Energy Conservation Procedures and Energy Conservation Technologies

Energy Conservation Guidebook for Buildings 2021

The Energy Conservation Center, Japan

The Guidebook has been prepared by the Energy Conservation Center, Japan as a part of energy conservation support for the purpose of providing information so that small- and medium-sized businesses can address energy conservation autonomously.
It includes the energy conservation procedures, basic energy conservation measures and effect estimation, tuning method, and so on. Together with our other energy conservation support measures, we hope you will make use of the Guidebook to improve your energy efficiency.

Contents

I Significance and Procedures of Energy Conservation

1. First-step Energy Conservation Activities for Carbon Neutrality

Of energy environmental issues, the most crucial one will be to realize "carbon neutrality" toward 2050. To this end, it is imperative to switch fossil fuels accounting for the most of current energy supply/demand to carbon-free energy such as renewable energy, while moving forward with thorough energy conservation.
The first-step energy conservation activities for "carbon neutrality" have the following advantages.

Social viewpoint

· Fundamental measure for carbon neutrality

Toward "carbon neutrality" intended for zero emission of greenhouse gas totally by 2050, energy conservation as well as introduction of renewable energy is a fundamental measure for low carbonization and decarbonization.

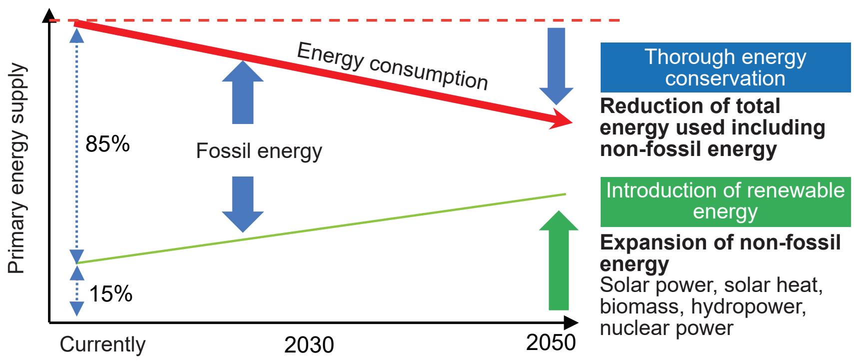
Economic viewpoint

· Cost reduction

"Profits" can be secured by the costs saved by energy conservation. This effect is similar to a sales increase. Once an energy conservation measure is taken, its effect continues for years.

· Compatibility with service improvement

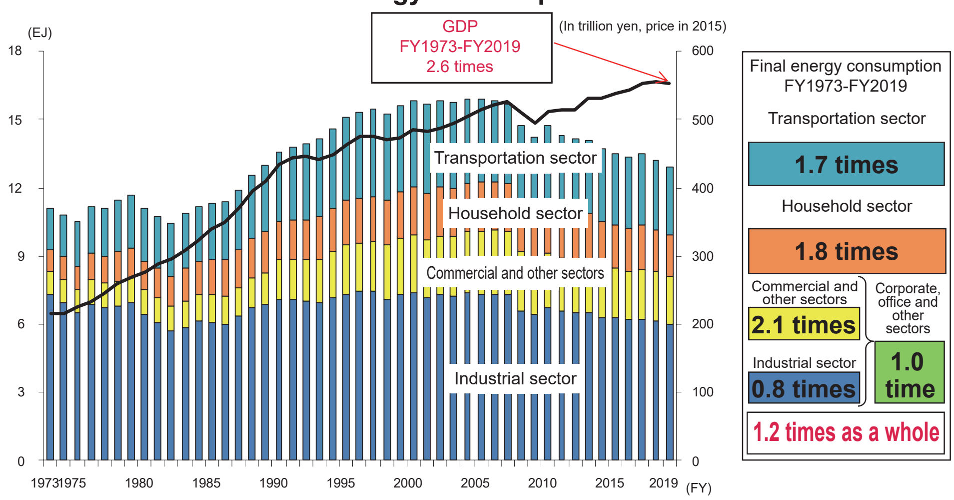
Energy conservation and CO_2 reduction are made compatible with service improvement by reviewing the service methods from a viewpoint of energy conservation.



[Reference]
Energy Consumption Trend in Japan

Compared with the first oil crises in 1973, total energy consumption has been restrained to approximately 1.2 times with respect to the growth of the GDP, approximately 2.6 times; the industrial sector has decreased its ratio (0.8 times) and commercial (2.1 times), household (1.8 times) and transportation (1.7 times) sectors have increased their ratios.

Transition of Final Energy Consumption and Actual GDP



Source: "Energy White Paper 2021" (Fig. [No. 211-1-1]), Ministry of Economy, Trade and Industry

2. Energy Conservation Procedure

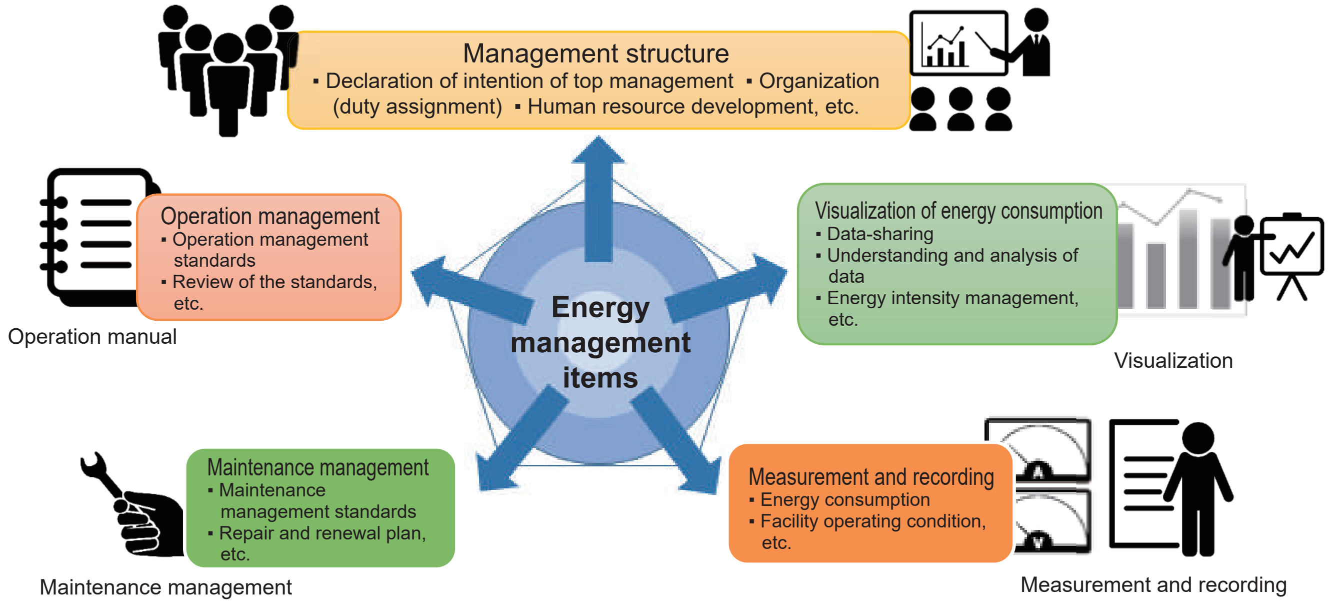
(1) Energy conservation technologies

Energy conservation technologies are intended to enhance energy usage efficiency and widely available for improvement of usage and energy management methods as well as higher equipment efficiency. Main items are shown in Section 3 "Energy Conservation Check List".

"Energy optimized audit" provided by the Energy Conservation Center, Japan and presented in Section 4 is optimal to the business operators who are going to address energy conservation.

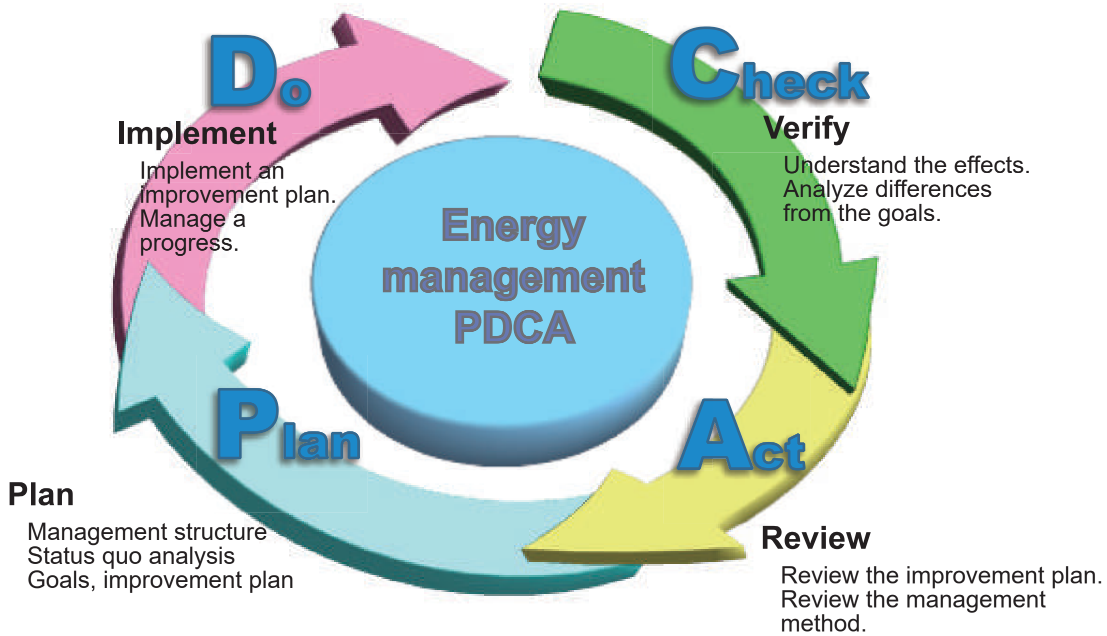
(2) Energy management

Energy conservation requires implementation of steady energy management. Enhance a management structure, visualize energy consumption and improve operation and maintenance of facilities, equipment, etc.



(3) PDCA

It is important to continuously upgrade energy management efforts through a PDCA cycle.



3. Energy Conservation Check List for Buildings

As the first step of energy conservation efforts, begin with [I] What can be implemented in daily operations, etc. As the next step, proceed from [II] Self-practicable efforts based on an expert's advice to [III] Efforts requiring capital investment.

[Legend] I. Efforts practicable in daily operations (almost no technological hurdle)
II. Self-practicable efforts (requiring technological knowledge such as short-term measurement, etc.) based on an expert's advice
III. Efforts requiring capital investment

Classification		I	II	III	Check item
[1] General management items	1. Energy management organization	○			Do you have a system capable of continuing energy conservation activities (energy conservation committee, etc.)? [Case A-2] [Case A-3]
		○			Do you implement PDCA for energy conservation activities on the premise of participation of the management?
		○			Do you decide a responsible person or a leader who promotes energy conservation?
		○			Do you set energy conservation goals (reduction of XX%, reduction of XX tons, etc.)?
		○			Do you post the energy consumption status so that employees can understand? [Case A-2]
		○			Do you set a policy and implementation plan for energy conservation measures? [Case A-3]
		○			Do you educate the personnel and conduct an energy conservation awareness campaign?
		○			Do you observe Cool Biz*1 and Warm Biz*2?
		○			Do you secure a time and a budget for addressing energy conservation? [Case A-3]
	2. Measurement, recording and maintenance	○			Do you manage documents such as an equipment ledger and drawings?
		○			Do you identify the energy conservation equipment to be concentratedly managed? [Case A-1]
		○			Do you have the operation records (daily reports monthly reports, etc.) of main facilities?
		○			Do you decide the management values for checking the operating status and their ranges? [Case A-3]
		○			Do you conduct daily inspection and maintenance of the facilities?
		○			Do you have the Energy Management Manuals of main facilities (air conditioning, ventilation, lighting, production facilities, etc.)?
		○			Do you periodically calibrate the measuring instruments?
		○			Do you periodically clean and replace the filters, strainers, etc.?
			○		Do you periodically repair the piping, etc. and check for a leakage (water, steam, compressed air, etc.)?
	3. Energy management	○			Do you aggregate (graph, etc.) and visualize monthly and annual energy consumptions?
			○		Do you measure and record energy consumption by type and usage purpose to always monitor (visualize)?
			○		Do you measure hourly power consumption to manage peak power?
			○		Do you analyze the energy consumption status in view of the outside temperature, etc.?
	4. Energy intensity, etc. management	○			Do you calculate the unit prices of energy common to business establishments (e.g.: yen/kWh, yen/liter, yen/m^3)?
		○			Do you manage the energy intensity ("energy consumption/total floor area", "energy cost/total floor area", etc.)?
			○		Do you manage the energy intensity and cost by department?
[2] Heat source and heat transfer facilities	1. Energy conservation of heat source facilities	○			[Chiller/Water heater/chiller] Do you stop the equipment "at the office closing time" in compliance with the operation rules?
			○		[Chiller/Water heater/chiller] Do you stop the heat source one hour before ending heating/cooling and operate only the transfer equipment?
			○		[Chiller/Water heater/chiller] Do you relax the cold water outlet temperature when a cooling load is low? [Case B-1]
			○		[Chiller/Water heater/chiller] Do you adjust the cooling water inlet temperature to an appropriate value? [Case B-3]
				○	[Chiller/Water heater/chiller] Do you cover cold heat demand in the interim and winter periods by producing cold water in a cooling tower?
				○	[Chiller/Water heater/chiller] Do you consider renewal to the high-efficiency heat source facilities?
				○	[Chiller/Water heater/chiller] Do you introduce a heat storage system (nighttime heat storage) when an air conditioning load is high in summer?
		○			[Steam boiler] Do you make efforts to ensure an adequate blow rate such as managing the water quality?
			○		[Steam boiler] Can you lower a steam pressure setting value?
				○	[Steam boiler] Do you implement manual adjustment/automatic control to ensure that an efficient number of units are running?
				○	[Steam boiler] When a load fluctuates greatly, do you introduce an accumulator and a hot water storage tank?
				○	[Steam boiler] Do you consider introduction of the higher-efficiency boilers?
		○			[Combustion equipment] Do you check whether an air ratio is adequate, based on oxygen concentration in an exhaust gas? [Case B-5]
			○		[Combustion equipment] Do you carry out maintenance and inspection of the burners (cleaning, replacement of worn parts)?
				○	[Combustion equipment] Do you consider optimizing a burner capacity according to a changed load capacity, etc.?

*1 Cool Biz: Japanese government campaign encouraging the people to wear lighter clothes and the companies to set their air conditioners to 28°C
*2 Warm Biz: Japanese government campaign encouraging the companies to set their heater thermostats to 20°C during the winter

Classification		I	II	III	Check item
[2] Heat source and heat transfer facilities	2. Energy conservation of heat transfer facilities	○			[Pump] Do you stop the pump "at the office closing time" in compliance with the operation rules?
		○			[Pump] Do you cut down on an excessive flow rate (margin ratio) by adjusting a valve and an impeller?
			○		[Pump] Do you lower a flow rate on weekdays and holidays, and during nighttime with an inverter, etc.?
				○	[Pump] Do you adjust a flow rate by using the inverter, controlling the number of running units and using the sensors? [Case B-2] [Case B-4]
				○	[Pump] Do you improve a route and seal the piping?
		○			[Fan] Do you stop the fan "at the office closing time" in compliance with the operation rules?
		○			[Fan] Do you cut down on an excessive airflow rate (margin ratio) by adjusting a damper?
			○		[Fan] Do you adjust an airflow rate on weekdays and holidays, and during nighttime with an inverter, etc.?
				○	[Fan] Do you adjust an airflow rate by a combination of the inverter and sensors?
				○	[Fan] Do you improve a route and seal the ducts?
	3. Prevention of heat losses and heat recovery	○			[Piping system, load facilities] Do you check for a steam leak, etc. and take a measure?
		○			[Piping system, load facilities] Do you check the heat retaining material for peeling, wetting, etc. and repair or newly coat it?
			○		[Piping system, load facilities] Do you inspect and replace a steam trap regularly?
			○		Do you change an outside air inlet rate according to the season?
				○	Do you periodically manage the exhaust gas temperature and take a measure when it is high?
				○	Do you recover the steam drain and the heat from the exhaust gas?
	4. Cleaning and installation environment	○			Do you periodically clean the fins of the outside units?
			○		Do you periodically clean the heat exchanger and the heat transfer surface and remove scales?
				○	Are there no objects blocking ventilation of the outside units?
[3] Air conditioning and ventilation facilities	1. Operation management of air conditioning	○			Do you properly manage the room temperature and humidity according to the season?
		○			Do you set weekly and annual rules and observe the scheduled operation (prevention of forgetting to turn off the switch)?
		○			Do you stop air conditioning in an unused area (including a stop of air conditioning after a meeting)?
		○			Do you ensure that air conditioning starts just before the office opening time (e.g. 15 min. before opening the office)?
		○			Do you manage air conditioning during overtime hours?
			○		When cooling is required during an intermediate period or winter, do you utilize cooling with the outside air?
			○		Is an outside air inlet rate adequate (example of the management standard: Indoor CO_2 concentration = 800 to 950 ppm)?
			○		[At warming up before daily operation] Do you stop an intake of the outside air? [Case C-1]
			○		[At warming up before daily operation] Can you shorten an operating time?
				○	Do you shut off an entry of the outside air from an opening such as a door, which is left open all the time?
				○	Do you quantitatively understand the irregularity of indoor temperature distribution?
	2. Improvement of air conditioning efficiency	○			Do you shield the outdoor units from the sunshine and sprinkle water to them in summer?
		○			Do you restrain an entry/leak of the heat from a window during daytime and in the early morning by utilizing a window blind?
		○			Do you periodically clean the filters?
			○		Do you attach light-shielding films to the window glasses, and plant by the windows? [Case C-2]
			○		Do you allow the low-temperature outside air into the room at night in summer (nighttime purge)?
			○		Do you prevent mixture of heating and cooling in an identical room?
				○	Is it possible to reduce an air-conditioned area (partitions, lining of the high ceiling, etc.)?
				○	When there are not many people in a spacious air-conditioned area, do you use a spot cooler?
				○	Do you employ the walls and ceilings, etc. with high insulation?
				○	Are the window glasses properly heat-insulated (double glass, etc.) and airtight?
				○	Do you prevent an entry of draft into the air-conditioned area?
				○	Do you upgrade to the higher-efficiency air conditioners?
	3. Management and efficiency improvement of the ventilation facilities	○			Do you stop ventilation of an unused area or when not used?
			○		Do you introduce and utilize the total heat exchanger? [Case C-3]
			○		Do you adjust a ventilation rate by an optimized ventilation frequency, intermittent operation, etc.?
			○		For ventilation fans in the electric room, machine room, etc., do you implement room temperature control operation?
				○	Do you locally exhaust for the heat generation equipment?

