3.4 Guideline for Energy Efficiency Improvement and Conservation for Commercial Buildings

3.4.1 Basic Items

To grasp energy conservation measures and energy conservation potential, energy conservation audit is carried out. In energy audit, the effective energy conservation measures and the calculation of potential are done by an investigation of the management & operation situation of energy consumption facilities and a measurement, etc.

(1) The Situation of the Energy Management

To promote energy conservation, it is necessary to implement energy management and improve efficiency as described as follows. In energy audit, it is necessary to confirm the enforcement level for the following contents.

(a) Target oriented management by PDCA cycle

(b) Energy consumption and intensity management

(c) Maintenance management of facilities

(d) Facilities functions management (for efficient operation)

(e) Operation management of facilities

(f) LCC(Life Cycle Cost) management of the facilities

Contents and effect of the energy management is shown in Table 3.4.1-1.

Table 3.4.1-1 Outline of Energy Management

Items	Contents	Measures / Effect
1) Energy management system	・ Establish organization and employee education ・ Setting of Energy conservation target and budget ・ Setting of the management standard ・ Grasping present situation of energy conservation	・ Establishing an organization including TOP management, employee, tenant and facilities managers and enforcing PDCA. ・ Reinforcement of enlightenment and guidance to a resident.
2) Situation of a measurement and record	・ Preparation of the drawing and documents of the building ・ Installation of measuring instruments, operation, maintenance ・ Enforcement of a measurement and record	・ The measurement and analysis with detailed range according to different facilities and sectors as detailed as possible

Items	Contents	Measures / Effect
3) Energy consumption management	・ Daily record situation ・ Daily and monthly consumption ・ The power balance ・ Annual comparison graph	・ Analyzing the measurement data by trend and graph. Energy intensity and CO_2
4) Maintenance of the machinery	・ Periodic inspection and daily check ・ Machinery and system performance management (COP) ・ Machinery cleaning（Filter, Strainer etc.)	・ The adoption of the high maintenance such as preventive and predictive maintenance is examined ・ Adjustment on the performance management with maintenance company are desirable.
5) Energy intensity management	・ Heat intensity ($MJ/m^2 \cdot Y$) ・ Electricity intensity ($kWh/m^2 \cdot Y$) ・ CO_2 intensity ($t\text{-}CO_2/m^2 \cdot Y$)	・ The information as described in left column for different area and facilities is obtained as detailed as possible.
6) Management system	・ The adoption of the BEMS system	・ Introduction of optimizing control by LCC

Though it is possible to improve the energy management by introducing automation systems such as BEMS, BAS, the introduction rate of these systems in Indonesia is still low and most management is done by human resources Therefore, to reduce the energy consumption, it is necessary to establish an organization structure, set the energy reduction targeted value, then select and implement energy reduction measures, and finally measure and the evaluate the effect. To increase the energy reduction effectively, every section's participation should be completed in the building.

The concept of Life Cycle Cost

The life cycle cost (LCC) is a method to evaluate economy by considering all investment such as energy expense and maintenance expense (a life cycle cost) in its life period from the building stage to broken stage. Generally the initial cost is not more than about 20% of the total (life cycle) cost.

In order to reduce the equipment cost at the construction stage, the energy conservation facilities for air-conditioning are usually not installed. The initial cost of useful energy conservation equipments can be recovered within several years, so it is very important to make the owner understood the financial benefit by energy conservation.

(2) The Energy Consumption Characteristic of the Building

A building is finished through the stages of plan, design, and construction. And, it is possible to elaborate the peculiar energy consumption characteristics at both stages of plan and design.

In designing stage, capacities of various kinds of facilities, machines and a devices in the building have been decided to the value more than the demanded maximum load. At the stage of

the final inspection by the owner before the building completion, there exist no real load, and the capacity of equipment is set at designed one. Therefore, the capacity of equipment is lager than the real load, so it is not efficient to operate under this designed condition.

To adjust the excessive facilities capacity to match the actual load leads to energy and cost reduction. And it is necessary to perform adjustment at least once a year periodically, because the actual load demand changes according to the use of the building and climatic condition.

The energy consumption of a building is reduced largely by this adjustment and finally it becomes stable at a minimum value. However, with time passing the deterioration of the machinery and an increase of tenant changes, and again energy consumption begins to increase, then it becomes necessary to enhance the maintenance and/or conduct an additional to keep the consumption level.

(3) Audit of the Facilities Capacity Adjustment

To reduce the energy consumption in buildings, at first, it is necessary to confirm whether the facilities are operated with high efficiency catching up the fluctuation of the actual load. The audit is done by analyzing the records of diary operation. The running situation of equipments in some day with the worst weather condition or the maximum annual energy consumption should be investigated and analyzed.

Take an example of air-conditioning system; it should be checked that whether the temperature difference between the inlet and outlet temperature of cool water of air-conditioning at the hottest day is almost equal to that of designed.

When the temperature difference deviates from the design value, it should be adjusted and matched with a designed value by changing the water flow of cool water circulation pump. That is to say, when an actual temperature difference is smaller than the designed value, the extra water is circulated and extra energy is supplied. The water flow of pump condition should be checked by reading the actual current value to meet the necessary water volume which is indicated by the characteristic curve of the pump.

It is important to confirm the fact whether the facilities are running with high efficiency following the fluctuation of the actual partial load, because usually the facilities are operated with a partial load throughout one year.. The audit is done by analyzing these records of running situation.

As for some day, when the load is 80%, 60%, 40% and 20% of annul maximum energy consumption, the running situation should be compared with the one with maximum energy consumption and the room of efficiency improvement will be analyzed.

In recent years, many buildings install the inverter systems which can follow partial load automatically to adjust the facilities running condition. In this case, it is necessary to adjust the automatic system based on the analysis of the record of the running situation. However, in old buildings, most of equipments only can be operated at the peak load, in such case, it is necessary to adjust by hand the medium flow to meet the partial load running.

To promote the reduction of energy consumption in buildings, it becomes a precondition to make the facilities installed in the buildings run with high running efficiently. Therefore, in daily running and maintenance, it is necessary to monitor the running situation whether it runs with high efficiency for partial load.

To grasp appropriate running situation of the facilities, effective measurement points and items are shown in Table 3.4.1-2.

Table 3.4.1-2 Measurement Points and Items for Each Facility

Machinery name	Main part of machinery				Machinery inlet		Machinery outlet			Others			
	Voltage	Electric current	Itgrating watt-hour	Integrating running time	Temperature	Pressure	Temperature	Pressure	Integrating flow	Integrating flow	Hygrometer	CO_2 concentration	Running rotational speed
Chiller	○	○	◎	○									
Air-conditioner					◎		◎						
Condenser					◎		◎						
Cooling tower	○	○	○		○		○						
Cold water (supply header)					◎	○							
Cold water return header)							◎	○					
Heat exchanger (primary wate)r					◎	○	◎	○					
Heat exchanger (secondary water)					◎	○	◎	○					
Cooling water pump	○	○	◎										
Cold water pump	○	○	◎										
Cold water circulation pump	○	○	◎										
PAC air conditioner condensation machine	○	○			◎		◎						

Machinery name	**Main part of machinery**				**Machinery inlet**		**Machinery outlet**			**Others**			
	Voltage	Electric current	Itgrating watt-hour	Integrating running time	Temperature	Pressure	Temperature	Pressure	Integrating flow	Integrating flow	Hygrometer	CO_2 concentration	Running rotational speed
Cold water coil					◎		◎		○				
Air washer					◎	◎							
around conditioner	○	○	○		◎	○	◎	○	○				
around fan coil													
Fan	○	○	○									○	
Filter						○		○					
Heat exchanger	○	○	○		○		○				○		
Supply water piping										○			
Water supply piping										○			
Elevator	○	○	○										
Escalator	○	○	○										
Power for each floor lighting			◎										
Power for consent			◎										

(4) Energy Intensity

Energy intensity management is prescribed as an evaluation standard of the energy consumption by Energy Conservation Law in Japan. Energy intensity is defined as energy conservation amount divided by unit production amount such as raw materials, power and labor which is necessary to produce an industrial products.

The energy intensity is calculated by (energy consumption/ production), and it is said that consumption efficiency is high when this value is low. The energy consumption in numerator is a total amount, which is calculated by converting respectively the use amount of fuel like oil and gas, steam and electricity into the thermal energy, J (Joule). And finally, they are converted into the calorific equivalent value of the crude oil. Though the product amount in denominator is generally set as the following unit such as kg, ton, kl, m^3,㎡. And it is necessary to choose a parameter which is little influenced by external factors (like market). When the numerator is the thermal energy, the value is called as energy intensity; and when it is electricity consumption or CO_2 emission, the value is called as electricity intensity or CO_2 emission intensity. In commercial buildings, it is popular that the floor area is used as a denominator of intensity calculation. The energy conservation status can be clarified by energy intensity. And it is easy to compare with the other similar buildings by using this intensity.

Detailed examination with energy intensity on different facilities, different sectors and different location can lead the effect of energy conservation further.

Draft conversion value of representative fuel in Indonesia is shown in Table 3.4.1-3.

Table 3.4.1-3 Conversion Value

Conversion		Calorie	CO_2	Note
Crude oil	(m^3)	38.51(GJ)	2.65 kg- CO_2/ℓ	4.1868kJ=1kcal
LNG	(m^3)	37.23(GJ)	2.56 kg-CO_2/ℓ	0.33 ℓ/kWh
LPG	(m^3)	25.53(GJ)	1.76 kg- CO_2/ℓ	
Heavy oil	(m^3)	41.73(GJ)	2.87 kg- CO_2/ℓ	
Diesel oil	(m^3)	38.68(GJ)	2.66 kg- CO_2/ℓ	
Kerosene	(m^3)	34.80(GJ)	2.39 kg- CO_2/ℓ	
Electricity	(kWh)	11.63(MJ) ＝2,778(kcal)	0.7623 (kg- CO_2/kWh)	
Electric contract charge (Example)＝29,500 (RP/kVA/month]				
Charge according to use (Example)=439 Rp /kWh				

3.4.2 The Checkpoint of the Energy Conservation Audit

Buildings are generally classified as four large categories: 1) the buildings user, 2) the operator of buildings and equipment 3) the maintenance manage of buildings and equipment, 4) the facility management of buildings and equipment. The basic item requested for each category is different respectively to achieve the energy reduction target.

1) For the building user, the waste is requested to be excluded thoroughly.

2) For the operator of buildings and equipment, the equipments are requested to be operated with high running efficiency.
3) For the maintenance manager of buildings and equipment, the function of individual equipment is requested to be secured.
4) For the facility management of a buildings and equipment, the investment with good energy conservation effect is requested by considering the balance between the investment to reduce energy and the return.

For the above-mentioned four categories of building, the contents should be considered respectively for different sectors and the energy conservation measures with good energy reduction measures. The potential energy conservation countermeasures are shown in Table 3.4.2-1~Table 3.4.2-4

Table 3.4.2-1 Energy Conservation Countermeasures Taken by the Users of a Building

Item	Energy conservation countermeasures	Energy conservation effect
1) The usage of the room	(a) Rooms with the same usage or the related function to be arranged in same floor or adjacent floor.	Utilization frequency of the elevator to be reduced
	(b) Rooms with similar heat load characteristic to be supplied the air by same air-conditioner	Prevention of over-cooling and environmental preservation
2) Arrangement of heat generating equipments	(a) Computers and related equipments to be arranged in the same space.	Environment improvement, reduce the air-conditioning load by installing the heat exhausting equipments
	(b) OA machinery such as a copier and the PC to be arranged in the same space and exhaust heat.	
3) Limitation of the work time and place	(a) Equipments to be stopped at once on holiday	Reduce the energy of lighting and the air conditioning
	(b) Limitation of a place for over-time work and the time of over time.	
4) The obstacle removal of the air conditioning	(a) Remove goods in the inlet and outlet of air-conditioner so not to disturb circulation of the air conditioner.	Improve the running efficiency of the air conditioner.
	(b) A partitioning wall to be moved to not disturb circulation of the air-conditioner and more lighting	
5) The guidance to the user of works style	(a) Adjust the clothes according to individual difference.	Improve running efficiency of the air conditioner and reduce the sensible temperature with the individual difference
	(b) Make a group, change the air-conditioner and install the assistance air-conditioner for the duties which need special air-conditioner environment condition being different from common air-conditioner	
6) Effective use of the lighting	(a) The business space to be settled respectively according to necessary luminance standard	Reduce the lighting energy and heat load of air conditioning.
	(b) Optimization arrangement of work desk to be able to use maximally the existing lighting	
	(c) Work space which needs high illuminance to be arranged near the window.	

