First Step for Carbon Neutrality

# Energy Conservation Guidebook for Factories 2022

Energy Conservation Procedures and
Energy Conservation Technologies

*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.

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# 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.

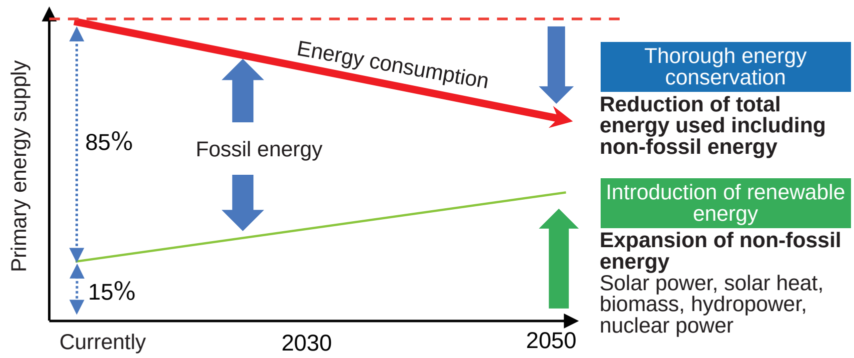
**Economic viewpoint**

### · 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 improved productivity

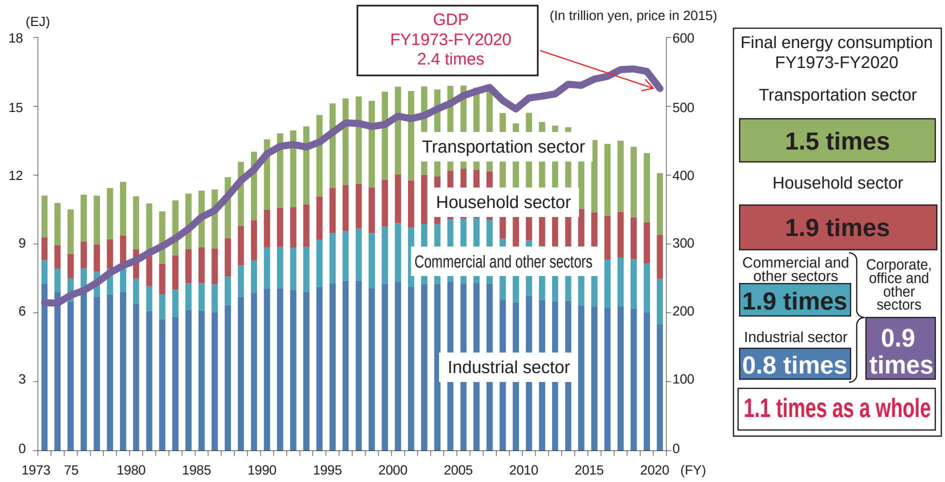
Energy conservation and $CO_2$ reduction are made compatible with improved productivity by reviewing production and service methods, rationalizing a production line and providing services more efficiently from a viewpoint of energy conservation.




**[Reference]**
**Energy Consumption Trend in Japan**

Compared with the first oil crises in 1973, total energy consumption has been restrained to approximately 1.1 times with respect to the growth of the GDP, approximately 2.4 times; the industrial sector has decreased its ratio (0.8 times) and commercial (1.9 times), household (1.9 times) and transportation (1.5 times) sectors have increased their ratios.

**Transition of Final Energy Consumption and Actual GDP**




Source: "Energy White Paper 2022" (Fig. [No. 211-1-1]), Ministry of Economy, Trade and Industry

## 2. Energy Conservation Procedure

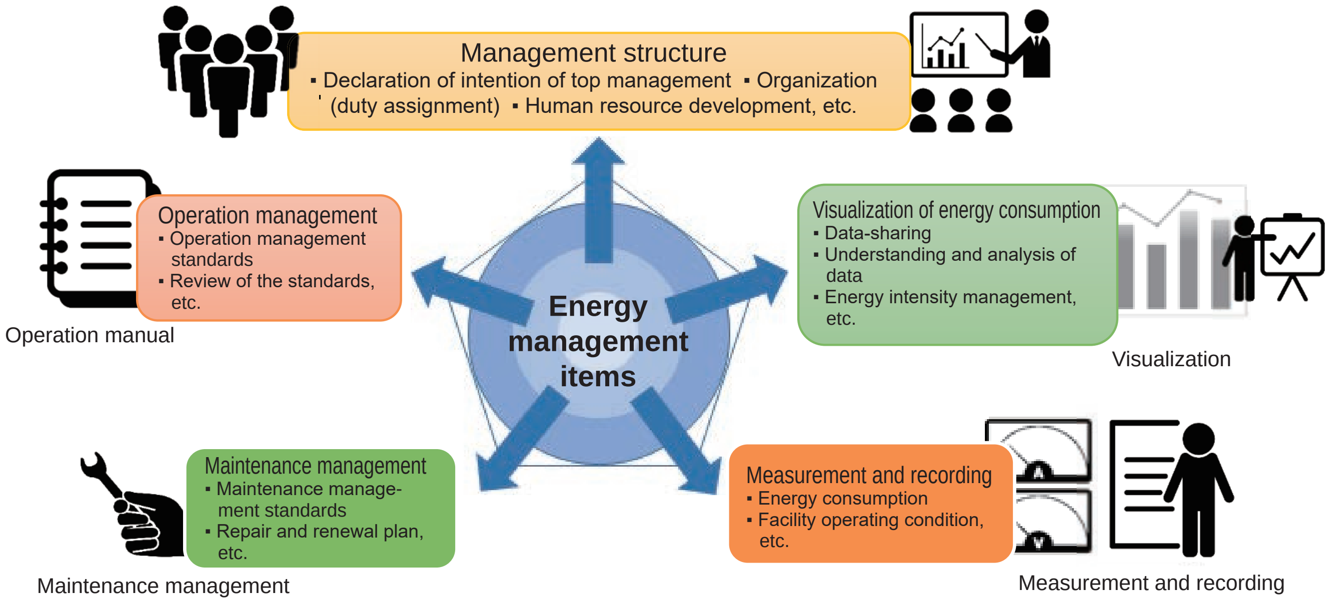
### (1) Energy conservation technologies

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.

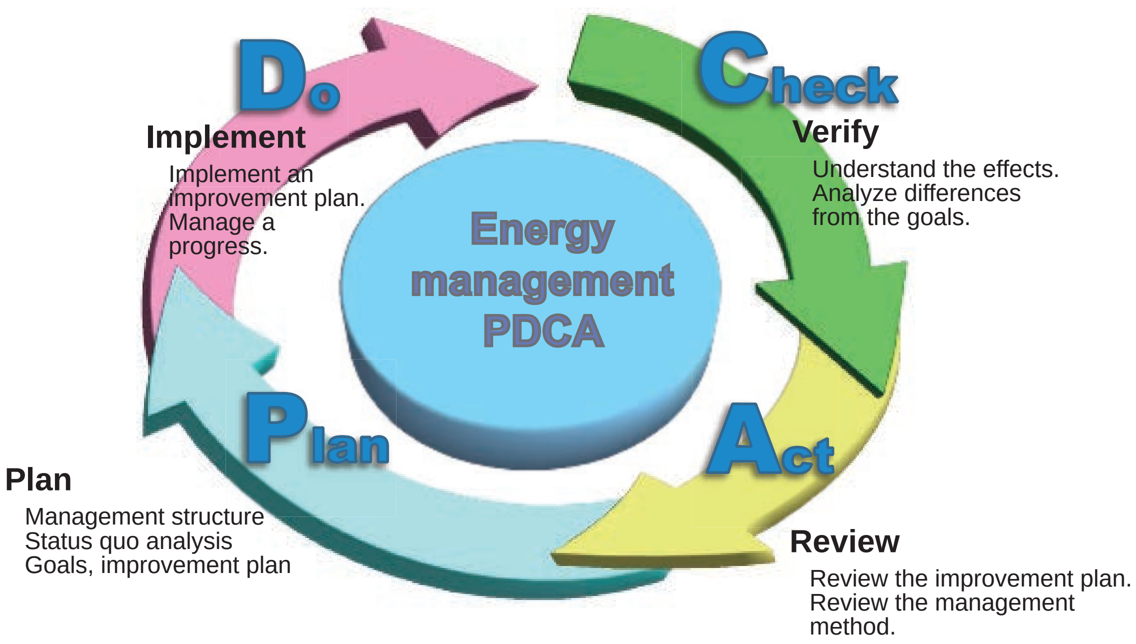
### (2) Energy management

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 Factories

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-1] [Case A-2] |
| | | ○ | | | Do you implement PDCA for energy conservation activities on the premise of participation of the management? [Case A-1] [Case A-2] |
| | | ○ | | | Do you decide a responsible person or a leader who promotes energy conservation? [Case A-1] |
| | | ○ | | | Do you set energy conservation goals (reduction of XX%, reduction of XX tons, etc.)? [Case A-1] [Case A-2] |
| | | ○ | | | Do you post the energy consumption status so that employees can understand? [Case A-1] [Case A-2] |
| | | ○ | | | Do you set a policy and implementation plan for energy conservation measures? |
| | | ○ | | | Do you educate the personnel and conduct an energy conservation awareness campaign? [Case A-2] |
| | | ○ | | | Do you observe Cool Biz*1 and Warm Biz*2? |
| | | ○ | | | Do you secure a time and a budget for addressing energy conservation? |
| | 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-2] |
| | | ○ | | | 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? |
| | | ○ | | | 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? [Case A-1] [Case A-2] |
| | | | ○ | | 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? [Case A-1] |
| | | | ○ | | Do you analyze the energy consumption status in view of the outside temperature, production volume, etc.? |
| | | | ○ | | Do you consider merger of production process management and energy management (reduction of fixed energy, 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/m³)? |
| | | ○ | | | Do you manage the energy intensity ("energy consumption/production volume", "energy cost/production volume", etc.)? |
| | | | ○ | | Do you manage the energy intensity and cost by process, product and department? |
| | 5. Management cycle PDCA | ○ | | | Do you review energy conservation goals? |
| | | ○ | | | Do you examine the effects of the improvement measures that have been implemented in the past? |
| | | ○ | | | Do you review implementation plans for future facility improvements and measures? |
| [2] Air conditioning, ventilation, freezing and refrigeration facilities | 1. Management of the air conditioning facilities | ○ | | | 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? |
| | | | ○ | | Do you relax the cold water outlet temperature when a cooling load is low? |
| | | | | ○ | Do you shut off an entry of outside air such as draft in an air-conditioned area? |
| | | | | ○ | Do you control an outside air introduction rate? |
| | | | | ○ | Do you control the number of heat source equipment (chillers, etc.)? |
| | | | | ○ | Do you implement local exhaust or radiation shutoff with respect to the heat-generating equipment? |
| | 2. Energy conservation measures for air conditioning | ○ | | | Do you take an anti-solar radiation measure for the windows (planting by the windows, blinds, curtains, etc.)? |
| | | ○ | | | Do you periodically clean the filters and the fins of outdoor units? |
| | | ○ | | | Do you shield the outdoor units from the sunshine and sprinkle water to them in summer? |
| | | | ○ | | Have you utilized cooling with outside air when cooling is required during an intermediate period or winter? |
| | | | | ○ | Do you apply a heat-shielding paint to the roof and plant on the rooftop? |
| | | | | ○ | Do you employ the walls and ceilings, etc. with high insulation? |