	Classification	I	II	III	Check item
[3] Air conditioning and ventilation facilities	3. Management and efficiency improvement of the ventilation facilities			○	Do you control an outside air inlet rate with a CO_2 sensor, etc.? [Case C-4]
				○	Do you change ventilation rate control from a damper system to an inverter system?
				○	As a measure to prevent an excessive ventilation rate in a parking lot, do you implement intermittent operation or ventilation rate control based on the CO and CO_2 concentrations? [Case C-5]
[4] Freezing/refrigeration facilities	1. Freezers and refrigerators	○			Do you set adequate setting temperature rules for the goods and cargos in the freezers and refrigerators to manage them?
		○			Can you reduce a door opening/closing frequency, door opening time and take-in/-out frequency?
		○			Do you secure a cold air flow in the freezers and refrigerators (overloaded or not)?
			○		Can you reduce frequency of defrosting according the season?
				○	Do you install an air curtain, etc. to the door to reduce an entry of the outside air?
				○	Do you reduce heat generation of facility internal lighting (e.g. introduction of LEDs)?
				○	Are there any frozen parts due to heat insulation failure in heat insulation treatment of the wall surface or door?
				○	Do you introduce the higher-efficiency freezers and refrigerators?
	2. Showcases	○			Do you close a nighttime cover at night?
			○		Can you reduce frequency of defrosting according the season?
				○	Do you install an air curtain?
				○	Do you upgrade to the higher-efficiency showcases?
[5] Water heating and water supply/drain systems	1. Water heating system	○			Is the hot water tank temperature adequate?
		○			Do you stop the water heating system and a circulation pump during nighttime and on holidays?
		○			Do you stop feeding hot water during other than the winter (for washing hands, etc.)?
			○		Do you periodically remove inner scales from a water heater?
				○	Do you utilize the waste heat of the combustion exhaust gas (preheat of the combustion air, feedwater, etc.)?
				○	When heating less water, can you change from a centralized water heating system to an individual water heating system?
				○	Do you employ a higher-efficiency water heater (latent heat recovery type water heater, EcoCute, etc.)?
	2. Water supply/drain system	○			Do you install a water-saving device (water-saving packing, water-saving shower head, etc.) in a bathroom, kitchen, hand-washing sink, etc.?
			○		Are the feed water flow rate and pressure adequate?
				○	Do you recycle drainage (toilet flushing, water sprinkling, floor cleaning, car washing, etc. after drainage treatment)?
[6] Lighting, power receiving and transforming facilities, electric facilities	1. Management and energy conservation of the lighting facilities	○			Do you decide and manage a luminosity standard for each room?
		○			Do you turn off the lights by the windows (utilization of daylight)?
		○			Do you turn off the lights when they are unnecessary such as in an empty room and during a lunch break?
		○			Do you adjust the lighting time and number of outdoor lights according to daylight hours?
		○			Do you clean the lighting apparatuses and replace the old lamps?
			○		Do you use a motion detector to turn on/off the lighting in toilets, warehouses, etc.?
			○		Are the lighting fixtures properly positioned (height and layout) with respect to required luminosity?
				○	Do you subdivide a lighting circuit to turn off the lights in an empty area, etc.?
				○	Do you dim or turn off the lights with automatic dimmer control?
				○	Do you replace with LED lighting? [Case D-1] [Case D-2] [Case D-3]
				○	Have you considered task ambient lighting? (All-room lighting → Overall + Hand lighting) [Case D-3]
	2. Management and energy conservation of the power receiving and transforming facilities	○			Do you manage power consumption for each department (monthly and daily) (understanding of the actual situation, graph, etc.)?
			○		Do you use a demand monitoring device to reduce contract demand? [Case E-2]
			○		Is the power-receiving end of the electric equipment at the rated voltage (necessary to adjust the voltage when too high or low)?
			○		Is a power factor adequate (e.g. a measure is necessary if it is less than 95%)?
				○	When load fluctuations are great (low nighttime power, etc.), do you install an automatic power factor regulator?
		○			[Transformer] Do you shut off the primary-side power of an unnecessary transformer?
			○		[Transformer] When a load factor has a margin, do you integrate the transformers or optimize the transformer capacity? [Case E-1]
			○		[Transformer] Do you strike a load balance among three phases?
			○		[Transformer] Do you examine the load factor to level the load (load control)?
				○	[Transformer] Do you upgrade to the higher-efficiency transformers? [Case E-1]

Classification		I	II	III	Check item
[6] Lighting, power receiving and transforming facilities, electric facilities	3. Energy conservation of the automatic vending machines	○			Do you turn off the backlight?
		○			Do you stop operation on holidays and during nighttime (timer function)?
				○	Do you request a supplier to upgrade to an energy-saving type (heat pump type, etc.)?
	4. Management of the OA equipment	○			Do you turn off the power when unnecessary (holidays, etc.)? [Except for fax machines]
			○		Do you set to the energy-saving mode (nighttime/holidays)?
				○	Do you replace with a power-saving type?
[7] Elevators, etc.	1. Management of the elevators	○			During a lower-use period on holidays, at night and on weekdays, do you operate fewer units?
			○		Do you stop them less frequently at the floors with lower use frequency?
	2. Management of the escalators	○			Do you operate fewer units on holidays and at night?
				○	Are they automatically operated with a motion detector?
[8] Optimized energy utilization	1. Load leveling		○		Have you reviewed an operation form (working hours, operation rate, load factor, etc.)?
			○		Have you considered lowering demand response and raising demand response in view of your own daily power load curve?
				○	Have you considered introduction of a heat storage unit?
				○	Have you considered introduction of an absorption type water heater/chiller?
				○	Have you considered introduction of storage batteries (lithium-ion batteries, NAS batteries, etc.)?
	2. Cogeneration		○		Do you improve the operation after checking an operating condition (dependency rate, power generation efficiency, exhaust heat utilization rate, overall efficiency, etc.)?
				○	Have you considered introduction of a cogeneration system? [Case E-3]
	3. Renewable energy	○			Have you considered purchasing various menus of renewable energy electricity?
		○			Have you considered purchasing a certification of renewable energy electric power?
			○		Have you considered introduction of wood-burning stoves and pellet-burning stoves?
				○	Have you considered introduction of solar power generation? [Case G-1]
				○	Have you considered introduction of a solar water-heating system?
				○	Have you considered introduction of earth thermal/underground water heat pump air conditioning?
				○	Have you considered switching to heat supply by a heat pump?
	4. Utilization of unused heat		○		Have you considered utilization of the waste heat from the building (electrical room) for heating and hot water supply?
				○	Have you considered utilization of the low-temperature waste heat, using a heat pump or a binary power generator?

4. Utilization of Energy Audit

"Energy optimized audit" conducted by ECCJ is a project by the Agency of Natural Resources and Energy, "Subsidies for Promotion of Optimized Energy Utilization for Small- and Medium-sized Enterprises in FY2021".
Energy conservation is the most effective means for decarbonization. Moving one step further forward, "energy optimized audit" is a new service intended to accelerate decarbonization by adding "renewable energy proposals" to reduction of energy consumption by "energy audit".

(1) Flow of the audit

- Apply for an audit menu suitable to the usage of electricity and fuels of the factory, building, etc. to be audited.
- After confirming payment of an audit expense, our visit schedule will be coordinated to dispatch experts.
- At site, we will check the actual operating status and management status of the facility to prepare an audit report.
- We will explain the audit results at a briefing and give advice for implementation of proposals.

Application and payment → (After about 2 weeks) On-site audit → (About 1 month after audit) Submission of report → Audit results briefing

Audit menu

Audit A	Menu to be audited by one expert	¥9,500 (tax excluded) *1 **¥10,450 (tax included)**
Audit B *2	Menu to be audited by two experts (briefing held by one expert)	¥15,000 (tax excluded) *1 **¥16,500 (tax included)**

*1 A bank transfer fee for the audit expense shall be borne by an applicant.
*2 Business establishment having a lot of equipment using the heat such as boilers and large air conditioners, or relatively large-scale business establishment

(2) Business operators eligible for the audit

Those meeting one of the following conditions

- Small- and medium-sized enterprises (those stipulated by the Small and Medium-Sized Enterprise Basic Act)
  Those falling under *1 are excluded.
  (The small- and medium-sized enterprises falling under the conditions in *1 are also acceptable if they meet the following conditions.)
- Factories, buildings, etc. with annual energy consumption (crude oil equivalent) of 100 kl to less than 1,500 kl in principle
  (Even if less than 100 kl, acceptable in case of receiving low-voltage power, high-voltage power or extra high-voltage power)

*1 ① Small- and medium-sized business operators whose stocks are directly or indirectly possessed 100% by a corporate body with a capital or investment of ¥500,000,000 or more
② Small- and medium-sized business operators whose annual average taxable income of each year or each fiscal year of the most recent past 3 years exceeds ¥1,500,000,000

■Application form

Select "Energy Optimized Audit" at the Energy Conservation and Power-saving portal site (https://www.shindan-net.jp), followed by "Factory" or "Building". Particularly, in the case of a small-scale building, select and download an application form for "Simplified Version for Buildings" and send it by e-mail, fax or postal mail to apply.

■Address (Contact information)

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Energy optimized audit
Free dispatch of lecturer
Download each application form from here

Energy Conservation and Power-saving Portal Site
shindan-net.jp
https://www.shindan-net.jp/

* Download the application form at the website, fill in with necessary information and send it to each secretariat by e-mail or fax to apply.

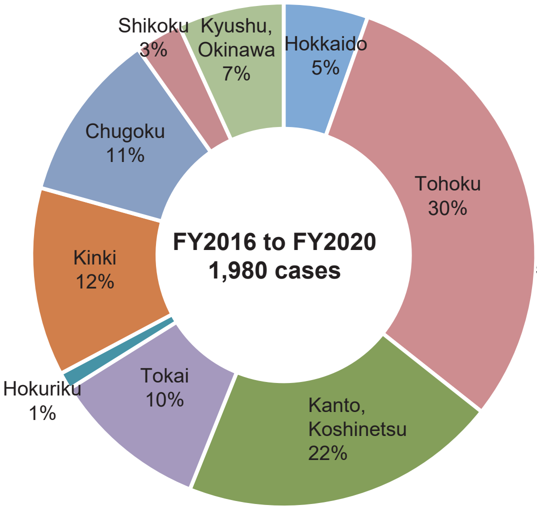
Energy audit | Search

II Energy Audit of Buildings and Results

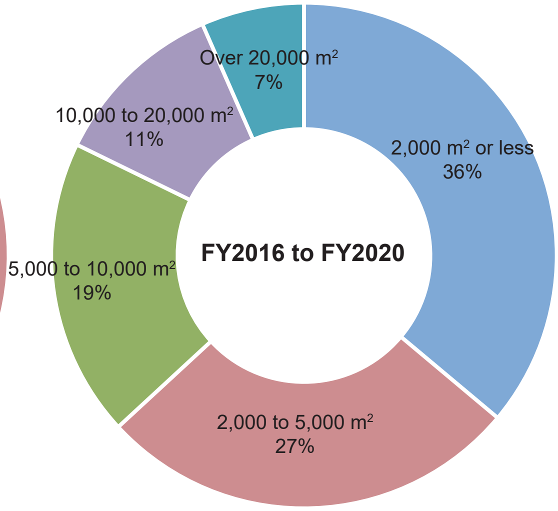
The following outlines the energy audits of buildings (commercial facilities) implemented by the Energy Conservation Center, Japan. Utilize them as reference data for management of the energy consumption and energy intensity, and consideration of improvement proposals.

1. Outline of Audited Buildings

The left figure below shows the ratio of energy audits of buildings (FY2016 to FY2020) by region. The right figure below classifies the scale of audited buildings by total floor area.

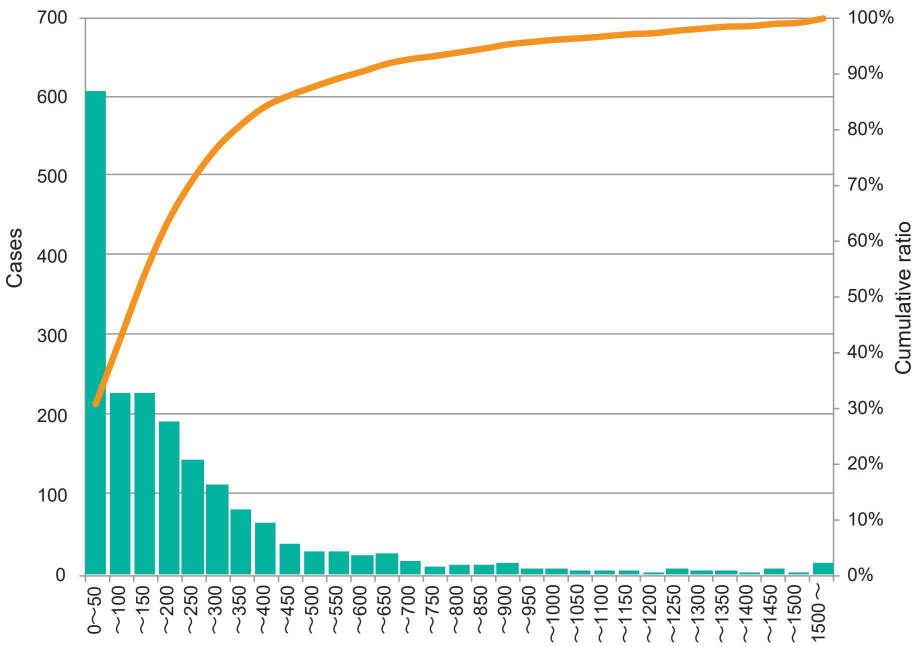


Ratio of audits by region



Ratio of audits by scale

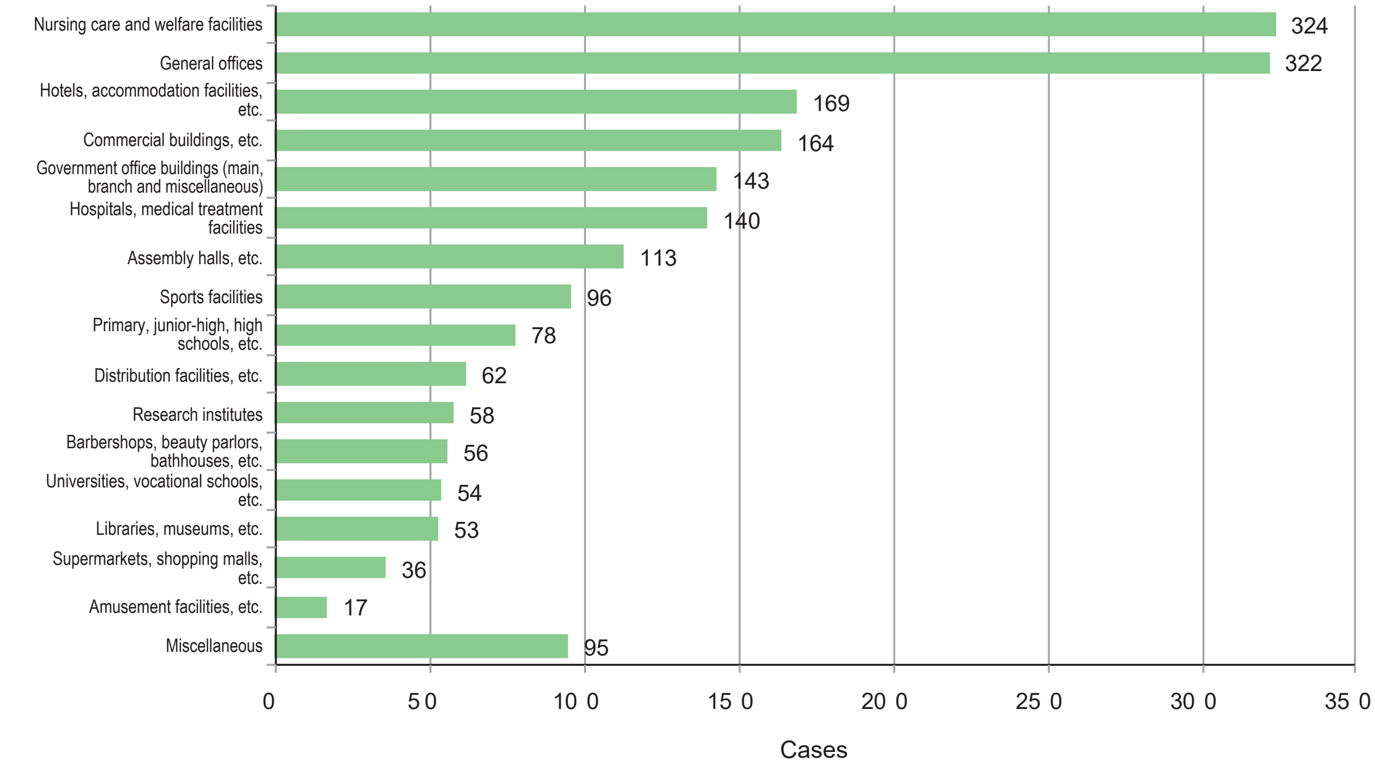
The following shows the distribution of annual energy consumption (crude oil equivalent value) of the audited buildings (FY2016 to FY2020). The number of cases of less than 50 kl is the highest.



Energy consumption in crude oil equivalent (kl/year)

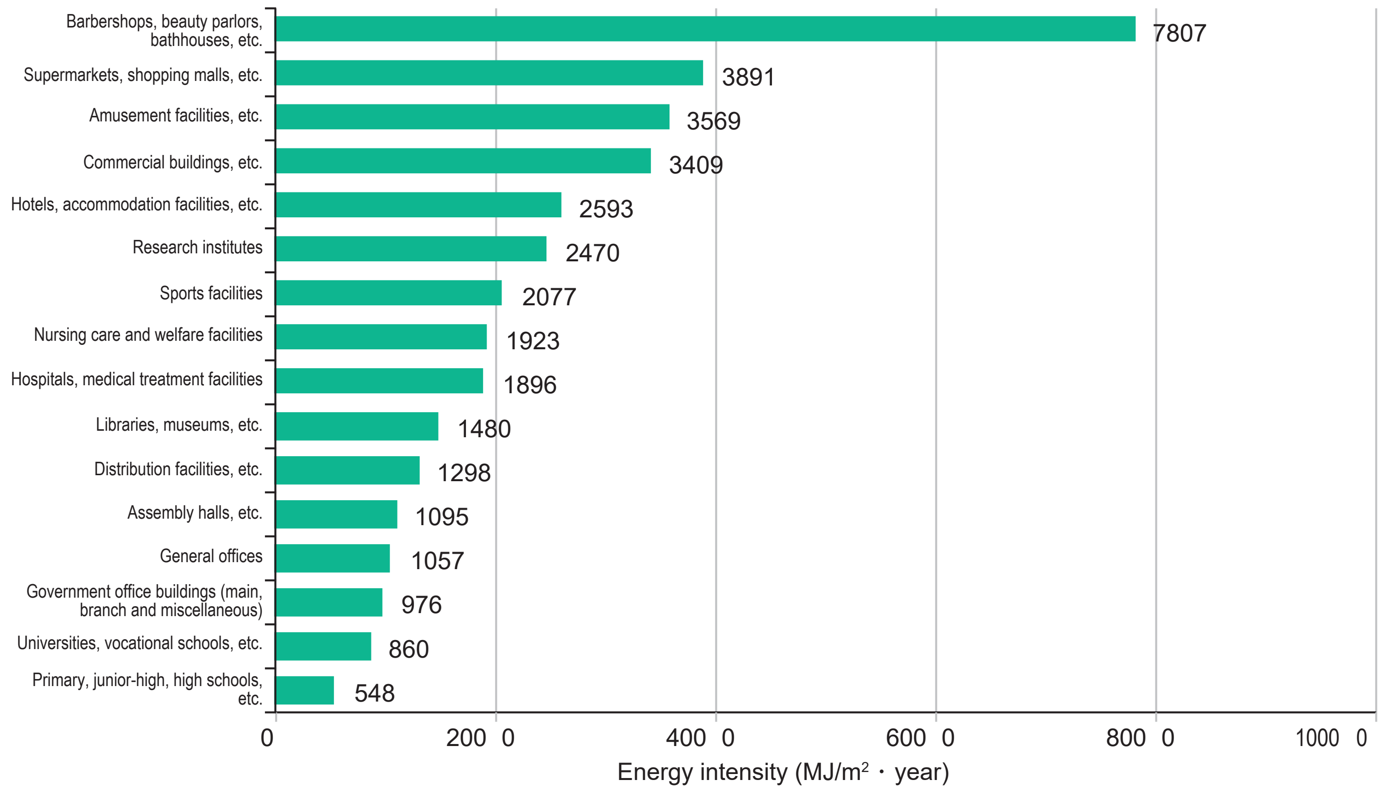
2. Number of Audit Cases by Type of Industry and Intended Use of Building

The following shows the number of energy audit cases of buildings by intended use in FY2016 to FY2020.