Item	Energy conservation countermeasures	Energy conservation effect
	(d) Work space to be arranged to make the sunlight easy to shoot	
	(e) Lighting to be turned off when the room is not used or the sunlight is good	
7) The operation of the window shade	(a) Window shades to be closed when there is sunlight	Reduce the heat load of air conditioning. and the load about 1/4 of all loads are influenced by the sunlight
	(b) Window shades to be opened to emit the heat from indoor to outdoors at night.	
8) Open and close of the door	(a) The door in stair hall to be always closed	Reduce heat load of air conditioning.
	(b) The door in outdoors or in the place without air-conditioning to be closed	

Table 3.4.2-2 Energy Conservation Taken by the Operator of a Building

Items	Energy conservation countermeasures	Energy conservation effect
1) Reduce fresh air	(a) Fresh air not to be input at pre-cooling	Useless energy not to be consumed
	(b) The adjustment of fresh air ・ Fresh air to be adjusted to match the numbers of the staff in indoors (Japan; Minimum $20m^3$/ per person every hour) ・ Fresh air opening and shutting control according to CO_2 density controller	Reduction of the fresh air load
2) Change the indoor temperature and humidity setting	(a) Change the living room thermostat setting	Improve energy conservation about 10% when setting temperature 1 degree UP of the air conditioner (Japanese METI advice;28^0C)
	(b) The temperature and humidity setting in the passage space such as corridor and hall being higher than that in the living room	
	(c) Temperature and humidity setting indoor to be change according to the outdoor temperature ・ Setting value to be higher according to the rise of the outdoor temperature	
	(d) Change the living room humidity starter setting ・ Dehumidify when the indoor humidity being more than 70% ・ Set a high dew point when a dew point control being introduced.	Reduction of the air conditioning load. Reduction of load is about 17% when dew point arise from 10℃to 12℃.
	(e) Review indoor temperature and humidity requested by the computer	Reduction of the air conditioning load Reduction of the air conditioning latent heat load
	(f) Reheat with the purpose of dehumidification not to be done excluding the room be requested	Reduction of the air conditioning latent heat load
	(g) Reheat not to be done and control room temperature by the volume of air when indoor latent heat load being decreased	Reduction of re-heat energy and the air transportation power （Change from CAV to VAV）

Items	Energy conservation countermeasures	Energy conservation effect
3) Prevention of indoor excessive cooling	(a) Adjust the temperature of the cool water circulated in air-conditioner and fan coil unit according to the change of the load(Raise at low load)	Useless energy not to be consumed, at the same time, indoor environment to be improved
	(b) Adjustment of the outlet air volume ・ Adjust supply air volume to match the indoor load ・ Close the fan of the fan-coil unit and it is used as convector when the indoor load being little	
	(c) Adjust the air volume to prevent indoor over cooling	
	(d) Perform manual regulating when the facilities of automatic control being insufficient	
4) Adjust the start and stop time of the device and shorten the pre-cooling time	(a) Adjust the start and stop time by weekday, weekend day and seasons.	Useless energy not to be consumed
	(b) Regulate the pre-cooling time according the temperature difference between the outdoor air and the indoor	
	(c) Reduce the fresh air volume in one hour after air conditioner starting and before air conditioner closing	Decrease of the fresh air load
	(d) Running with the temperature be set in the hour when the room is started to be used	Reduction of the driving energy
	(e) Chiller to be stopped and pump and supply fan operated only in the one hour before the cooling end	
	(f) Shorten the running time of supply fan to be used in machine room and parking.	
5) Reduce the air supply volume	(a) Regulation of the supply and discharge air volume for machine room and parking. ・ Necessary minimum air volume setting ・ Pulley- down of the fan to be introduced for the surplus control of air volume	Reduction of the running power Power of fan is in proportion to the cube of the supply air volume, therefore, reduction of 10% air volume to cut down 27% power consumption
6) Control of air-conditioning running	(a) Air-conditioning in unnecessary room to be closed	Useless energy to be not consumed
	(b) Work with air-conditioning to be selected and local air-conditioning to be adopted	Reduce the running energy
	(c) Air-conditioning control for the over-time work	Reduce the running energy
7) High efficiency running of the	(a) Group management of chiller running ・ Reduce the running unit at partial load	Improve overall efficiency Improve COP

Items	Energy conservation countermeasures	Energy conservation effect
chiller plant	(b) Adjust the outlet temperature setting of cold water in the chiller ・ Change the outlet temperature setting of cold water with the outdoor temperature (Energy conservation can be obtained by increase the value) ・ Change the inlet temperature control of cold water	
	(c) Adjust the temperature setting of cooling water ・ The setting value of cooling water temperature control is below until the permissible temperature of a chiller	Improve COP
8) Combustion Equipment	(a) Optimization of air ratio and combustion temperature	Improvement of the burning efficiency
9) Running management of water supply and drainage and sanitary equipments	(a) Reduce and limit the hot water supply time and range	
	(b) Stop the forced circulation pump when a little hot water supply being need	
	(c) Lower the hot water supply temperature according the use	
	(d) Insert a water saving ring in the port of the flashbulb	Water saving
10) The management of the lighting equipments	(a) Turn off the lighting not to be used	Useless energy to be not consumed
	(b) Turn off the lighting of the window	Reduce the lighting electricity Reduce the air conditioner load
	(c) Turn off surplus lighting of the work space	
	(d) Shortening and limit the lighting time before work starting ・ Lighting per every work floor for the cleaning work in the morning.	
11) Management of power facilities	(a) Turn off the lighting and fan in the elevator when being not used	Power saving
	(b) Automatic door of the entrance to be operated by hand when the outdoor temperature being low	Reduce the running power
	(c) Reduce the operating of elevator and escalator when users being few (utilization rate to be about 50%)	
	(d) Reduce the number of the stop of elevator	
12) The operating management of electric facilities	(a) Balance three-phase circuit load	Reduction of the transformation loss
	(b) Reduce the running unit or switch off with low load, when an interception switch device of the transformer being not used	

Table 3.4.2-3 Energy Conservation Countermeasures by the Maintenance Manager of a Building

Items	Energy conservation countermeasures	Energy conservation effect
1) Maintenance and cleaning of equipments	(a) Cleaning of the air conditioner, a filter of a fan coil	Improvement of heat exchange efficiency
	(b) Cleaning of the condenser and evaporator of a chiller	Improvement of heat exchange efficiency
	(c) Cleaning of a lighting equipment and exchanging old lamps	Improvement of lighting efficiency
2) Check of automatic control device	(a) Precision check of sensors	Improvement of control precision
	(b) Operation checks such as an automatic valve, a damper	
	(c) Check of control machinery of a chiller plant	
3) Strengthening the monitor device	(a) Grasp the consumption situation of the energy and indoor environmental situation by adding the meter and measuring instruments	Improvement of the energy consumption efficiency
	(b) Check and review of the management items.	
4) Repair and exchange of the device	(a) Repair the part with performance deterioration, machinery and the device due to corrosion and abrasion	Improvement of the machinery efficiency
	(b) Change when performance being not restored even be reviewed	
5) Other	(a) Improve the lighting efficiency by cleaning indoor wall surface	Improvement of the lighting effect

Table 3.4.2-4 Energy Conservation Plan by Operating Manager of a Building

Items	Energy conservation countermeasures	Energy conservation effect
1) Reconstructed of building	(a) Reinforcement of heat insulation for the exterior wall ・ Change of an insulation sash ・ Install an insulation panel outside of exterior wall ・ Introduction of double-sash or the pair glass ・ Remodel of insulation forms for roof and floor	Reduction of the building energy load
	(b) Prevention of the sunlight ・ Improve reflectance by changing the color of roof and exterior wall ・ Change reflection forms or introduce the absorption windowpane ・ Stick a heat reflection film on a windowpane ・ Installation of louver and eaves ・ Installation of window shade and the curtain ・ Installation of roof sprinkling and storage water facilities ・ Sunlight reduction by the planting	Reduction of the building energy load

Items	Energy conservation countermeasures	Energy conservation effect
	(c) Prevention of the draft ・ Install a air curtain or the revolving door in the building entrance ・ Install an air curtain and a flexible transparent curtain in the import entrance of the delivery space	Reduce the air load by preventing the inflow of outdoor air
2) Repair of air conditioning and ventilation facilities	(a) Install air curtain	Reduce the air load to prevent the entrance of the fresh air Reduction of the air conditioner load Reduction of the exhaust power, Reduction of the air conditioning load Environmental improvement and reduction of the fresh air load Reduction of the exhaust power
	(b) Install local exhaust system in the area where large heat generating	
	(c) Hood with heat exhaust to be installed as lower as possible to emit little heat to surroundings	
	(d) Install smoking zone to exhaust the cigarette smoke.	
	(e) Ventilation facilities like rest room to be operated only in use time	
	(f) Ventilation facilities in the parking to be automatically controlled by using a CO2 monitor	
3) The repair of chiller facilities	(a) Change into high efficiency chiller facilities	Running power of the chillers facilities being expected to reduce 20-30%
	(b) Repair of the chiller facilities operating control system ・ Running capacity control to be able to run always at high efficiency point according to the load change load	System efficiency being expected to improve 20-30%
4) Repair of cold water circulating system and air supply system	(a) Automatically control to be installed to make the flow of cooling water and cooling air in cold water circulating system and air supply system match with the thermal load	Reduction of cold water circulating power and the ventilation power
	(b) Cooling water flow and air supply volume to be reduced by using as large as possible temperature difference of cold water and air supply	
	(c) Change into high efficiency pumps and blowers	
	(d) Reinforcement of heat insulation for the piping and the duct	Reduction of the heat loss
	(e) Change opening cold water circulating system into closing water route	Reduction of the cold water circulating power
5) Change air conditioning method	(a) Subdivide air conditioning zone	Environmental improvement and energy conservation
	(b) Change all air system into water-air system or refrigerant-air system	The improvement of the system efficiency
	(c) Change re-heating system into variable air system	
	(d) Introduce a quantity of fresh air control system	Reduction of the fresh air load
	(e) Install all heat exchangers	Reduction of the fresh air load

Items	Energy conservation countermeasures	Energy conservation effect
6) Repair of water supply and drainage and sanitary equipments	(a) Water saving method introduction ・ Change into water saving type appliance Introduction of automatic washing method of the toilet	 Water saving Water saving and convenience improvement
	(b) Efficient utilization of the water ・ Introduction of rainwater use facilities ・ Introduction of gray water facilities	 Water saving Water saving
	(c) Hot water supply system improvement ・ Change central method into local method ・ Insulation reinforcement of hot water supply	 Improvement of hot water supply energy efficiency Reduction of hot water supply energy loss
7) Repair of lighting equipments	(a) Prevention of the surplus lighting ・ Introduction of the lighting control	Reduction of the lighting electricity
	(b) The limit of the lighting range ・ Individual switch installation for each lighting equipment ・ Subdivision of the lighting wiring circuit ・ Introduction of automatically light controller with the timer ・ Introduction of the task ambient method	
	(c) Change into high efficiency lamp (CFL, Hf, T8)	Improvement 30-45% of the lighting efficiency
	(d) Change into high efficiency appliance and install a reflector	
8) Repair of elevator facilities	(a) Introduction of the inverter	Reduction of the operating power
	(b) Introduction of the group management control	
9) Repair of electric facilities	(a) Introduction of power factor improvement control system	

3.4.3 Energy Efficiency Improvement Countermeasures in the Commercial Building

(1) Energy Intensity by Building use and Potential Energy Conservation Measures

Table 3.4.3-1 shows the electricity intensity data obtained by The World Bank based on 65 buildings in Indonesian. Figure 3.4.3-1~Figure 3.4.3-4 show potential energy conservation measures for various use of buildings.