*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] Air conditioning, ventilation, freezing and refrigeration facilities | 2. Energy conservation measures for air conditioning | | | 〇 | Do you implement the inverter-based control of a flow rate for heat transfer machines (pumps, blowers) according to a load? |
| | | | | 〇 | Is it possible to reduce an air-conditioned area (partitions, lining of the high ceiling, etc.)? |
| | | | | 〇 | When there are not many people in a spacious air-conditioned area, do you use a spot cooler? |
| | | | | 〇 | Do you recover and utilize the waste heat? |
| | | | | 〇 | Do you upgrade to the high-efficiency air conditioning facilities? |
| | 3. Ventilation facilities | 〇 | | | Do you stop ventilation of an unused area or when not used? |
| | | | 〇 | | Do you implement room temperature control operation for electric room, machine room, etc.? |
| | | | 〇 | | Do you adjust a ventilation rate by proper ventilation frequency and intermittent operation, etc.? |
| | | | 〇 | | Do you change an outside air inlet rate according to the season? |
| | | | | 〇 | Do you implement local exhaust as an excessive exhaust control measure for the entire room? |
| | 4. Refrigeration and freezing facilities | 〇 | | | Is the facility internal temperature adequate? [Case B-1] |
| | | 〇 | | | Are the cold water inlet and outlet temperature/pressure and the refrigerant inlet and outlet pressure adequate? |
| | | 〇 | | | Do you manage the cooling water quality (electrical conductivity)? |
| | | | 〇 | | Can you reduce frequency of defrosting according to the season? |
| | | | 〇 | | Do you control a flow rate for the pumps of the chiller and cooling tower (introduction of an inverter, etc.)? |
| | | | | 〇 | Do you reduce frequency of a door opening/closing, shorten an opening time, install an air curtain, and so on? |
| | | | | 〇 | Do you reduce heat generation of facility internal lighting (e.g. introduction of LEDs)? |
| | | | | 〇 | Are there any frozen parts due to heat insulation failure in heat insulation treatment of the wall surface, ceiling, piping or door? |
| | | | | 〇 | Do you introduce the high-efficiency refrigeration and freezing facilities? [Case B-2] |
| [3] Pumps, fans and compressors | 1. Management of the pumps and fans | 〇 | | | Do you check opening and closing of the valves daily (prevention of forgetting to close)? |
| | | | 〇 | | Are the working flow rates (airflow, water flow) and pressure adequate? |
| | | | 〇 | | Aeration tank blower: Do you operate intermittently and/or reduce an airflow rate on holidays and during nighttime? |
| | | | | 〇 | Do you implement the inverter-based rotating speed control for flow rate? [Case C-1] [Case C-3] |
| | | | | 〇 | Do you adjust a flow rate, using units control and sensors according to a load? |
| | | | | 〇 | Are the route and size of piping and duct adequate? |
| | 2. Management of the compressors | 〇 | | | Do you check opening and closing of the valves daily (prevention of an air leak due to forgetting to close)? |
| | | 〇 | | | Do you clean the filter at the air inlet port? |
| | | 〇 | | | Do you optimize the discharge pressure and working-end pressure? [Case C-4] |
| | | | 〇 | | Do you inspect and repair an air leak? [Case C-2] |
| | | | 〇 | | Do you optimize an air blow rate (nozzle structure, blow time, etc.)? |
| | | | 〇 | | Are the compressors exhausting outdoors (measure to lower the feed air temperature)? |
| | | | 〇 | | Have you checked whether the size and route of piping are adequate? |
| | | | | 〇 | Do you optimize the model, capacity and number of operating units and control the number of units according to a load? |
| | | | | 〇 | Do you install an air receiver when the load fluctuates greatly? |
| | | | | 〇 | Do you classify into the high- and low-pressure lines? |
| | | | | 〇 | Have you changed aeration for cooling and purging to the blowers, etc.? [Case C-5] |
| | | | | 〇 | Have you considered pulsed air blow? [Case C-6] |
| | | | | 〇 | Do you reduce a pipe resistance (bypass piping) or conduct looping (consideration of pressure loss, etc.)? |
| | | | | 〇 | Can you upgrade to the high-efficiency compressors (inverter-based control of a flow rate, etc.)? |
| [4] Heat facilities such as boilers and industrial furnaces | 1. Management of the combustion facilities | 〇 | | | Do you periodically check whether the air ratio and exhaust gas temperature are adequate? [Case D-4] |
| | | | 〇 | | Do you carry out maintenance and inspection of the burners (cleaning, replacement of worn)? |
| | | | | 〇 | Do you consider optimization of the burner capacity according to a change of the load capacity, etc.? |
| | | | | 〇 | Do you reduce the heat capacity of the furnace body and furnace internal carrier? |
| | | | | 〇 | Is the combustion control unit operating stably? |
| | | | 〇 | | Is a ventilation rate fully secured? |
| | | | | 〇 | Do you upgrade to the high-efficiency models? [Case D-2] |
| | 2. Heat retention and radiation prevention of the furnaces, ducts, heat facilities, etc. | 〇 | | | Do you check whether the thermal insulation materials of the furnace wall are adequate and have no damage? |
| | | | 〇 | | Is the furnace internal pressure properly controlled (prevention of hot gas blowout and entry of the outside air, check for the opening, scale-down)? |
| | | | 〇 | | When the temperature of the furnace wall outer surface and exhaust duct is high, have you taken a thermal-insulating/heat-retaining measure? |
| | | | | 〇 | Do you take a thermal-insulating/heat-retaining measure for the high-temperature facilities? |
| | | | | 〇 | Do you fully scale down or seal the opening of the furnace? [Case F-2] |

| Classification | | Ⅰ | Ⅱ | Ⅲ | Check item |
|---|---|---|---|---|---|
| [4] Heat facilities such as boilers and industrial furnaces | 3. Operation and efficiency management | ○ | | | Do you check whether the capacity of the combustion facilities is adequate (load factor, start/stop status)? |
| | | ○ | | | [Boiler] Do you periodically measure and record the steam pressure/flow rate, blow rate, etc.? |
| | | ○ | | | [Boiler] Do you make efforts to ensure an optimum blow rate by managing the water quality, and so on? |
| | | | ○ | | [Boiler] Can you set the steam pressure lower? |
| | | | ○ | | [Boiler] Do you level a steam load? |
| | | | | ○ | [Boiler] Do you implement manual adjustment/automatic control to ensure the efficient number of operating units? |
| | | | | ○ | [Boiler] Do you introduce an accumulator when the load fluctuates greatly? |
| | | | | ○ | [Boiler] Do you consider introduction of the high-efficiency boilers? |
| | 4. Management of the steam system and waste heat recovery | ○ | | | Piping system and load facilities: Do you check for a steam leak and an improper heat-retaining measure? [Case D-1] |
| | | | ○ | | Do you periodically inspect and replace a steam trap? |
| | | | ○ | | Is the piping size adequate? Is there any unnecessary piping? |
| | | | | ○ | Have you considered integration of multiple steam systems? |
| | | | | ○ | Do you recover steam drain? [Case D-3] |
| | | | | ○ | Do you utilize flash steam? |
| | 5. Heat recovery of exhaust gas and reduction of drainage | | ○ | | Do you circulate and utilize cooling water? |
| | | | | ○ | Do you recover the waste heat of combustion exhaust gas? [Case F-1] |
| | | | | ○ | Do you circulate and utilize the exhaust gas? |
| | | | | ○ | Do you recover the heat of hot waste water? |
| | 6. Management of the heat exchangers | ○ | | | Has temperature efficiency worsened? |
| | | | ○ | | Do you carry out periodic maintenance and inspection (contamination, clog, etc.)? |
| | | | | ○ | Do you consider introduction of the high-efficiency heat exchangers? |
| [5] 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? |
| | | | ○ | | Toilets, warehouses, etc.: Do you use a motion detector to turn on/off the lighting? |
| | | | ○ | | 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 E-1] |
| | | | | ○ | Have you considered task ambient lighting? (All-room lighting → Overall + Hand lighting) |
| | 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? |
| | | | ○ | | [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 high-efficiency transformers? |
| | 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? |

| Classification | | Ⅰ | Ⅱ | Ⅲ | Check item |
|---|---|---|---|---|---|
| [6] Electric motors and electric heating facilities | 1. Management of the 3-phase induction motor, etc. | ○ | | | Do you notice abnormal heating or noise of the electric motors? |
| | | ○ | | | Do you check whether the supply voltage and rotating speed of the electric motors are adequate? |
| | | | ○ | | Do you prevent no-load operation (idling)? |
| | | | | ○ | Are they operated according to a load (inverter-based rotating speed control, unit numbers control)? |
| | | | | ○ | Do you introduce the high-efficiency motors (including permanent-magnet motors)? |
| | 2. Management of the electric heating facilities | ○ | | | Do you check whether the power factor is adequate? |
| | | ○ | | | Do you control the thermal insulation and heat retention of the furnace wall? |
| | | | ○ | | When the supply voltage is low, do you optimize it by reviewing a wiring size, and so on? |
| | | | ○ | | Are the heating time and temperature adequate? |
| | | | ○ | | Have you considered centralization of intermittent operation? |
| | | | ○ | | Do you shorten an opening/closing time at the entrance and exit when preheating a material and loading/unloading a product? |
| | | | | ○ | Do you enhance the load factor (reduction of heat storage losses, cooling losses, etc.)? |
| | | | | ○ | Do you scale down a lid or opening, and take a measure to reduce a furnace internal gas leak? |
| [7] Production facilities and drainage facilities | 1. Production facilities | ○ | | | Do you turn off the facilities when a production line is stopping or when they are not operating (reduction of fixed power)? |
| | | | ○ | | Do you shorten an idling time of the production facilities? |
| | | | | ○ | Are the products and production facilities not overcooled? |
| | | | | ○ | Do you consider introduction of manufacturing facilities with higher production capability and efficiency than conventional ones? |
| | 2. Drainage facilities | | ○ | | As for aeration tank for drainage treatment, do you reduce a blower's air blow during a non-operating time (nighttime and holidays)? |
| | | | | ○ | Can you recover and utilize a gas at the time of methane fermentation? |
| | | | | ○ | Can you recover waste heat from hot drainage by utilizing a heat pump? |
| [8] Miscellaneous | 1. Load leveling | | ○ | | Have you considered peak shifting in power use? Have you reviewed an operation form (working hours, operation system, 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, waste heat utilization rate, overall efficiency, etc.)? |
| | | | | ○ | Have you considered introduction of a cogeneration system (including a fuel cell-based system)? |
| | 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 as to a boiler? |
| | | | | ○ | Have you considered introduction of a heat source facility (boiler, water heater/chiller, etc.) based on woody biomass, etc.? |
| | | | | ○ | Have you considered the possibility of switching to electric heating (induction heating, energization heating, etc.) as to a combustion furnace? |
| | | | | ○ | Have you considered mixed combustion of hydrogen and ammonia as a fuel or switching of fuel?* |
| | | | | ○ | Have you considered switching to a hydrogen burner in a combustion furnace?* |
| | 4. Utilization of unused heat | | ○ | | Have you considered utilization of the waste heat from the equipment (compressor, furnace) or a building (electrical room) for heating or hot water supply? |
| | | | | ○ | Have you considered utilization of the low-temperature waste heat, etc. using a heat pump or a binary power generator (utilization of cooling water and low-temperature exhaust gas)? |

* The future fuels such as hydrogen and ammonia are the items becoming feasible after they have been introduced and spread.

## 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 FY2022".
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 content | Guide of annual energy consumption (crude oil equivalent) | Audit expense |
|---|---|---|---|
| Audit A | Menu to be audited by one expert | Less than 300 kl | ¥10,450 (tax included)*1 |
| Audit B *2 | Menu to be audited by two experts (briefing held by one expert) | 300 kl to less than 1,500 | ¥16,500 (tax included)*1 |
| Extensive audit | Menu to be audited by two experts after a prearrangement meeting (with one expert) | 1,500 kl or more | ¥23,100 (tax included)*1 |

*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)

Igarashi Building 5F, 2-11-5 Shibaura, Minato-ku, Tokyo 108-0023 Japan
Secretariat of Energy Audit, The Energy Conservation Center, Japan
Phone: +81-3-5439-9732
Fax: +81-5439-9738
E-mail: ene@eccj.or.jp

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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.

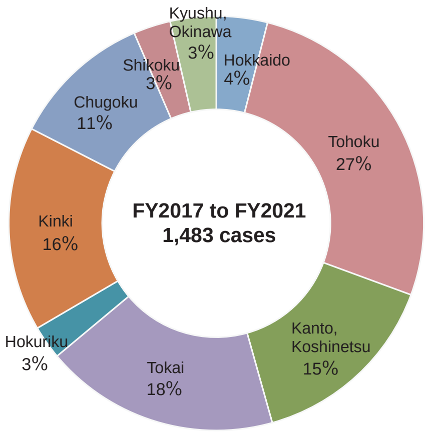
Energy audit | Search

# II Energy Audit of Factories and Results

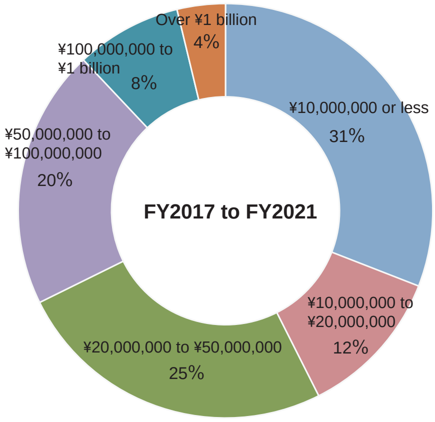
The following outlines the energy audits of factories implemented by the Energy Conservation Center, Japan. Utilize them as reference data for management of the energy consumption and energy intensity, and consideration of improvement proposals.

## 1. Outline of Audited Factories

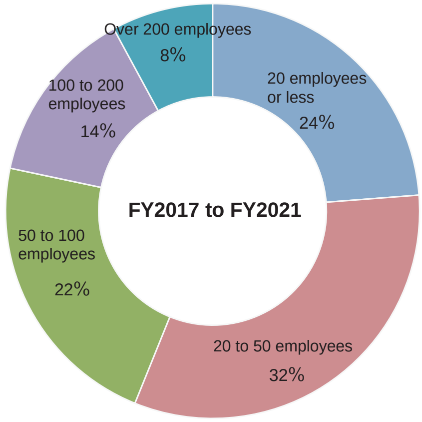
An energy conservation audit ratio of factories (FY2017 to FY2021) is shown by region and scale (capital and number of employees). For annual energy consumption (crude oil equivalent) of the factories, a histogram is used to show its distribution.