3. Energy Intensity by Type of Industry and Intended Use of Building

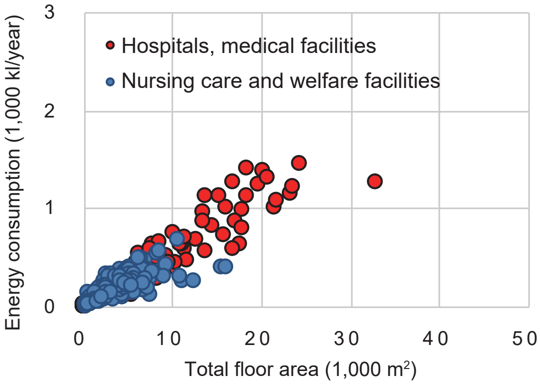
The energy intensity is an important index for evaluating the energy management status. This is indicated by energy consumption per total floor area in the following. Refer to the following values when evaluating the energy intensity.



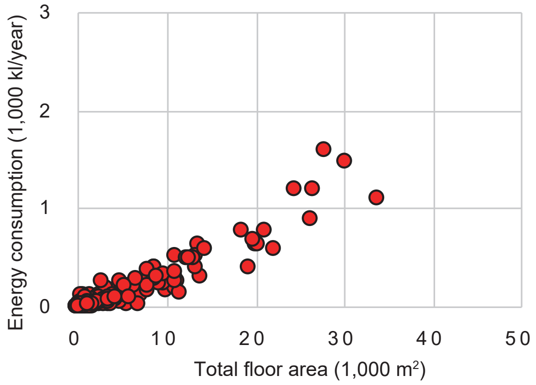
4. Energy Consumption by Type of Industry and Intended Use of Building

The following shows the energy consumption of the audited buildings in FY2016 to FY2020 in the form of the scatter diagram based on the total floor area. Refer to it when comparing with other facilities.

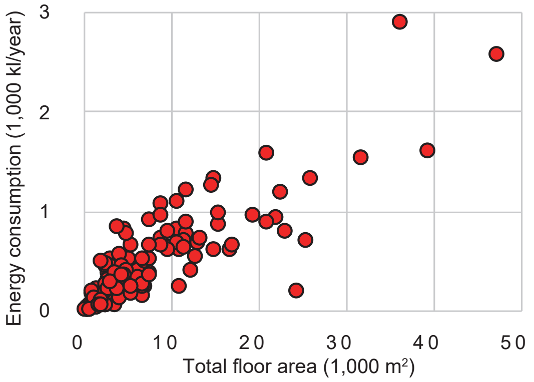
■Nursing care and welfare facilities, hospitals, medical treatment facilities



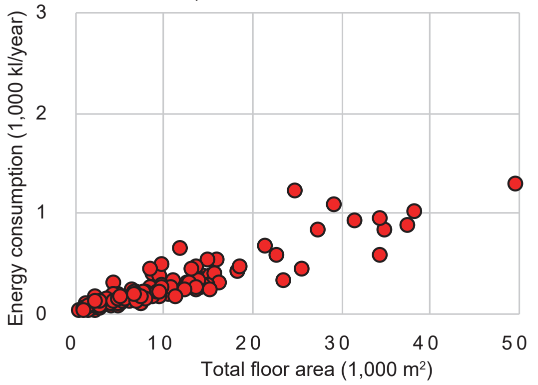
■General offices



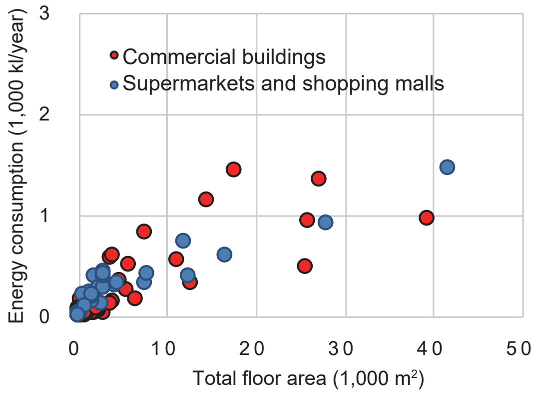
■Hotels, accommodation facilities, etc.



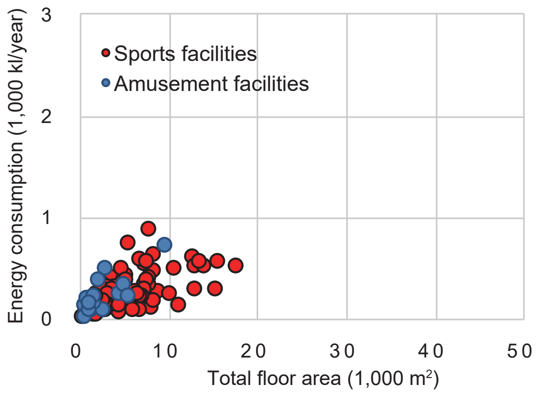
■Government office buildings (main, branch and miscellaneous)



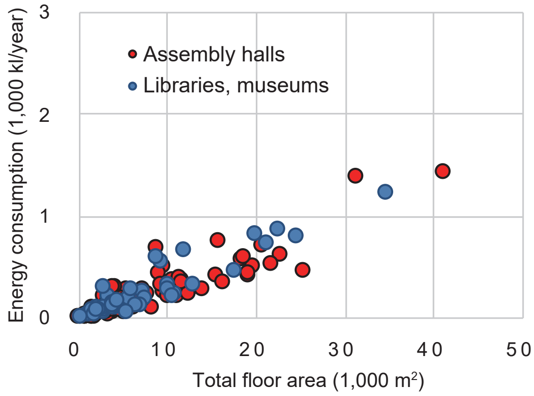
■Commercial buildings, etc.



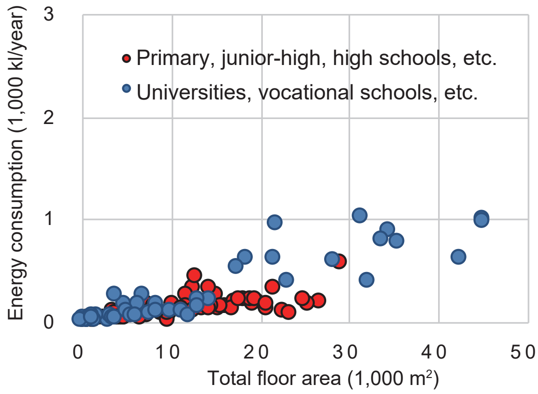
■Sports and amusement facilities



■Assembly halls, etc.



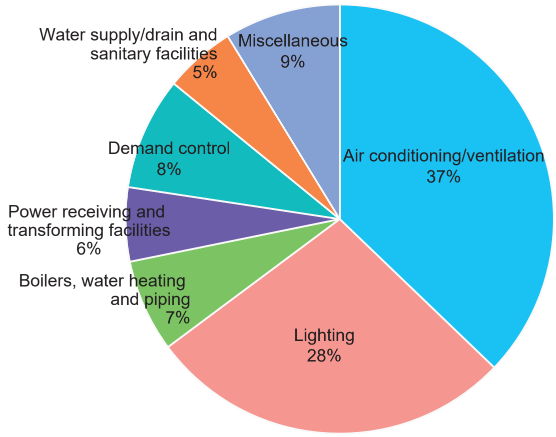
■Schools



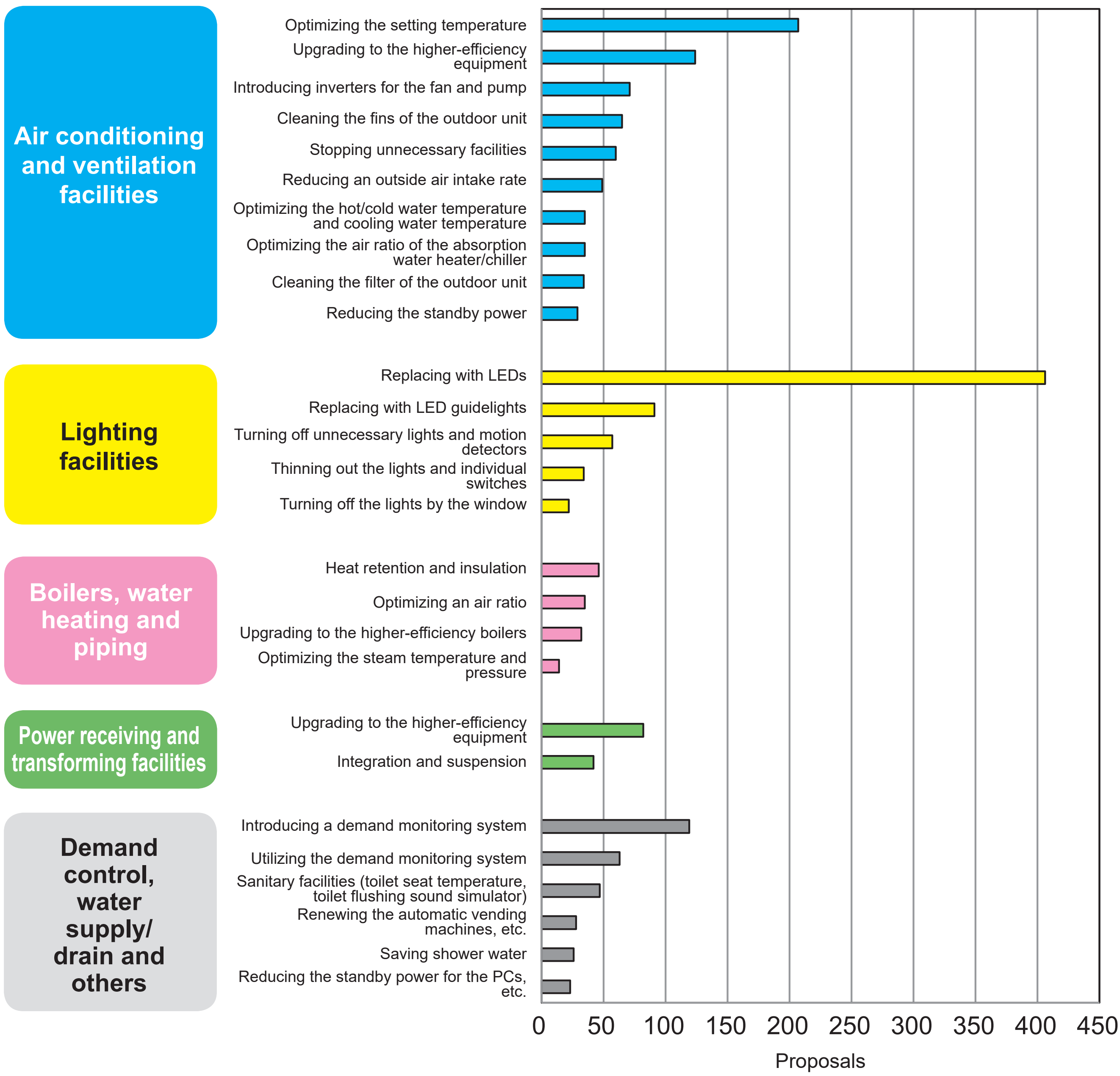
5. Improvement Proposal Items by Audit

After investigating the status quo of the building, the energy audit presents an improvement proposal.
The right pie chart shows the ratio of the recent improvement proposals for each facility. There are many proposals for the air conditioning and lighting facilities, basically reflecting the ratio of energy consumption of the buildings.

The following figure itemizes the proposals for each classification of target facility.
For the air conditioning/ventilation facilities, optimization of the setting temperature is proposed much more than the others. For lighting, renewal to LEDs is proposed very much.



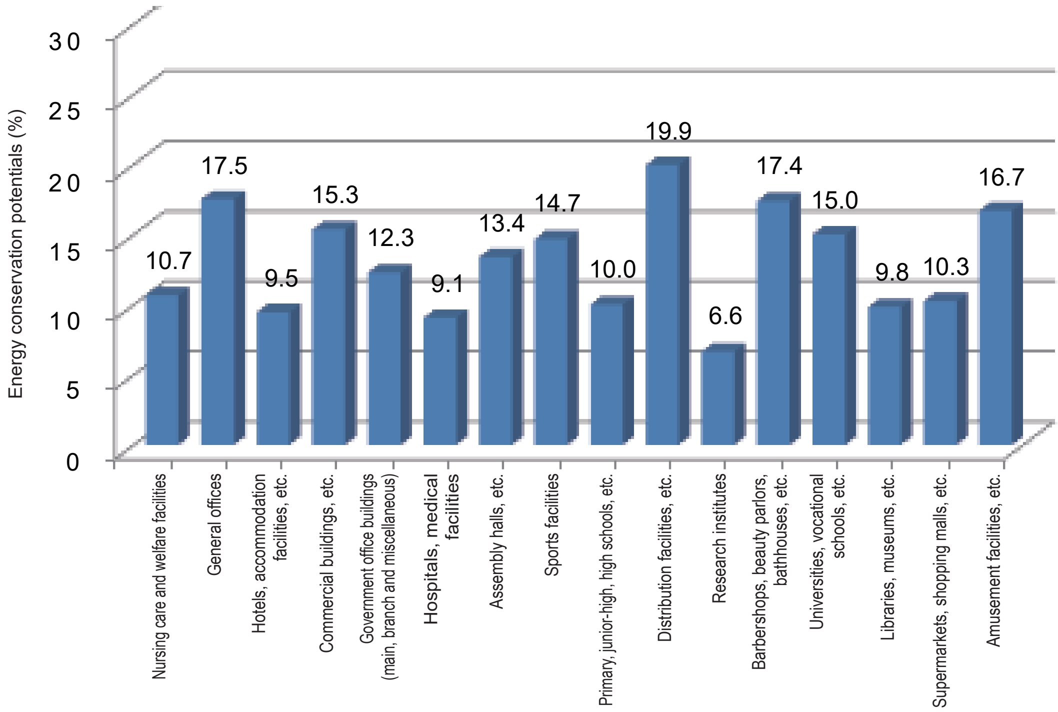
Improvement proposals by energy audits of buildings



6. Energy Conservation Potentials by Type of Industry and Intended Use of Building

The following compiles the energy conservation rate of the improvement proposals based on the energy audits for each industry type and intended use. This energy conservation rate is a ratio of proposed energy conservation to energy consumption of the audited facilities. This indicates an energy conservation potential for that facility. Refer to it when addressing energy conservation activities.

Energy conservation potentials by intended use (%)



7. Presentation Meeting of Energy Audits and Technologies

The "Presentation Meeting of Energy Audits and Technologies" has been held throughout the country since FY2014 for the purpose of providing energy conservation technologies and information for small- and medium-sized businesses across Japan.
It provides the information on the successful energy conservation cases with an energy audit as an opportunity, latest energy conservation technologies, viewpoints of energy conservation promotion and specific implementation methods. The meeting is planned online in FY2021. For the dates and details of presentation, see the Energy Conservation and Power-saving portal site "shindan-net.jp".

Appearance of the meeting in FY2019

Held online in FY2020 (video streaming)

8. Utilization of Energy Conservation and Power-saving Portal Site

Useful information is provided for promoting energy conservation and power-saving, such as introduction of audit cases and video-based tuning methods in addition to introduction of detailed energy conservation support services and application methods. Also, a self-audit tool allows you to compare the energy intensity with the same kind of facilities.

Energy conservation support service

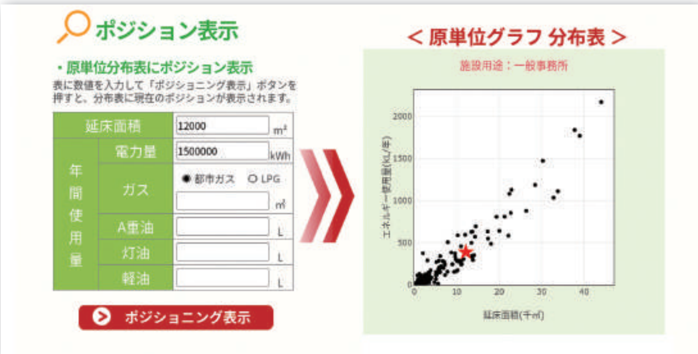
Different services are presented such as the energy optimized audit and free dispatch of lecturer. Apply for them from here.

Introduction of the energy audit cases

Based on the energy audit cases, many successful cases are presented as to the viewpoints and specific practicable methods of energy conservation promotion, company-wide energy management, approaches to energy conservation, etc. The cases can be searched for each major type of industry, facility, energy conservation technology, etc.

Energy audit tool for buildings

By inputting the information of your own facility, you can see the position of energy intensity and major energy conservation measures for the buildings of the same kind of application.



Energy conservation animation channel

Auditing and a typical energy conservation tuning method are presented in videos for easy understanding.

Energy optimized audit
Free dispatch of lecturer
Download each application form from here

Energy Conservation and Power-saving Portal Site

shindan-net.jp

https://www.shindan-net.jp/

* Download the application form at the website, fill in with necessary information and send it to each secretariat by e-mail or fax to apply.

Energy audit | Search

III Energy Conservation Improvement Proposals

The following describes the typical energy conservation improvement cases and helpful energy conservation activity cases in the energy audits provided by the Energy Conservation Center, Japan (the information has been changed for the public).

A. Energy Conservation Activities, Management Structure, etc.

Case A-1: Practice of "Positive Energy Conservation" with Full Participation of the Employees and Operational Improvement of Air Conditioning by Utilization of IoT

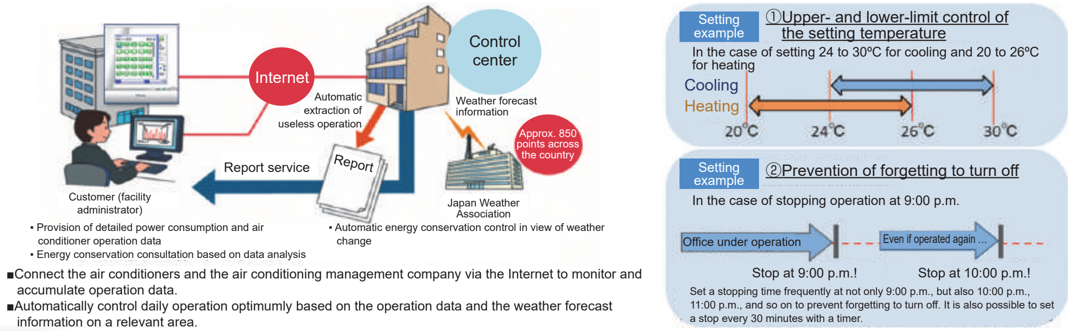
1. Background to approaching the activities

Since the facilities prioritize comfort of users, energy conservation activities had not been promoted because of different anxieties such as "We have awareness of energy conservation, but we are too busy to spare time", "There is no full-time administrator", "How we can manage to strike a balance between comfort and energy conservation?" and "How we can continue to greatly save energy in operation and management of air conditioners". With the opportunity of having known the IoT-based energy conservation measures for air conditioning, however, they addressed those activities.