Table 3.4.3-1 Example of Electric Power Intensity by Usage

	(kWh/y)	Conversion value (MJ)	Japanese (MJ)
Hotel	198.2	2305.1	2,810
Office	203.4	2365.5	2,000
Shopping Mall	228.9	2662.1	2,830 (Department Store)
Hospital	249.9	2906.3	3,060
Government office Building	(158.7)	(1845.7)	1,560
Computer Building	(614.2)	(7,143.1)	5,590
The average for all sectors	216.2	2514.4	

( ); Estimate： It is a value estimated referring to the value of Japan

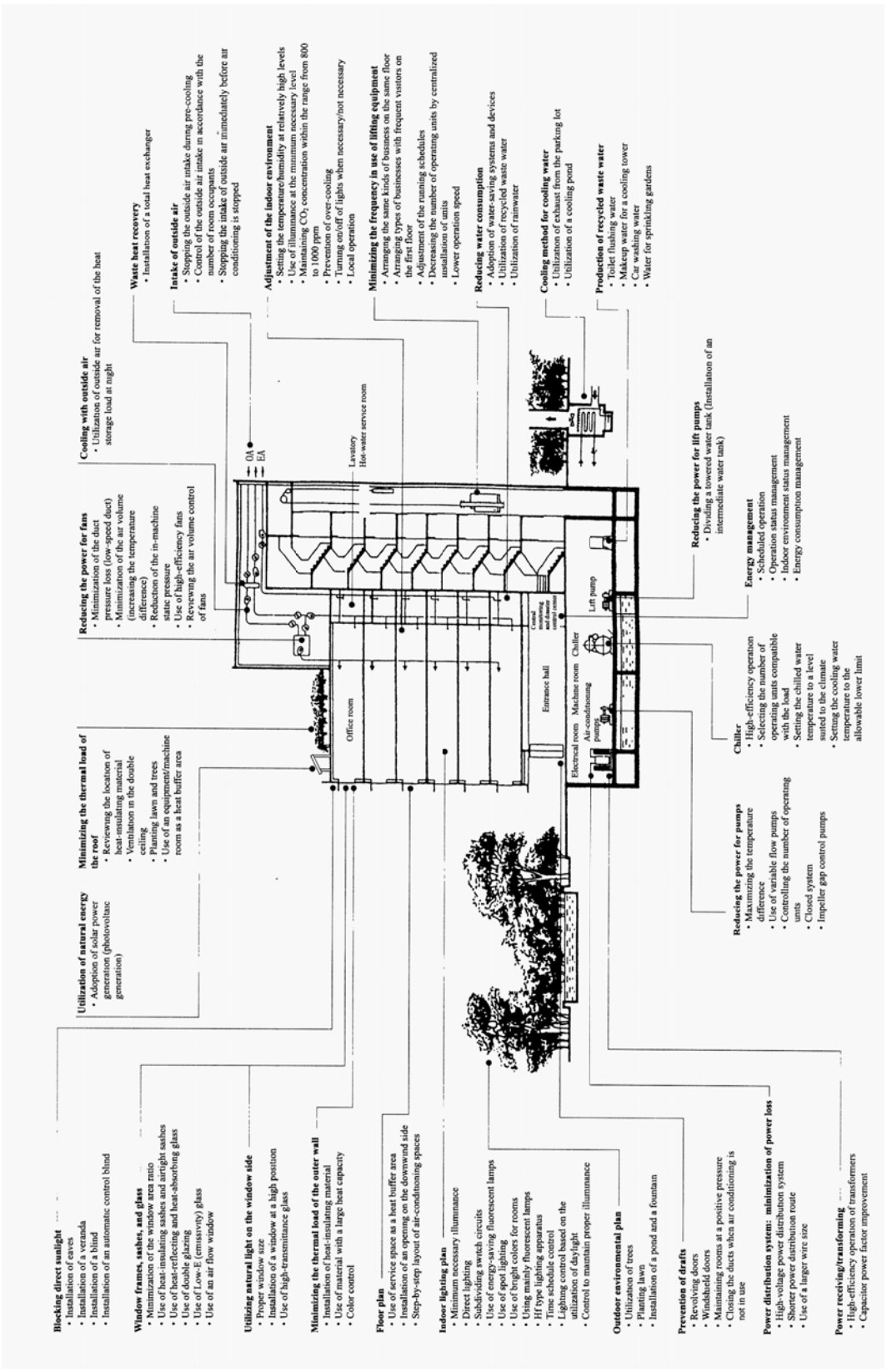


Figure 3.4.3-1 Guidelines for Energy Conservation Measures for Office Buildings The source; ECCJ

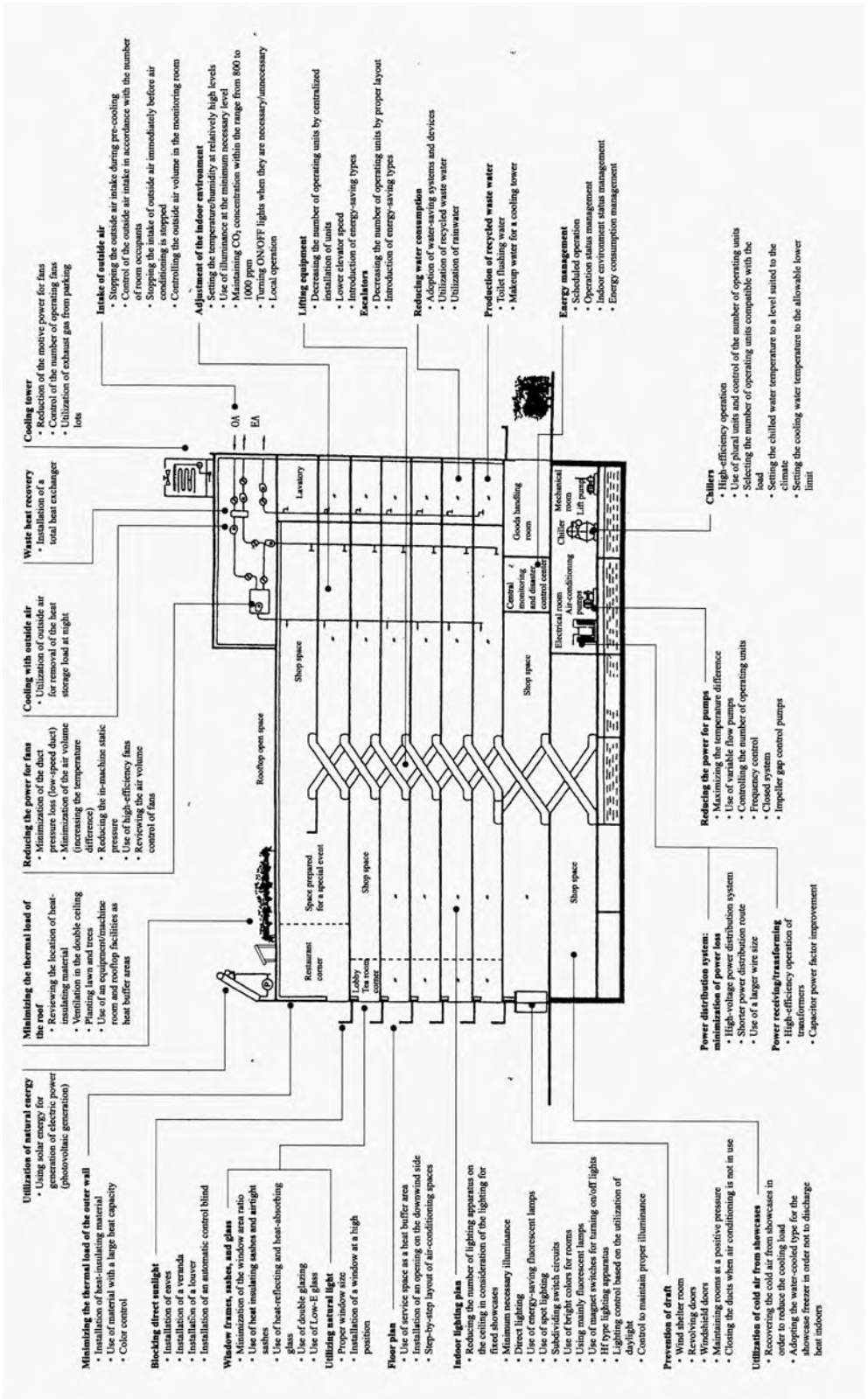


Figure 3.4.3-2 Guidelines for Energy Conservation Measures for Large Retail Shops The source; ECCJ

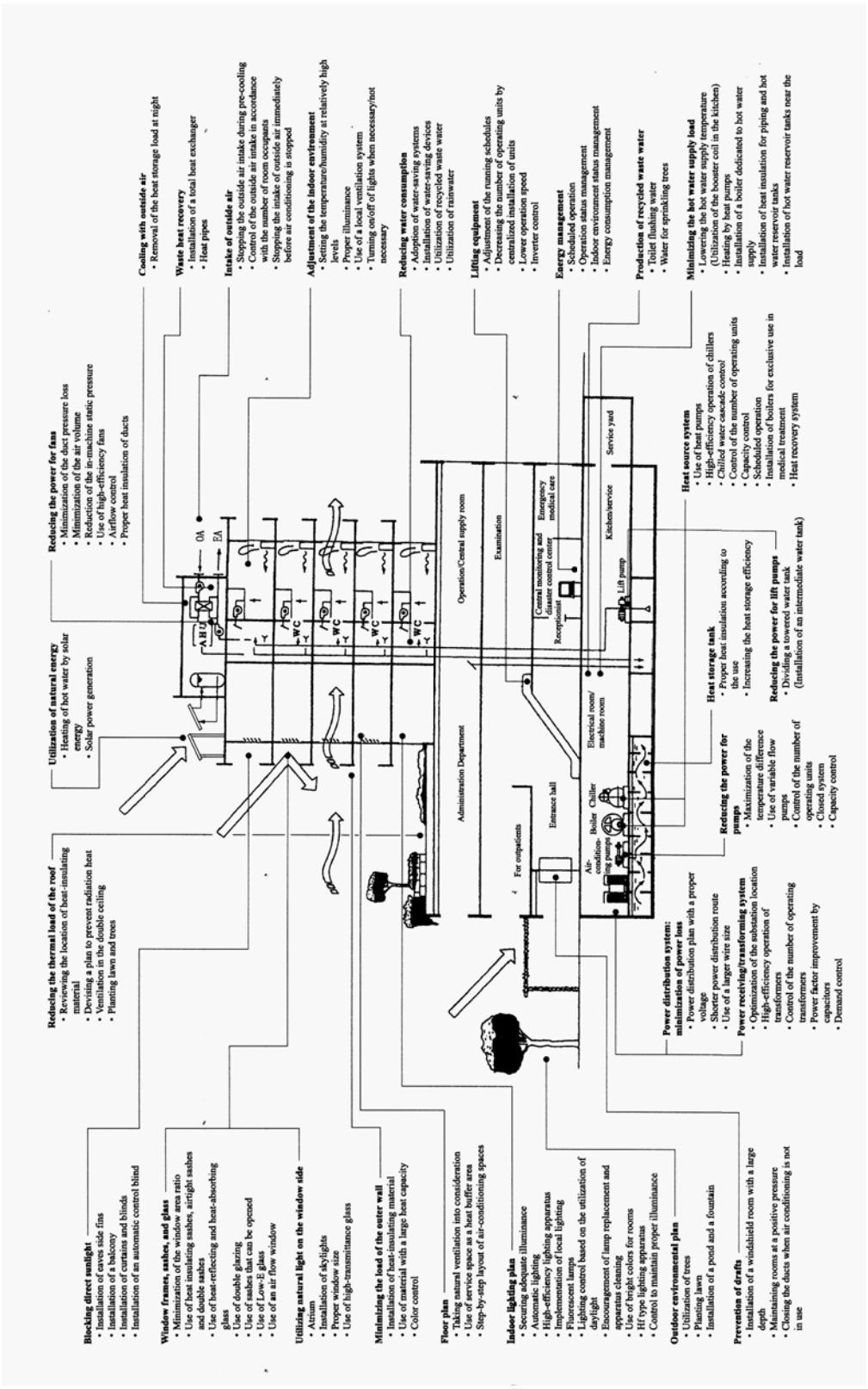


Figure 3.4.3-3 Guidelines for Energy Conservation Measures for Hospitals Buildings The source; ECCJ

