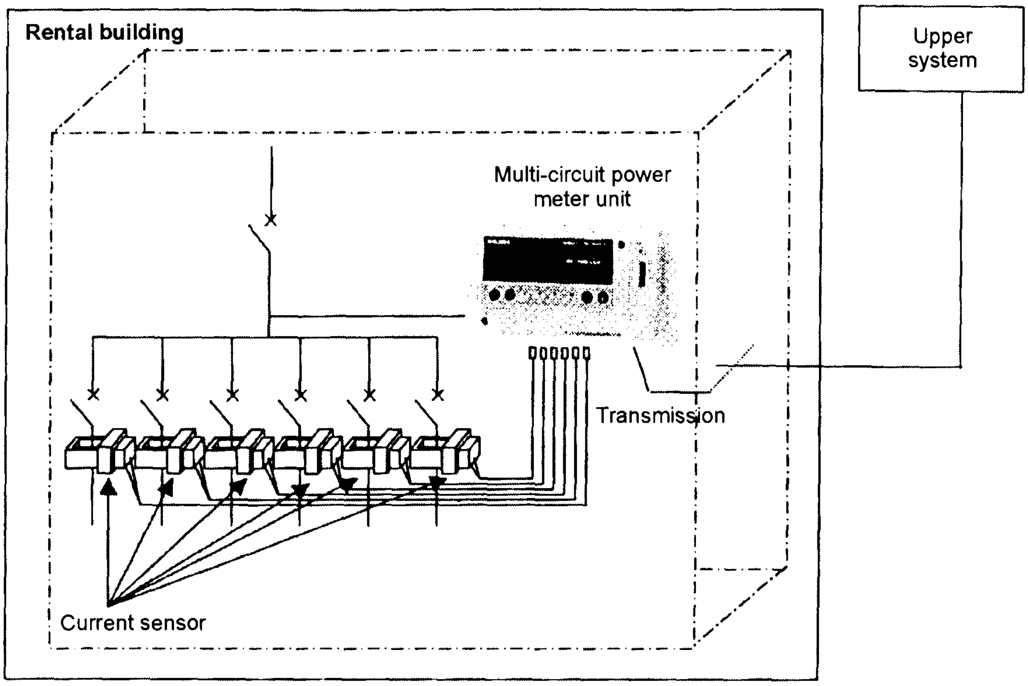
2) Upper-level system: Data collection server using a central monitoring system or the Web

Collects measured data and sends information to office LAN. Connection to a LAN is a prerequisite. In terms of cost, consider use of an existing central monitoring system or a new system.

3) PCs

Data is displayed on each PC. Using a Web browser, data is displayed via LAN and collected.

(2) Connection method



(3) Usage method

Energy is measured for each branch breaker of the rental building's distribution board. The number of measurement points is 12 in total - for six lighting circuits and six outlet circuits. Measured data is collected by the upper-level system (central monitoring system or data collection server using the Web). Monitoring is done using PCs of people working in the building.

At the 12 measurement points, daily, monthly, and yearly (seasonal) load variations can be determined for each work division and purpose (lighting, outlets).

It is possible to implement quantitative energy conservation activities.

4. Expected effects

For 7% of electrical energy used, reduction is possible through quantitative management.

1) Reduction in energy usage = 300,000 kWh × 0.07 = 21,000 kWh/year

2) Reduction in electricity charges = 21,000 kWh × ¥14/kWh = ¥294,000/year

5. Introduction costs, etc.

(1) Equipment costs (outline calculation)

- Multi-circuit power meter unit About ¥500,000 (2 units)

(2) Engineering work expenses (ref.)

- Cost of installing measuring equipment

  Work expenses depend on the installation locations, but can be calculated approximately by multiplying the work cost per installation point by the number of points.

- Cable laying expenses

  Depend largely on cable wiring length.

6. Other matters (points to bear in mind, etc.)

- LAN installation is required.

5.4 Comprehensive demand management system

Case 4-A **Using an integrated power management system incorporating PCs, collect and analyze data on electrical energy usage, in order to implement effective energy conservation measures.**

1. Outline

Because electric power management has so far been done at the main receiving and distribution points only, the amount of energy used has not been understood, and no improvement plan has been proposed. Also, even though energy conservation measures have been taken for some equipment, because they cannot be linked with the usage conditions for other equipment, it has not been possible to clarify the effects.