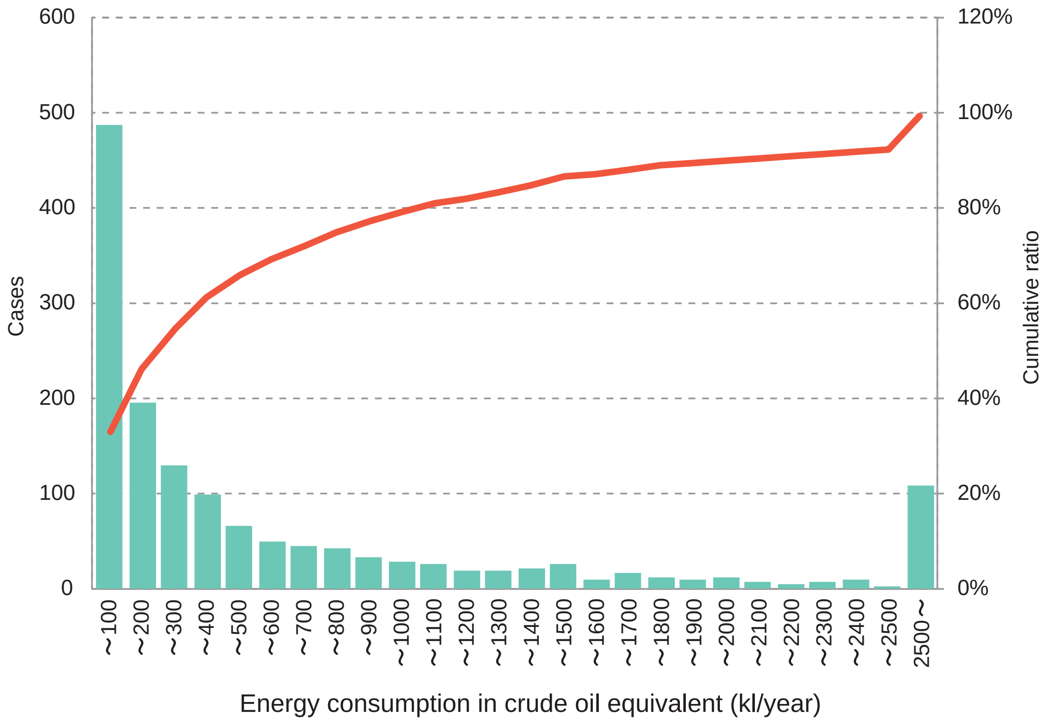

Ratio of audits by region




Ratio of audits by capital

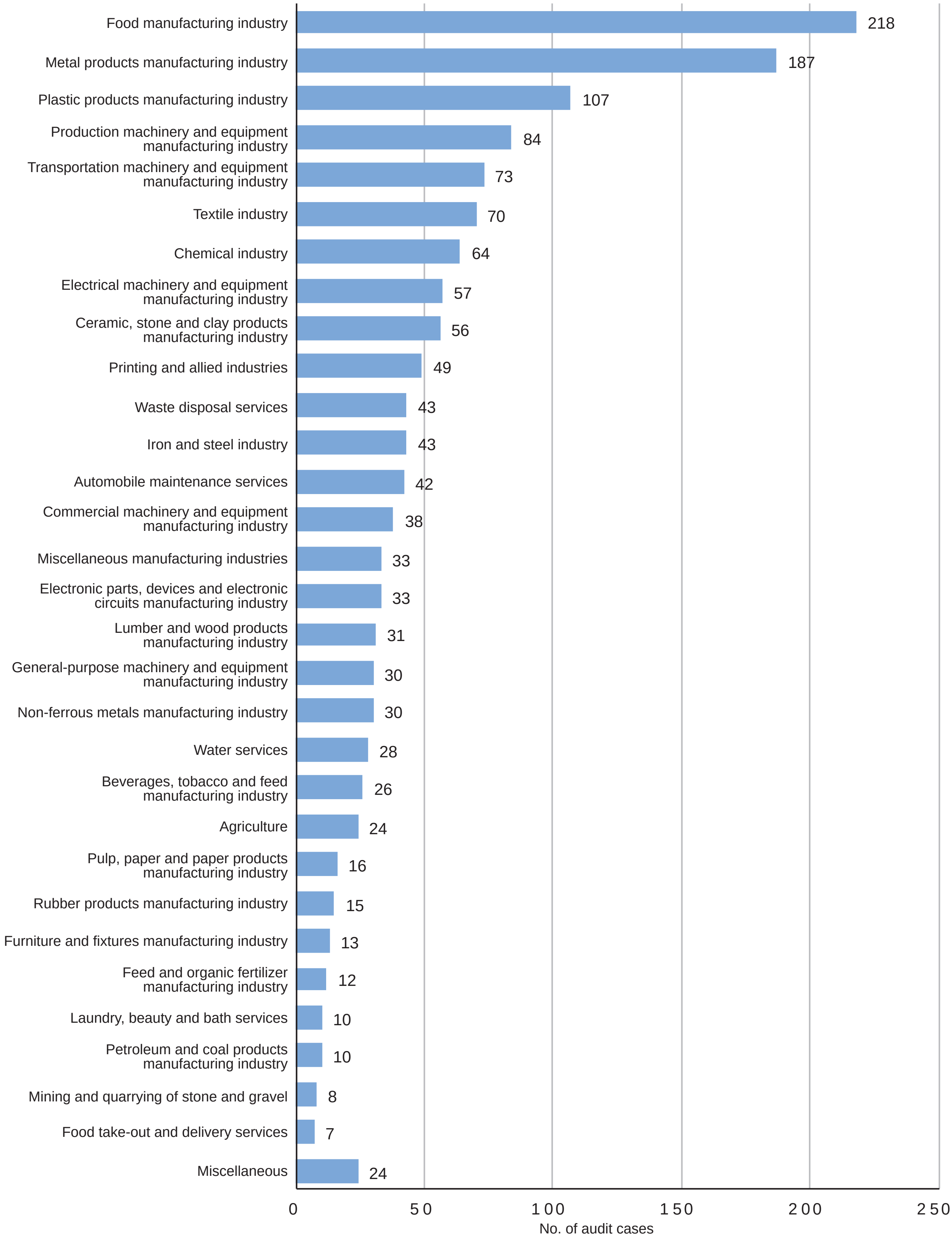



Ratio of audits by number of employees



## 2. Number of Audit Cases by Type of Industry

The following shows the number of energy audit cases (FY2017 to FY2021) by type of industry.

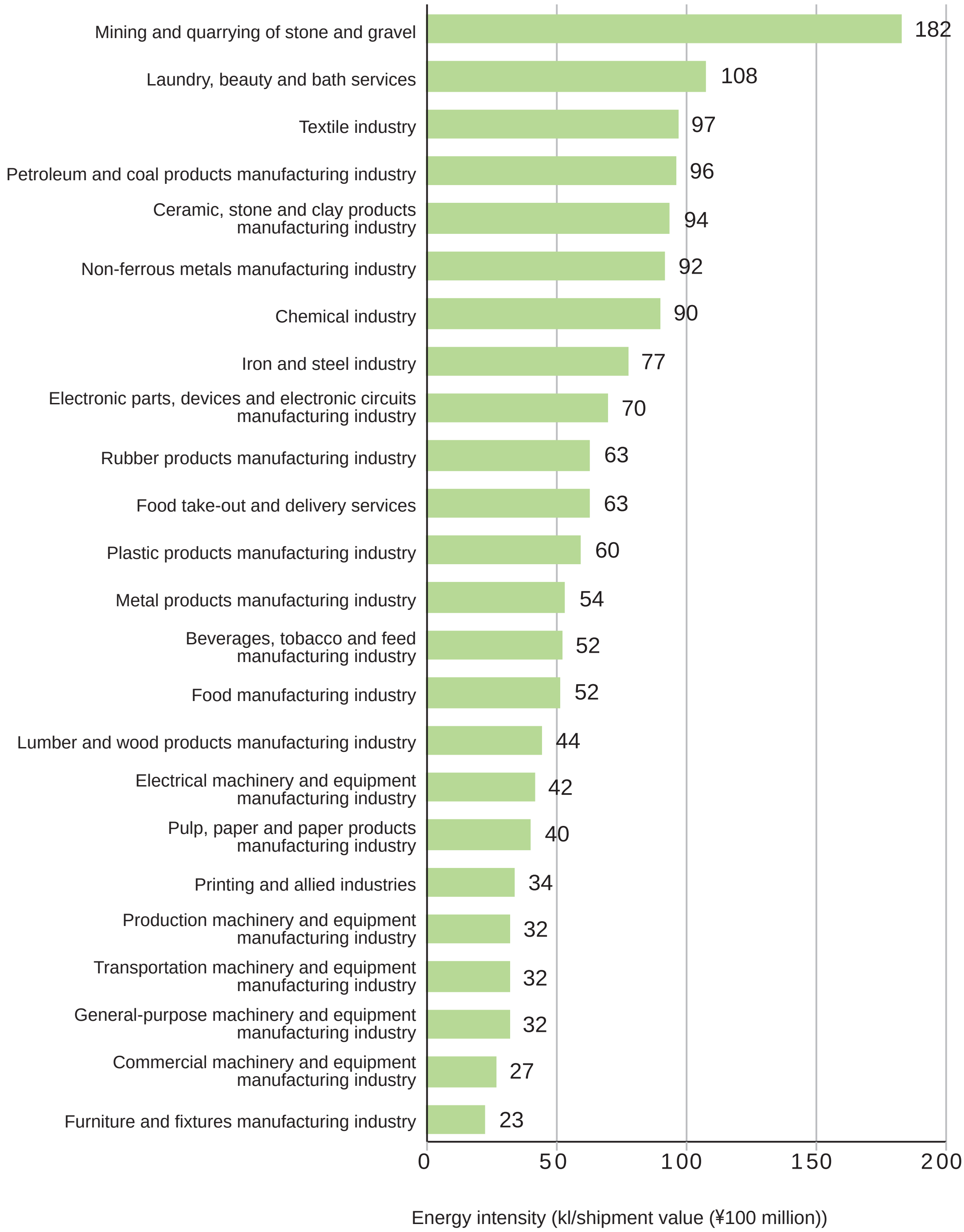


## 3. Energy Intensity by Type of Industry

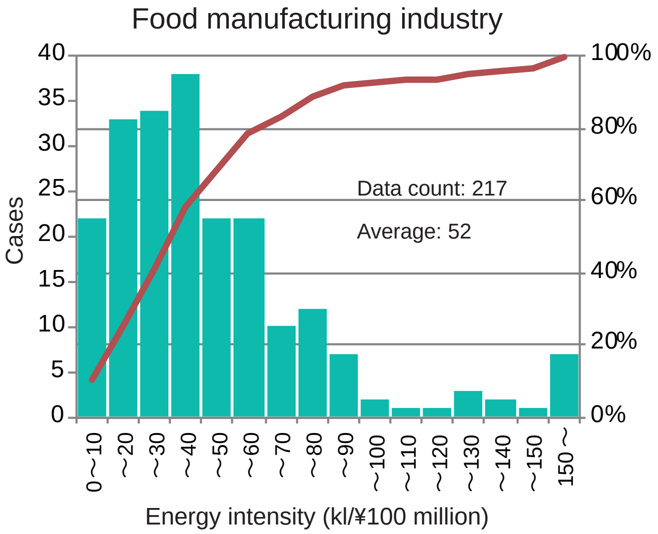
The energy intensity is an important index for evaluating the energy management status. This is indicated by energy consumption per production volume, etc. and calculated by the following formula.

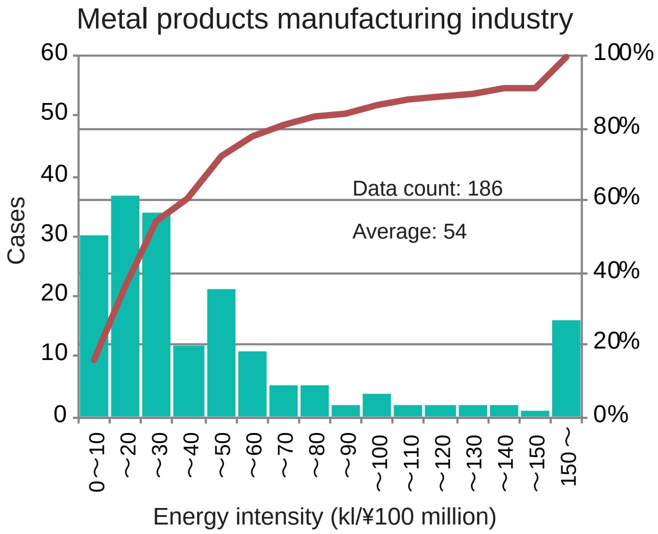
$$\text{Energy intensity} = \frac{\text{Energy consumption (kl in crude oil equivalent, etc.)}}{\text{Volume closely associated with energy consumption (production volume, shipment value, etc.)}}$$

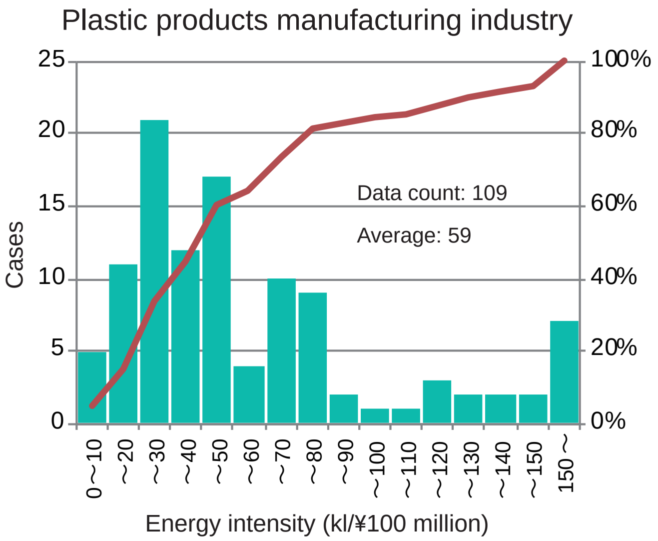
The following figure compiles energy intensity data obtained by the energy audits of factories and calculates their simple averages by type of industry. In order to use an identical index for all types of industries, a crude oil equivalent value of annual energy consumption is divided by the shipment value to be used as the index. Refer to the following values when evaluating the energy intensity of your company.