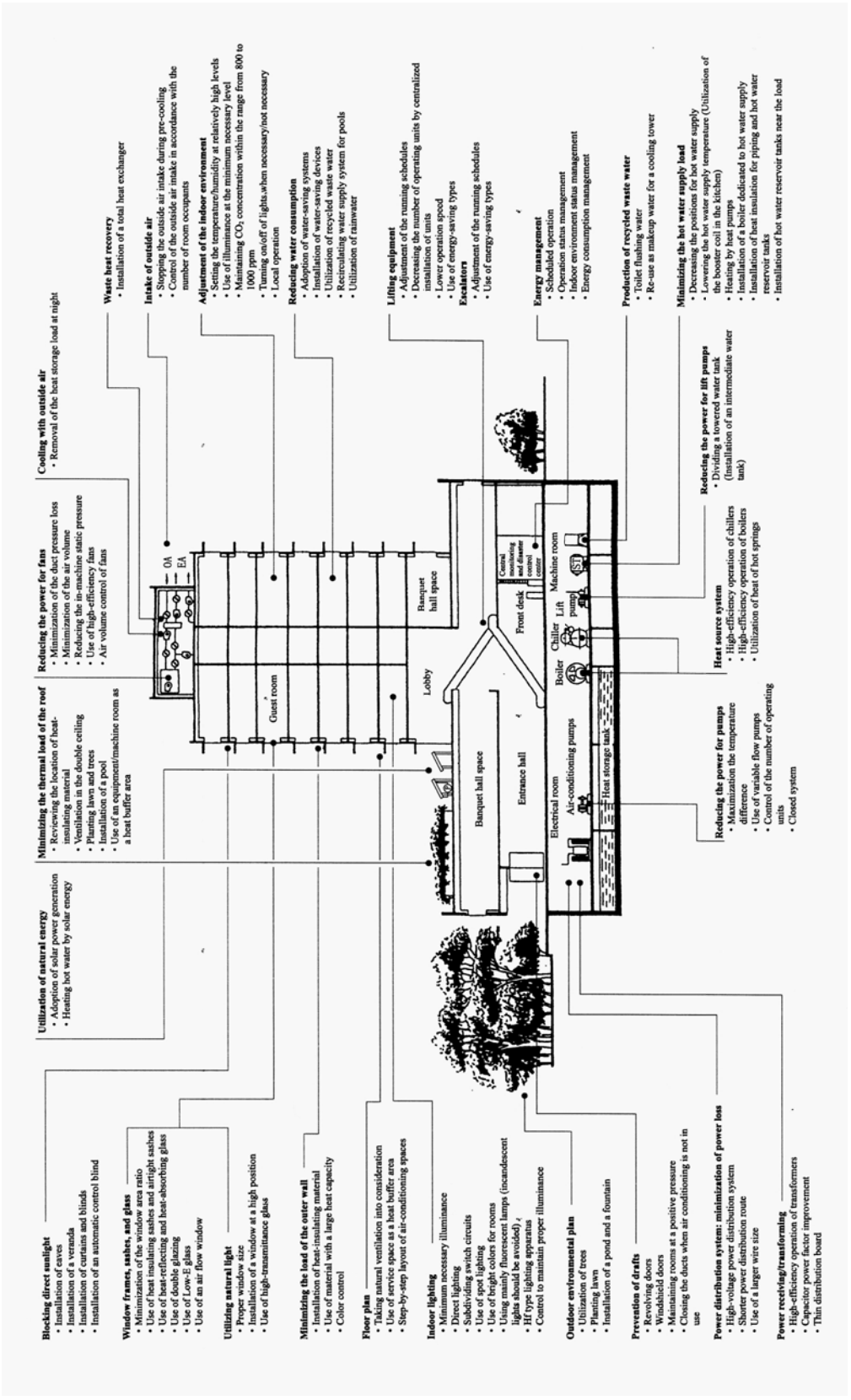


Figure 3.4.3-4 Guidelines for Energy Conservation Measures for Hotels Buildings The source; ECCJ

(2) Energy Conservation Measures for Various Usage of the Commercial Building

The need for the commercial building is changing year by year. It is necessary to achieve the energy conservation by improving and maintaining the environment and function of the building. In 2007 JICA investigation, based on the on-site energy auditing result and experiences in Japan, these energy conservation measures by each sub-sector in commercial buildings are described as follows.

1) Energy conservation for the office building (office)

The characteristics of the office building are that energy conservation can be achieved by the cooperation of the tenant and following the change of lifestyle. One typical feature is increase in cooling load. In our on-site surveys, cooling load was consumed about 50% of total energy consumption. Lighting load is the second biggest. We should focus on these two major loads firstly. Useful countermeasures are mentioned bellow:

a) Change the indoor temperature setting level (without additional investment)
In general, the air-conditioning energy decreases by 10% when the indoor air-conditioning setting temperature is raised at 1 degree.

b) The illumination of the window side in daytime is wasteful
An unnecessary illumination should be turned off by installation of daylight sensor or change of electricity distribution line to lighting fixtures.

c) Reduction of intake fresh air volume can achieve cooling load reduction.
The cooling load reduction can be achieved by intake stop during air-conditioning start-up time and the intake control with CO_2 sensor etc.

2) Energy conservation for the shopping center

Shopping center's energy intensity is comparatively high. Especially, energy consumption on air-conditioning and illumination makes about 70 % of the whole consumption. The useful countermeasures are as follows:

a) Improvement of the condition of illumination environment
The tenant shop should be showed up, so it is necessary to enlarge the illuminance difference between the common area and the tenant area relatively.

Shopping center's energy saving can be achieved by switching the common area lighting operation into three patterns a day.

For instance, in the morning energy conservation mode can be applied. The common area can be lightened by daylight in the afternoon and tenant area is lightened a little bit blighter than the common area. And at night time normal mode can be applied.

b) Decrease of distribution power line loss
In general, the shopping center is huge, so the distribution power system is complex and hard to be measured by the equipment. Therefore it is necessary to start with the maintenance of the distribution power system first of all.

c) Installation of BAS system
The measurement and the control by the BAS (Building automation system) are useful to get data for EE&C automatically.

d) Countermeasure to reduce the entrance cooling load and utilizing daylight are useful.
In a store, the lighting electricity is very large because of the large area ratio, high lighting and large share of incandescent electric lamp. In addition, air conditioning load is large for fresh air invasion from exit and entrance.

A wind screen room in exit and entrance should be established, and the daylight use in exit and entrance and near the window should be examined.

e) The number of customer fluctuates by time zone.
To meet the fluctuation of energy load, the automatic operation device (patterns) should be installed

3) Energy conservation for the hospital

In the hospital the energy consumption pattern is different by each department. Moreover, in general, buildings and equipments scatter in wide area, so the reduction of the transportation loss through the piping and wiring should be focused.

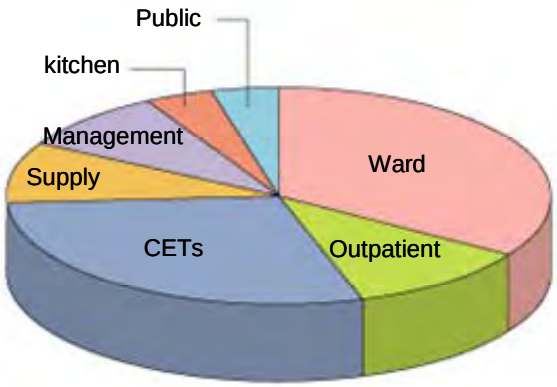


Figure 3.4.3-5 An Energy Consumption by Each Department

a) The hospital consumes of a lot of energy
A lot of steam and hot water is consumed; the amount of consumption of heat is large. It is necessary to consider the efficiency securing of the combustion equipment (The fuel is saved thorough the management of the air ratio of the steam boiler), measures of the steam leakage, and the heat loss prevention from the piping system, etc.

b) Hospital's energy consumption at nighttime is large as well as the hotel.
The energy consumption of central medical care section is large. There is a feature that the standby power is large and the power consumption at nighttime is not so small. (The power supply to highly developed medical equipment cannot be stopped at

nighttime).

c) The buildings are scattered in the large area.
The wire loss increases because of scattered electric power cable. It is necessary to consider the electric wire size and the arrangement of the power factor capacitor.

4） Energy conservation for the hotel

The hotel's specified feature is 24 hours operation.

It has the wide entrance for customer's convenience and a big heat loss through it. The temperature of air-conditioning is set considerably low in Indonesia.

Expected potential technologies are as follows;

a) Air-conditioning stop in vacant rooms and a diligent turning off. "The first step of energy conservation is exclusion of uselessness".
b) The lighting pattern should be changed according to the usage pattern of the rooms.
c) Turning off the display illumination at preparation for banquet hall
The illumination of a specific place such as banquet halls is classified into the display illuminations such as chandeliers and the general illumination to keep the luminance of the room. As for the display illumination such as chandeliers, the amount of the electric power consumption is large compared with the general illumination.

The point of energy conservation is that only a general illumination is lit at the preparation time and the display illumination should not be turned on then. This measure is popular in Japanese hotel.

d) Use of daylight
e) Stop air-conditioning when guest room is cleaned
When the indoor air-conditioning machine (fan coil etc.) in the guest room stops, centralized air-conditioning is still operated. Therefore, the room does not become a very bad working environment, even if fan coil stops during cleaning time. Moreover, as for the illumination, opening the curtain and the use of daylight should be recommended. And only light in the bathroom should be turned on, (Making the manual).

f) Review of air-conditioning operation time
g) Making the manual on energy conservation management of each department
It should be recommended to make the energy conservation manual and post it on the wall.

This helps the employees aware the energy conservation under common recognition.

h) Propriety at operating time of kitchen ventilation fan
The impact of exhausted fan is large, because the volume of treated conditioned-air is quite large. So the point of this energy conservation is how to shorten the time of the fan operation as much as possible.

i) Raise the temperature setting of fresh air cooling machine properly
Most hotels drive the fresh air cooling machine for 24 hours a year. Running and temperature setting of the outdoor equipments have great influence on the energy consumption of air-conditioning. Temperature setting of the outdoor equipments without super-cooling (cooling temperature of outdoor air) is the key point of energy conservation.

j) Replacing the incandescent lamp to CFL
As for the hotel, the lighting time of the illumination of a common area is quite long because it has been operating for 24 hours. The energy conservation can be achieved by changing from the incandescent lamp to CFL.

k) Air-conditioning management of banquet hall
The banquet hall is applied for a various use, such as marriage, meeting, and the conferences. Effective operation pattern of cooling should be examined.

3.4.4 Energy Conservation for Air Conditioner Energy Conservation for E

(1) Energy Conservation Measures for Air-conditioning

The share of the energy consumption items investigated by JICA for various building is shown in the following figure. Commonly, air-conditioning demand is the largest. It is over 1/2 of the whole demand of the buildings. The lighting demand is the second largest value following air-conditioning in the office and the shopping center. On the other hand, hot water supply is large in hotel and hospital. Therefore, these loads are the dominant object of the energy conservation measures firstly.

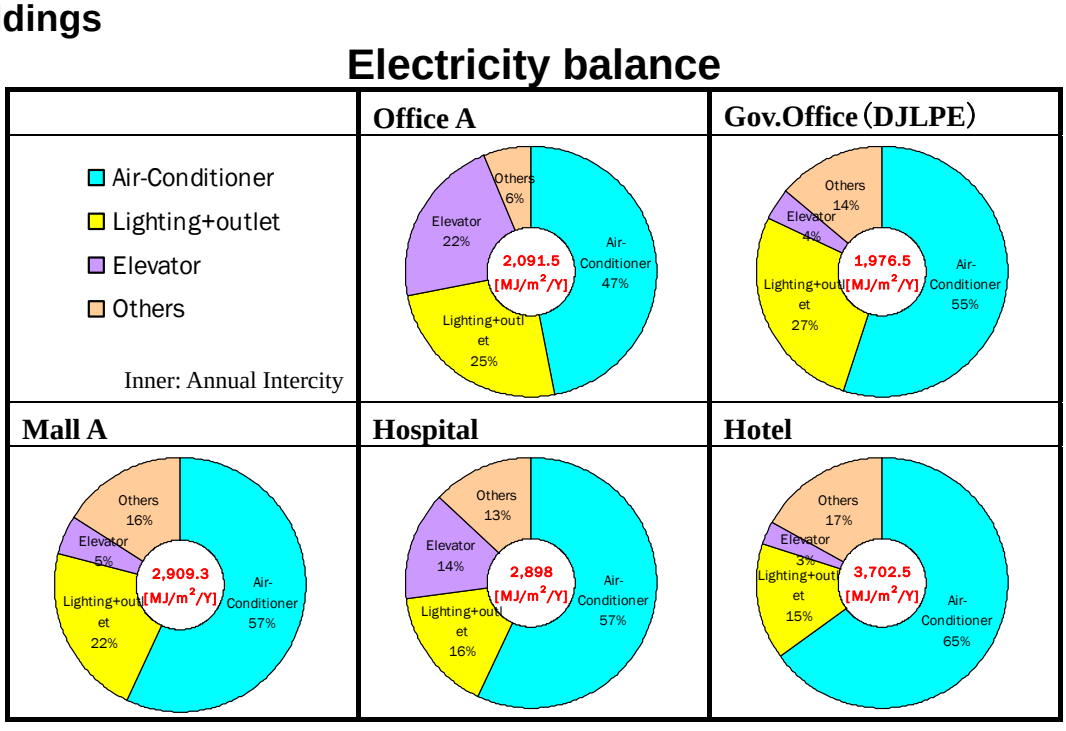


Figure 3.4.4-1 Break down of Electricity Consumption in Commercial Buildings

1) Rationalization of temperature setting level

Generally, the air-conditioning energy decreased by 10% when the indoor air-conditioning setting temperature is raised at 1 degree. If assuming that air-conditioning consumed 50% of the annual total energy, the annual energy conservation effect by raising 1°C temperature will achieve 5% (＝50% × 10%) of total energy consumption.