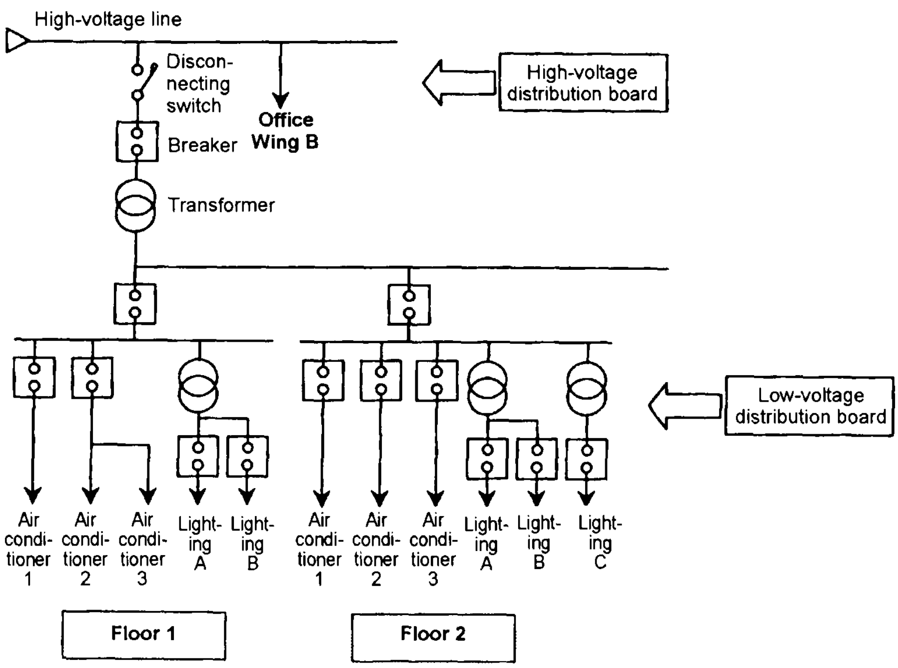
Accordingly, a power management system using a PC, which can collect, store, and analyze energy usage data for each application, was adopted. Through this means, measures for unmanned locations and a medium-term plan for energy conservation have become possible. It is also possible to analyze data through regular recording patrols and manual calculations.

2. Outline of subject facility

(1) Subject equipment: Energy usage by air conditioners and lighting

(2) Contract power: 1,500 kW

(3) Wiring schematic (outline)



3. Proposed system

(1) Outline of equipment introduced and its functions

1) Power data collection package

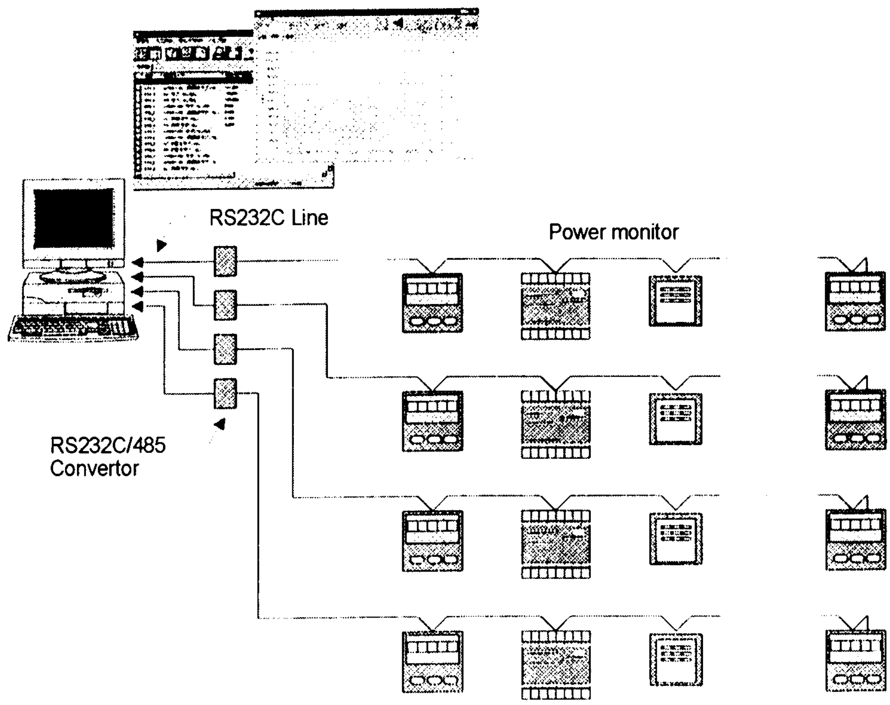
By installing a software package on a general-purpose PC that can run Windows 95/98, NT4.0, or the like, the following functions are achieved.