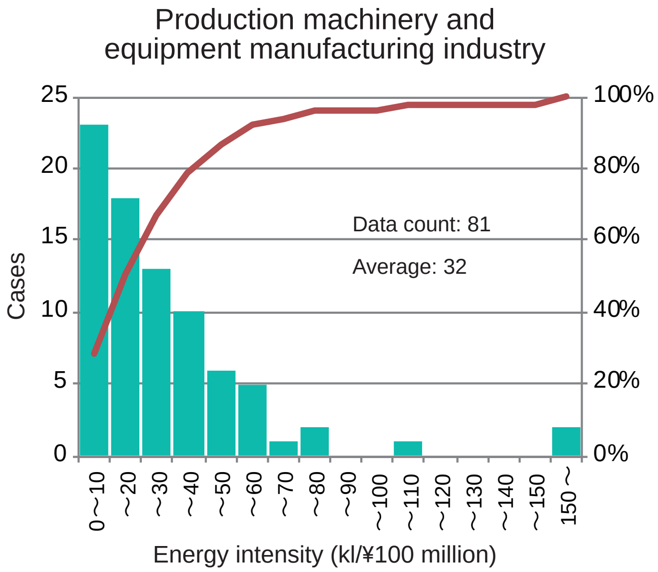


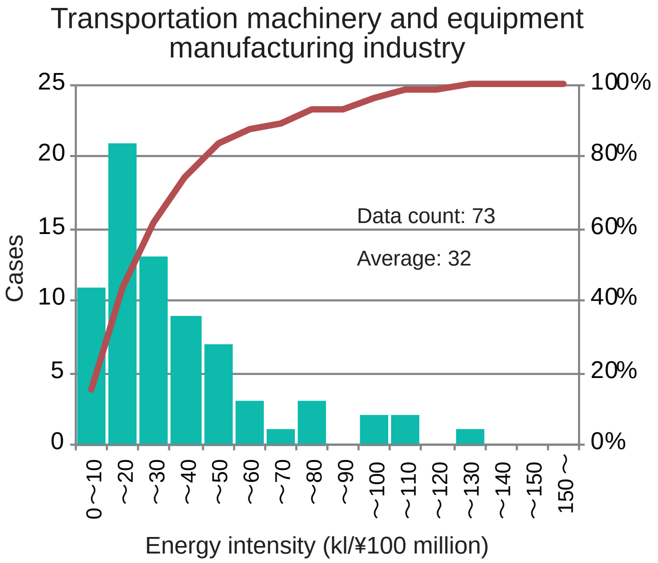
The following shows the distribution of energy intensity as to 6 types of industries with more audit cases. Even within an identical type of industry, the products range widely, resulting in a broader distribution of the energy intensity.

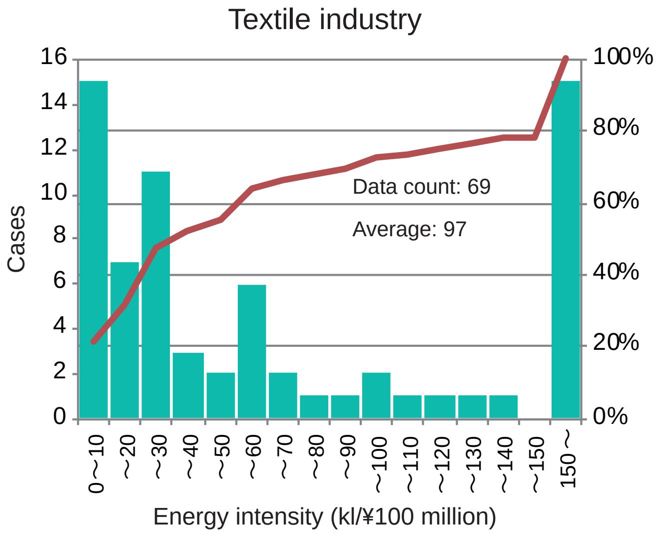


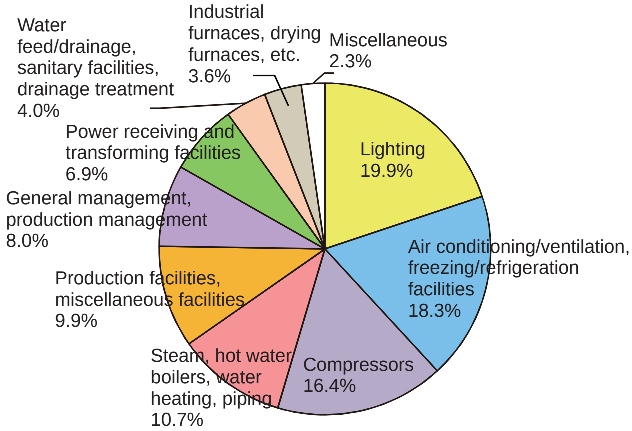



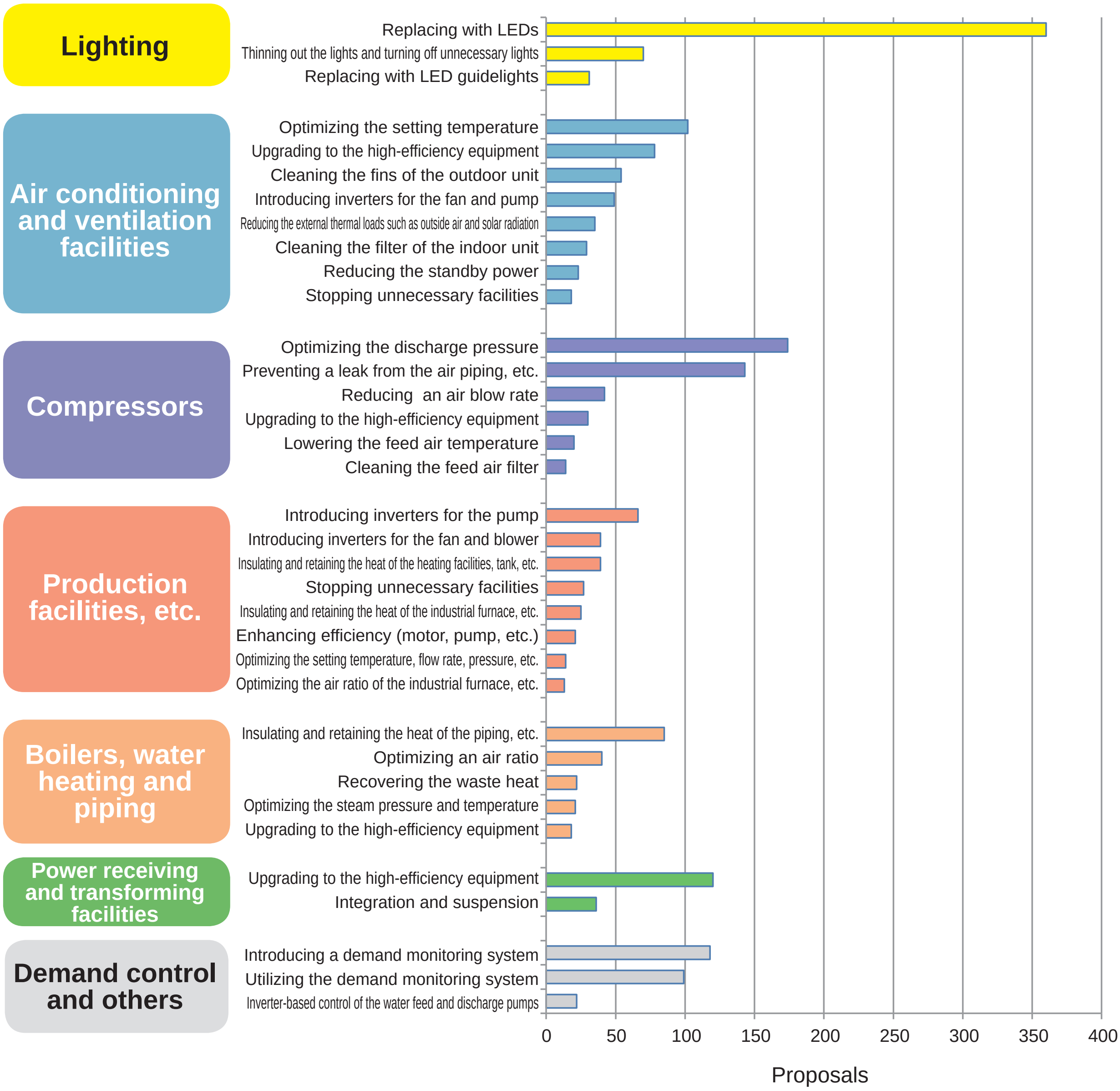



## 4. Improvement Proposal Items by Audit

After investigating the status quo of the factory, the energy audit presents an improvement proposal.
The right pie chart classifies the target facilities as to the improvement proposals by the latest factory audits.
The following table totalizes the number of cases by proposal for each classification of facilities. For your information, you can understand what kind of improvement proposals are presented more according to the facility.

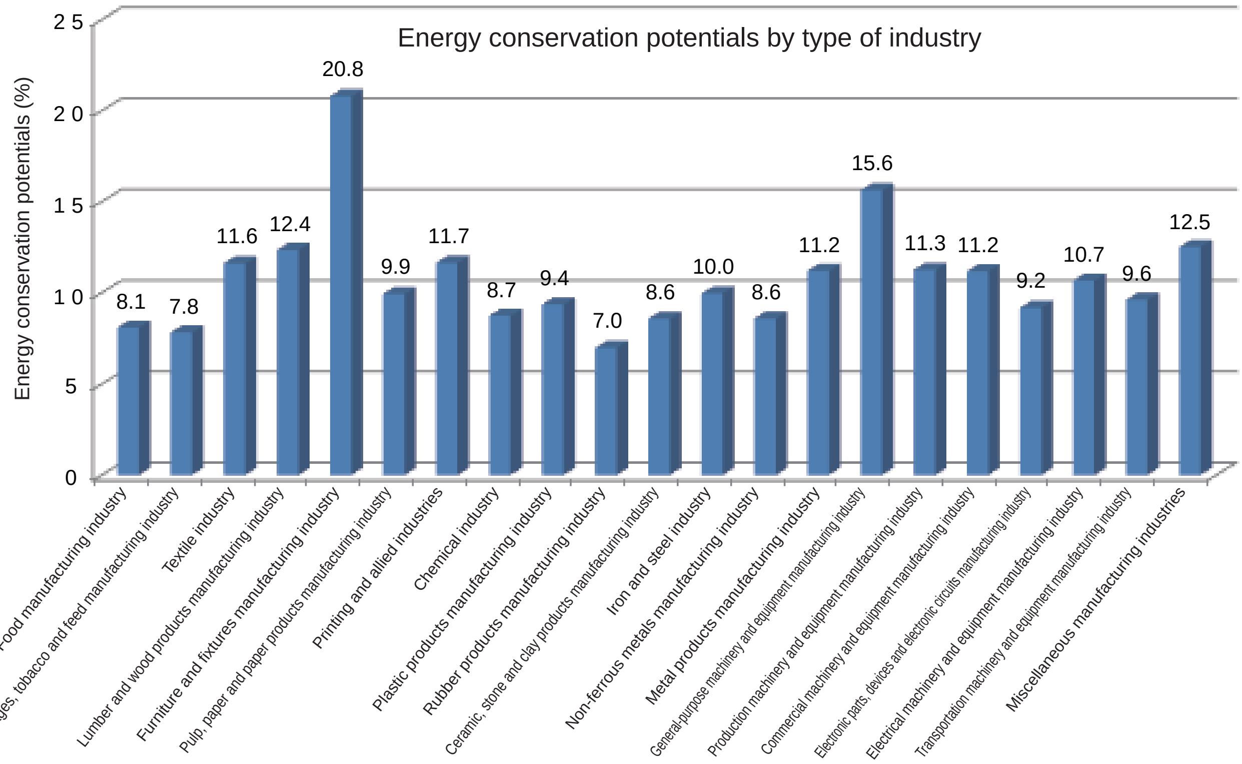



(Note) Improvement proposals by energy audits of factories



## 5. Energy Conservation Potentials by Type of Industry

The following compiles the energy conservation rate of the improvement proposals based on the energy audits for each type of industry. This energy conservation rate is a ratio of proposed energy conservation to energy consumption of the audited business establishment.
This figure shows an energy conservation potential for each type of industry, roughly ranging from 7 to 15%.




## 6. 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 Presentation Meeting for FY2022 is planned to be held in Tokyo and Osaka regions with attendance of presenters and be streamed online at a later date. 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 FY2021 (video streaming)

# 7. 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 other company in the same industry.

## Energy conservation support service

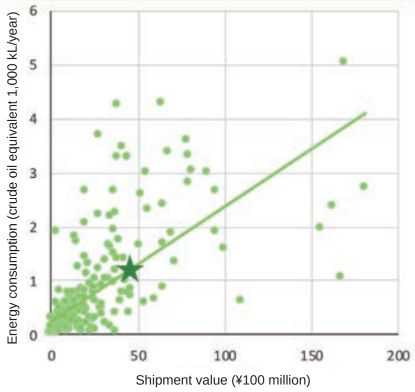
Different services are presented such as the energy optimized audit and free dispatch of lecturer. Apply for them from here.