2. Improvement measure

Measure	Implementation items and effects
General management items Implemented by facility personnel	Business was conducted in casual wear (Cool Biz) with cooperation of the users in extremely hot summer to manage the setting temperature goal of the air conditioners. When casual wear was not enough, the setting temperature was changed to cope with the situation.
	The air conditioners and floor heating are combinedly used in winter. Since floor heating consumes much electric power, however, a rule was made to increase the setting temperature of the air conditioners and reduce the use of floor heating with cooperation of the users when it is cold.
Energy conservation for air conditioning and ventilation facilities (employment of IoT)	The air conditioners which often failed or malfunctioned due to aging were put through maintenance work such as replacement of parts to restore normal performance.
	Because there were no full-time personnel for the air conditioners, a controller was added to automatically operate them.
	A management company employed IoT to visualize the operating status of the air conditioners of the facilities, thereby setting the temperature suitable for the facilities and automating the setting to cut down on useless operation. This allows immediate remote response to a sudden change of a facility operation schedule and utilization of weather forecast information to implement optimum automatic energy conservation operation for the day.

Visualization of the operating status connecting the air conditioners and the control center of the management company (overview of IoT)



3. Results

All employees addressed these energy conservation activities together to "work out usage so as to maintain minimum comfort". As a result, their awareness of energy conservation was heightened to produce different ideas of energy conservation. Electric power cost was reduced by optimized air conditioning, allowing the surplus to be allotted for maintaining and improving services. From now on, we would like to think about development to demand management.

Case A-2: Activation of the Energy Conservation Activities by the Audit

1. Background to approaching the activities

As a result of taking the energy audit as an opportunity and launching an Energy Conservation Promotion Committee to address, energy conservation has been greatly enhanced throughout the facilities, changing the employees' awareness of energy conservation.

2. Improvement measure

Measure	Implementation items and effects
Energy conservation promotion structure (Full-participation energy management structure)	Taking the energy audit as an opportunity, the Energy Conservation Promotion Committee was launched to enhance the facility employees' awareness of energy conservation. As a result of activities, tap water and power consumptions and their costs were actively posted to enlighten the personnel.

The following readily practicable measures were addressed first as the activities.

- Turn off unnecessary lighting by the window, etc. during daytime.
- Reduce an annual lighting time by thorough management of lighting time.
- Stop an electric toilet seat in a warm season.
- Adjust a water volume for adjustable water faucets.

3. Results

Awareness of energy conservation awakened by the energy audit has prevailed throughout the facilities. The wastes were numerically indicated to motivate the employees to do what they can do now. A change of awareness of energy conservation has an effect on the daily remainders to the employees (paying attention to the switches for lighting and air conditioning, and so on). The significance of energy conservation was realized in view of the numerical values of implemented energy conservation effects.

Case A-3: Energy Conservation Activities in View of the Facility Renewal Plan

1. Background to approaching the activities

This is a case of preparing a long-term (12 years) facility renewal plan to promote energy conservation in a planned way, addressing high-efficiency lighting and introduction of the demand monitoring equipment.

2. Improvement measure

Measure	Implementation items and effects
Management structure, goal setting and capital investment plan	The long-term facility renewal plan (12-year plan) has been prepared for major facilities. In line with the plan, they have been addressing the capital investment (higher-efficiency lighting, introduction of the demand monitoring equipment).
Energy Management Manuals for major facilities	For the practicable measures for workers such as stopping the AHU fans in the lobby during nighttime and thinning out the lights in the corridor, the rules have been prepared and the responsible personnel were appointed to implement.
	For boiler units control and optimization of the air ratio, the operation and management standards have been prepared to manage.
Management structure and assessment of energy conservation by the review meeting	On the bases of the usage of electricity, gas and tap water, energy conservation has been evaluated every other month as to how it reflected the impact of the climate, number of users and renewal of facility during the term. If an error is found, it has been verified and improved together with the personnel in each department and on-site personnel.

3. Results

A long-term plan will be prepared and implemented for energy conservation cases expected of large effects and associated with capital investment. It is planned to introduce the demand monitoring equipment, replace the fluorescent lamps with the LEDs, renew the evacuation guide lamps and introduce the absorption chillers.

B. Heat Source and Heat Transfer Facilities, etc.

Case B-1: Adjusting the Cold Water Outlet Temperature of the Gas Absorption Type Water Heater/Chiller

1. Current problem

In certain elderly welfare facilities (total floor area of 3,900 m^2), a water heater/chiller has its cold water outlet temperature set to 7°C during a cooling period without being changed.

2. Improvement measure

Alleviate the cold water outlet temperature within the range of not running short of an air conditioner's capacity in an intermediate period during which a cooling load drops, thereby lowering the energy consumption of a chiller. Raise the cold water outlet temperature from 7 to 9°C during the low-load period in May to June and October to reduce the fuel consumption of the gas absorption type water heater/chiller.

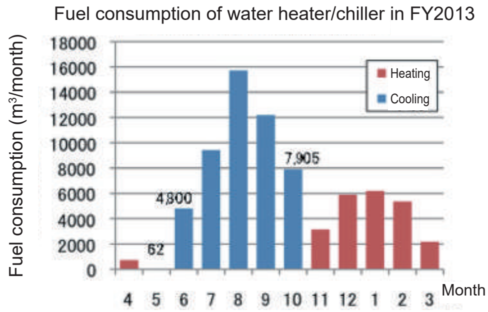


Fig. 1 Fuel consumption of water heater/chiller

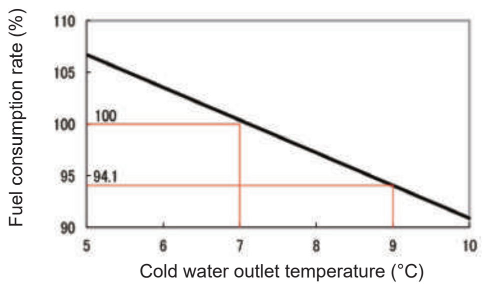


Fig. 2 Cold water outlet temperature and fuel consumption rate

3. Effect estimation

(1) Calculation formula

Fuel reduction: Current fuel consumption (m^3/year) x (Current fuel consumption rate (%) – Improved fuel consumption rate (%))

(2) Prerequisites for calculation

Fuel consumption in the intermediate period: 12,800 m^3/year, See Fig. 1 (62 m^3 (May) + 4,800 m^3 (Jun.) + 7,905 m^3 (Oct.) = 12,767 m^3)

Fuel consumption rate: See Fig. 2 (Currently 7°C, 100% → 9°C, 94.1% after improvement)

Fuel heating value: City gas 13A

4. Effects

①	Fuel consumption (current)	12,800	m^3/year	Fig. 1
②	Fuel consumption (improved)	12,040	m^3/year	
③	Reduced fuel consumption	760	m^3/year	
④	Energy conservation rate	5.9	%	③ / ①
⑤	Saved amount of money	78	¥1,000/year	③ x ¥102/m^3
⑥	Reduction in crude oil equivalent	0.9	kL/year	③ x 44.8 MJ/m^3 x 0.0258 kL/GJ
⑦	CO_2 reduction	1.7	t-CO_2/year	③ x 44.8 MJ/m^3 x 0.0136 x (44 / 12) t-CO_2/GJ

[Reference] Comfort of air conditioning

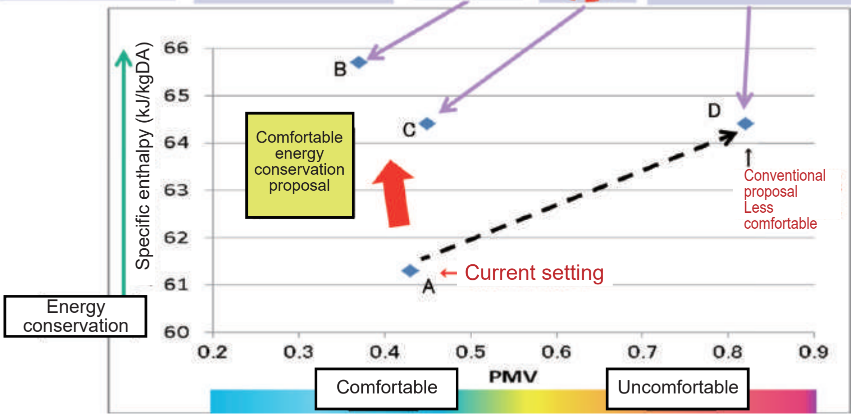
Energy conservation is achieved by optimizing the air conditioning setting temperature, but you may feel uncomfortable depending on the room requirements. To improve comfort in such a case, there is a method to utilize an air current with a circulator, etc. If an air conditioner can vary the evaporation temperature of its refrigerant, you can maintain comfort by separately controlling the temperature and humidity. One of comfort indicators is PMV. In the following cases, it is possible to make energy conservation compatible with comfort.

(1) Improvement of comfort
When the room temperature setting is increased to 28°C, you may feel uncomfortable (A → D). Comfort can be further enhanced by methods such as the following compared to the conventional ones.

①28°C setting + Effective utilization of the air current (circulator, fan, etc.) (D → C)
②Increase the humidity and decrease the temperature when the humidity can be controlled. (D → B)

◎Humidity control method (outline)
i) When cold water is utilized for air conditioning: Increase the cold water outlet temperature of the chiller.
ii) When the refrigerant is utilized for air conditioning: Adjust an expansion valve to increase the evaporation temperature of the refrigerant.

Requirement	A: Current setting	B	C	D: Conventional proposal
Room temperature (°C)	27	26.6	28	28
Humidity (%)	60	70	60	60
Wind velocity (m/s)	0.1	0.1	0.3	0.1



(Note) Enthalpy (EH): Indicates the total energy of the atmosphere. Cooling is performed to lower EH.

Fig. 3 Relations among temperature, humidity, wind velocity and comfort

(Note: For details of adjustment, consult or inquire a professional contractor.)

(2) PMV (Predicted Mean Vote)
PMV is a windchill index proposed by Professor Fanger of Technical University of Denmark as evaluation of human feelings. It is calculated from 6 elements: temperature, humidity, average radiation temperature, air current velocity, amount of clothing and amount of activity (Fig. 4).
PMV = 0 indicates a state neither hot nor cold and free from thermal discomfort, with which 95% of residents are satisfied. In the range of PMV = –0.5 to +0.5, 9 of 10 persons feel comfortable (Fig. 5).

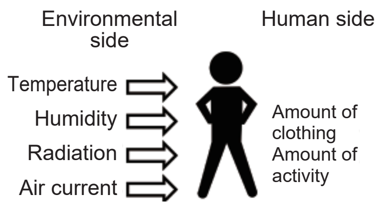
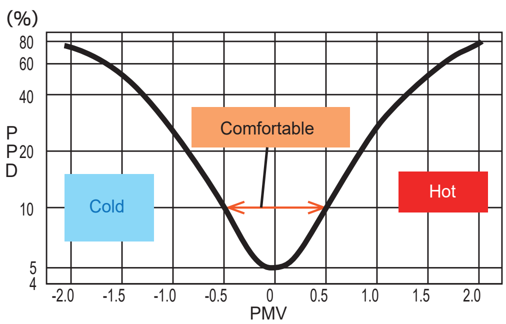


Fig. 4 Six elements of PMV calculation



PMV	Hot/cold feeling
1.51 or more	Hot
0.51 to 1.51	Slightly hot
–0.50 to 0.50	Neutral
–1.51 to –0.50	Slightly cold
–1.51 or less	Cold

Fig. 5 PMV and hot/cold feeling

Case B-2: Introducing Inverter-based Control for the Chiller Cooling Water Pump

1. Current problem

A chiller in a commercial building (total floor area: 12,900 m^2) has high piping pressure losses because the discharge valve of a cooling water pump is throttled to control a flow rate.

2. Improvement measure

Valve-based flow rate control is done by changing a piping resistance. To the contrary, inverter-based flow rate control changes pump characteristics, producing high energy conservation effects. Introduce the inverter to control the flow rate by controlling the rotating speed of the pump, and open the valve fully to save the energy.

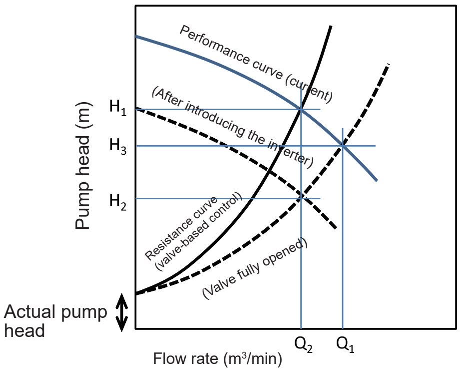


Fig. 1 Pump characteristic curve

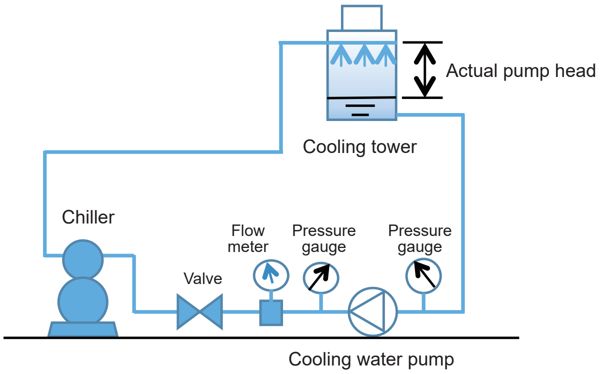


Fig. 2 Conceptual diagram of cooling water piping

3. Effect estimation

(1) Calculation formula
Current power consumption: Pump motor power (kW) x Operating time (h/year)
Improved power consumption: Power consumption (current) x Ratio of current power to improved power / Inverter efficiency

(2) Prerequisites for calculation
Pump motor power (current): 30.6 kW
Inverter efficiency: 0.95
Operating time: 800 h/year
Pump power (valve fully opened): 37 kW
Flow rate ratio (Q_2/Q_1): 1/1.25, See Fig. 1.
Pump heat (H_3): 30 m, Ditto
Actual pump head: 3 m, See Fig. 2
Ratio of current power to improved power (H_2/H_1): 0.654, See Fig. 1.

4. Effects

①	Power consumption (current)	24,500	kWh/year	
②	Power consumption (improved)	16,900	kWh/year	
③	Reduced power consumption	7,600	kWh/year	①−②
④	Energy conservation rate	31	%	③ / ①
⑤	Saved amount of money	144	¥1,000/year	③ x ¥19/kWh
⑥	Reduction in crude oil equivalent	2.0	kL/year	③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ
⑦	CO_2 reduction*	3.6	t-CO_2/year	③ x 0.470 t-CO_2/1,000 kWh

(* For the CO_2 emission factor, use the one provided by your contracted power company.)

5. Implementation of the proposal and tuning

In implementing the proposal, measure the current flow rate, pressure (pump head), power consumption, etc. to examine energy conservation effects thoroughly. After installing the inverter, control the rotating speed to a conventional cooling water rate and measure the actual results of energy conservation effects.

(1) Tuning point

Change flow rate control from a method to control opening with a control valve to the one to control the flow rate by controlling the rotating speed of the pump with the inverter. Gradually opening the valve, lower the pump rotating speed by the inverter. Checking that there is no abnormality, fully open the valve at the end. (See Fig. 3.)

(2) Measurement items (See Fig. 4.)

①When a flowmeter is not installed, install an external ultrasonic flowmeter, etc. which is not accompanied by facility remodeling.

②Utilize an existing pressure gauge for the pressure (pump head). When continuous measurement is required, remove and reinstall the existing pressure gauge.

③Use a pump current and power for monitoring a pump overcurrent and checking an energy conservation volume. There is also a clamp type wattmeter which measures a voltage with a clip.

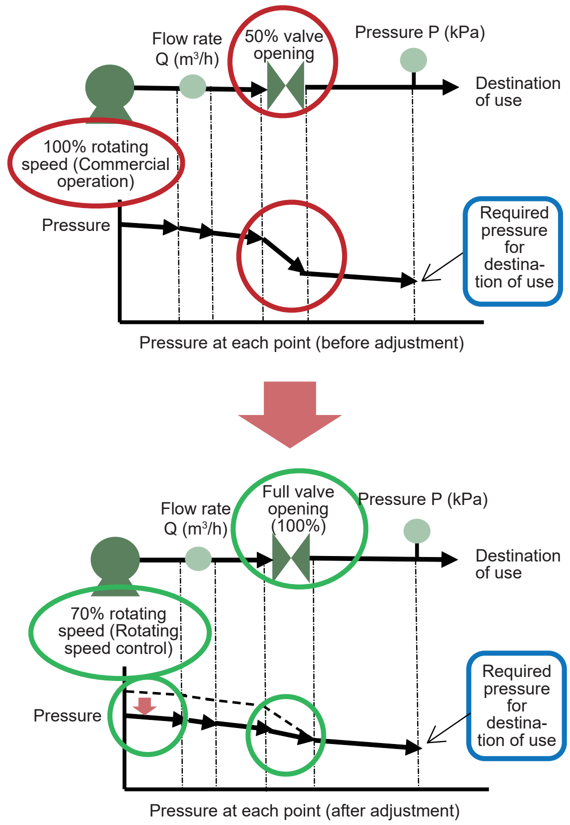


Fig. 3 Concept of inverter frequency control

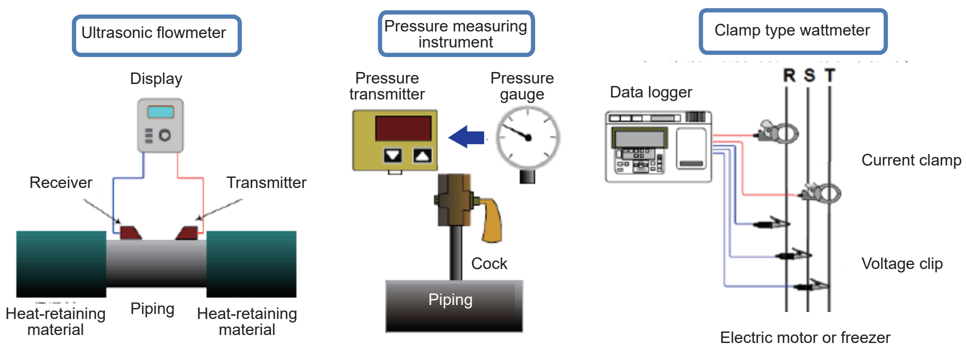


Fig. 4 Main measuring instruments

(Source: Newly published Energy Conservation Tuning Manual, The Energy Conservation Center, Japan)

(3) Tuning procedure

①Preparation (understanding of the status quo)

- Check and record the current operating condition through measurement. To make it double sure, record the valve opening so as to restore the status quo.
- Check the current operating level on the pump performance curve.

②Implementation

- Start operation under the current operating requirements (control the flow rate with a regulating valve and ensure 100% rotating speed of the pump).
- Checking that there is no abnormality with the pump current, etc., open the regulating valve gradually and lower the rotating speed of the pump to adjust the destination pressure to the same as the status quo.
- After fully opening the regulating valve, check that the flow rate, pressure (pump head), current (electric power), etc. are compatible with the characteristics of the pump performance curve.
- Changing the rotating speed within the possible range, measuring the flow rate, pressure and pump electric energy, and organizing them in a graph, etc. will be useful for future operation.
- By forecasting the rotating speed and pump electric energy for each operating condition throughout the year, it is possible to calculate reduced electric energy when the pump is controlled by the inverter.

Case B-3: Controlling the Cooling Water Setting Temperature of the Chiller

1. Current problem

A turbo chiller in an office building (total floor area: 22,400 m[2]) operates with the cooling water inlet temperature of 30°C throughout the year.

2. Improvement measure

Chiller efficiency is improved by lowering the cooling water temperature.
Finely control the cooling water setting temperature at the peak cooling load time and during other light cooling load period to improve chiller efficiency.