a. Data is collected via serial communication from power data collectors installed for each system. Integrated energy, voltage, current, power factor, reactive power, apparent power, and all higher harmonic distortion factors are displayed in real time (it is possible to group the data for each item of equipment and system).
b. If the collected data exceeds set values, this is indicated by an alarm function that changes the display color of icons.
c. Daily, monthly, and yearly reports can be printed and displayed for each group.
d. Bar graphs and line graphs can be displayed. Statistical analysis is possible from daily (monthly, yearly) load graphs of cumulative usage for each application.

2) Power data collectors

Have a PC communications function, and are installed at monitoring points for collecting each type of power data.

(2) System configuration



(3) Usage method

Using the standard screens of the package, the following kinds of monitoring and analysis are possible.

a. Instantaneous data and occurrence of alarms can be monitored remotely in real time, without patrolling.
b. Collected data can be used to create a database.
c. By understanding energy usage for each consumption location and application, energy conservation analysis is possible through unit management.
d. The timing of equipment operation and periods when staff are absent can be clarified, making it easy to propose energy conservation measures.
e. By comparing data before and after energy conservation measures are taken, the effects can be quantitatively understood. It is also easy to draw up medium-term plans by referring to monthly (yearly) load graphs.
f. Various tables can be created automatically, making manual compilation unnecessary.

4. Expected effects

If, as a result of specific energy conservation measures after system introduction, energy usage can be reduced by 5%, the following financial results are achieved.

- Reduction in contract power: 1,500 kW × 0.05 = 75 kW
- Reduction in electricity charges:
  75 kW × ¥1,650/kW/month × 85% × 12 months/year × 1.05 = 884,000/year

5. Introduction costs, etc.

(1) Equipment costs (outline calculation)

- Software package: About ¥100,000
- Power data collectors (24 units): About ¥920,000
  (Converters such as CTs not included)

(2) Engineering work expenses (ref.)

About ¥1,000,000, but depends largely on wiring length and locations.

6. Other matters (points to bear in mind, etc.)

Through combination of PLCs, scheduled starting and stopping of each equipment item, determination of items with low priority for each time, and reduction of power for these items, it is possible to further conserve effort and energy. Also, by using a Web monitoring package, remote monitoring by browser is possible.

Case 4-B-1 **Collect power and energy measurement data from measuring equipment using a Web data collection server with measurement, recording, and data analysis functions, and understand the energy usage situation in order to conserve energy.**

1. Outline

With annual energy usage of 1,00,000 kWh, energy usage management was conducted once per month, by visual patrols to check usage for the building overall and for each transformer (for air conditioning, lighting, and outlets). The building has six floors, and the electrical equipment includes three transformers for each application in a high-voltage "cubicle." None of the people working in the building knew the amount of energy used.

Accordingly, energy conservation activities involving all employees were carried out, with the goals of raising energy conservation awareness and clarifying target management. For this purpose, energy usage was measured, and energy usage for each work division, purpose, and time was communicated to all people working in the building. To communicate the measured data, the World Wide Web, a product of recent remarkable advances in IT, was used. Points regarding waste and improvement in terms of power usage became clear, and sustained, steady improvement was possible.