## Self-audit tool

By inputting the information of your own facility, you can easily calculate $CO_2$ emissions and see the position of energy intensity and specific energy conservation measures with respect to other company in the same industry.

<Example of food manufacturing industry>

| Total | |
|---|---|
| Annual energy consumption (crude oil equivalent kL) | 1199.9 kL/year |
| Annual $CO_2$ emissions | 2230.5 t-$CO_2$/year |
| Scope 1 | 695.6 t-$CO_2$/year |
| Scope 2 | 1534.8 t-$CO_2$/year |




## 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 conservation animation channel

Auditing and a typical energy conservation tuning method are presented in videos for easy understanding.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# III Energy Conservation Improvement Proposals

The following describes the typical energy conservation improvement 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: Energy Conservation Activities Approached by All Employees

#### 1. Background to approaching the activities

Based on the management's conviction, "A manufacturing company should pay attention to the environment", all employees participated in the energy conservation activities, centering on visualization of energy and elimination of waste.

#### 2. Improvement measure

| Measure | Implementation items and effects |
|---|---|
| Energy conservation promotion structure (energy management structure participated by all employees), human resource development | A responsible person was decided for each management item so that all employees have their roles in the energy conservation activities, and recording and management by objective were implemented, thereby ensuring periodic assessment by a manger. |
| | All employees visited the waste disposal facilities to enhance their environmental awareness. |
| Measurement, recording, maintenance (visualization) and management of energy consumption | Power consumption was graphed by season and hour (Fig. 1). The effect of turning off the PCs and lighting during a lunch break was confirmed, leading to a motivation. |
| | The weight of waste was measured, recorded and posted for each workplace, enhancing a motivation for reduction. |
| | While all employees were implementing the energy conservation activities, they noticed different things for the first time, further promoting the activities. |
| Setting the goal | Based on the values obtained by visualization, a specific reduction goal and an activity plan were prepared through discussion. The plan was presented and the activity status was entered every 3 months and checked by a manager. |
| Posting the posters | The posters were posted for power saving, PC power-off, standby power reduction, etc. |

The activities began with the following readily practicable measures.

・Turn off unnecessary lighting.
・Utilize remote switches to thin out lighting.
・Visualize an air leak from the piping, etc. with foams to repair a leaking area.
・Utilize a reed screen or a curtain to prevent sunlight from entering the room.
・Paste an insulating sheet to a glass door.

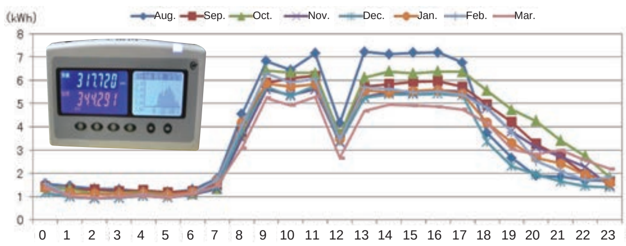



Fig. 1 Hourly average power consumption by month

#### 3. Results

The activities participated by all employees produced not only the effects of energy conservation, but also the following results.

・There was a change in the employees' environmental awareness.
・Work efficiency was improved from a viewpoint of energy conservation.
・Communications between the employees were facilitated.
・Utility costs were reduced to improve a profit rate.

## Case A-2: Approach to the Energy Conservation Activities as Part of Management Reform

### 1. Background to approaching the activities

Under the management's policy, "Enhance efficiency of production activities as well as eliminate energy waste", the energy conservation activities began with visualization of energy which leads to enhancement of the employees' awareness.

### 2. Improvement measure

| Measure | Implementation items and effects |
|---|---|
| Energy conservation promotion structure (Full-participation energy management structure) | "What is actually wasted" was shown to the employees to notify that they can do it if they try. Waste, namely power consumption on holidays, was "visualized" and it was habituated to turn off the circuit breakers on the weekends to greatly reduce power consumption on holidays (Fig. 1). |
| | As a result of quantifying the effect by implementing readily practicable matters such as turning off unnecessary lighting, controlling the air conditioner's temperature setting and operating time thoroughly, and repairing a leak from the compressed air piping, the employees were motivated to actively approach the energy conservation activities at each workplace (Fig. 2). |
| | With scores of wattmeters installed, power consumption for each facility was "visualized" by an in-house data collection system to check daily. Importance of "visualization" was realized. |
| Measurement, recording, maintenance (visualization), energy consumption management and human resource development | An "Energy Conservation Committee" was launched to clarify the scope of power management for each department, and a PDCA cycle for energy conservation was advanced for sure through power audit, improvement, monthly report, etc. |
| | Young employees were elected for the "Energy Conservation Committee" for each department and instructed by external experts. |

As a result of approaching the following readily practicable measures, there were the effects of energy conservation beyond the management's expectation.

- Turning off unnecessary lighting
- Controlling the air conditioner's setting temperature and operating time thoroughly
- Investigating and repairing an air leak from the compressed air piping
- Optimizing the compressor discharge pressure

Fig. 1 Indication for easy lights-out check


Fig. 2 Posting wasted power consumption due to air leak

### 3. Results

By visualizing actual waste to show the effects of reducing standby power, turning off unnecessary lighting, and so on, each workplace built a structure to actively approach the energy conservation activities.

Management's comment:
It is important to maintain the employees' motivation and visualize energy consumption and the results of activities. We would like to actively introduce energy-saving equipment down the road.

# B. Air Conditioning and Freezing/Refrigeration Facilities, etc.

## Case B-1: Optimizing the Setting Temperature of the Freezer

### 1. Current problem

A setting criterion of –25°C has been specified for a certain freezer where frozen foods are stored, but it is actually operated at –28°C, well below the criterion. At lower temperatures, more energy is consumed to generate the cold heat.

### 2. Improvement measure

Control the freezer temperature at the setting criterion of –25°C. The evaporation temperature of a refrigerant can be increased by increasing the setting temperature, thereby improving efficiency of the chiller and reducing power consumption.

### 3. Effect estimation

(1) Calculation formula

Current power consumption: Chiller motor capacity (kW) x Motor load factor (%) x Operating time (h/year)

Power consumption after improvement: Power consumption (status quo) x Ratio of current power to improved power

(2) Prerequisites for calculation

Chiller motor capacity: 27 kW (refrigerant: R-404A)

Motor load factor: 60%

Freezer temperature: –28°C for the moment, –25°C after improvement

Refrigerant evaporation temperature: 10°C lower than the refrigerator temperature

Refrigerant condensation temperature: 35°C

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

Ratio of current power to improved power: 88% (power ratio drops to 88% by alleviating the temperature by 3°C)

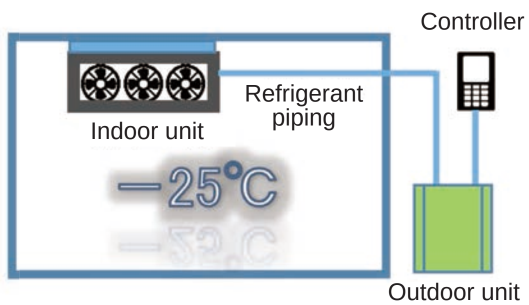



Fig. 1 Freezer

### 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | Power consumption (current) | 141,900 | kWh/year | |
| ② | Power consumption (improved) | 124,900 | kWh/year | |
| ③ | Reduced power consumption | 17,000 | kWh/year | ①−② |
| ④ | Energy conservation rate | 12 | % | ③ / ① |
| ⑤ | Saved amount of money | 323 | ¥1,000/year | ③ x ¥19/year |
| ⑥ | Reduction in crude oil equivalent | 4.4 | kL/year | ③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ |
| ⑦ | $CO_2$ reduction* | 7.7 | t-$CO_2$/year | ③ x 0.453 t-$CO_2$/1,000 kWh |

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

## Case B-2: Replacing the Air-cooled Chiller with the Heat-Cold Simultaneous Feed Heat Pump

### 1. Current problem

A certain noodle-making factory heats noodles in a 98°C boiling tank heated by a boiler and cools them in 2°C cold water in the next process. Cold water is produced by an ice heat storage system based on an air-cooled chiller, but the chiller has aged and the waste heat is not utilized.

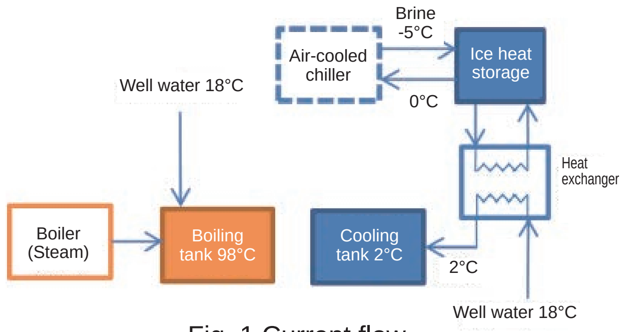



Fig. 1 Current flow

### 2. Improvement measure

Replace the aged chiller with a heat pump capable of simultaneously feeding the heat and cold (HP in Fig. 2), which has high efficiency compared with the chiller, and install a new hot water storage tank. At the same time, 18°C well water has been directly heated by boiler steam conventionally. After improvement, however, feed water is heated to 60°C by the recovery heat from cold water production using the heat pump to reduce the boiler's load, contributing to energy conservation.

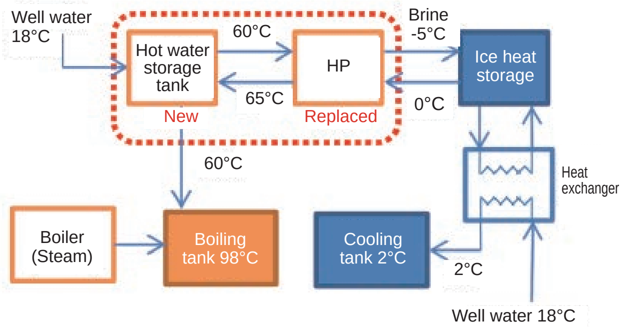



Fig. 2 Improved flow

### 3. Effect estimation

(1) Calculation formula

Power consumption: Cooling heat quantity (GJ/year) / Cooling COP / 0.0036 (GJ/kWh)

HP heating volume: Cooling heat quantity (GJ/year) / Cooling COP x Heating COP

Boiler heating heat quantity (improved): Heating heat quantity (GJ/year) – HP heating volume (GJ/year)

Fuel consumption (improved): Boiler heating heat quantity (GJ/year) / Boiler efficiency / Lower heating value of fuel (GJ/1,000 $m^3$)

(2) Prerequisites for calculation

Specific heat of water: 4.2 MJ/(t･K)

Water temperature: Well water 18°C

Cold water (2°C) volume: 6 t/h x 5 h/day x 300 days/year = 9,000 t/year

Cooling heat quantity: 9,000 t/year x (18°C – 2°C) x 4.2 MJ/t･K = 605 GJ/year

Hot water (98°C) volume: 3 t/h x 5 h/day x 300 days/year = 4,500 t/year

Heating heat quantity: 4,500 t/h x (98°C – 18°C) x 4.2 MJ/t･K = 1,512 GJ/year

Current heat source: Air-cooled chiller (COP 1.6), boiler (efficiency 85%)

Heating value of fuel (City gas 13A): Lower 40.5 GJ/1,000 $m^3$

Improved heat source: Heat pump (heating COP = 2.75, cooling COP = 1.75)

* It is assumed that there was no other increase or decrease in heat storage losses, pump power, etc.

Table 1 Status quo

| Item | | Cold water | Hot water |
|---|---|---|---|
| Required heat quantity (GJ/year) | | 605 | 1,512 |
| Air-cooled chiller (GJ/year) | Input | Cooling | Boiler |
| | 378 | 605 | 1,512 |
| COP | 1.00 | 1.60 | |

Table 2 Post-improvement status

| Item | | Cold water | Hot water | |
|---|---|---|---|---|
| Required heat quantity (GJ/year) | | 605 | 1,512 | |
| HP (GJ/year) | Input | Cooling | Heating | Boiler |
| | 346 | 605 | 952 | 560 |
| COP | 1.00 | 1.75 | 2.75 | |

## 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | Power consumption (current) | 105,000 | kWh/year | |
| ② | Fuel consumption (current) | 43.9 | 1,000 $m^3$/year | |
| ③ | Power consumption (improved) | 96,000 | kWh/year | |
| ④ | Fuel consumption (improved) | 16.3 | 1,000 $m^3$/year | |
| ⑤ | Reduced power consumption | 9,000 | kWh/year | ①−③ |
| ⑥ | Reduced fuel consumption | 27.6 | 1,000 $m^3$/year | ②−④ |
| ⑦ | Energy conservation rate | 43 | % | Calculated in crude oil equivalent |
| ⑧ | Saved amount of money | 2,986 | ¥1,000/year | ⑤ x ¥19/kWh + ⑥ x ¥102/$m^3$ |
| ⑨ | Reduction in crude oil equivalent | 34.3 | kL/year | Calculation formula omitted |
| ⑩ | $CO_2$ reduction | 65.6 | t-$CO_2$/year | Calculation formula omitted |

## [Reference] Heat pump system and COP

Fig. 3 shows a configuration of the heat pump system. A substance called a refrigerant circulates in the heat pump through a compressor, heat exchanger (condensation), expansion valve, heat exchanger (evaporation) and compressor in that order. When the refrigerant is compressed, it is turned from a gas into a liquid while emitting the heat (condensation), and when it is expanded, it is turned into the gas while absorbing the heat (evaporation). Thus, the refrigerant circulates while repeating compression and expansion (condensation and evaporation), thereby pumping up the heat from the low-temperature side to the high-temperature side.