2) Rationalization of intake fresh air volume

The outside fresh air should be introduced into indoor in order to keep cleanness of indoor air building air-conditioning system in general. According to the Building Standard Law of Japan, The fresh air volume is at least 20m^3/h per person to keep less than 1,000 ppm indoor CO_2 density. The fresh air load is about 20% - 30% of total cooling load. If the fresh air volume is decreased within the range which the Indoor Environmental Protection Standard can be satisfied, the fresh air cooling load decreases and save energy consumption. The energy conservation measures for fresh air control includes adjusting the reasonable opening level of the fresh air damper, the damper shutting when pre-cool fresh air and automatically controlling of damper by CO_2 sensor etc.

3) Decrease of invasion heat from window glass

The solar radiation heat load of external structure is about 1/4 of total cooling load in summer. The window glass load (invasion heat of window = directly sunshine radiation heat and heat conduction of glass) is about 75%. Therefore, it is effective to decrease the window invasion heat in order to reduce the external structure load. Countermeasures of decreasing invasion heat are described as follows.

a) Application of multilayer glass
The heat transfer coefficient of window glass will becomes small by using double and triple glasses, and then the invasion heat can be lowered considerably.

b) Using of blind and curtains
The directly sunshine radiation can be intercepted and about 15% - 20% invasion heat can be reduced by using blind and curtains in the window with sunshine. Moreover, it will gain large effect by setting the blind in the outside of the window.

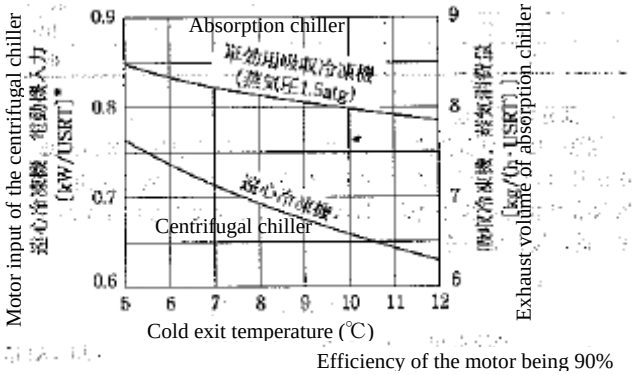
4) Effective operation of chiller

The temperature control of chillers can be done as follows considering the season characteristic and partial load characteristic.

a) The cold water temperature is controlled by controlling the exit water temperature.
b) The temperature of cooling water is lowered as much as possible.

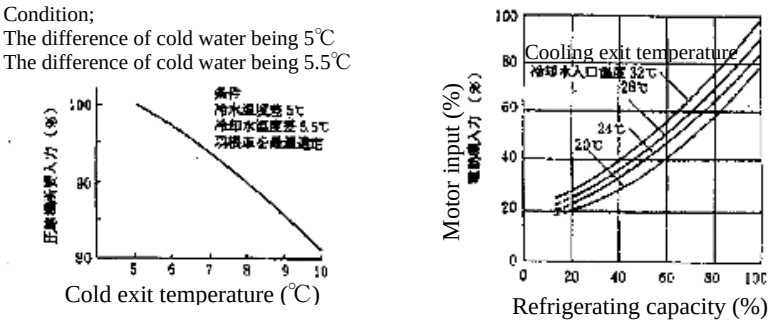
The necessary input decreases by raising the exit cold water temperature in chiller (Figure 3.4.4-2). However, it doesn't decrease at all loads because raising the exit cold water temperature decreases the air-conditioning ability. Therefore, the energy conservation can

be obtained by raising the exit cold water temperature in the low load operation period. As shown in Figure 3.4.4-3 and Figure 3.4.4-4, the energy conservation operation can be achieved by the efficiency improvement of the centrifugal chiller and the absorption chiller with the lower cooling water temperature.



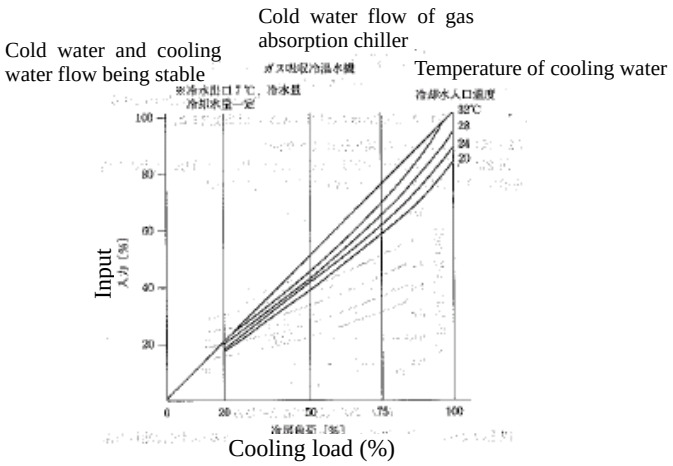
Source: ECCJ energy conservation pocketbook 2007

Figure 3.4.4-2 The Relationship between the Exit Cold Water Temperature and the Electric Motor Input of Chiller.



Source: Air harmony sanitary engineering handbook

Figure 3.4.4-3 The Relationship between the Cooling Water Temperature and the Electric Motor Input of centrifugal Chiller



Source: ECCJ energy conservation pocketbook 2007

Figure 3.4.4-4 The Relationship between the Cooling Water Temperature and the Electric Motor Input of Absorption Chiller

5) Temperature adjustment of cold water and cooling water

In the cold water type, the input energy of the turbo chiller is mainly influenced by the evaporation temperature and the condensation temperature of the refrigerator. That is to say; it is influenced by the exit cold water temperature. Therefore, raising the chiller exit cold water temperature or the evaporation temperature of the refrigerator as much as possible within the range being the thermal and humidity condition permitted at the air-conditioning space leads to the efficiency improvement of the chiller. On the other hand, in the same air-conditioning load, it needs to increase the number of coil rows and the flux of the air-conditioning equipment when the cold water temperature and the evaporation temperature are raised. That causes the increase of the pump power conflicting with the effect of energy conservation of chiller, so it is necessary to examine the relationship between both sides enough. By the way, according to the trial calculation of a certain building where the efficiency of the chiller power occupying all power for air-conditioning is high, about 3% of total energy consumption can be saved by improving the supply water temperature from 5°C to 8°C.

Moreover, energy conservation from the condensation temperature decrease needs to lower the cooling water temperature in the cooling tower, which causes the raise of the cooling tower blower power similarly. Therefore, in the chiller system, it is necessary to attempt energy conservation from the view of entire system, considering not only the main equipment but also the cooling tower and other attached equipments

6) Chiller multi-unit control

As we know, the annual average load ratio of a chiller is about 40% - 50% generally. The load ratio with the highest COP of centrifugal chiller is about 75%. Considering the annual load ratio, the number of the chiller that can make the chiller operated with the maximum efficiency as much as possible need to be decided. For example, if introducing two chillers with same capacity, 50% load is set as the control point. 50% load is set as the operation

boundary if two chillers with same capacity are set up, then only one chiller should be operated in the lower load and both two chillers should be operated in the higher load. The comprehensive efficiency can be improved by using such chiller multi-unit control. As a result, it obtains energy conservation compared with the case that only one chiller is running with two times capacity.

The number of centrifugal chiller is controlled by the input electricity value. The reason is that the input electricity value is the best parameter to show clearly the operation condition of chiller compared with the heat amount control method.

Compared with the method that operates small number of chillers as much as possible by using proportion control measuring the exit cold water temperature of chiller, it is advisable to start additional chiller considering the criteria of not only the electric current value but also the temperature of exit cold water temperature plus 2.0°C.

Moreover, in the load decreasing condition, the operation number of chillers should be decreased according to the entrance cold water temperature besides the electric current value. It is preferable that the operation rotate of the plural number chiller should be arranged to average the annual operation time of chillers.

7) Cleaning of heat exchanger tube

After a long time operation of the turbo chiller, the screw attachment on the cooling water tube (heat transfer tube) causes the increase of the electricity consumption and operation trouble. In order to decrease the electricity consumption, keep steady operation condition and extend equipment operating life, the periodic condensation tube cleaning with chemicals is very important.

8) Water quality management

The chiller breakdown caused by the water entering into equipment is the most serious trouble in chiller troubles. The water infiltrating into refrigerator will lead to refrigerator resolution, inside rust of equipment and dielectric breakdown of electric motor and so on. The restoration of those troubles need lots of time and cost. One reason that cause inside water infiltration of equipment is the corrosion due to water pollution. The standard value of water quality management is generally adopt the standard improved by the Japan Refrigeration and Air Conditioning Industry Association

In water quality management, the regular pursuit is very important, especially, the water concentrate of the opening cooling water should be attended. In this case, by the chemical injection treatment for the water, the concentration rate can be raised up to about eight times by operating the blow device work with monitoring the conductivity and PH value. The replenishment water amount for the cooling water can be greatly decreased by this measurement. The concrete management includes concentrate management and the chemicals density management.

9) Air tightness maintenance management

In the turbo chiller, the air tightness maintenance is important. The air tightness deteriorate causes air invades into equipment inside, and then the extra electricity is consumed with the rise of condensing pressure. After a long time stop, air invasion in equipment inside causes the failure operation because of the trip of high pressure in condensation. Moreover, the corrosion by acid in the invasion air or the refrigerant resolution caused by the moisture happens. There is a constant relationship between pressure and condensation (saturation) temperatures of the refrigerator. So the air invasion can be checked by measuring the refrigerator pressure. It is supposed that the air leakage happened if the temperature difference between saturation temperatures under measured pressure and refrigerator condensation temperature is over 1.5°C, then it is necessary to make investigation.

There also has another method to check air leak, such as air tightness test and vacuum test. As the air tightness test, the inside equipment is pressurized with chokedamp, and then the leakage respect is investigated with the gas leakage container. As about the vacuum test, the pressure in equipment inside is made less than 99.991kPa (750 mm Hg) by using the vacuum pump, then the air leak can be judged by checking the vacuum condition.

10) Load cutting from the source

The number of office apparatuses, such as computer and copier, is increasing recently, that causes the electrical outlet load increases from $10W/m^2$ - $40W/m^2$. Because the rejection heat from these office apparatuses becomes cooling load, it needs to be discharged locally outside before it diffuses into indoor.

11) Zero energy band control

Regarding the existing indoor temperature control system, the air-conditioning system start operation when a little temperature increase over 26°C setting temperature. By setting band (for example 2-3°C), the air-conditioning system operation can be mitigated. No air-conditioning when the room temperature is in this range. The range where energy is not used is called zero energy bands.

12) Utilization of the exhaust heat

The amount of low temperature exhaust heat (called as city exhaust heat and unutilized heat) from resident, city and factory is very rich, but it is difficult to be utilized because of the low temperature. It is individually used for supplying hot water heating by using heat pump to recover the air-conditioning exhaust heat. There is also the report that about 20% electricity consumption amount has been decreased by the district heating and cooling system using river water. Moreover, by using the double glass window in the building opening area, the air-conditioned exhausted air flows between double glasses, then is used to mitigate the influence from outside (Ventilation window).

(2) Evaluation index of air-conditioning equipment

Several evaluation indexes that evaluate the air-conditioning equipment and the energy consumption condition are defined. These indexes are shown in Table 3.4.4-1. These indexes are to be checked periodically whether they are in the normal value or not.