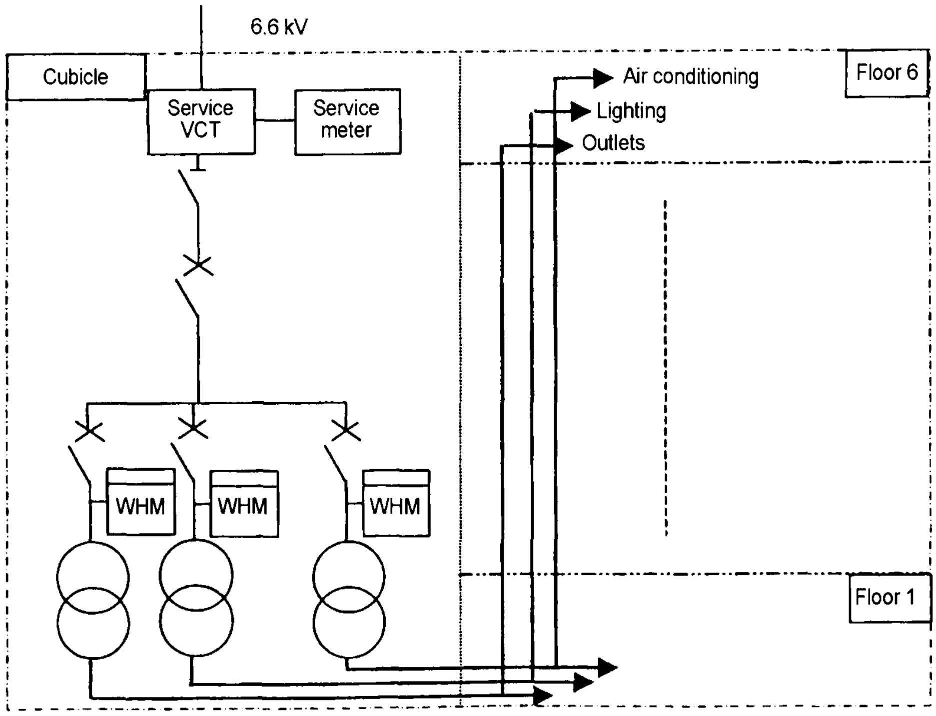
2. Outline of subject facility

(1) Business type: Company building

(2) Contract power: 1,000 kW

(3) Energy usage: 1,000,000 kWh/year

(4) Wiring schematic (outline)



3. Proposed system

(1) Outline of equipment introduced and its functions

1) Web data collection server (using network computers)

a. From each measuring instrument, electric power data (energy consumption, etc.) are transmitted and collected. The basic data collection interval is one hour. Also, for specified equipment, for detailed energy conservation analysis, data was also collected during set periods in short time units, for example, at 5-minute intervals.

b. The collected data were sent to a LAN via the Web.
Data were displayed in graphical form for ease of understanding. They were displayed for daily, monthly, and yearly units. Also, the collected data were saved as CSV (Comma Separated Value) files.

2) Measuring instruments

The instruments mentioned in Case Study 3, of a type incorporating a communications function, are used.

3) PC

The data are displayed on a PC. Using a Web browser, data are displayed on screen via LAN and collected.

(2) Connection method

See **Figure: Connection diagram for integrated power management system with Web data collection server**

(3) Usage method

Measurement of energy usage is expanded in scope from "each transformer" to "the trunk feeders on each floor." The number of measurement points is increased from the previous 3 to 18. Measuring equipment is installed for each low-voltage feeder on each floor, transmission lines are laid for data collection, and the equipment is connected to the Web data collection server. The server can be installed at any location where LAN connection is possible. Monitoring is done using PCs of people working in the building.

At the 18 measurement points, daily, monthly, and yearly (seasonal) load variations are determined for each floor and each purpose (air conditioning, lighting, outlets). Through such means, quantitative energy conservation activities can be implemented.

1) Regarding energy consumption and equipment at inessential times (before working hours, during holidays, and during overtime hours), energy usage beyond what is necessary (air conditioner temperature settings) and energy wastage are clarified and reduced.

2) An energy usage plan, including energy conservation, is drawn up, with quantitative reductions based on measured data. (Implementation of target management)

3) Through a quantitative grasp of energy conservation performance, it is possible to accurately determine and analyze the implementation status of the energy conservation plan. Also, if it appears possible that plan targets will not be attained, the plan can be supplemented by corrective measures.

4. Expected effects

For 7% of electrical energy used, reduction is possible through quantitative management.

1) Reduction in electrical energy usage = 1,000,000 kWh × 0.07 = 70,000 kWh /year

2) Reduction in electricity charges = 70,000 kWh × ¥14/kWh = ¥980,000/year

5. Introduction costs, etc.

(1) Equipment costs (outline calculation)

- Web data collection server: About ¥500,000
- Measuring instruments: About ¥600,000 (12 units)

(2) Engineering work expenses (ref.)