On the cooling process side in Fig. 3, brine (antifreeze liquid like ethylene glycol solution) leaving the heat pump system at –5°C cools an object in the cooling process and returns to the heat pump system at 0°C. Because it leaves at –5°C and returns at 0°C, the heat $Q_1$ moves from the cooling process to the heat pump system.
On the heating process side, the hot water returning from the process at 60°C is heated to 65°C and returned to the process. On this side, the heat $Q_2$ moves from the heat pump system to the process.
A drive force to compress and circulate the refrigerant is input to the heat pump system as an external task L (motor drive power).

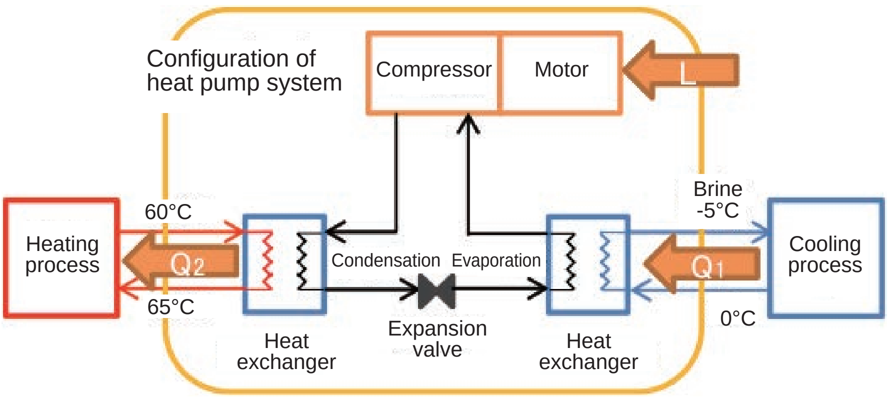



Fig. 3 Conceptual diagram of heat pump

$Q_1/L$ is referred to as a cooling COP (Coefficient of Performance) and $Q_2/L$ as a heating COP.

- COP is represented as "rated cooling & heating capacity / rated power consumption". By using the rated cooling & heating capacity and the rated power consumption in the same unit (kW or kJ/h), COP becomes a dimensionless numerical value. Because more heat is moved with respect to input as COP becomes higher, it means that the heat pump system has high performance.
- The external work L and the motor drive force W has relationship represented by "L (kJ/h) = W (kW) / 3,600" and, thus, the external work in the unit of kJ/year can be converted into the value in kW. In the case where both the power consumption and cooling & heating capacity are shown in the same unit of kW on the specifications, etc., COP can be calculated without any unit conversion.

# C. Pumps, Fans, Compressors, etc.

## Case C-1: Inverter-based Flushing Pumps

### 1. Current problem

The degreasing and flushing processes of the coating facilities have flushing pumps for shower washing of products. Currently, a flow rate is controlled with a valve and pressure losses due to the valve result in power losses.

### 2. Improvement measure

Install an inverter for the flushing pump and open the valve fully to control the flow rate by motor rotating speed. This will reduce power consumption of the pump.

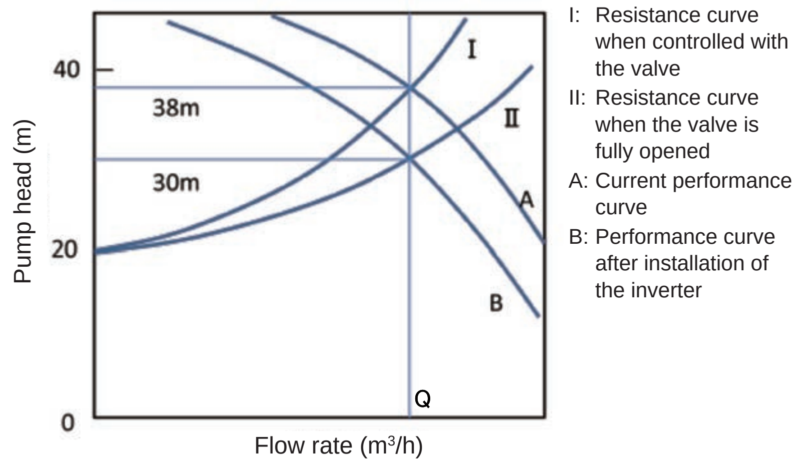



Fig. 1 Pump characteristic curve

### 3. Effect estimation

(1) Calculation formula

Current power consumption: Current power consumption of pump motor (kW) x Operating time (h/year)

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

(2) Prerequisites for calculation

Power consumption of pump motor (current): 14.3 kW

Operating time: 20 h/day x 250 days/year = 5,000 h/year

Total pump head: Currently 38 m, After improvement 30 m (The flow rate remains unchanged before and after installation of the inverter, but the total pump head is lowered by the pressure losses of the valve.)

Actual pump head (shower pressure): 20 m

Ratio of current power to improved power: 0.79

Inverter efficiency: 0.95

### 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | Power consumption (current) | 71,500 | kWh/year | |
| ② | Power consumption (improved) | 59,500 | kWh/year | |
| ③ | Reduced power consumption | 12,000 | kWh/year | ①−② |
| ④ | Energy conservation rate | 17 | % | ③ / ① |
| ⑤ | Saved amount of money | 228 | ¥1,000/year | ③ x ¥19/kWh |
| ⑥ | Reduction in crude oil equivalent | 3.1 | kL/year | ③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ |
| ⑦ | $CO_2$ reduction* | 5.4 | t-$CO_2$/year | ③ x 0.453 t-$CO_2$/1,000 kWh |

(* For the $CO_2$ emission coefficient, 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.

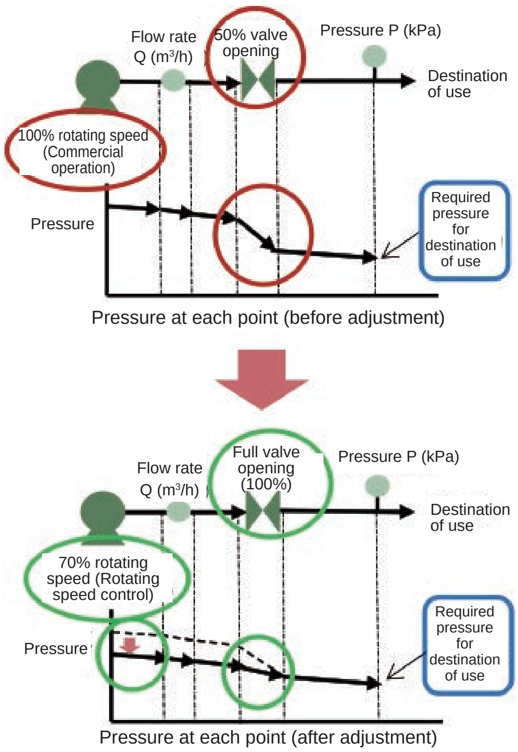


Fig. 2 Concept of inverter frequency control

(1) Tuning point
Change flow rate control from adjustment by valve opening to inverter-based control of pump rotating speed. 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. 2.)

(2) Measurement items (See Fig. 3.)
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.

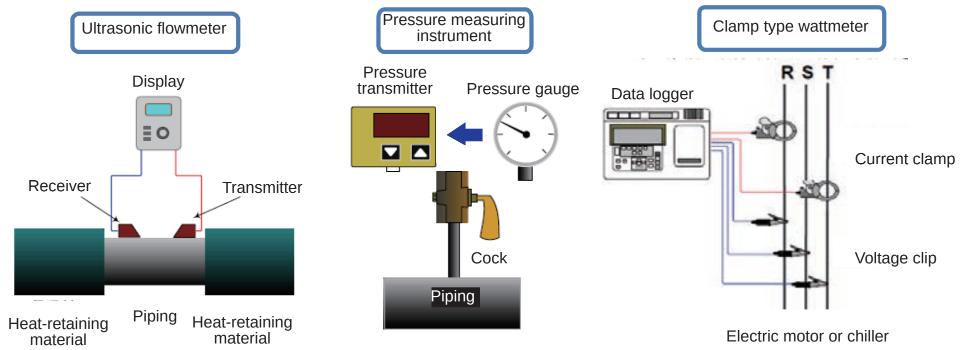


Fig. 3 Main measuring instruments
(Source: Newly published Energy Conservation Tuning Manual, The Energy Conservation Center, Japan)

(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 to the conventional flow rate.
・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.

The following page introduces an explanatory video of the detailed procedure.
https://www.shindan-net.jp/movie_ch/

# Case C-2: Preventing the Leak from the Air Piping

## 1. Current problem

A leak from the air piping is repaired at the time of daily inspection, but not measured quantitatively. The piping used for a long period has many leaks, resulting in a higher airflow rate of the compressor.

## 2. Improvement measure

Reduce compressor power by identifying a leak spot of the air piping which feeds the compressed air from the compressor to the facility using compressed air, and taking a leak preventive measure. In addition to a daily sequence of finding a leak based on air leak sound to repairing the leak, manage a leak rate* regularly; once it increases, find individual leak spots and take a measure.

* A ratio of an air outflow rate by leak to an air feed rate to the air piping

(1) Simple leak rate estimation method

A leak rate can be obtained by the following method.

①When factory operation is suspended, close all the valves on the part of the facility using the compressed air and start the compressor to boost the air pressure in the piping (Figs. 1 and 2).

②Preset $P_1$ and $P_2$ ($P_1 > P_2$) in the vicinity of the normal pressure and measure the time $t_1$ required for $P_2$ to turn to $P_1$ at the time of boosting the pressure.

③Stop the compressor (or close the main compressor valve) and measure the time $t_2$ required for $P_1$ to turn to $P_2$ at the later time of stepping down the pressure.

④Based on $t_1$ and $t_2$, the leak rate is expressed by the following formula.

Leak rate = $t_1 / (t_1 + t_2)$

In case the leak is low (Fig. 1), the piping pressure drops slowly, extending $t_2$ (if the leak is zero, $t_2$ becomes ∞). In case the leak is high (Fig. 2), on the other hand, the pressure drops rapidly, shortening $t_2$. The leak rate differs from one system to another, depending on the piping length, number of branches, number of valves, etc. Manage the leak rate, and if its value increases, find a leak spot and take a measure.

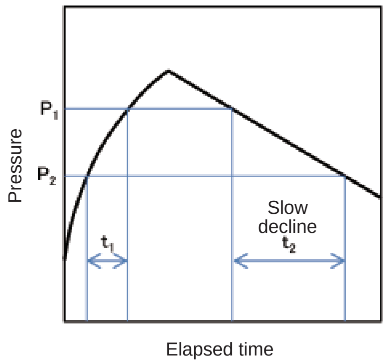



Fig. 1 Air piping leak check chart
(Normal time, with low leak amount)

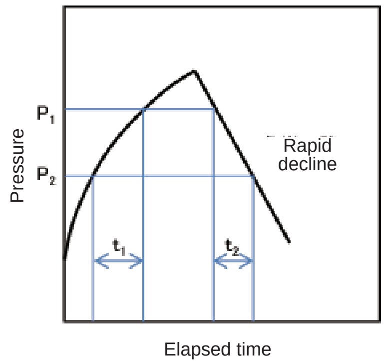



Fig. 1 Air piping leak check chart
(With high leak amount)

(2) Detection of a leak spot

Prior to detecting a leak spot, prepare an air piping system diagram so that you can see a piping system and connected equipment at a glance (Fig. 3). Find the leak spot along the air piping. Easily leaking spots include a piping joint, valve, rubber hose joint, solenoid valve, etc. To detect the leak spot, there is a method to use a leak detector designed to detect an ultrasonic wave generated at an air leak spot and to display it on a monitor, in addition to simply relying on your five physical senses (hearing, touch, etc.). Some detectors are capable of obtaining a rough leak rate at each part besed on the signal strength.

(3) Characteristics of ultrasonic detector

Some ultrasonic detectors are capable of roughly determining the leak rate at each part and displaying the values on a two-dimensional monitor. As an ultrasonic detector is typically compact and portable, it enables leak testing over an extensive range to be completed in a short period of time, and is capable of visualizing the actual conditions of leak (leak spot, leak rate, etc.) quickly.