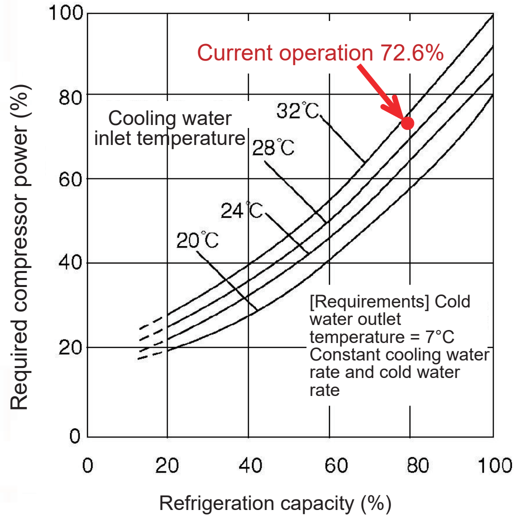


Fig. 1 Cooling water temperature and compressor power

(Source: Air conditioning and Sanitary Engineering Handbook (1987))

3. Effect estimation

(1) Calculation formula

For the required power (%) after changing the cooling water temperature, read the value at the predetermined refrigeration capacity in Fig. 1.

Table 1 Compressor power and cooling water temperature of turbo chiller

Month	Current power consumption kWh	Average temperature °C	Relative humidity %	Wet-bulb temperature °C	Cooling water inlet temperature °C			Required power %	Reduction rate %	Reduced electric energy kWh
					Current	Improved	Improvement value			
6	27,936	23.8	66.8	19.4	30	25	5.0	66	9.1	2,542
7	26,862	27.3	68.0	22.8	30	28	2.0	70	3.6	967
8	29,011	28.9	65.0	23.7	30	29	1.0	71	2.2	638
9	25,788	25.6	66.7	21.1	30	27	3.0	68	6.3	1,625
Total	109,597									5,772

The reduction rate indicates reduction from the current required power (%).
Lower cooling water temperature results in higher power for a cooling tower fan, but it was excluded from the effect estimation because it is assumed to be approximately several percent of the overall reduced electric energy.

(2) Prerequisites for calculation

Current cooling water inlet temperature setting: 30°C
Chiller load factor (refrigeration capacity): 80%
Current required power: 72.6% (See Fig. 1.)
Improved cooling water inlet temperature setting: 25 to 29°C (See Table 1.)

4. Effects

①	Power consumption (current)	109,600	kWh/year	Table 1
②	Power consumption (improved)	103,800	kWh/year	① – ③
③	Reduced power consumption	5,800	kWh/year	Table 1
④	Energy conservation rate	5.3	%	③ / ①
⑤	Saved amount of money	110	¥1,000/year	③ x ¥19/kWh
⑥	Reduction in crude oil equivalent	1.5	kL/year	③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ
⑦	CO_2 reduction*	2.7	t-CO_2/year	③ x 0.470 t-CO_2/1,000 kWh

(* For the CO_2 emission factor, use the one provided by your contracted power company.)

Case B-4: Introducing the Inverter for the Air Conditioner Fan

1. Current problem

The airflow rate of the air conditioners in an airport lobby remains set to 80% (constant damper opening) regardless of busy and quiet hours of departure and arrival.

2. Improvement measure

Rotating speed control of an air conditioner fan can reduce more power consumption than airflow rate control by damper opening. Introduce an inverter and control the rotating speed in 2 stages during busy and quiet hours.

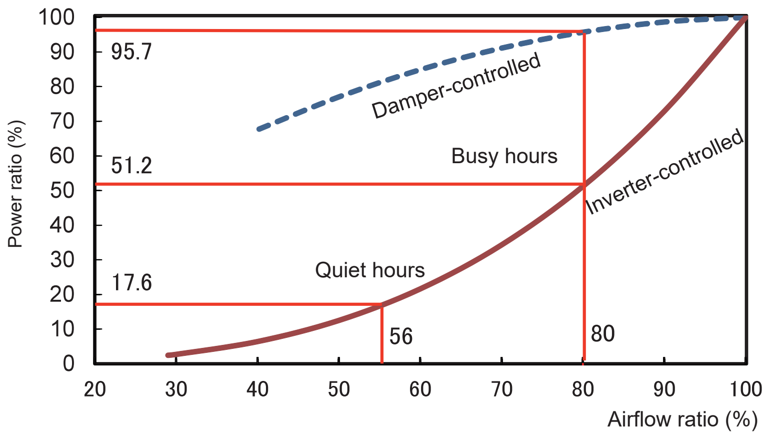


Fig. 1 Airflow ratio and power ratio of fan

3. Effect estimation

(1) Calculation formula

Current power consumption: Fan motor capacity (kW) x Motor load factor (%) x Power ratio (current) x Operating time (h/year)

Improved power consumption: Power consumption (current) x Ratio of current power to improved power / Inverter efficiency

(2) Prerequisites for calculation

Fan motor capacity: 55 kW
Motor load factor: 80%
Air feed ratio: (Current) 90% (Improved) Busy hours 80%, Quiet hours 56%
Power ratio: (Current) 95.7% (Improved) Busy hours 51.2%, Quiet hours 17.6%
Motor operating time: (Current) 2,736 h/year (Improved) Busy hours 2,052 h/year, Quiet hours 684 h/year
Inverter efficiency: 0.95
Ratio of current power to improved power: 0.447 = (2,052 x 0.512 + 684 x 0.176) / (2,736 x 0.957)

4. Effects

①	Power consumption (current)	129,600	kWh/year	
②	Power consumption (improved)	60,980	kWh/year	
③	Reduced power consumption	68,620	kWh/year	①−②
④	Energy conservation rate	53	%	③ / ①
⑤	Saved amount of money	1,304	¥1,000/year	③ x ¥19/kWh
⑥	Reduction in crude oil equivalent	17.6	kL/year	③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ
⑦	CO_2 reduction*	32.3	t-CO_2/year	③ x 0.470 t-CO_2/1,000 kWh

(* For the CO_2 emission factor, use the one provided by your contracted power company.)

Case B-5: Controlling the Boiler Combustion Air Ratio

1. Current problem

A hot water boiler for air conditioning in an education facility (total floor area: 10,400 m²) has 8.8% high exhaust gas oxygen concentration, being operated at an excessive air ratio*. If a combustion facility has an excessive air ratio, its combustion temperature and efficiency drop.

(* Air ratio: Ratio of a theoretical air volume to an actually used air volume)

2. Improvement measure

Control the air ratio to 1.3, the range specified by the EC Guideline of the Energy Conservation Act (fuel is a city gas).

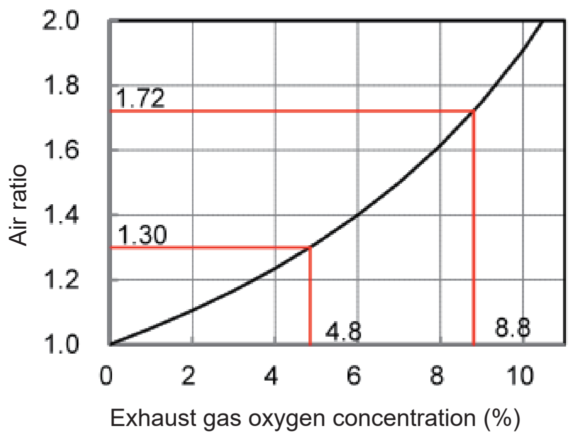


Fig. 1 Exhaust gas oxygen concentration and air ratio (13A gas)

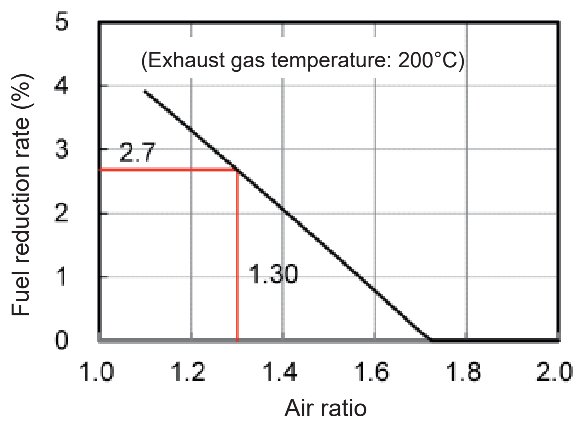


Fig. 2 Air ratio and fuel reduction rate (13A gas)

3. Effect estimation

(1) Calculation formula

Air ratio: 21 / (21 – Exhaust gas oxygen concentration (%))

Fuel reduction: Current fuel consumption (m³/year) x Fuel reduction rate by improved air ratio (%)

(2) Prerequisites for calculation

Current boiler fuel consumption: 72,100 m³/year (city gas 13A)

Exhaust gas oxygen concentration: Currently 8.8%, Improved to 4.8%

Air ratio: Currently 1.72, Improved to 1.30

Exhaust gas temperature: 200°C (constant)

Fuel reduction rate by improved air ratio: 2.7%, See Fig. 2.

4. Effects

①	Fuel consumption (current)	72,100	m³/year	
②	Fuel consumption (improved)	70,200	m³/year	
③	Reduced fuel consumption	1,900	m³/year	
④	Energy conservation rate	2.6	%	③ / ①
⑤	Saved amount of money	194	¥1,000/year	③ x ¥102/m³
⑥	Reduction in crude oil equivalent	2.2	kL/year	③ x 44.8 MJ/m³ x 0.0258 kL/GJ
⑦	CO_2 reduction	4.2	t-CO_2/year	③ x 44.8 MJ/m³ x 0.0136 x (44 / 12) t-CO_2/GJ

5. Implementation of the proposal and tuning

(1) EC Guideline of the Energy Conservation Act
The Energy Conservation Act stipulates the standard air ratio and standard waste gas temperature as the "EC Guidelines" as listed in Table 1 as to boiler combustion management and the like. Check if the boiler meets these Guidelines (O_2 concentration corresponding to the air ratio is added for your reference by the Energy Conservation Center, Japan).

Table 1 Standard air ratio and standard waste gas temperature of boilers (excerpts*1)

Category		Load factor (%)	Liquid fuel			Gaseous fuel		
			Air ratio	O_2 concentration (%)	Waste gas temperature (°C)	Air ratio	O_2 concentration (%)	Waste gas temperature (°C)*2
General boilers*2	Evaporation volume of 30 t/h or more	50 to 100	1.1 to 1.25	1.9 to 4.2	200	1.1 to 1.2	1.9 to 3.5	170
	10 t/h or more and less than 30 t/h	50 to 100	1.15 to 1.3	2.7 to 4.8	200	1.15 to 1.3	2.7 to 4.8	170
	5 t/h or more and less than 10 t/h	50 to 100	1.2 to 1.3	3.3 to 4.8	220	1.2 to 1.3	3.3 to 4.8	200
	Evaporation volume of less than 5 t/h	50 to 100	1.2 to 1.3	3.5 to 4.8	250	1.2 to 1.3	3.5 to 4.8	220
Small once-through boilers*3		100	1.3 to 1.45	4.8 to 6.5	250	1.25 to 1.4	4.8 to 6.0	220

*1 Public notice by METI: Excerpted from EC Guideline of Business Operators for Rationalization of Energy Use at Factories, etc., Appendix Table 1(A), (1) for air ratio, and Appendix Table 2(A), (1) for waste gas temperature.
- The standard air ratio values in this table set the air ratio measured at the exhaust outlet of the furnace when combusting at near the rated load after inspection or repair.
- The standard waste gas temperature sets the waste gas temperature in combustion at a 100% load factor under the 20ºC inlet temperature of the boiler ventilator after periodic inspection.

*2 Boilers other than small ones (See the Order for Enforcement of the Industrial Safety and Health Act, Article 1, Paragraph 4.)
*3 Of small boilers, those defined by the Order for Enforcement of the Air Pollution Control Act, Table 1 (Article 2 related), Clause 1.
There are exemptions of the air ratio and the waste gas temperature. See "Remarks" in their respective tables.

(2) Boiler combustion control
Operate a fuel and an air volume required for combustion in order to maintain the steam pressure in a constant range, which fluctuates depending on steam consumption.

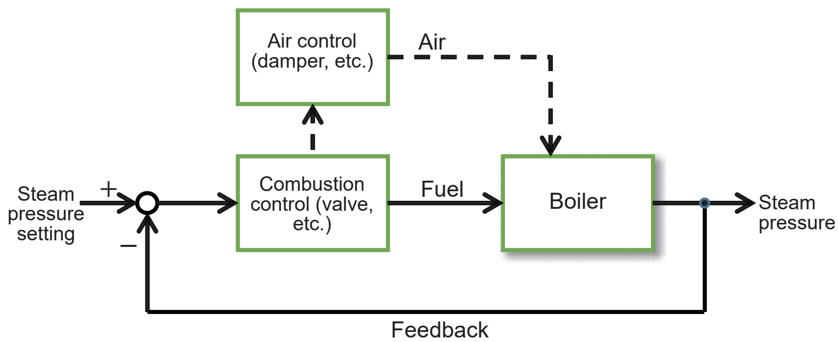


Fig. 3 Boiler combustion control

(3) Measurement of the exhaust gas oxygen concentration
Small- and medium-capacity boilers used for general industries and buildings are not provided with an oxygen densitometer, and most of them do not have feedback operation by continuous measurement. To check if the air ratio is adequate, accordingly, it is necessary to prepare an oxygen densitometer to measure oxygen concentration in the exhaust gas. You may ask a boiler manufacturer, etc. for measurement in many cases. In measurement, however, note the following.

- Even if multiple boilers are installed, measurement needs to be conducted so that the values of individual boilers will be correctly evaluated. With other boilers stopping, if measurement is made in the exhaust gas collecting piping, etc., the oxygen concentration may become higher than the reality due to leak air.
- It is necessary to measure when a boiler load is stable in the range in Table 1. Generally, the oxygen concentration is higher at low load.
- When measuring air pollution such as dust and soot, and NOx, care should be taken to check if these requirements are met.

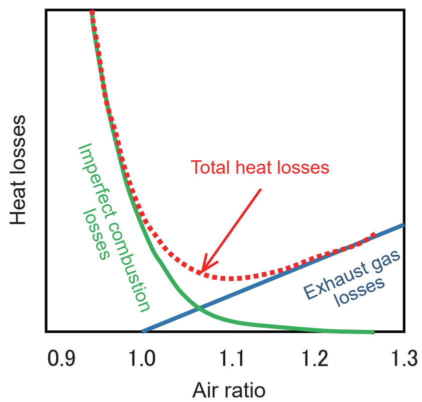


Fig. 4 Composition of combustion losses (example)

(4) Air ratio control
Because the air ratio fluctuates depending on the load factor, season (outside air temperature), etc., it is necessary to consult a boiler manufacturer, etc. to control it. Too low the air ratio results in troubles such as dust and soot or heat losses due to imperfect combustion (Fig. 4).

C. Air Conditioning and Ventilation Facilities, etc.

Case C-1: Stopping an Outside Air Intake during Warming Up Air Conditioning

1. Current problem

In an office building (total floor area: 14,500 m^2), a total heat exchanger is also operated to take in the outside air during warming-up operation one hour before (8:00 a.m.) starting daily work. At start-up time when there is almost no one in the rooms, it is hardly necessary to take in the outside air, wasting air conditioning energy by taking in the outside air in the high-temperature, high-humidity state in summer and low-temperature dry state in winter (Fig. 1).

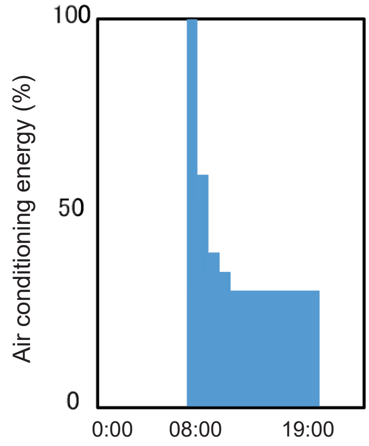


Fig. 1 Start-up image

2. Improvement measure

Stop operating the total heat exchanger during warming-up operation not to take in the outside air, thereby reducing power consumption of air conditioning and that of the total heat exchanger.

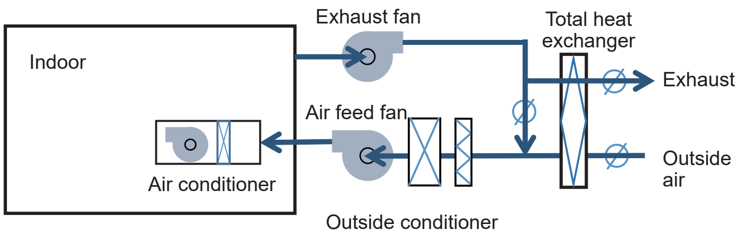


Fig. 2 Example of total heat exchanger system

Table 1 Current outside air intake volume

Type	Specifications of total heat exchanger
Area 1	Air feed 20,720 m^3/h x 15 kW Exhaust 16,400 m^3/h x 11 kW
Area 2	Air feed 21,220 m^3/h x 15 kW Exhaust 16,900 m^3/h x 11 kW

3. Effect estimation

(1) Calculation formula

Reduced power consumption is as follows.

Air conditioner: Outside air intake volume (kg/h) x Difference in specific enthalpy of indoor and outdoor air (kJ/kg) x (1 – total heat exchanger efficiency) x Operating time (h/year) / Air conditioning facility COP / 3,600 (kJ/kWh)

Total heat exchanger: Total heat exchanger fan power (kW) x Operating time (h/year)

(2) Prerequisites for calculation

Outside air intake volume: 41,940 m^3/h (See Table 1.) → 50,328 kg/h (air density at 20°C: 1.2 kg/m^3)

Total heat exchanger efficiency: 0.55, Total fan motor capacity: 52 kW (See Table 1.)

Operating time: 176 h/year for heating, 88 h/year for cooling

Air conditioning facility COP: 3.5 for heating, 3.0 for cooling

Difference in specific enthalpy of indoor and outdoor air: 17.8 kJ/kg (average value) for heating, 8.7 kJ/kg (average value) for cooling

(Note) Specific enthalpy of the air: Total heat quantity possessed by the air including steam (with reference to 0°C, 1-kg dry air)

4. Effects

①	Reduced power consumption	21,000	kWh/year	
②	Energy conservation rate	–	%	
③	Saved amount of money	399	¥1,000/year	① x ¥19/kWh
④	Reduction in crude oil equivalent	5.4	kL/year	① x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ
⑤	CO_2 reduction*	9.9	t-CO_2/year	① x 0.470 t-CO_2/1,000 kWh

(* For the CO_2 emission factor, use the one provided by your contracted power company.)

Case C-2: Reducing the Solar Radiation Load through the Window Glass

1. Current problem

In the buildings located in the areas where cooling consumes more power than heating does, there is a high solar radiation load through the southwestern windows during a cooling season, consuming high electric power during cooling.

2. Improvement measure

Apply a light-shielding film to the window glass to reduce the solar radiation load in summer. (When heating in winter, heating energy increases.)

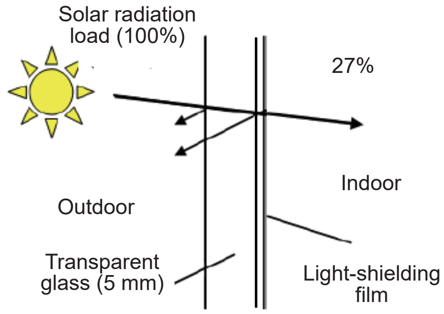


Fig. 1 Window glass and light-shielding film

3. Effect estimation

(1) Calculation formula

Incident heat quantity: Amount of solar radiation (kWh / (m^2•day)) x Solar radiation heat acquisition rate x Glass area (m^2)

Reduced air conditioning heat quantity: When cooling, current indoor heat input (kWh) – Improved indoor heat input (kWh); reversed when heating

Reduced power consumption: Total of reduced air conditioning heat quantity / Air conditioner COP

* Amount of solar radiation: Data cited from NEDO "National Solar Radiation Data Map" (Azimuth: 45° from the due south, Angle of inclination: 90°).