- Cost of installing measuring instruments

  Work expenses depend on installation locations, but can be calculated approximately by multiplying the work cost per installation point by the number of installation points.

- Cable laying expenses

  Depend largely on cable wiring length.

6. Other matters (points to bear in mind, etc.)

- LAN installation is necessary. However, by using one PC exclusively for the system, it is also possible to use PC data collection equipment in the conventional way.
- Cost can be kept down by using standard functions, without adding special functions.

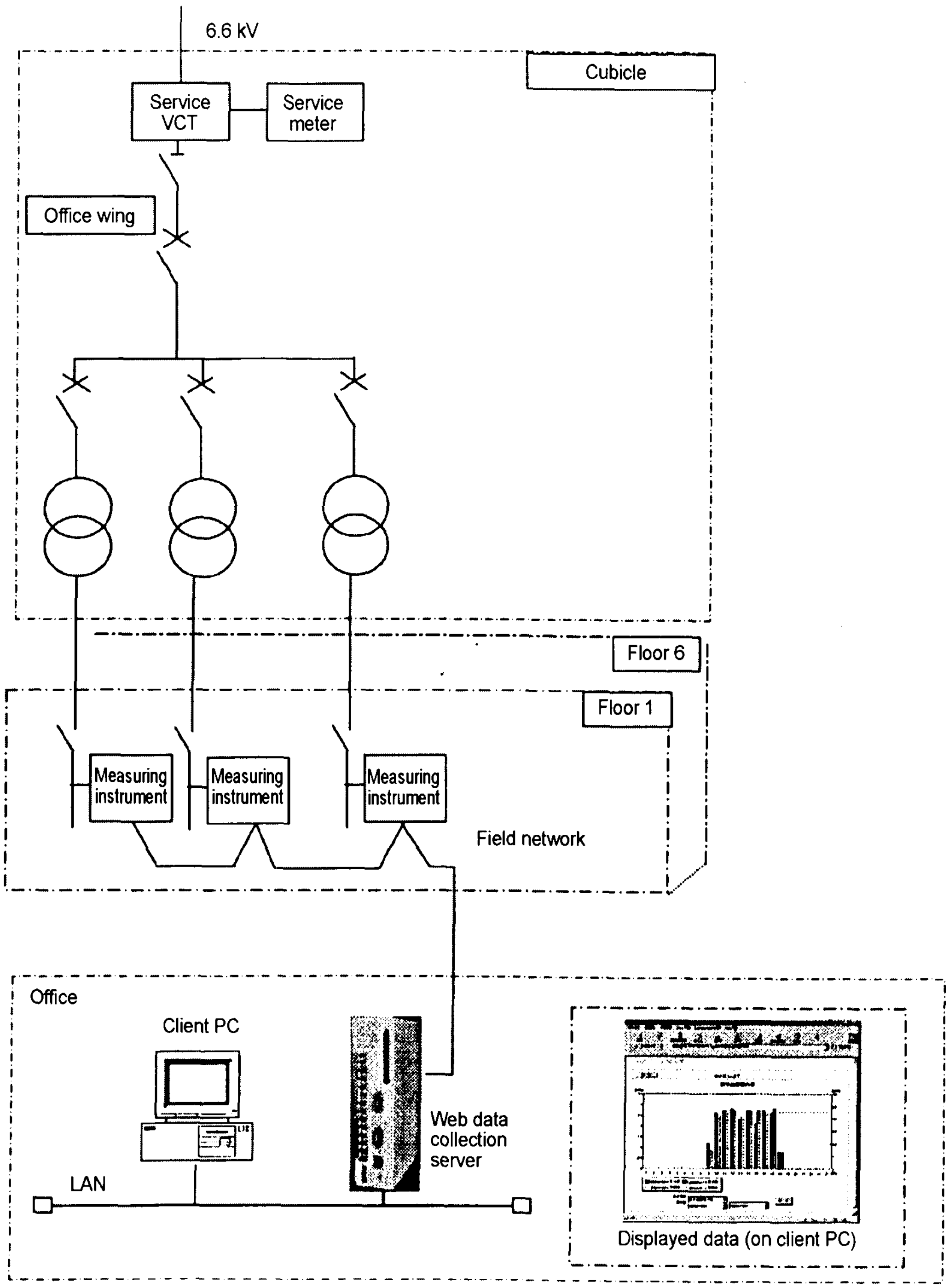


Figure: Connection diagram for integrated power management system with Web data collection server

Case 4-B-2 **Energy conservation through comfortable air conditioning control**

1. Main points and outline

This type of control is a method of energy conservation for air conditioning equipment in buildings.