Table 3.4.4-1 Energy Consumption Evaluation Indexes in Air-conditioning

Evaluation method		Basic expression	period	Denominator	Numerator	Example
Evaluation of Energy Intensity		$\frac{\text{Period Energy (or load)}}{\text{Scale}}$	Month, season, period, Year	Total floor area; Equivalent total floor area; Air-conditioning area; Capacity; Air-conditioning Capacity;	Air-conditioning load; Secondary energy; Primary energy; Energy resource;	Annual primary energy consumption amount for total floor area; Basic energy consumption unit; Energy budget; (MJ/m^2•Year) (GJ/m^2•Year)
			Hour	Floor area; External surface area Capacity;	Heat transfer amount; Air-conditioning amount;	External structure integrated heat transfer rate (kcal/m^2• h •°C) (W/m^2•°C)
Efficiency Evaluation	Efficiency	$\eta = \frac{\text{Output Energy}}{\text{Input Energy}}$	Hour, Month, Season, Period, Year	Secondary energy; Primary energy;	Air-conditioning load; Secondary energy	Period boiler efficiency $\eta = \frac{\text{Winter Output (load) Sum}}{\text{Winter Energy Input Amount}}$
	Coefficient	$COP = \frac{\text{Output Energy}}{\text{Input Energy}}$		Secondary energy; Primary energy Energy resource	Air-conditioning load; Room load (Removal heat amount), air-conditioning unit (coil) load; (actual); air-conditioning unit (coil) load; (Assume) Heat source load	Heat source energy Co-efficiency $COP_{HS\text{-}n} = \frac{\text{Heat Source Output}}{\text{Energy Input Amount}}$

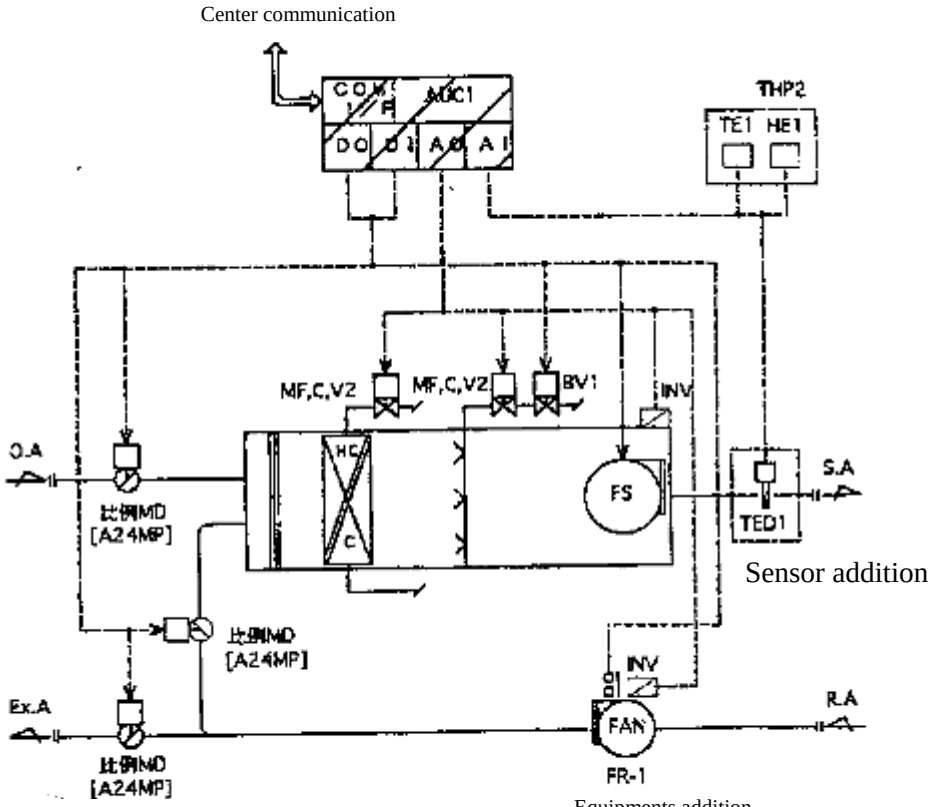
3.4.5 Energy Conservation for Transportation Equipment

(1) Control of Ventilation Transportation System

1) Control of ventilation volume

In an air-conditioning system with fixed volume, the fan power can be reduced by controlling the rotational speed with installing the inverter device in the fan in following conditions. 1) There is surplus capacity of cooling to maintain indoor thermal environment. 2) There is surplus amount of the introduction fresh air.

Generally, the air volume (motor rotational speed) is decided by the temperature, and sometimes, the CO_2 density is applied to adjust it. Moreover, it is necessary to set the lowest rotational speed limitation to protect floating dust increase due to the decrease of the air change rate and the indoor temperature unbalance due to the decrease of the indoor air velocity (Figure 3.4.5-1).



Controlling items
1. Air supply temperature control (present indoor temperature control)
2. Volume control by indoor temperature.
3. Load reset control
4. Inverter control

Equipments addition
. Inverter addition
. Air supply temperature sensor addition
. Change of control software for air-conditioner
. Measurement meter addition of power, electricity

Source：Building Energy Comprehensive Management Technique
The Building Energy Manager's Association of Japan 2000

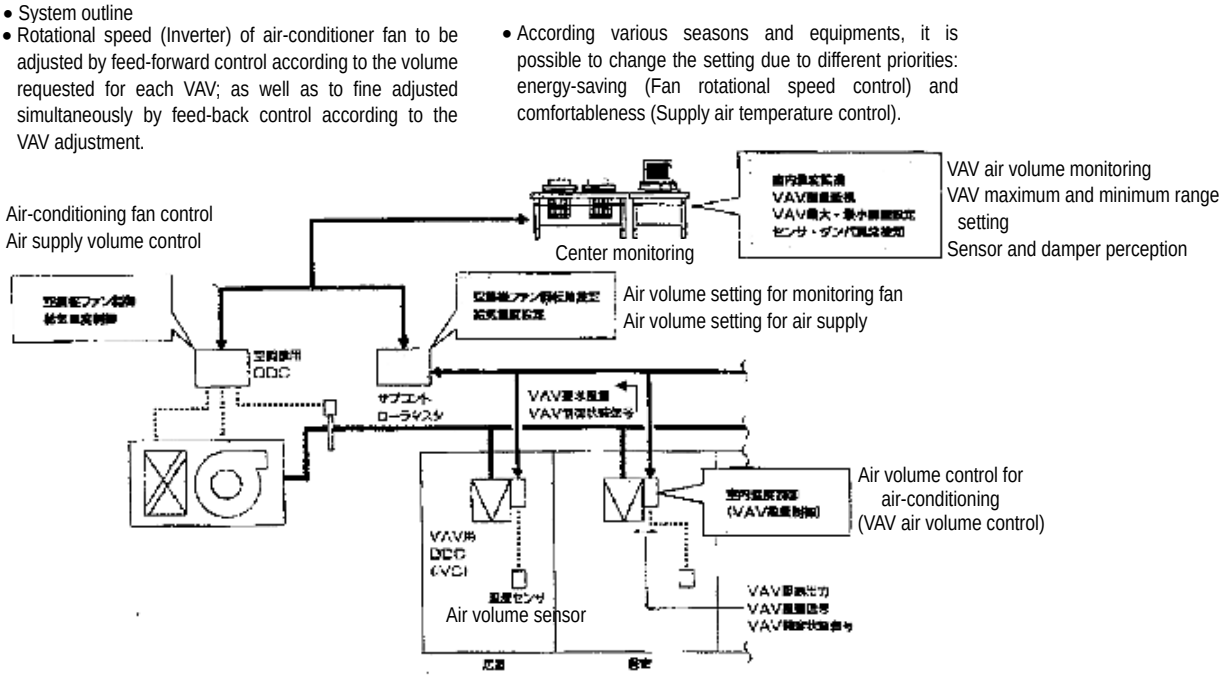
Figure 3.4.5-1 Example of Inverter Control

2) VAV control

VAV system is a system that controls air-conditioning load by executing respectively the temperature control for each VAV unit. Each VAV unit keeps the indoor temperature constant by controlling the supply air volume. On the other hand, although it is making efforts to prevent air deficiency of the supply air to maintain indoor temperature for each VAV unit by cool air-conditioning system, the supply air temperature and the necessary supply air volume influence mutually. Although the VAV opening degree is controlled by the temperature sensor in VAV unit, it is necessary to introduce enough outside fresh air amounts to maintain indoor air quality because the necessary supply air volume does not depend on the indoor air-conditioning load.

The optimization air supply temperature and volume is requested in the air-conditioning control. Figure 3.4.5.1-2 is a control example. In this example, it executes the optimization air volume control with minimum pressure drop by the following control method: feed-forward control with request air volume in each VAV unit and feed-forward control for minute adjustment with signal of VAV opening degrees. Moreover, in the condition

that the energy conservation control by changing the supply water temperature is used together in the heat source side, it is necessary to make individual control because the energy conservation due to water supply temperature change and the energy conservation due to transportation power influence mutually.



Source：「Building Energy Comprehensive Management Technique」
The Building Energy Manager's Association of Japan 2000

Figure 3.4.5-2 VAV Control

3) Other energy conservation management of ventilation equipment

- Decrease of ventilation transportation power
  The ventilation should be stopped when it is unnecessary in the lavatory, hot water making room, storehouse and the equipment room, etc.
- Maintenance of ventilation equipment
  Checking and maintaining of the fan belt.
- Decrease of ventilation load
  Decreasing the ventilation load via outside air introduce volume decrease by introducing the smoking limitation, smoking room and the air cleaner device.
- Ventilation control of parking lot
  The ventilation control at a lower load is done by schedule or CO_2 sensor.
- Replace of large amount ventilation
  Decreasing the ventilation amount by setting cooling equipment when there need large amount ventilation to removal internal heat generation in the electricity transfer room and the equipment room, etc.
- Temperature control of equipment room ventilation

Ventilation to be controlled by the temperature sensor in the space the ventilation is not necessary below a constant temperature like the equipment room.

- Decreasing ventilation volume by limited locally exhausts
  Decreasing the outside fresh air intake by locally exhaust for the air polluters like combustor and copier.
- Change of kitchen exhaust hood
  Decreasing the ventilation load by changing the kitchen exhaust hood into the type integrated with air supply.

4) Utilization of the natural ventilation

It is possible to decrease energy consumption for air-conditioning by the utilization of the natural ventilation in the buildings and factories. At night, the remaining heat indoor is discharged by the air ventilate from open part (window and ventilation louver).

(2) Control of the water transportation system

1) Control of the water supply pressure

The cool water secondary pump in heat source system should always supply the clod water to each air-conditioning unit and fan-coil with certain pressure.

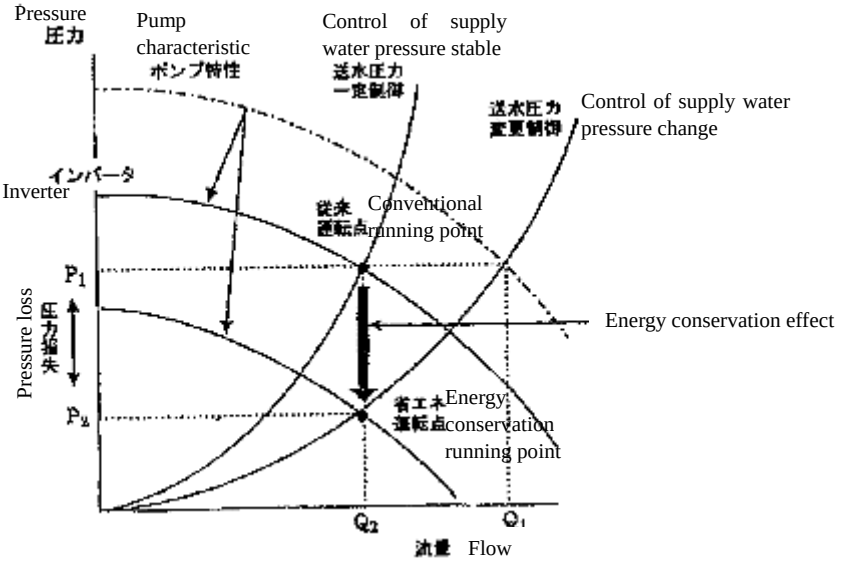


Figure 3.4.5-3 Energy Conservation of Water Supply Pressure Control

This water supply pressure is set to the value that can supply enough water at the maximum load. Therefore, in the partial load condition, the pressure balance of the entire system is kept by the pressure drop due to the control of valve. The pump is controlled by the lowest pressure that can supply enough necessary water to each air-conditioning system, and then it can gain energy conservation because the pump is running at the low

rotational speed. (Figure 3.4.5-3)

The instrumentation system is a system that collects and grasps the measured data, such as valve opening degree, supply air temperature and indoor temperature, indicating each air-conditioning unit load condition, and then judge the water deficiency, finally, the deficiency information is transferred to the center equipment. In the center equipment, the best water supply pressure value of the entire system is decided based on transferred deficiency information from each air-conditioning system, and then the decided pressure value is sent to the controller of the pressure control loop.