Table 1 Calculation of indoor heat input

Month	Amount of solar radiation* (kWh/m^2•day)	Incident heat quantity (kWh/day) Current	Incident heat quantity (kWh/day) Improved	Air conditioning Mode	Air conditioned days [Days]	Indoor heat input (kWh) Current	Indoor heat input (kWh) Improved	Reduced air conditioning heat qty. (kWh)
1	2.44	420	130	Heating	18	7,554	2,342	–5,212
2	2.55	439	136	Heating	19	8,333	2,583	–5,750
3	2.66	458	142	No heating/cooling				
4	2.80	482	149	Cooling	10	4,816	1,493	3,323
5	2.73	470	146	Cooling	19	8,922	2,766	6,156
6	2.41	415	129	Cooling	22	9,119	2,827	6,292
7	2.51	432	134	Cooling	20	8,634	2,677	5,957
8	2.92	502	156	Cooling	23	11,552	3,581	7,971
9	2.50	430	133	Cooling	20	8,600	2,666	5,934
10	2.85	490	152	Cooling	10	4,902	1,520	3,382
11	2.60	447	139	No heating/cooling				
12	2.49	428	133	Heating	18	7,709	2,390	–5,319
						104,986	47,579	22,734

(2) Prerequisites for calculation

Window glass: Azimuth = 45° from the due south, Angle of inclination = 90°, Thickness = 5 mm, Area = 200 m^2

Solar radiation heat acquisition rate: (5-mm glass) 0.86, (Glass + light-shielding film) 0.27

Air conditioner COP: 3.5 for cooling, 3.7 for heating

4. Effects

①	Reduced power consumption	6,700	kWh/year	
②	Energy conservation rate	–	%	
③	Saved amount of money	127	¥1,000/year	① x ¥19/kWh
④	Reduction in crude oil equivalent	1.7	kL/year	① x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ
⑤	CO_2 reduction*	3.1	t-CO_2/year	① x 0.470 t-CO_2/1,000 kWh

(* For the CO_2 emission factor, use the one provided by your contracted power company.)

Case C-3: Improving the Total Heat Exchanger

1. Current problem

In an assembly hall (total floor area: 5,200 m^2), a total heat exchanger in a hall air conditioning line is not functioning. A heat load due to the outside air accounts for 20 to 30%, there is a high ratio of an air conditioning load in general office buildings. Furthermore, more outside air is required in a room with many people such as an assembly hall, with the heat load accounting for higher percentage of the air conditioning load.

2. Improvement measure

Recover the function of the total heat exchanger and enable heat recovery from air conditioning exhaust to reduce an outside air load.

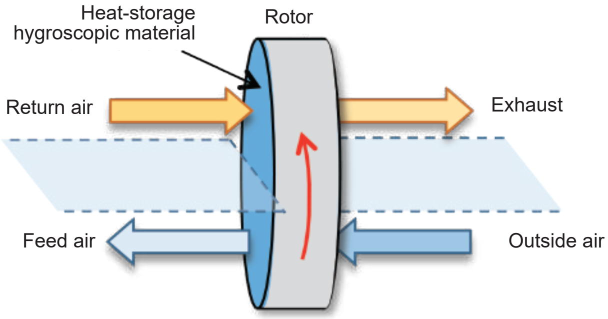


Fig. 1 Rotary total heat exchanger

3. Effect estimation

(1) Calculation formula

Calculate for heating operation and cooling operation by the following formula and totalize the results.

Heat source gas reduction: Outside air intake volume (kg/h) x Difference in specific enthalpy of indoor and outdoor air (kJ/kg) x Heat exchange efficiency of total heat exchanger (%) x Operating time (h/year) / Lower heating value of fuel (MJ/m^3) / Hot/cold water generator COP

(2) Prerequisites for calculation

Outside air intake volume: 26,352 kg/h (21,960 m^3/h)

Air conditioning time (h/year): 170 h/year for cooling, 170 h/year for heating (2 hours/day)

Hot/cold water generator COP: 1.0 for cooling, 0.8 for heating

Difference in specific enthalpy of indoor and outdoor air: 13.9 kJ/kg (average value) for cooling, 31.5 kJ/kg (average value) for heating

(Note) Specific enthalpy of the air: Total heat quantity possessed by the air including steam (with reference to 0°C, 1-kg dry air)

Heat source fuel heating value: City gas 13A, 40.5 MJ/m^3 (lower heating value)

Heat exchange efficiency of total heat exchanger: 60%

4. Effects

①	Reduced fuel consumption	3,500	m^3/year	City gas 13A
②	Energy conservation rate	–	%	
③	Saved amount of money	357	¥1,000/year	① x ¥102/m^3
④	Reduction in crude oil equivalent	4.0	kL/year	① x 44.8 MJ/m^3 x 0.0258 kL/GJ
⑤	CO_2 reduction	7.8	t-CO_2/year	① x 44.8 MJ/m^3 x 0.0136 x (44 / 12) t-CO_2/GJ

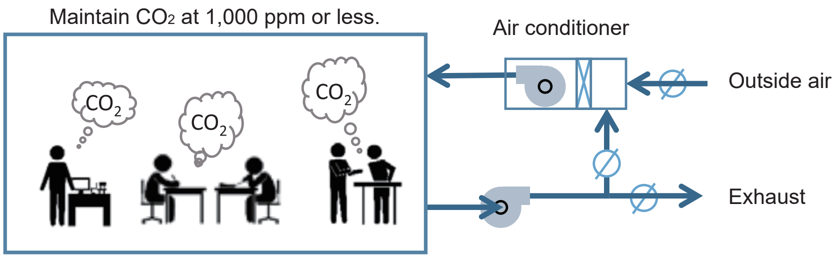
Case C-4: Reducing the Outside Air Intake Volume by Indoor CO_2 Concentration Management

1. Current problem

The indoor CO_2 concentration of an assembly hall (total floor area: 19,600 m^2) is 600 ppm, well below the concentration standard (1,000 ppm or less) specified by the "Act on Maintenance of Sanitation in Buildings" (an outside air intake volume is excessive). An excessive intake of the outside air increases a cooling load in summer and a heating load in winter.

2. Improvement measure

Increase an indoor CO_2 concentration control value to 800 ppm and control an outside air intake volume within the range of not exceeding this standard value to lower an outside air load during heating/cooling.



* Personal CO_2 emissions range from 10 to 90 L/(h ▪ person), depending on an amount of activity.

Fig. 1 CO_2 concentration control by introduction of outside air

3. Effect estimation

(1) Calculation formula

Totalize the respective outside air reductions in cooling and heating operations.

Outside air reduction rate: 1 – {(Current indoor CO_2 concentration – CO_2 concentration of outside air) / (Improved indoor CO_2 concentration – CO_2 concentration of outside air)}

Reduced outside air volume: Current outside air intake volume (kg/h) x Outside air reduction rate

Fuel reduction: Reduced outside air volume (kg/h) x Difference in specific enthalpy of indoor and outdoor air (kJ/kg) x (1 – Heat exchange efficiency of total heat exchanger) x Operating time (h/year) / Lower heating value of fuel (MJ/m^3) / Hot/cold water generator COP

(2) Prerequisites for calculation

CO_2 concentration: Current indoor air 600 ppm, Improved indoor air 800 ppm, Outside air 400 ppm

Air density (20°C): 1.2 kg/m^3

Current outside air intake volume: 20,000 m^3/h x 1.2 kg/m^3 = 24,000 kg/h

Heat exchange efficiency of the total heat exchanger: 55%

Air conditioner operating time: 750 h/year for cooling, 1,000 h/year for heating

Hot/cold water generator COP: 1.0 for cooling, 0.8 for heating

Difference in specific enthalpy of indoor and outdoor air: 12.1 kJ/kg (average value) for cooling, 30.2 kJ/kg (average value) for heating

(Note) Specific enthalpy of the air: Total heat quantity possessed by the air including steam (with reference to 0°C, 1-kg dry air)

Fuel heating value: City gas 13A, 40.5 MJ/m^3 (lower heating value)

4. Effects

①	Reduced fuel consumption	6,200	m^3/year	City gas 13A
②	Energy conservation rate	–	%	
③	Saved amount of money	632	¥1,000/year	① x ¥102/m^3
④	Reduction in crude oil equivalent	7.2	kL/year	① x 44.8 MJ/m^3 x 0.0258 kL/GJ
⑤	CO_2 reduction	13.9	t-CO_2/year	① x 44.8 MJ/m^3 x 0.0136 x (44 / 12) t-CO_2/GJ

Case C-5: Changing the Operating Method of the Ventilation Fan in the Parking Lot

1. Current problem

To feed and exhaust the air into/from the underground parking lot of a government office building, both air feed and exhaust fans are intermittently operated 3 times a day in the time period during which official vehicles enter and leave intensively.

2. Improvement measure

Because there is a vehicle approach path widely open to outside the parking lot, stop the air feed fans and operate only the exhaust fans. As a result of checking the CO concentration in the parking lot in this state, it was found out that this approach path could be utilized to introduce a required outside air volume and maintain an environment. When the CO concentration increases, operate the air feed and exhaust fans temporarily.

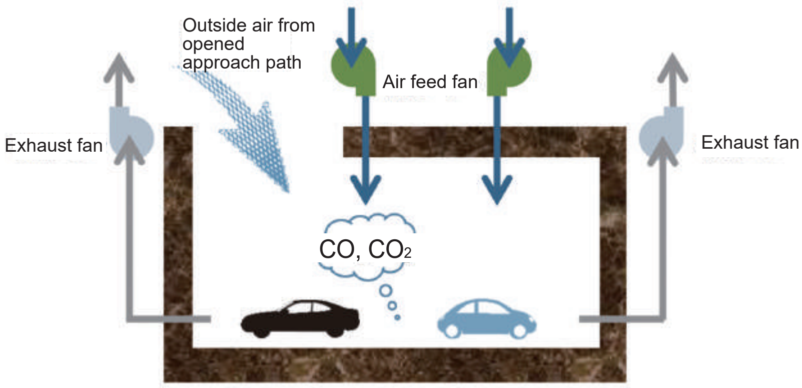


Fig. 1 Schematic diagram of parking lot

3. Effect estimation

(1) Calculation formula

Electric energy consumption: Fan power (kW) x Average load factor (%) x Operating time (h/year)

(2) Prerequisites for calculation

Status quo: All the air feed fans and exhaust fans are operated.
After improvement: Only the exhaust fans are operated.
Air feed fan: 5.5 kW x 2 units
Exhaust fan: 5.5 kW x 2 units
Average load factor: 80%
Fan operating time: 1 h/each x 3 times/day x 310 days/year = 930 h/year

4. Effects

①	Power consumption (current)	16,400	kWh/year	
②	Power consumption (improved)	8,200	kWh/year	
③	Reduced power consumption	8,200	kWh/year	①−②
④	Energy conservation rate	50	%	③ / ①
⑤	Saved amount of money	156	¥1,000/year	③ x ¥19/kWh
⑥	Reduction in crude oil equivalent	2.1	kL/year	③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ
⑦	CO_2 reduction*	3.9	t-CO_2/year	③ x 0.470 t-CO_2/1,000 kWh

(* For the CO_2 emission factor, use the one provided by your contracted power company.)

D. Lighting Facilities, etc.

Case D-1: Replacing the Fluorescent Lamp Fixture with the LED

1. Current problem

Conventional fluorescent lamps are used in the conference rooms, lobby, guest rooms, offices of the hotel-type facilities intended for lodging and training. Having been 15 years since their installation, it is about time to replace them.

2. Improvement measure

Replace the conventional fluorescent lamps with LED lamps to enhance energy conservation.
In response to the request of the facility side, use the reflectors, frames, etc. of the current fluorescent lamp fixtures without changing the appearance of the ceiling, replace a stabilizer with a DC power unit, replace plug sockets, and attach straight-tube LEDs.
These replacement work requires a qualified electrician.

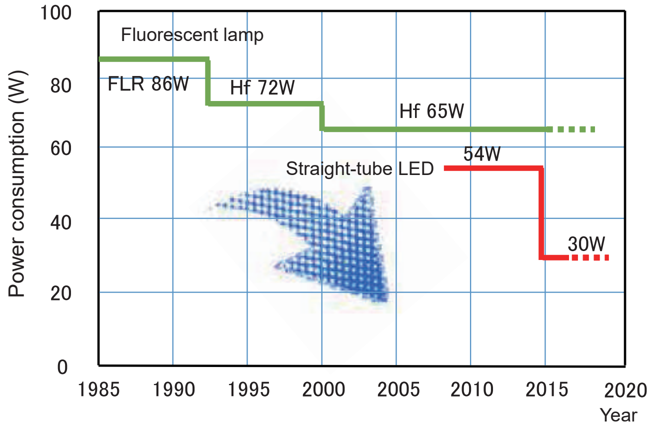


Fig. 1 Transition of power consumption of lighting fixture
(Example of power consumption for obtaining the illuminance equivalent to two 40 W lamps)

3. Effect estimation

(1) Calculation formula
Current power consumption: Power consumption (current) (W/unit) x Quantity (units) x Lighting time (h/year)
Improved power consumption: Power consumption (improved) (W/unit) x Quantity (units) x Lighting time (h/year)

(2) Prerequisites for calculation
Power consumption (current): 86 W/unit
Power consumption (improved): 30 W/unit
Quantity: 800 units
Lighting time: 8.3 h/day x 358 days/year = 2,970 h/year

4. Effects

①	Power consumption (current)	204,300	kWh/year	
②	Power consumption (improved)	71,300	kWh/year	
③	Reduced power consumption	133,000	kWh/year	①−②
④	Energy conservation rate	65	%	③ / ①
⑤	Saved amount of money	2,527	¥1,000/year	③ x ¥19/kWh
⑥	Reduction in crude oil equivalent	34.2	kL/year	③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ
⑦	CO_2 reduction*	62.5	t-CO_2/year	③ x 0.470 t-CO_2/1,000 kWh

(* For the CO_2 emission factor, use the one provided by your contracted power company.)

Case D-2: Introducing the LED Guide Light

1. Current problem

Many conventional fluorescent guide lights are installed in a certain museum. Being continuously energized and inefficient, they consume plenty of electric power.

2. Improvement measure

Replace them with high-efficiency LED guide lights to enhance energy conservation. They shall be replaced with the guide lights of the same class. When replacing, it is necessary to notify the competent fire station in advance.

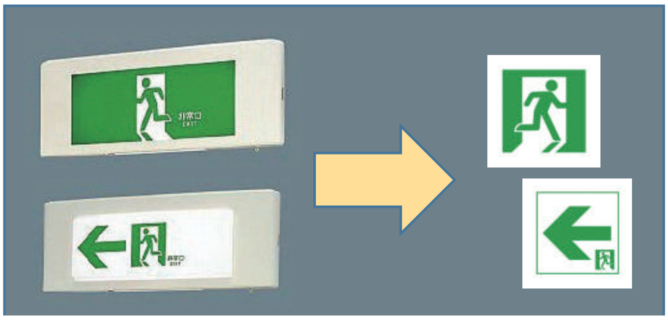


Fig. 1 Appearance of fluorescent (left) and LED (right) guide lights

3. Effect estimation

(1) Calculation formula

Current power consumption: Power consumption/unit (current) (kW) x No. of installed units x Energizing time (h/year)

Improved power consumption: Power consumption/unit (improved) (kW) x No. of installed units x Energizing time (h/year)

(2) Prerequisites for calculation

Table 1 lists the detailed specifications of the guide lights.

Lighting time: 24 h/day x 365 days/year = 8,760 h/year

Table 1 Current and improved power consumption and reduced electric energy of guide lights

Specifications	Current		Improved		No. of units	Power consumption		
	Type	Power consumption (W)	Type	Power consumption (W)		Current (kWh/year)	Improved (kWh/year)	Reduction (kWh/year)
B-class large-sized, one-sided	40 W fluorescent lamp	43.0	LED	3.5	3	1,130	92	1,038
B-class medium-sized, one-sided	20 W fluorescent lamp	23.0	LED	2.7	60	12,089	1,419	10,670
C-class one-sided	10 W fluorescent lamp	15.0	LED	2.3	8	1,051	161	890
Total					71	14,270	1,672	12,598

4. Effects

①	Power consumption (current)	14,300	kWh/year	
②	Power consumption (improved)	1,700	kWh/year	
③	Reduced power consumption	12,600	kWh/year	①−②
④	Energy conservation rate	88	%	③ / ①
⑤	Saved amount of money	239	¥1,000/year	③ x ¥19/kWh
⑥	Reduction in crude oil equivalent	3.2	kL/year	③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ
⑦	CO_2 reduction*	5.9	t-CO_2/year	③ x 0.470 t-CO_2/1,000 kWh

(* For the CO_2 emission factor, use the one provided by your contracted power company.)

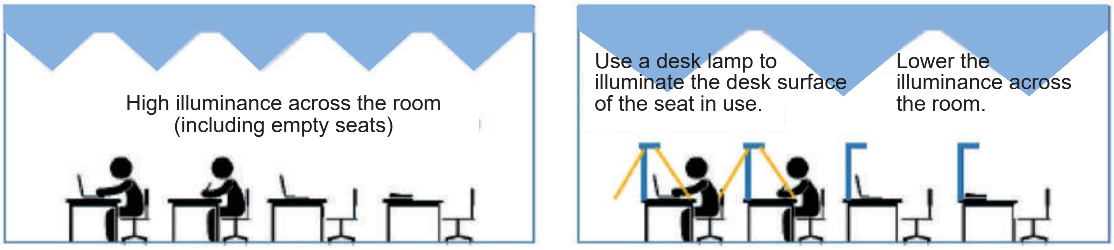
Case D-3: Introducing Task Ambient Lighting

1. Current problem

Fluorescent lamps are attached to the ceiling of an office. Because they double as task lighting to illuminate the working surface, the entire room has high illuminance, including an empty area, wasting the lighting power.

2. Improvement measure

Thin out the existing fluorescent lamps attached to the ceiling to switch to ambient lighting which illuminates the entire room, and newly install a low-power consumption LED desk lamp at each desk for task.



(a) Overall lighting system (b) Task ambient lighting system

Fig. 1 Overall lighting system and task ambient lighting system

3. Effect estimation

(1) Calculation formula

Current power consumption: Power consumption of the fluorescent lamp (W/unit) x Current quantity (units) x Lighting time (h/year)

Improved power consumption: Power consumption of the fluorescent lamp (W/unit) x Improved quantity (units) x Lighting time (h/year) + Power consumption of the desk lamp (W/unit) x Quantity (units) x Lighting time (h/year) x Lighting rate

(2) Prerequisites for calculation

Power consumption: Fluorescent lamp 86 W/unit, LED desk lamp 12 W/unit
Quantity (current): 33 fluorescent lamps (current)
Quantity (improved): 17 fluorescent lamps (improved) (16 units thinned out), 36 LED desk lamps
Lighting time: Daily work hours of 13 h x 293 days/year = 3,800 h/year
Desk lamp lighting rate: 50% (assumed to be a seat occupancy rate)
Note: Completely shut off the power for the thinned-out lamps.