Table 1 Air leak check - comparison between ultrasonic and other systems

| Inspection method | Daily inspection | | | Periodic inspection | |
|---|---|---|---|---|---|
| | Five physical senses | | Soap water (visual recognition using bubbles) | Equipment | |
| | Sound | Touch | | Sound (noise meter) | Ultrasonic |
| Determination of leak spot | △ | ○ | ○ | – | ◎ |
| Estimation of leak rate | △ | – | – | ○ | ◎ |
| Advantages | • No cost | • Capable of detecting even a small leak. | | • Capable of estimating a leak rate. | • Capable of displaying leak spots and leak rates on a two dimensional monitor.<br>• Capable of measuring while the equipment is operating.<br>• Portable. |
| Disadvantages | • Only large leaks can be detected.<br>• Difficult to determine a leak spot. | • Detectable only within user's reach. | • Detectable only within user's reach.<br>• Not usable in a place where water is prohibited. | • Only measurable, in principle, while equipment is stopped. | • Special instrument is required.<br>• May require service of an expert service provider. |

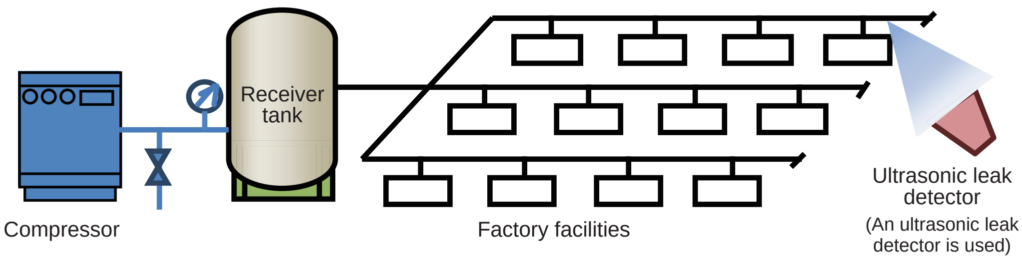



Fig. 3 Measurement of compressed air leak

## 3. Effect estimation

(1) Calculation formula

Current power consumption: Compressor motor capacity (kW) x Motor load factor (%) x Operating time (h/year)
Improved power consumption: Power consumption (current) x Ratio of current power to improved power

(2) Prerequisites for calculation

Compressor motor capacity: 37 kW (inverter-controlled)
Motor load factor: 80%
Operating time: 20 h/day x 300 days/year = 6,000 h/year
Leak rate (current): 20% (measurement result)
Leak rate (improved): 4% (If the number of leaks is reduced to prevent 80% of them, the improved leak rate is 20% x (1 – 0.8) = 4%.)
Ratio of current airflow rate to improved one: 0.84 (Fewer leaks reduce the airflow rate of the compressor.)
Ratio of current power to improved power: 0.84 (The inverter-controlled compressor controls the airflow rate with the rotating speed, and the ratio of airflow rate and power is almost same.)

## 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | Power consumption (current) | 177,600 | kWh/year | |
| ② | Power consumption (improved) | 149,200 | kWh/year | |
| ③ | Reduced power consumption | 28,400 | kWh/year | ①−② |
| ④ | Energy conservation rate | 16 | % | ③ / ① |
| ⑤ | Saved amount of money | 540 | ¥1,000/year | ③ x ¥19/kWh |
| ⑥ | Reduction in crude oil equivalent | 7.3 | kL/year | ③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ |
| ⑦ | $CO_2$ reduction* | 12.8 | t-$CO_2$/year | ③ x 0.453 t-$CO_2$/1,000 kWh |

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

The following page introduces an explanatory video of the detailed procedure.
https://www.shindan-net.jp/movie_ch/

## Case C-3: Inverter-based Scrubber Fan

### 1. Current problem

An exhaust scrubber in a factory has an airflow rate adjusted with a damper, having power losses corresponding to the pressure losses of the damper. The airflow rate is constant throughout the year, but it can be lowered on holidays because there is less generation of odor.

### 2. Improvement measure

Install an inverter for a scrubber fan and adjust the airflow rate by changing the motor rotating speed instead of using the damper. On holidays, lower the airflow rate to reduce power consumption of the fan.

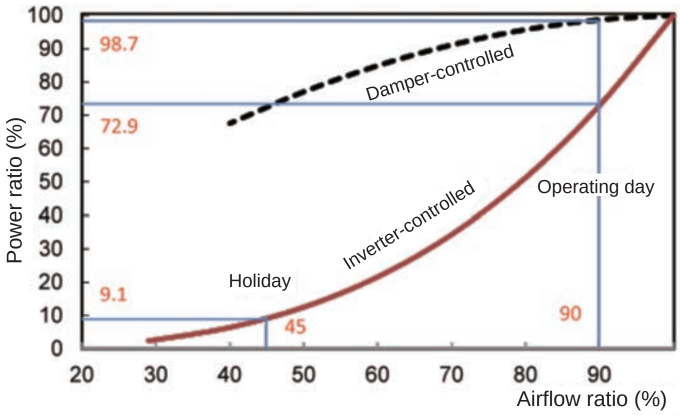



Fig. 1 Airflow ratio and power ratio of fan

### 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: 37 kW

Motor load factor 90%

Air feed ratio: Currently 90%, After improvement 90% on operating days and 45% on holidays

Power ratio: Currently 98.7%, After improvement 72.9% on operating days and 9.1% on holidays

Motor run time: Currently 8,760 h/year, After improvement 6,000 h/year on operating days and 2,760 h/year on holidays

Inverter efficiency: 0.95

Ratio of current power to improved power: 0.535 = (6,000 x 0.729 + 2,760 x 0.091) / (8,760 x 0.987)

### 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | Power consumption (current) | 287,900 | kWh/year | |
| ② | Power consumption (improved) | 162,100 | kWh/year | |
| ③ | Reduced power consumption | 125,800 | kWh/year | ①−② |
| ④ | Energy conservation rate | 44 | % | ③ / ① |
| ⑤ | Saved amount of money | 2,390 | ¥1,000/year | ③ x ¥19/kWh |
| ⑥ | Reduction in crude oil equivalent | 32.4 | kL/year | ③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ |
| ⑦ | $CO_2$ reduction* | 57.0 | t-$CO_2$/year | ③ x 0.453 t-$CO_2$/1,000 kWh |

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

# Case C-4: Reducing the Compressor Discharge Pressure

## 1. Current problem

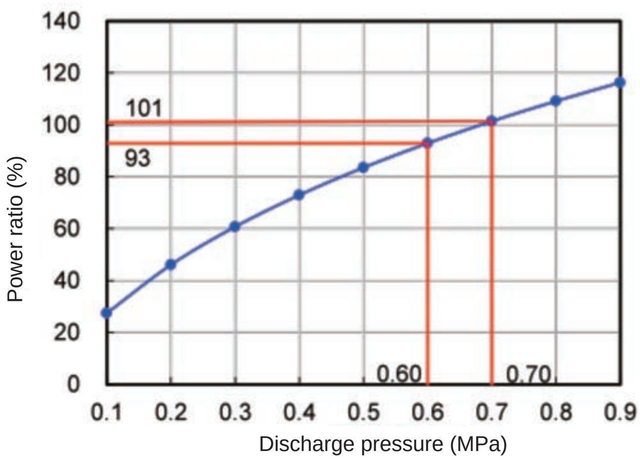
A compressor has been installed as a common air pressure source for the factory and the pressure is regulated by a reducing valve for use. The compressor consumes more electric power as the discharge pressure increases.

## 2. Improvement measure

Because the discharge pressure is higher than the required pressure, lower the former from 0.7 MPa to 0.6 MPa.
[Note] Lowering the discharge pressure is effective to the positive displacement compressors such as reciprocating and screw compressors.

## 3. Effect estimation

(1) Calculation formula
  Current power consumption: Compressor motor capacity (kW) x Motor load factor (%) x Operating time (h/year)
  Improved power consumption: Power consumption (current) x Ratio of current power to improved power
(2) Prerequisites for calculation
  Compressor motor capacity: 74 kW (37 kW x 2 units)
  Motor load factor: 80%
  Operating time: 20 h/day x 250 days/year = 5,000 h/year
  Discharge pressure: Currently 0.7 MPa → After improvement 0.6 MPa
  Ratio of current power to improved power: 0.92 = (93 / 101) See Fig. 1.




[Requirements]

| | |
|---|---|
| Suction air temperature | 20℃ |
| Suction air humidity | 60% |
| Suction pressure | -50mmAq. |
| Compression stages | 1 stage |
| Flow rate | Constant |

Fig. 1 Compressor discharge pressure vs. power consumption (theoretical values)

## 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | Power consumption (current) | 296,000 | kWh/year | |
| ② | Power consumption (improved) | 272,300 | kWh/year | |
| ③ | Reduced power consumption | 23,700 | kWh/year | ①−② |
| ④ | Energy conservation rate | 8 | % | ③ / ① |
| ⑤ | Saved amount of money | 450 | ¥1,000/year | ③ x ¥19/kWh |
| ⑥ | Reduction in crude oil equivalent | 6.1 | kL/year | ③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ |
| ⑦ | $CO_2$ reduction* | 10.7 | t-$CO_2$/year | ③ x 0.453 t-$CO_2$/1,000 kWh |

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

## 5. Implementation of the proposal and tuning

To reduce the discharge pressure, there are measures on the part of using the compressed air (reducing and optimizing the required pressure of each equipment, reducing the piping resistance, preventing a leak, and so on), but the following describes a method for regulating the discharge side while monitoring the end pressure.

(1) Tuning points
Measure the discharge pressure and flow rate of the compressor, and the end pressure of the piping, and check whether the discharge pressure can be lowered. If the consumption of the compressed air fluctuates, consider with the data at the highest consumption. When the destination of use is diversified and the timing is unknown, it is necessary to continuously measure and record.

(2) Measurement items

- Pressure (compressor discharge pressure, end pressure of the piping)
  Measurement is imperative. If a pressure gauge is not available, find a spot such as a drain port or a purge line, where the pressure can be extracted.
- Electric power
  A clamp type wattmeter, etc. is convenient, which combines a clamp ammeter and voltage measurement with a clip. An airflow rate can be estimated from an electric power value, using the characteristic curve of the compressor. When multiple compressors are used, record individual electric powers.

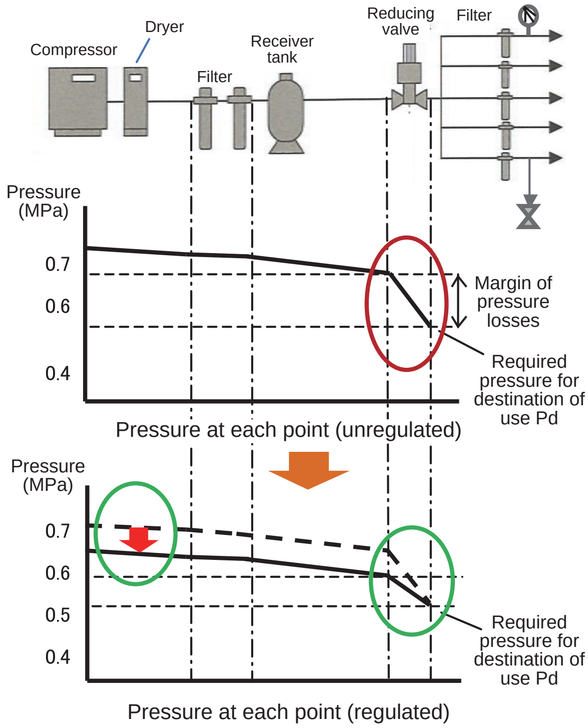


Fig. 2 Reduction of compressor discharge pressure

(3) Tuning procedure

①Preparation (understanding of the status quo)

- Prepare an air piping system diagram to check and record the current valve (reducing valve) opening, etc.
- Continue measurement during a pressure fluctuation period in order to grasp the pressure fluctuations of the compressor.
- When the working pressure fluctuates from one product to another, make measurement during the maximum working pressure period.
- Record the production requirements such as a type of product and a production volume.
- Based on the trends of pressure and flow rate, check a difference between the discharge pressure and the end pressure, a margin and stability for the required pressure, pressure fluctuations at the time of a sharp increase of the flow rate, and so on to determine the reduction range of the discharge pressure.
- When there is a large difference between the discharge pressure and the end pressure, and it is throttled with the reducing valve, there is a potential to lower the discharge pressure, which corresponds to a margin of pressure regulation with the reducing valve.
- When there is a large pressure difference without much throttling with the reducing valve, it is likely that the piping size is small in comparison with the flow rate, or that the inside of the piping has been contaminated more.
- By forecasting the discharge pressure and compressor's electric energy for each operating condition throughout the year, it is possible to forecast reduced electric energy when the compressor discharge pressure is lowered.

②Implementation

- Lower the discharge pressure in two steps or so, not at once. When this is done, regulate the reducing valve as well.
- Patrol periodically to check for any abnormality during implementation of tuning.

The following page introduces an explanatory video of the detailed procedure.
https://www.shindan-net.jp/movie_ch/

# Case C-5: Replacing the Compressor with the Roots Blower

## 1. Current problem

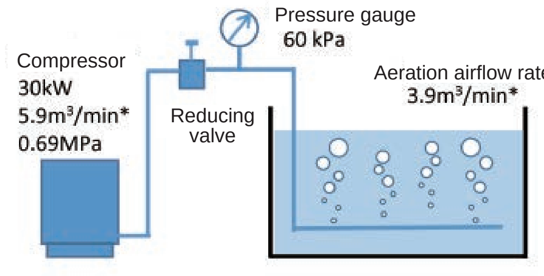
The aeration air of a drainage treatment tank (required pressure of about 60 kPa (0.06 MPa)) is fed by the compressor (discharge pressure of 0.69 MPa), wasting pressurization energy.

## 2. Improvement measure

Replace the compressor with a roots blower because the pressure of about 60 kPa required for aeration is obtained from the roots blower. It is operable at lower power because the discharge pressure is low. Use a pulley or an inverter to regulate an airflow rate of the roots blower.
Machines for compressing air are classified into fans, blowers, and compressors depending on the degree of pressure increase, with the definitions listed below.