2) Secure efficiency of fluid machinery and piping

- Secure highly efficiency of pump
- Prevention of water leak from a pump and pipe system
- Secure insulation effect of pipe to prevent heat loss and condensation. Especially, in the cool water pipe, the insulation effect extremely down is happened frequency because the surface condensation.
- Recovery from the flux decrease that is occurred because of the foreign thing and friction in the pump impeller.

3) Controllability of pump flux

- Examination on the appropriate of the pressure setting point which is set to control rotational speed (speed control).
- Examination on the possibility of rotational speed control adoption in the flux change
- Examination on the conversion that changing the constant flux amount system (changing the two-way valve operation into three-way valve operation) into the flux change system.
- Realization of the appropriate pump number division and the operation time leveling
- Check on energy characteristic of variable speed motor

4) Flux adjustment and load control possibility

- In the super large flux condition, the energy consumption is obstructed by the rotational speed decreasing or the valve and damper narrow down.
- Size adjustment of control valve and control damper. The excessive size damages the controllability and easily cause the energy waste in load side.

5) Use temperature difference

- The possibility to expand the temperatures difference (supply and return) should be examined. (It is necessary to analyze the heat exchanger characteristic.）
- Seasonal re-setting of the heat transfer medium temperature（improvement of the heat source COP）

- Density increasing of heat transfer medium, for example, the ice slurry transportation and so on.(using in the condition that the indoor load increases）

3.4.6 Equipment of Control System

(1) BEMS (Building Energy)

The building management automation becomes popular by the development of the computer in the factory automation (FA) and the office automation (OA). BEMS which controls efficiency and manages building energy will be developed as a system in the 21st century.

1) Outline of BEMS

BEMS is a system that optimizes and minimized the building energy consumption by using the energy consumption and indoor environment data. It aims to achieve the best environment with minimum energy.

In detail, it is composed of measurement device, controller, monitoring instrument, data storage, data analysis, etc. The related management systems are summarized in Table 3.4.6-1.

Table 3.4.6-1 BEMS concept

Function	Monitor	BA	BMS	EMS	BEMS
Monitor and display	○	○	○	○	○
Control		○	○	○	○
Measurement		○	○	○	○
Building management			○		○
Energy management				○	○
Energy optimization					○

2) BEMS function

As shown in Figure 3.4.6-1, the BEMS is an integrated composition, and its function is listed as follows.

a) Monitor and display
- Abnormality and breakdown（Including remote supervision）
- Start and stop operations
- Operation state display

b) Control
- Automation of equipment (for FA、OA equipment)
- Equipment operation by digital switchboard
- Securing of amenity environment

c) Building management
- Decrease of LCC
- Maintenance expense decrease and comfortable environment improvement

- Extension of maintenance interval
- Control of the operation number of equipment and operation time
- Enhancement of building security function

d) Energy management
- Energy efficiency management and control.
- Operation control by the data of the temperature, humidity, heat amount and electricity amount.

e) Energy optimization
- The most comfortable environment achievement with minimum energy consumption.
- Optimization management of heat load fluctuation by using COP energy management.
- Optimization management of the entire system.
- Energy conservation, cost reduction and CO2 reduction plan

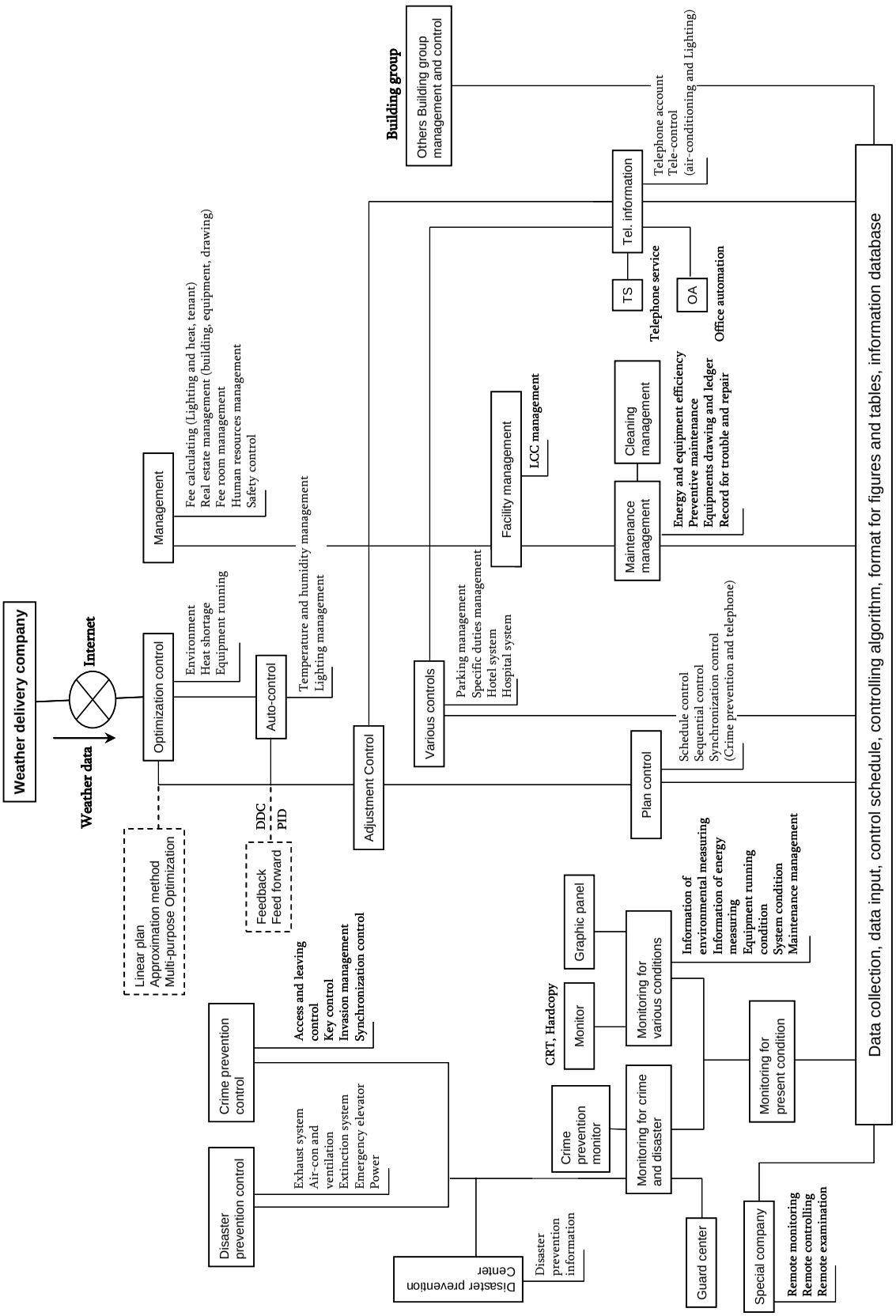


Figure 3.4.6-1 The Integrated BEMS Composition

3.4.7 Lighting equipment

(1) Inverter Type Hf Fluorescent Lamp and Automatic Control

The electronic ballast used for inverter type fluorescent lamp has become popular replacing the magnetic ballast used for the traditional fluorescent lamp. The lighting device which changes the power-frequency into high-frequency has the following merits: less and economical electricity consumption, no uneven light, small size and lightweight and so on.

1) Merits of inverter lighting (electronic ballast)

a) Efficiency improvement of lamp----- The total luminous flux improves more than 20% by using the more than 40kHz high-frequency lighting.
b) Reduce of ballast loss----- The ballast using high-frequency can miniaturize and then decrease loss.
c) It is adaptable to widely condition----- The inverter lighting can be used in all of voltage range from 100-254 V voltage (Phase voltage: 3φ440V).
d) Small size and lightweight----- Because the ballast and capacitor can be miniaturized and lightened, it is possible to miniaturize and lighted the total lighting device. Easy to implementation and variety of design.
e) Easy control on illuminance ----- The light amount (illuminance) of the fluorescent lamp can be easily adjusted according to daylight amount, using the following adjustment method: Light adjustment controller that can continuously adjust the light amount and lighting control system that combining the illuminance sensors or time switches and so on.
f) Three kinds of fluorescent lamps can be used----- The electronic ballast can be applied for the Hf lighting (T8), the rapid magnetic ballast fluorescence lamps (FLR), the glow magnetic ballast fluorescence lamps (FL).

2) Automatic dimmer system

a) Outline of the system----- Hf fluorescent lamp can achieve big energy conservation compared with the old model lamp, and the lighting control is also possible. The launching luminous flux of Hf fluorescent lamp can be changed arbitrarily by the dimmer control.
Because the electricity consumption is proportion to the luminous flux, the energy can be saved by decreasing excessive illuminance.

b) Light adjustment control
In order to secure the setting brightness, the light adjustment is done by the following signals: signal from illuminance sensor and human sensor installed in light adjustment devices, specified time input signal from timer and signal from wireless remote control and so on. There is a case that 50% electricity consumption is reduced by the HF fluorescent lamp and dimmer. (Refer to Figure 3.4.7-1).

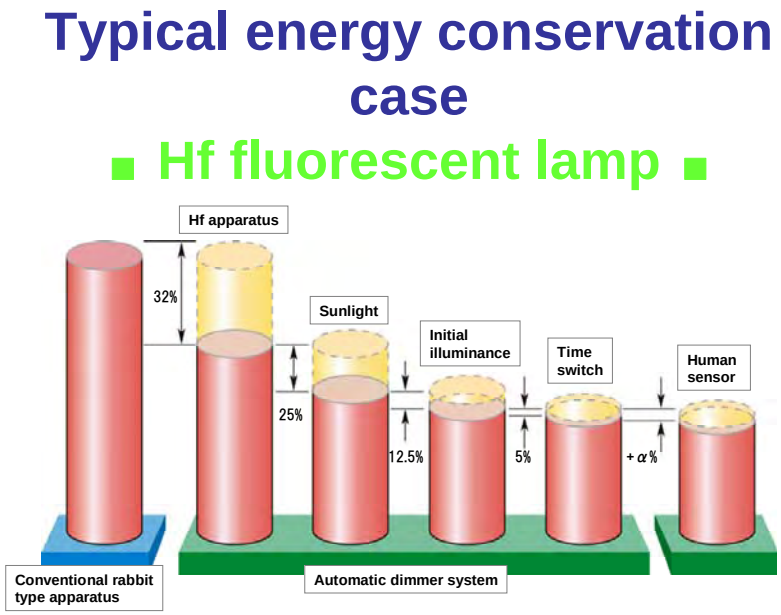


Figure 3.4.7-1 Effect of Energy Conservation by Mode

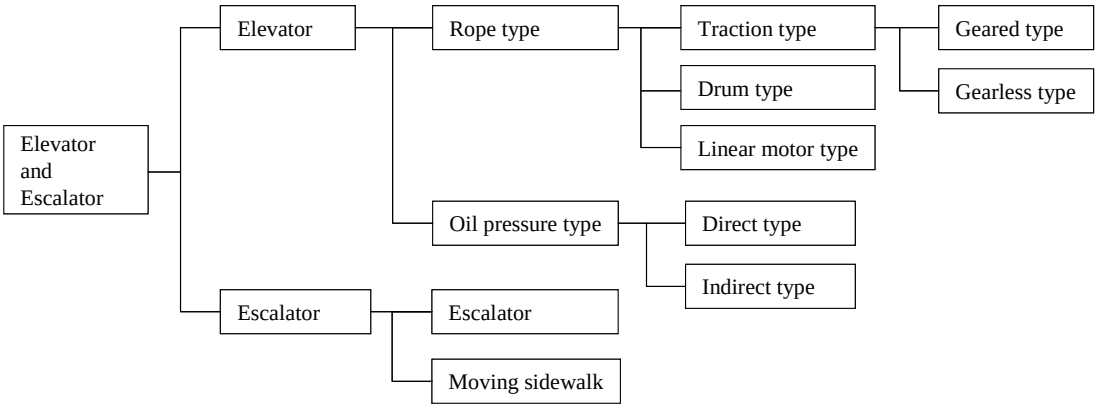
(2) High Efficiency Fluorescent Lamp and Reflector

Although it is not still spread in Indonesia, the adoption of High efficiency fluorescent lamp (T8,Hf) and the addition of the specular reflector have about 10% and 45% energy conservation potential, respectively. These are spreading in other countries, and can] be introduced in Indonesia soon, because they need comparatively small investment.