4. Effects

①	Power consumption (current)	10,800	kWh/year	
②	Power consumption (improved)	6,400	kWh/year	
③	Reduced power consumption	4,400	kWh/year	①−②
④	Energy conservation rate	41	%	③ / ①
⑤	Saved amount of money	84	¥1,000/year	③ x ¥19/kWh
⑥	Reduction in crude oil equivalent	1.1	kL/year	③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ
⑦	CO_2 reduction*	2.1	t-CO_2/year	③ x 0.470 t-CO_2/1,000 kWh

(* For the CO_2 emission factor, use the one provided by your contracted power company.)

E. Power Receiving and Transforming Facilities, Power Leveling Facilities, etc.

Case E-1: Renewing and Integrating the Transformers

1. Current problem

Transformers in an electric room have been installed and used for 25 years or more. Compared with the recent ones, they are less efficient and subject to higher power losses. One of them is used under a considerably light load; its power losses are not low.

2. Improvement measure

Integrate low-load No. 2 with No. 1 and renew No. 1, No. 3, No. 4 and No. 5 to high-efficiency top runner II transformers.

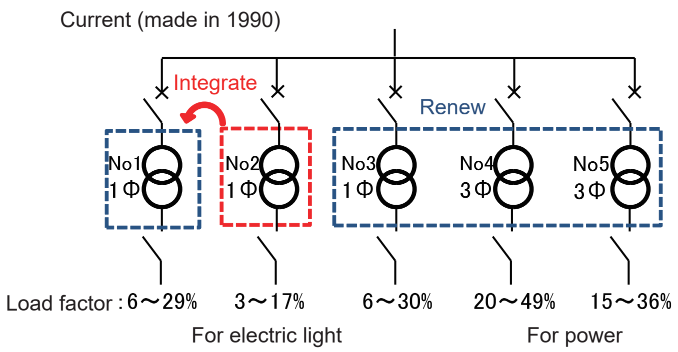


Fig. 1 Configuration of transformers

3. Effect estimation

(1) Calculation formula (Calculate on each of current and improved transformers. Fig. 2 shows the results.)

Load losses: Load losses (W) x {(Working load factor)^2 x Working hours (h/year) + (Load factor on holidays and at night)^2 x Nighttime and holiday hours (h/year)}

No-load losses: No-load losses (W) x Energizing time (h/year)

Power consumption (Total losses): Load losses (kWh/year) + No-load losses (kWh/year)

(Total losses)

(2) Prerequisites for calculation

Table 1 shows the specifications and load factor of the transformer.

Working hours: 14 h/day x 364 days/year = 5,096 h/year

Energizing time: 24 h/day x 365 days/year = 8,760 h/year

Nighttime and holiday hours: 8760 h – 5,096 h = 3,664 h/year

Table 1 Current and improved specifications and load factor of transformers

Name	Transformer rating	Current (made in 1990)				Improved (Top runner II)			
		Generated losses at rating (W)		Load factor (%)		Generated losses at rating (W)		Load factor (%)	
		Load losses	No-load losses	During working hours	Nighttime and holiday	Load losses	No-load losses	During working hours	Nighttime and holiday
No.1	500 kVA, single phase, 60 Hz	5,262	817	29	6	3,540	430	39	8
No.2	300 kVA, single phase, 60 Hz	3,372	562	17	3	Integrated with No.1			
No.3	300 kVA, single phase, 60 Hz	3,372	562	30	6	2,195	340	30	6
No.4	500 kVA, three-phase, 60 Hz	6,685	998	49	20	3,710	565	49	20
No.5	300 kVA, three-phase, 60 Hz	4,250	784	36	15	2,530	415	36	15

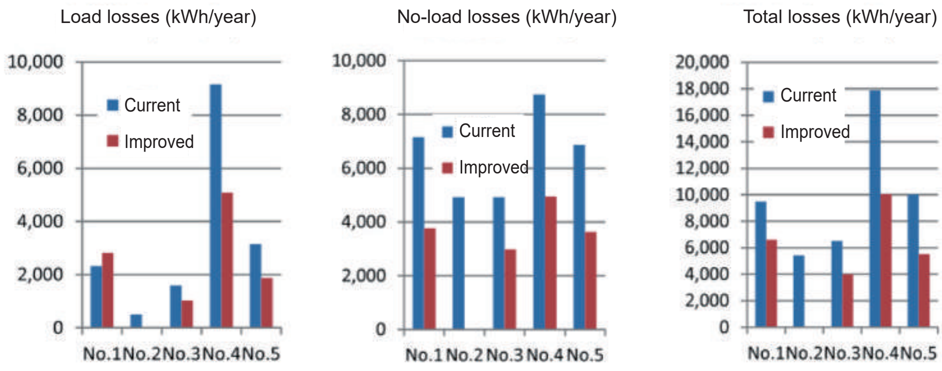


Fig. 2 Power losses of each transformer (current and improved)

4. Effects

①	Power consumption (current)	49,400	kWh/year	
②	Power consumption (improved)	26,200	kWh/year	
③	Reduced power consumption	23,200	kWh/year	①－②
④	Energy conservation rate	47	%	③ / ①
⑤	Saved amount of money	441	¥1,000/year	③ x ¥19/kWh
⑥	Reduction in crude oil equivalent	6.0	kL/year	③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ
⑦	CO_2 reduction*	10.9	t-CO_2/year	③ x 0.470 t-CO_2/1,000 kWh

(* For the CO_2 emission factor, use the one provided by your contracted power company.)

[Reference] Structure and losses of the transformer

(1) Principle and structure of the transformer
Fig. 3 shows the structure of the transformer. An iron core made of layered thin silicon steel sheets is insulated and a conductor (normally, copper wire) is coiled around it. If an AC voltage is applied to the primary coil, a magnetic flux is generated in the iron core, and the AC voltage is induced to the secondary coil. The figure illustrates quantitative relations between the AC voltages E_1 and E_2, and coil turns N_1 and N_2.

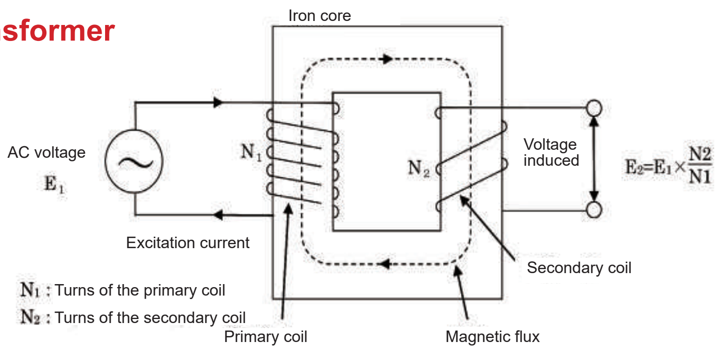


Fig. 3 Structure of transformer

(2) Losses of the transformer, and highest-efficiency load factor
Once the AC voltage is applied to the primary coil to generate the magnetic field in the iron core, there occur the losses (iron losses: no-load losses) due to an alternating magnetic field generated in the iron core. Furthermore, the induced voltage generated on the secondary side causes a load current to run to the secondary coil, producing Joule losses (copper losses: load losses) to the primary and secondary coils.
These two points are the main losses of the transformers. Because the operating time of the transformer is long, no-load losses and load losses tend to be considerably high; energy conservation measures are effective.
The highest-efficiency load factor k depends on no-load losses and load losses, having the relations of the following formula. In the conventional transformers, k was largely around 0.5. In the recent high-efficiency transformers, however, it tends to be 0.3 to 0.4, getting closer to a low-load operating point.

$$k^2 \text{ x Load losses (at rating) (W) = No-load losses (W)}$$

Case E-2: Peak Power Demand Control by Demand Monitoring

1. Current problem

The maximum demand power of a certain inn was 300 kW in the previous year. It has been increasing year after year because of insufficient demand (maximum demand power) control, adding to the basic charge of the power cost.

2. Improvement measure

Monitor a demand to control it under a target value. When it is likely to exceed the target value, stop the allowable facilities. Aim to reduce 10 kW from the status quo to 290 W.

Concept of prioritizing the stoppable facilities

List and prioritize the stoppable facilities. The following describes the general consideration procedure.

①Organize the rated power consumption, actual working load power (load factor), quantity, etc. of main facilities (Fig. 1).

②Examine the season (Fig. 2) and time period when the maximum power is required. Hourly power consumption data will be collected by installing a demand monitor, etc. in the future (Fig. 3).

③The demand is calculated every 30 minutes. Taking the above season and time period into account, consider if any equipment can be stopped for about 1 hour at that time.

④For air conditioning, there are other methods such as tentatively alleviating the setting temperature (raise in summer and lower in winter) and reducing an outside air intake volume, in addition to stopping. However, note that the effects change depending on the indoor-outdoor temperature difference, etc.

Equipment	Installation site	Specification	Power consumption (kW)	Qty.	Total power consumption (kW)	Load factor (at peak, %)	Electric power (kW)	Power saved at peak
Lighting	Office	Fluorescent lamp FLR 40	0.085	200	170	100	170	*
	Common area	Fluorescent lamp FDL18	0.022	500	110	100	110	*
	Guest room	Halogen lamp	0.04	20	0.8	100	0.8	
	Bath room	330 W	0.33	9	3	100	3	*
	Parking lot	330 W	0.33	5	1.7	100	1.7	
	Entire building	Guide light	0.015	36	0.5	100	0.5	
Air conditioner	Office	Air conditioner 1	10	2	20	80	16	*
	Common area	Air conditioner 2	20	4	80	80	64	*
	Guest room	Air conditioner 3	15	10	150	70	105	
	Banquet hall	Air conditioner 4	25	2	50	70	35	*
	Bath room	Air conditioner 5	10	3	30	80	24	*
Freezer/ refrigerator	Kitchen	.	.	.	.	.	.	.
	Butler	.		.				
			.					.

Fig. 1 List of main equipment

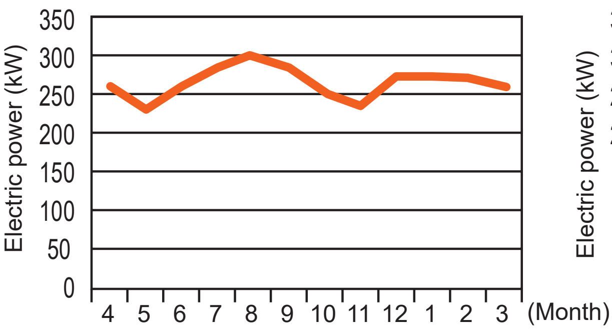


Fig. 2 Example of monthly power consumption

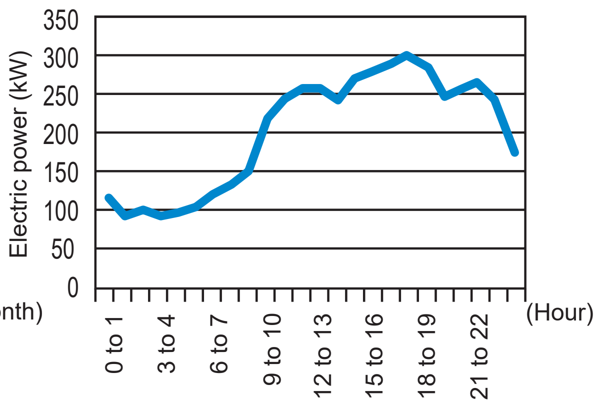


Fig. 3 Example of hourly power consumption

3. Effect estimation

(1) Calculation formula

Basic charge: Contract demand (kW) x Basic charge rate (yen/kW•month) x (185 – pf) / 100

(2) Prerequisites for calculation

Contract demand: Current 300 kW, Target 290 kW (Reduced power 10 kW)

Power factor (pf), basic charge rate: 100%, ¥1,500/kW•month (amount of money depends on the contract)

4. Effects

①	Contract demand (current)	300	kW	
②	Contract demand (improved)	290	kW	
③	Reduced contract demand	10	kW/year	①−②
④	Reduction rate	3.0	%	③ / ①
⑤	Saved amount of money*	153	¥1,000/year	③ x ¥1,500/kW x (185–100) / 100 x 12

(* For the basic charge rate, use the value provided by your contracted power company.)

[Reference] Demand monitor and peak power demand control

(1) Outline of the demand monitor
Fig. 4 shows the configuration of the demand monitor (also referred to as a demand control system).
This device counts the pulses output from the commercial watt-hour meter of the power company according to electric energy and outputs an alarm, etc. when approaching a preset demand. Normally, this device can be connected to a PC to "display", "output a warning", "output a load opening/closing signal", and "record and tabulate data". Furthermore, it allows the remote operation by utilizing IoT technology, such as stop of unnecessary facilities according to an alarm signal, etc. output from the demand monitor.
(2) Peak power demand control
Peak power demand control is intended to lower the maximum 30-minute demand related to the basic power charge of your own company as much as possible to reduce the power cost. In a broader sense, it plays a role of a national energy policy, “leveling of an electricity demand” which lowers the fluctuations of the electricity demand across Japan, caused depending on the season or time period (Fig. 5). The following describes the specific peak power demand control measures.

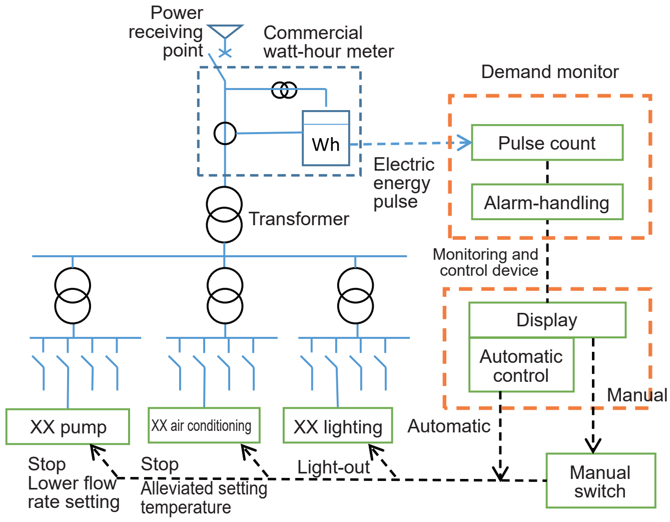


Fig. 4 Configuration of demand monitoring control
(Source: Energy Management Training, "New Training" textbook)

①Peak-shaving
As in this case, stop the allowable facilities during that time period to lower the electric energy.
②Shift
Avoid the peak time period and shift to before or after that or nighttime and holidays. Total power consumption is not reduced, but power consumption during the peak time period is reduced.
In the case of air conditioning, you may produce ice or hot water in the heat storage tank by nighttime electric power to utilize them during the peak time period.
③Change
Change from electricity to a fuel. If you have the facilities such as an absorption type water heater/chiller which use a fuel instead of electricity, increase their operating ratio. Cogeneration (a system combining fuel-based private power generation and exhaust heat utilization) is also utilized.

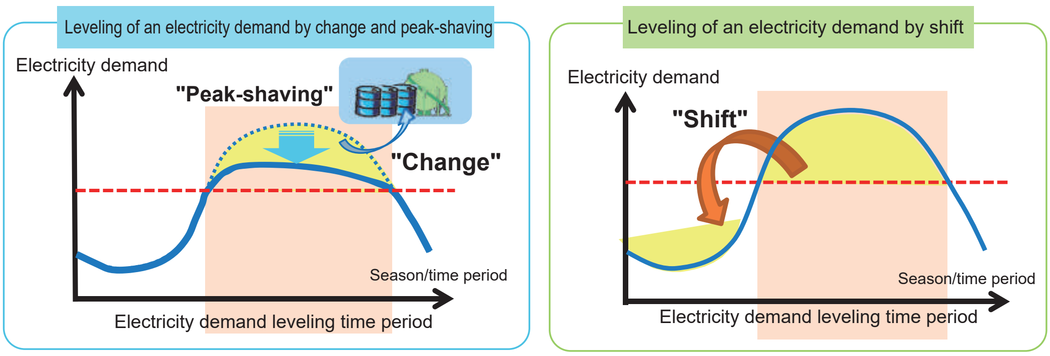


Fig. 5 Leveling of an electricity demand
(Source: Agency for Natural Resources and Energy, "Revisions of the Act on the Rational Use of Energy")

Case E-3: Improving Waste Heat Utilization of the Cogeneration System

1. Current problem

A research institute (total floor area: 24,000 m^2) has a cogeneration system (CGS), utilizing its waste heat for air conditioning through heating/cooling switching GENELINK(Note).
Because there is a demand for both cooling and heating in the intermediate period (spring and autumn), however, a simultaneous heating/cooling type gas absorption water heater/chiller is separately used in place of GENELINK. Accordingly, the CGS waste heat is radiated from a cooling tower and not used in the intermediate period.
(Note) GENELINK is an alias of the waset heat input type absorption water heater/chiller which uses waste heat hot water generated from the cogeneration system as a heat source. (Source: Japan Society of Refrigerating and Air Conditioning Engineers)

Month	1	2	3	4	5	6	7	8	9	10	11	12	Remark
GENELINK type gas absorption water heater/chiller	Heating					Cooling						Heating	
Simultaneous heating/cooling type gas absorption water heater/chiller				Simultaneous heating/cooling						Simultaneous heating/cooling			
Gas consumption (m^3/day)				850	1,100					900	750		900 (m^3/day) on average

Fig. 1 Operating condition of simultaneous heating/cooling type gas absorption water heater/chiller

2. Improvement measure

In order to respond to a simultaneous demand for heating and cooling in the intermediate period, utilize a waste heat-based heat exchanger to produce hot water out of the waste heat. GENELINK allows you to produce both hot and cold water by producing cold water. The waste heat can be recovered in the intermediate period as well (Fig. 2).

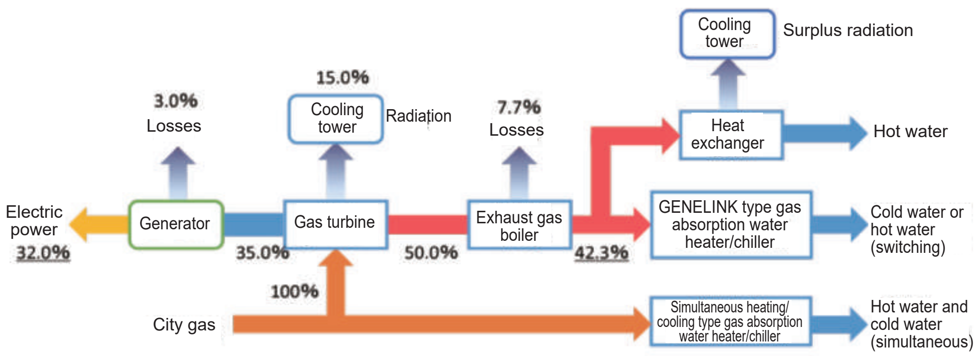


Fig. 2 CGS energy flow

3. Effect estimation

(1) Calculation formula
Concerning the simultaneous heating/cooling type gas absorption water heater/chiller in the intermediate period
Heating gas reduction: Heating load (MJ/day) / Lower heating value of gas (MJ/m^3) / Hot water production COP
Cooling capacity by the waste heat: (CGS waste heat recovery (MJ/day) – Heating load (MJ/day)) x GENELINK COP(Note)
Cooling gas reduction: (Cooling capacity by cooling load or by exhaust heat, whichever is lower) (MJ/day) / Lower heating value of gas (MJ/m^3) / Cold water production COP
Fuel reduction: (Heating gas reduction (m^3/day) + Cooling gas reduction (m^3/day)) x No. of annual operating days (days/year)
(Note) The CGS waste heat is first used for the waste heat-based heat exchanger to produce hot water, and the remaining waste heat is used for GENELINK to produce cold water. When the cooling capacity exceeds the cooling load, utilize it, taking the cooling load as an upper limit.