Even for the same room temperature, people may feel the room is "cold" or "hot," depending on conditions such as humidity and radiation temperature. For this reason, if, for example, air conditioning uses conventional temperature-fixed control, if comfort is given priority, room temperature is set low and wasteful use of air conditioning increases, and if energy conservation is given priority, set temperature is increased and comfort is lost.

Accordingly, in the method of "comfortable air conditioning control," a comfort index (PMV) is calculated based on various conditions such as temperature, humidity, and amount of clothing, and room temperature setting is dynamically varied while maintaining comfort.

As shown in Figure 1, PMV is determined using the comfort equation developed by Prof. Fanger of the Technical University of Denmark. The most comfortable situation occurs when PMV = 0, while for positive values people feel hot, and for negative values they feel cold. Factors that are difficult to measure in practice, such as radiation temperature and amount of activity, are calculated using a center device, or set values are used. In this control method, PMV values are calculated using an independent method involving neural networks.

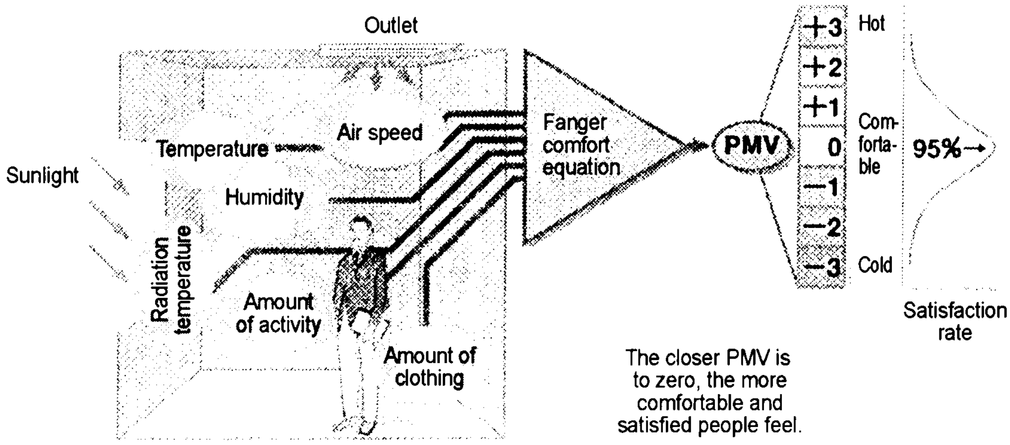


Figure 1 PMV concept

Figure 2 shows an example comparing the results of control for one day during the air-conditioning period in summer. With room-temperature-fixed control, room temperature is constant, but looking at changes in PMV, in many cases PMV is below zero, showing that air conditioning is excessive. By contrast, with comfortable air conditioning control, PMV is constant at zero, and room temperature is controlled at a slightly high level while maintaining comfortable conditions, and energy is conserved accordingly.

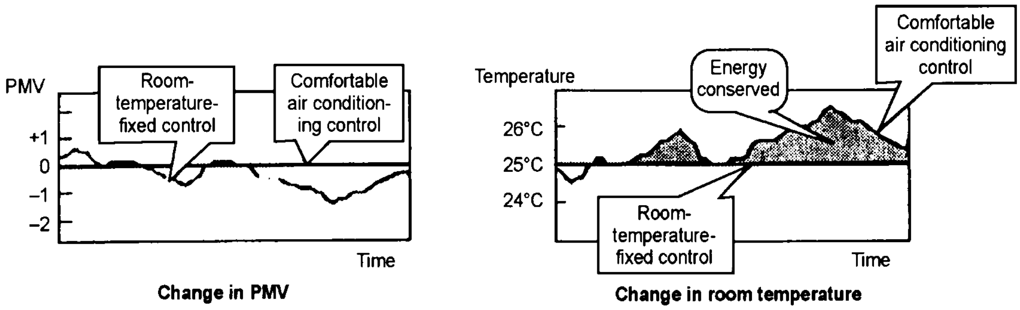


Figure 2 Comparison of control results

2. Outline of system subject to control

An actual example of this control method is outlined.