3.4.8 Elevator and Escalator

(1) Classification of Elevator and Escalator

Figure 3.4.8-1 shows the elevator and escalator classification according to the driving system. Elevator is divided roughly into the rope type elevator and the oil pressure type elevator pushed up by oil pressure. The rope type elevator includes the most spread traction type, drum type that winds rope up to net car and linear motor type that driven the basket through rope by the impellent generated by the linear motor setting in the counterweight side. The escalator is divided into two types. One is the structural escalator that always maintains the stile horizontal. The other is the structural moving sidewalk that doesn't install high difference between stiles.



Source : Energy conservation of office building by equipment operation management
The Building Energy Manager's Association of Japan {H8}

Figure 3.4.8-1 Elevator and Escalator Classification According to the Drive System

(2) Elevator

1) Control technology transition and energy conservation

Generally, the elevator is classified into medium- and low-speed elevator (less than 105m/Minute) and high-speed elevator (more than 120m/minute) according to the speed. Table 3.4.8-1 shows the transition of the rope type elevator from the view of control technology.

Table 3.4.8-1 Control technology transition of the rope type elevator

<table>
<tr><td colspan="2">year
Rated speed(m/min)</td><td>1,900
71</td><td>75</td><td>85</td><td>2,000
100</td></tr>
<tr><td rowspan="3">medium- and low-speed elevator</td><td>Less than 30</td><td>AC one step speed (with cogwheel decelerator)</td><td colspan="2">AC return control (with cogwheel decelerator)</td><td>Inverter control (with cogwheel decelerator, none electric resurrection)</td></tr>
<tr><td>45 - 60</td><td>AC two step speed (with cogwheel decelerator)</td><td colspan="2"></td><td></td></tr>
<tr><td>90 - 105</td><td>Ward Leonard Control (with cogwheel decelerator)</td><td colspan="2"></td><td></td></tr>
<tr><td rowspan="3">high-speed elevator</td><td>120 - 150</td><td colspan="2" rowspan="3">Ward Leonard Control (none cogwheel decelerator)</td><td rowspan="3">Thyristor Leonard Control (none cogwheel decelerator)</td><td rowspan="2">Inverter control (with/none cogwheel decelerator, with electric resurrection)</td></tr>
<tr><td>180 - 240</td></tr>
<tr><td>More than 300</td><td>Inverter control (none cogwheel decelerator, with electric resurrection)</td></tr>
</table>

Source :「Energy conservation of office building by equipment operation management」 The Building Energy Manager's Association of Japan {H8.3}

2) Power saving by inverter control

The improvement of electricity utilization efficiency is remarkable because of the

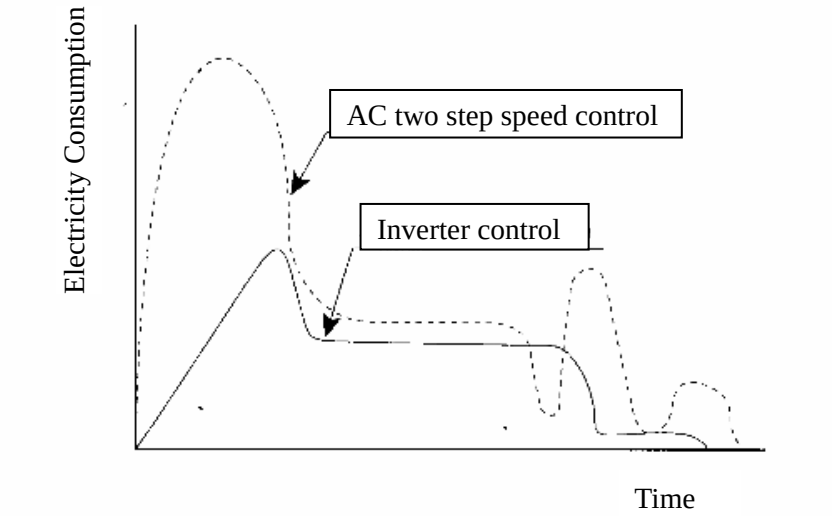
technology advancement in elevator. The energy conservation technology also has been introduced into the rope type and oil pressure type elevator. Especially, the practical use of the inverter control method makes it possible to remarkable decrease electricity consumption in each drive method. Therefore, it is expected that the electricity consumption is decreased greatly by changing the existing control method to inverter control method in elevator.

Table 3.4.8-2 shows the electricity consumption decrease ratio duo to inverter control compared with existing control method. Figure 3.4.8-2 is the electricity consumption comparison.

Table 3.4.8-2 Electricity Consumption Decrease Ratio by Inverter Control

Drive type	Existing control		Inverter control
Rope type	Middle- and low-speed	AC one step speed control	50－60%
		AC two step speed control	
		AC return control	40－50%
	High-speed	Ward Leonard Control	30－40%
		Thyristor Leonard Control	5－10%
Oil pressure type	Electromagnetic valve flux control		40－50%
	LM control (Landing time Minimizing)		More than 15%

(Source：「Energy conservation of office building by equipment operation management」 The Building Energy Manager's Association of Japan {H8.3})



Source：(Energy conservation of office building by equipment operation management) The Building Energy Manager's Association of Japan {H8.3}

Figure 3.4.8-2 Electricity Consumption Pattern of Inverter Control

3) Calculation method of electricity consumption for elevator

The electricity consumption for elevator can be calculated from the main design items by using the expressions listed in Table 3.4.8-3 with the electric motor output. The value of

motor output P is a little bit smaller than that of the rated output of the installed motor. The electricity consumption of each control method is calculated based on the P value disregarding the difference between P value and the rated output value.

Table 3.4.8-3 Rough Calculation Method of Electricity Consumption

Rough calculation method of electricity consumption
Output of electric motor
P = L*V*F / 6,120η

P: Output of electric motor(kW)
L: Rated live load {kg}
V: Rated speed (m/minute)

F：unbalance rate of hanging weight（Normal: 0.5）

η：Elevator comprehensive efficiency

・Winch without cogwheel decelerator : 0.7~0.75

・Winch with warm cogwheel decelerator : 0.5~0.6

Item	Control type	Roughly calculation expression
Middle- and low-speed	AC return control (Microcomputer type)	W＝0.36 * N / 2000 * P * T
	Inverter control (none resurrection)	W＝0.18 * N / 2000 * P * T
High-speed	Ward Leonard Control	W＝(0.1 + 0.26 * N / 2000) * P * T
	Thyristor Leonard Control	W＝0.26 * N / 2000 * P * T
	Inverter control (with resurrection)	W＝0.24 * N / 2000 * P * T
W : Daily electricity consumption amount（kWh /day） N : Daily start number for ten hours P（kW）: Motor input（Calculating value according the above data） T : Running time of elevator per day (hr / day)		

Note1: "N/2,000" in the expression is a value that a little higher than the value calculated by dividing the results of ten hours standard elevator in one day.
Note2: The electric motor efficiency (output/input) has been considered into the roughly calculation.
Energy conservation of office building by equipment operation management（H8.3）
The Building Energy Manager's Association of Japan
Source: Building Energy Comprehensive Management Technique)The Building Energy Manager's Association of Japan 2000

4) Energy management of elevator

a) Microcomputer control

In the past, the operation control part in the elevator control board was composed of electromagnetic relay. But now, it is composed of microcomputer. By using the microcomputer control, not only improvement of the operation performance, machine efficiency and long lifetime for elevator, but also 5% electricity saving can be achieved.

b) Inverter control

By adopting the inverter control, the crystal of the power electronics, the electricity consumption can be decreased by 50% compared with the AC two step speed control as shown in Figure 3.4.8-2. Moreover, by using the inverter control, it can realize the

improvement of riding comfort and running time shortening as well as the improvement of arrival floor performance with the high effective control.

c) Automatic turning off of lighting
The lighting automatic turning off is a mechanism that lighting is automatically turned off after a fixed time with no user, and it is lightened again when new calling comes. This device can save energy on holiday, night and un-busy time on weekday when few users exist. However, the lifetime of bulb becomes shortened, it is not suitable to apply this device in the conditions where calling comes so frequently.

d) Promotion to use stairs
The sections with a lot of traffic in-between floors should be located on the neighboring floor, such as upper and lower floor, and use the stairs should be promoted as much as possible.

e) Group management for operation improvement
If the operation of the elevator is driven independently in a building where two or more elevator is installed, the operation loss happens easily by one user's pushing two or more hall buttons. Energy conservation by changing the independent management into group management, it can reduce operation loss and improve operation efficiency of elevators. In addition, the service can be improved, such as shortening waiting time, due to the reduction of the delay operation and operation loss.

(3) Escalator

1) Energy management of escalator

a) Addition of automatic operation device
In recently years, the automatic operation type is increasing quickly in urban traffic such as the railway station. The automatic operation type stops the operation with no passenger by detecting passenger’s boarding with photoelectric device.

Figure 3.4.8-3 shows the concept of the automatic operation of an escalator.

It is the method that eliminates empty operation with no passenger by using the photoelectric device or the infrared sensor to check the existence of a passenger. In the station where fluctuation of passengers is quite big, about 20%-30% energy conservation effect can be expected compared with a continuous operation.

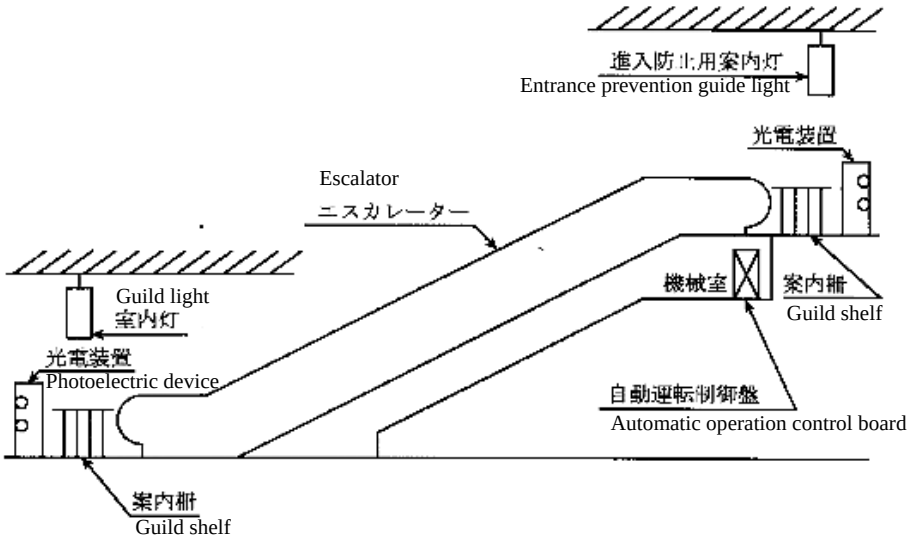


Figure 3.4.8-3 The Automatic Operation Control of Escalator

Source：(Energy conservation of office building by equipment operation management) The Building Energy Manager's Association of Japan

b) Addition of electricity saving operation device

In the department and shopping center, lots of escalators are installed to form smooth human flow. In these cases the automatic operation method is not suitable, because the human flow is psychologically obstructed due to intermittent operation. Therefore, an automatic Y-Δ switch electricity saving device is mainly introduced in the escalator to achieve the electricity saving. The electricity saving effect is less than that of the automatic operation method.

Automatic Y-Δ switch device is an electricity saving device that the stator winding, Y connection and the Δ connection, of the induction motor switching automatically according to the load. This device can achieve energy conservation by simply control that keeps continuous operation of escalator and does not need incidental equipment.

(4) Practical affairs of energy management for elevator and escalator

The energy consumption of the elevator is multifarious due to the various traffic demands of individual buildings and it is impossible to set a general reference value. Therefore, the energy reduction target is set based on the actual condition on operation and management of elevator in the building by analyzing the measurement or calculated energy consumption value. The key point on energy conservation of elevator is reducing the frequency of start and operation. The operation time can be shortened by the decrease of the frequency of start.

However, the service quality down should not be aware by passengers. For example, in the bank with multi elevators, the waiting time is extended because the enforcement of the partial operation, and then the business loss due to the extended waiting time is far exceeding energy conservation effect. It is necessary to pay attention on the adjustment with the operation management.