(2) Prerequisites for calculation

Concerning the simultaneous heating/cooling type gas absorption water heater/chiller in the intermediate period
No. of annual operating days: 22 days/month x 4 months/year = 88 days/year
Gas consumption: 900 m^3/day (Fig. 1)
COP: 0.85 for hot water production, 1.0 for cold water production
Fuel use ratio: Cooling : Heating = 50% : 50%
Heating load: 900 m^3/day x 50% x 40.5 MJ/m^3 x 0.85 = 15,491 MJ/day
Cooling load: 900 m^3/day x 50% x 40.5 MJ/m^3 x 1.0 = 18,225 MJ/day
CGS power output: 4,000 kWh/day (operation record)
CGS efficiency: 32.0% (power generation efficiency), 42.3% (heat recovery efficiency) (Fig. 2)
CGS waste heat recovery: 4,000 kWh/day x (42.3% / 32.0%) x 3.6 MJ/kWh = 19,035 MJ/day
GENELINK COP: 0.5
Lower heating value of gas (13A): 40.5 MJ/m^3

4. Effects

①	Fuel consumption (current)	79,200	m^3/year	(Fig. 1) 900 m^3/day x 88 days/year
②	Fuel consumption (improved)	35,700	m^3/year	
③	Reduced fuel consumption	43,500	m^3/year	
④	Energy conservation rate	55	%	③ / ①
⑤	Saved amount of money	4,437	¥1,000/year	③ x ¥102/m^3
⑥	Reduction in crude oil equivalent	50.3	kL/year	③ x 44.8 MJ/m^3 x 0.0258 kL/GJ
⑦	CO_2 reduction	97.2	t-CO_2/year	③ x 44.8 MJ/m^3 x 0.0136 x (44 / 12) t-CO_2/GJ

[Reference] Energy efficiency of the cogeneration system

The CGS is a system to simultaneously obtain electricity and heat from an internal combustion engine (gas turbine, gas engine, etc.) or a fuel cell. By fully utilizing electric energy and thermal energy generated by the CGS, energy efficiency is improved compared to a conventional system which separately feeds the heat from a boiler and the electric power from the grid power (see Fig. 3).

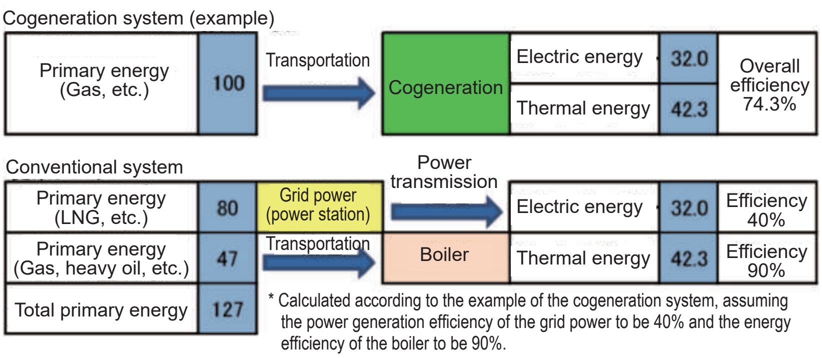


Fig. 3 Efficiency comparison between cogeneration system and conventional system (example)

F. ZEB, etc.

Case F-1: Realizing the Dissemination Type ZEB by Renewal of Medium-sized Office Buildings

1. Current problem

Aiming at carbon neutrality in 2050, Japan has been emphasizing the ZEB (Net Zero Energy Building) as an energy policy in order to greatly reduce energy consumption in the buildings and establishing subsidized projects, certification systems and registration systems to promote it. Constructed 23 years ago, the said building needs realization of the ZEB, but there are many issues.

4 stories above the ground plus 1-story penthouse, total floor area of 2,620 m^2
Medium-scale office building (Fukuoka prefecture)

2. Improvement measure

Various energy conservation technologies are easily introduced and spread in new buildings. However, renewal has many restrictions, setting back realization of the ZEB. Accordingly, we have tried to realize the ZEB by simply renewing the equipment combined with general-purpose technologies. As a procedure, we have analyzed and considered the existing equipment, etc. based on the actual energy usage, selected highly general-purpose products, and taken the initiative in the dissemination type ZEB such as building a management system, thereby achieving this.

3. Effect estimation

We have achieved the ZEB Ready by employing highly general-purpose products and technologies, and building a management system.

(1) Employment of a latent-sensible heat separation air conditioning system by high-efficiency multi air conditioners for buildings and desiccant outdoor units

By processing the humidity through the desiccant outdoor units and specializing in processing of the sensible heat through the multi air conditioners for buildings, temperature control and humidity control have been separated and individually controlled by high-efficiency equipment respectively, realizing compatibility between energy conservation and comfort.

(2) Employment of a unified management system of air conditioning, ventilation and lighting by a high-function controller

By controlling air conditioning, ventilation and lighting with one controller, schedule control was allowed such as prevention of being left turned on even in small- and medium-sized buildings with no administrator.

(3) Capacity optimization of air conditioners by analyzing air conditioning data with a remote monitoring system

In order to avoid inefficient operation (overengineering) by renewing the equipment to an air conditioning system with the same capacity as before, we have measured the operating condition of the air conditioners before renewal through a remote monitoring system, reviewed design requirements in comparison with before renewal, and considered and selected the air conditioning equipment, thereby renewing them.

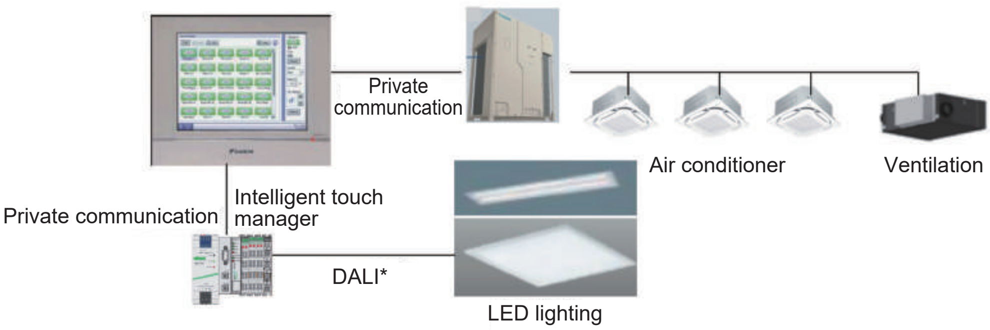


Fig. 1 Unified management system of air conditioning, ventilation and lighting

* General-purpose and extensible international standard for communication specifications for lighting control. Bidirectional communications and control are enabled even between the products of different manufacturers, allowing high-level lighting control using a dimming function.

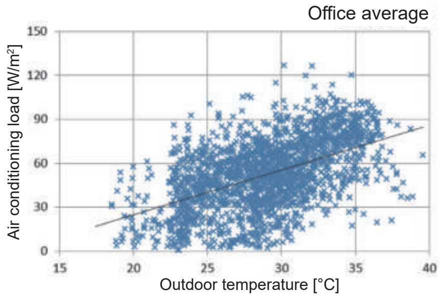


Fig. 2 Analysis of air conditioning data (Before renewal)

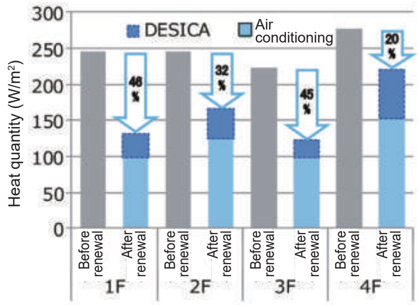


Fig. 3 Selection of air conditioning equipment

(4) Approaches to further energy conservation

①Introduction of a solar power generation system

Aiming at the Nearly ZEB, a solar power generation system has been introduced to try additional 6% energy conservation to a reference value.

②Arrangement of inner windows

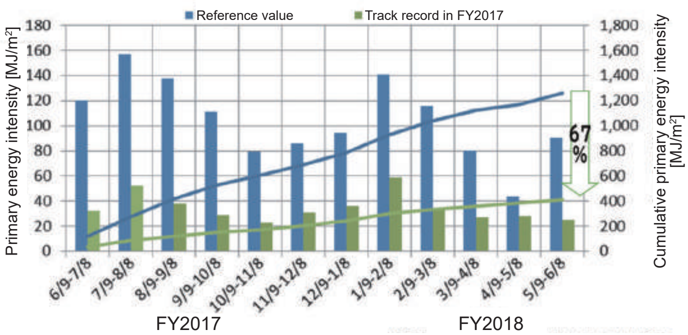
In order to improve amenity and control a setting temperature change, double windows have been introduced into an office area. An overall heat transmission coefficient has been improved from 5.0 W/(m²•K) to 3.0 W/(m²•K).

③Installation of a hot/cool space for outside personnel

A cool space has been installed near the 1st-floor entrance to control a setting temperature change of air conditioners by cooling down before entering the office.

④Thorough visualization by a ZEB monitor

- Battery-free temperature, humidity and CO_2 sensors have been connected to an air conditioning monitoring controller to manage an indoor environment.
- In order to understand power consumption by purpose such as air conditioning, ventilation, lighting and elevators, totally 130 wattmeters have been attached to the distribution boards on each floor to improve operation by measurement and analysis.
- Measurement data have been displayed on the ZEB monitor installed in front of the 1st-floor elevator to improve the employees' awareness of energy conservation.



* Excluded other than 7:00 a.m. to 9:00 p.m. on weekdays (standby power included)

Fig. 4 Transition of primary energy intensity

4. Effects

①	Reduced energy	32	kL/year	
②	Saved amount of money	2,600	¥1,000/year	

In renewing air conditioning of a medium-scale office building with a total floor area of 2,620 m² constructed in September 1996 (25 years ago), only already marketed air conditioners, ventilators and lighting equipment have been used to realize the ZEB Ready.

(1) Primary energy consumption calculated by the WEBPRO (energy consumption performance calculation program (non-housing version)) has achieved 55% reduction in comparison with the reference value, 1,267 MJ/(m²•year), by simply renewing lighting equipment, air conditioners and ventilators.

(2) Solar power generation, double windows, ZEB monitor, etc. have been installed, further energy conservation has been addressed by operational improvement, and primary energy consumption has been reduced 61% from the reference value (67% including solar power) one year after renewal, achieving the ZEB Ready.

G. Solar Power Generation, etc.

Case G-1: Introducing the Self-consumption Solar Power Generation System

1. Current problem

The rooftop of the facility to be audited has good solar radiation conditions and a vacant space (roof area of about 1,000 m^2) for installing a photovoltaic array*, but it has not been utilized so far.

* Array: Multiple photovoltaic panels arranged and connected

2. Improvement measure

Assuming that all generated power is self-consumed, the installed capacity of the photovoltaic array shall be 50 kW in view of the hourly power consumption characteristic (daytime power consumption is 50 kW or more) of the said business operator.

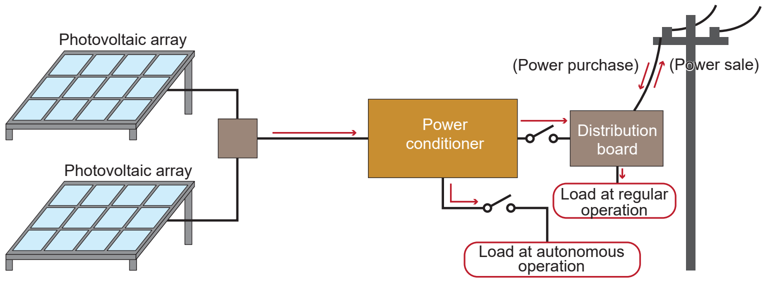


Fig. 1 Example of solar power generation system configuration

3. Effect estimation

(1) Calculation formula

Calculation of generated electric energy (kWh) at an intended facility

Reduced electric energy: Daily generated electric energy (kWh/day) x Self-consumption rate (%) of daily generated electric energy x No. of operating days (days/year)

Daily generated electric energy: Photovoltaic array output (kW) x Daily amount of solar radiation of array surface (kWh/(m^2•day)) x Total design factor x DC:AC ratio / Intensity of solar radiation (1 kW/m^2)

(2) Prerequisites for calculation

Installed capacity: 50 kW (equivalent to 25% of contract demand)
Array azimuth: 0º (building azimuth)
Inclination angle: 30º (optimum inclination angle of the relevant area)
No. of annual operating days: 365
Self-consumption rate: 100%
Amount of solar radiation of array surface: 4.04 (kWh/(m^2•day)) (average value of the relevant area)*1
Total design factor: 0.7*2
DC:AC ratio: 130%*3

*1 NEDO "National Solar Radiation Data Map" NP-9703
*2 NEDO "Guidebook for Introduction of Solar Power Generation"
*3 Comments on the procurement price, etc. in FY2020, Calculation Committee for Procurement Price, etc.

4. Effects

①	Reduced power consumption	67,094	kWh/year	
②	Energy conservation rate	—	%	
③	Saved amount of money	1,275	¥1,000/year	① x ¥19/kWh
④	Reduction in crude oil equivalent	17.3	kL/year	① x 9.97GJ/1,000 kWh x 0.0258 kL/GJ
⑤	CO_2 reduction*	31.5	t-CO_2/year	① x 0.470 t-CO_2/1,000 kWh

(* For the basic charge rate, use the value provided by your contracted power company.)

[Reference] Description of the common matters

(1) Electric energy unit price and fuel unit price
The electric energy unit price (average unit price including a basic charge) and fuel unit price are unified in the cases. Use your actual unit prices for your on-site consideration.

(2) Crude oil equivalent
This is used to evaluate energy amounts of electricity and different fuels by a common scale.
・Convert the heat quantity of the fuel (quantity x heating value), 1 (GJ), as crude oil, 0.0258 (kL).
・For electric power, convert the heat quantity of fuel required for generating and transmitting that electric energy into crude oil. (Energy of electric power, not heat quantity)

Fuel and electric power in crude oil equivalent (example)						Crude oil equivalent volume (kL)	
Type	Qty.		Heating value*		Heat qty. (GJ)		
Heavy oil A	1 (kL)	×	39.1 (GJ/kL)	⇒	39.1	×0.0258 (kL/GJ)	⇒ 1.009
LPG	1 (t)	×	50.8 (GJ/t)	⇒	50.8		⇒ 1.311
City gas 13A**	1 (1,000 m^3)	×	44.8 (GJ/1,000 m^3)	⇒	44.8		⇒ 1.156
Electric energy (daytime)***	1 (1,000 kWh)	×	9.97 (GJ/1,000 kWh)	⇒	9.97		⇒ 0.257
Electric energy (nighttime)***	1 (1,000 kWh)	×	9.28 (GJ/1,000 kWh)	⇒	9.28		⇒ 0.239

(The calculations in the cases are partly simplified. For official reports such as periodical ones, comply with the respective methods.)
*: The heating value is defined by the enforcement regulations for the Act on the Rational Use of Energy.
**: The heating value of the city gas uses the actual value of the supplied gas. A typical value is used in this Guidebook.
***: In the cases provided in this Guidebook, the electric power is always converted on the basis of daytime values.

(3) CO_2 emissions

[For the fuel]

As mentioned above, multiply a fuel amount by the heating value to calculate the heat quantity. Multiply this by a carbon emission factor to calculate a carbon amount. Furthermore, for conversion of molecular weight, multiply by 44/12 to calculate a carbon dioxide amount.

Type	Qty.	Heat qty. (GJ)	Carbon emission factor* (t-C/GJ)	CO_2 emissions (t)	
Heavy oil A	1 (kL) ⇒	39.1	× 0.0189	$\times\left(\frac{44}{12}\right)$	⇒ 2.71
LPG	1 (t) ⇒	50.8	× 0.0161		⇒ 3.00
City gas 13A	1 (1,000 m^3) ⇒	44.8	× 0.0136		⇒ 2.23

* Defined by the ministerial ordinance related to calculation of greenhouse gas emissions associated with the business activities of the specified emitter.

[For electric energy]

Multiply the electric energy by the CO_2 emission factor.

Electric energy	CO_2 emission factor*	CO_2 emissions	Remarks
1 (1,000 kWh)	× 0.470 (t-CO_2/1,000 kWh)	⇒0.470 (t)	The emission factor 0.470 is used in the cases, but normally, use the value of the contracted power company.

* The Act on Promotion of Global Warming Countermeasures obligates a business operator exceeding a certain scale or output to report the CO_2 emissions of the previous year. The actual emission factor and post-adjustment emission factor used for reporting should be annual factors for each electric utility (**).

For the latest emission factor, see "Pages Related to Emission Factors by Electricity Utility" (https://ghg-santeiko-hyo.env.go.jp/calc/denki), etc. The emission factor, 0.470 (t-CO^2/1,000 kWh), mentioned/used in this guidebook is an alternative value (most recent 5-year average, calculated by the government, of the total emission factor of utility generation and private power generation in Comprehensive Energy Statistics) in "Emission Factors by Electricity Utility (results in FY2019, published by the Ministry of the Environment and the Ministry of Economy, Trade and Industry on Jan. 7, 2021, partially added and updated on Jul. 19, 2021)".

Where to Apply and Contact for Energy Audit

The Energy Conservation Center, Japan provides an energy optimized audit (there are certain requirements).
Download an application form from the Energy Conservation and Power-saving portal site (https://www.shindan-net.jp) and send it to the following address by fax, regular mail or E-mail.

■Headquarters (Energy Audit Department)	Igarashi Building, 2-11-5 Shibaura, Minato-ku, Tokyo 108-0023	Phone: +81-3-5439-9732 Fax: +81-3-5439-9738
■Hokkaido Branch	Hokkaido Keizai Center Building, 2-2 Kitaichijo-Nishi, Chuo-ku, Sapporo 060-0001	Phone: +81-11-271-4028 Fax: +81-11-222-4634
■Tohoku Branch	Main Denryoku Building, 3-7-1 Ichibancho, Aoba-ku, Sendai 980-0811	Phone: +81-22-221-1751 Fax: +81-22-221-1752
■Tokai Branch	Ito Building, 3-23-28 Marunouchi, Naka-ku, Nagoya 460-0002	Phone: +81-52-232-2216 Fax: +81-52-232-2218
■Hokuriku Branch	Toyama Kogin Building, 5-13 Sakurabashi-dori, Toyama 930-0004	Phone: +81-76-442-2256 Fax: +81-76-442-2257
■Kinki Branch	Yotsuhashi KF Building, 1-13-3 Shinmachi, Nishi-ku, Osaka 550-0013	Phone: +81-6-6539-7515 Fax: +81-6-6539-7370
■Chugoku Branch	Inoue Building, 8-20 Kamihacchobori, Naka-ku, Hiroshima 730-0012	Phone: +81-82-221-1961 Fax: +81-82-221-1968
■Shikoku Branch	Takamatsu Kotobukicho Prime Building, 2-2-10 Kotobukicho, Takamatsu 760-0023	Phone: +81-87-826-0550 Fax: +81-87-826-0555
■Kyushu Branch	Asako Hakata Building, 1-11-5 Hakataeki-Higashi, Hakata-ku, Fukuoka 812-0013	Phone: +81-92-431-6402 Fax: +81-92-431-6405

Energy Conservation and Power-saving Portal Site
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This booklet has been prepared in the project by the Agency for Natural Resources and Energy, "Subsidies for Promotion of Optimized Energy Utilization for Small- and Medium-sized Enterprises in FY2021".

VEGETABLE OIL INK This print uses environmentally-friendly vegetable oil ink.
Recyclability This print is recyclable into printing paper.

2021.08/7K