(1)	Type of business:	Commercial building
(2)	Purpose of business premises:	Office, commercial facility, school, accommodation, etc.
(3)	Amount of energy used:	Class 2 Designated Energy Management Plant
(4)	Problems:	Achieving both comfort in indoor environments (office productivity) and energy conservation

3. Application of energy conservation control

As shown in Figure 3, complex calculations are performed by a BEMS (Building and Energy Management System).

Setting of the target PMV, and the data needed for control calculations, is done with a center device, and room temperature settings are calculated by locally installed controllers based on the center-set values and used to control the air conditioners.

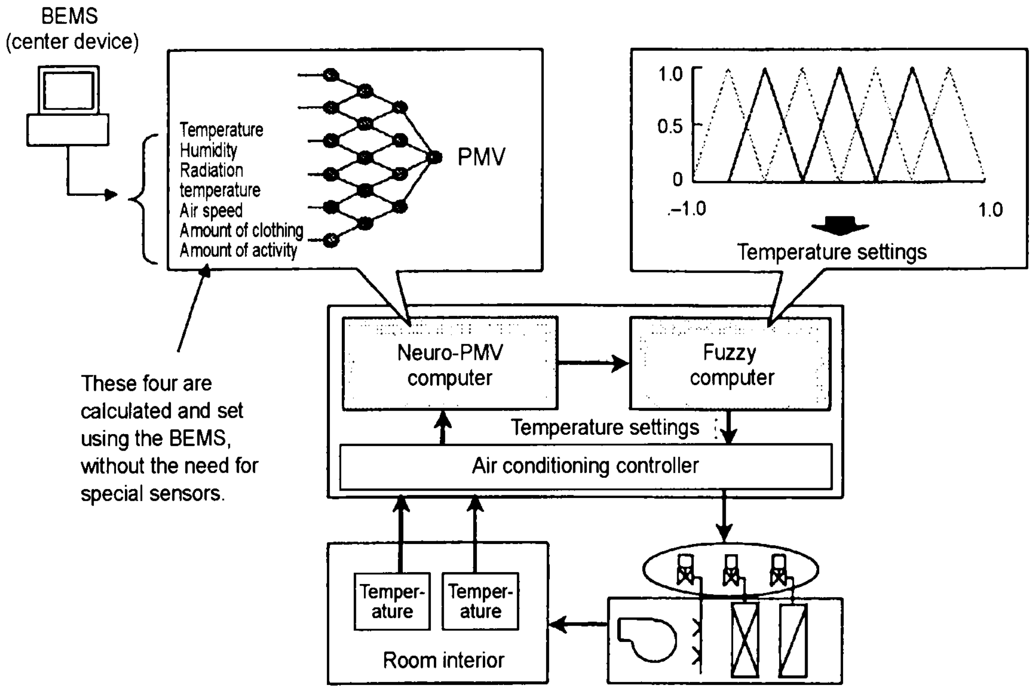


Figure 3 Configuration of comfortable air conditioning control

4. Equipment

The following equipment is needed.

Type	Name	Notes
Control equipment	Center device	
	Local controllers	
Sensors	Temperature sensor	
	Humidity sensor	
Operation unit	Hot and cold water valve	

5. Effects of introduction

As an example, energy conservation performance is shown for this control method in an office building (total floor area approx. 160,000 m^2).

In this case, as well as using VAV control / ventilation fan flow-rate control, based on calculated set temperature, to reduce air conditioning conveyance power, cold water flow is controlled to reduce the amount of heat consumed. The following table shows the results of measuring and comparing electric power and heat consumed during the summer (July, August).

* Electrical energy is calculated by multiplying measured current for the air conditioners by voltage and power factor.
* Amount of heat consumed is calculated by multiplying the difference between cold-water outlet temperature and inlet temperature by the flow rate.

	(1) Electrical energy	(2) Heating of cold water	Charges for (1) + (2)
Reduction rate	8.8%	11.6%	11.8%

6. Introduction costs

Depend on building scale (total floor area).

Recovering the investment takes about 3~7 years.