- Fans: Either the discharge pressure is less than 10 kPa, or the pressure ratio is less than 1.1
- Blowers: Either the discharge pressure is 10 kPa or higher and less than 0.1 MPa, or the pressure ratio is 1.1 or higher and less than 2.0
- Compressors: Either the discharge pressure is 0.1 MPa or higher, or the pressure ratio is 2.0 or higher

For example, in a case where a required pressure in an aeration tank is 60 kPa, it is recommended to select a blower (pressure range: 10 to 100 kPa).
A roots blower has an integrated rotor for air compression, is made with a simple structure, emits low noises, and operates at a high efficiency. It is commonly used as the aeration equipment for wastewater treatment.




* Airflow rate in the standard suction condition (20°C, absolute pressure = 101.3 kPa, relative humidity = 65%)

Fig. 1 Current operating condition of aeration tank

## 3. Effect estimation

(1) Calculation formula

Current power consumption: Compressor motor capacity (kW) x Power ratio x Operating time (h/year)

Improved power consumption: Roots blower motor capacity (kW) x Aeration airflow rate (m³/min) / Rated flow rate (m³/min) x Operating time (h/year)

(2) Prerequisites for calculation

Compressor: 30 kW, 0.69 MPa, 5.9 m³/min
Current aeration tank inlet pressure: 60 kPa
Aeration airflow rate: 3.9 m³/min
Compressor airflow ratio: 3.9 m³/min / 5.9 m³ = 66.1%
Compressor power ratio: 90% (See Fig. 2.)
Roots blower motor capacity: 11 kW
Roots blower rated pressure: 60 kPa
Roots blower rated flow rate: 6.1 m³/min
Operating time: 8,760 h/year

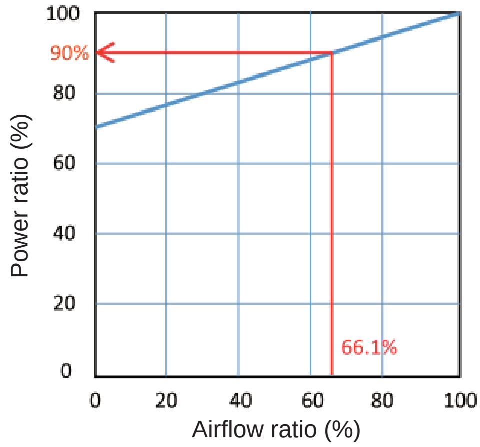



Fig. 2 Compressor (suction throttle control) power ratio

## 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | Power consumption (current) | 236,500 | kWh/year | |
| ② | Power consumption (improved) | 61,600 | kWh/year | |
| ③ | Reduced power consumption | 174,900 | kWh/year | ①−② |
| ④ | Energy conservation rate | 74 | % | ③ / ① |
| ⑤ | Saved amount of money | 3,323 | ¥1,000/year | ③ x ¥19/kWh |
| ⑥ | Reduction in crude oil equivalent | 45.0 | kL/year | ③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ |
| ⑦ | $CO_2$ reduction* | 79.2 | t-$CO_2$/year | ③ x 0.453 t-$CO_2$/1,000 kWh |

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

# Case C-6: Pulsed Air Blow

## 1. Current problem

Company A, a plastic products manufacturer, continuously blows the air to remove plastic refuse, but the compressor power has been increasing.

## 2. Improvement measure

Change an on-going continuous blow to a pulsed blow. A compressor airflow rate can be lowered by 50% without affecting a blow effect. Some pulsing equipment is opened and closed by only air feed to generate a pulsed blow without requiring the power supply.

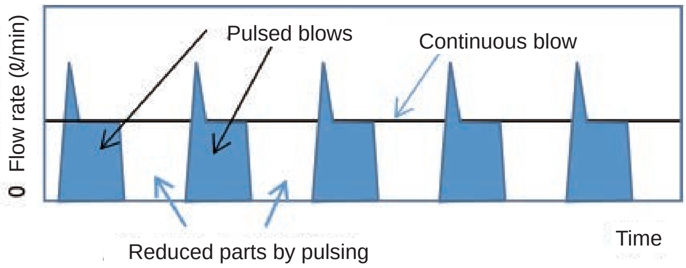



Fig. 1 Continuous blow vs. pulsed blow
(Source: FY2012 Successful Cases of Energy Conservation Grand Prize)

## 3. Effect estimation

(1) Calculation formula

Current power consumption: Unimproved nozzle blow rate ($m^3$/h/nozzle) x No. of nozzles x Blow time (h/year) x Rated compressor specific power (kW/$m^3$/h)

Improved power consumption: Power consumption (current) x Compressor power ratio (%)

(2) Prerequisites for calculation

Unimproved nozzle blow rate: 12 $m^3$/h/nozzle (200 ℓ/(min▪ nozzle))

No. of nozzles: 5

Compressor specific power: 0.164 kW/$m^3$/h (9.8 kW/$m^3$/min)

Compressor power ratio: 85% (at 50% lower airflow rate by suction throttle control)

Annual blow time: 10 h/day x 360 days/year = 3,600 h/year

## 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | Power consumption (current) | 35,400 | kWh/year | |
| ② | Power consumption (improved) | 30,100 | kWh/year | |
| ③ | Reduced power consumption | 5,300 | kWh/year | ①−② |
| ④ | Energy conservation rate | 15 | % | ③ / ① |
| ⑤ | Saved amount of money | 101 | ¥1,000/year | ③ x ¥19/kWh |
| ⑥ | Reduction in crude oil equivalent | 1.4 | kL/year | ③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ |
| ⑦ | $CO_2$ reduction* | 2.4 | t-$CO_2$/year | ③ x 0.453 t-$CO_2$/1,000 kWh |

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

# D. Boilers, Industrial Furnaces, etc.

## Case D-1: Thermal Insulation for the Steam Valve

### 1. Current problem

The steam valve of a steam header in a boiler room is not provided with thermal insulation, resulting in useless heat dissipation.

### 2. Improvement measure

Attach a detachable thermal insulation jacket to the bare steam valve to prevent heat dissipation and save energy.

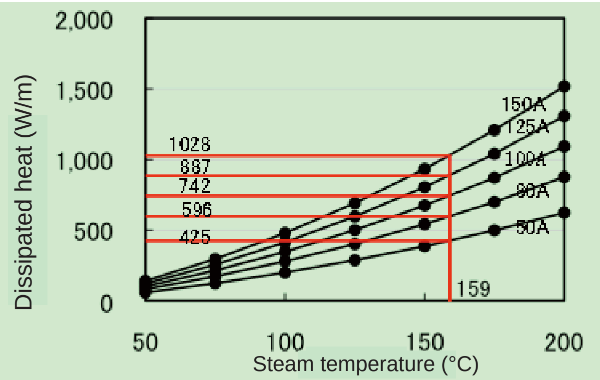


Fig. 1 Dissipated heat from bare steam piping
(Calculation requirements: Horizontal pipe, natural convection, ambient temperature = 20°C, emissivity $\varepsilon$ = 0.7)


Fig. 2 Example of thermal insulation of steam header valve

### 3. Effect estimation

(1) Calculation formula

Reduction of heat losses by thermal insulation: Σ {Valve length equivalent to straight pipe (m/pc.) x Dissipated heat from bare steam pipe (W/m) x No. of valves} x Thermal insulation efficiency (%) x Operating time (h/year)

Fuel reduction: Reduction of heat losses by thermal insulation / Lower heating value of fuel / Boiler efficiency (%)

Table 1 Dissipated heat of piping

| No | Name | Size | Qty. | Length equivalent to straight pipe(Note 1) | Dissipated heat/m(Note 2) | | Dissipated heat |
|---|---|---|---|---|---|---|---|
| | | | (pcs.) | (m/valve) | (W/m) | (MJ/m·h) | (MJ/h) |
| 1 | Flange type globe valve 10 kg/cm² | 150A | 7 | 1.50 | 1028 | 3.70 | 38.9 |
| 2 | | 125A | 1 | 1.40 | 887 | 3.19 | 4.5 |
| 3 | | 100A | 4 | 1.27 | 742 | 2.67 | 13.6 |
| 4 | | 80A | 2 | 1.25 | 596 | 2.15 | 5.4 |
| 5 | | 50A | 2 | 1.11 | 425 | 1.53 | 3.4 |
| | | | | | | Total | 65.8 |

Note 1: Datasheet for energy management (The Energy Conservation Center, Japan)
Note 2: See Fig. 1 for the dissipated heat/m.

(2) Prerequisites for calculation

Steam pressure and temperature (saturation): 0.5 MPa-G, 159°C
Thermal insulation efficiency: 89%
Boiler efficiency: 85%
Operating time: 2,400 h/year
Lower heating value of fuel: 40.5 MJ/m³ (City gas 13A)

## 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | Reduced fuel consumption | 4,100 | $m^3$/year | |
| ② | Energy conservation rate | - | % | |
| ③ | Saved amount of money | 418 | ¥1,000/year | ① x ¥102/$m^3$ |
| ④ | Reduction in crude oil equivalent | 4.7 | kL/year | ① x 44.8 MJ/$m^3$ x 0.0258 kL/GJ |
| ⑤ | $CO_2$ reduction | 9.2 | t-$CO_2$/year | ① x 44.8 MJ/$m^3$ x 0.0136 x (44 / 12) t-$CO_2$/GJ |

## 5. Thermal images (infrared thermography)

Fig. 3 and Fig. 4 show the examples of thermal images of the bare steam piping around the boiler. Some non-contact radiation thermometers digitally measure the spot temperature. To find a high-temperature area, there are those capable of measuring in the form of image.

<Examples of thermal images of bare steam piping>

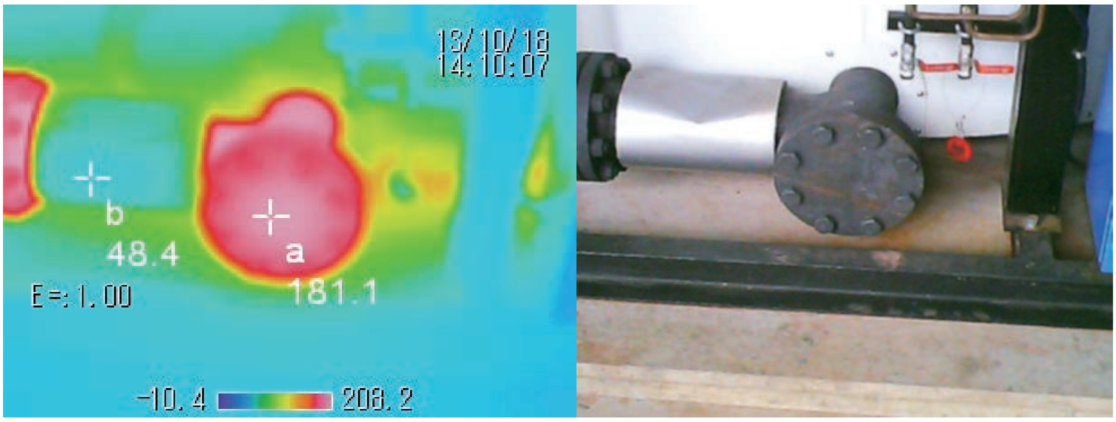



Fig. 3 Side flange area of boiler

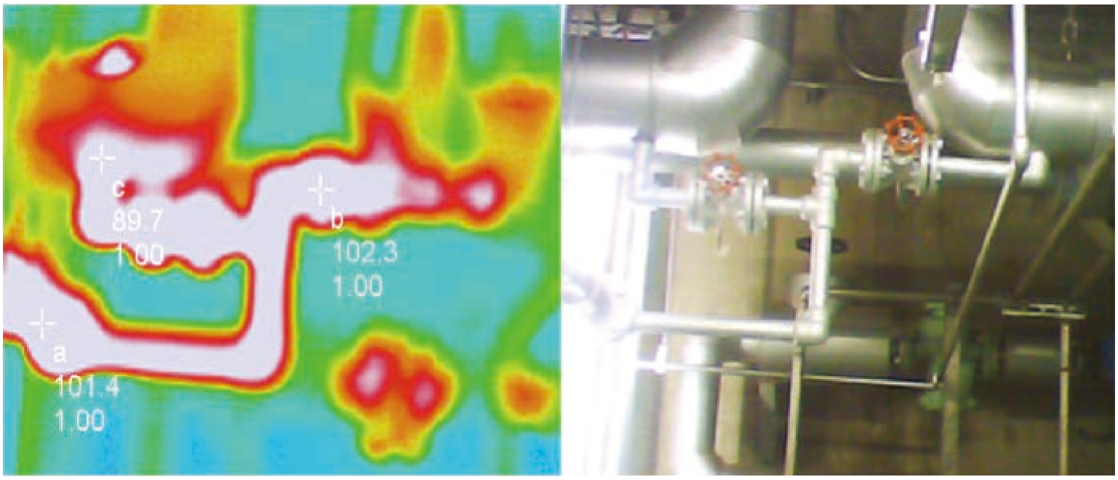



Fig. 4 Steam trap

# Case D-2: Replacing the Boiler for Higher Efficiency

## 1. Current problem

The current heavy oil-fired water tube boiler is inefficient and produces a lot of $CO_2$. It was installed more than 30 years ago and has greatly aged.

## 2. Improvement measure

Considering a deteriorated heavy oil tank and piping, switch a fuel to city gas taking account of low carbonization and introduce a small once-through boiler which has high efficiency and can control a load easily. Also, the facilities with a remote monitoring function are capable of always monitoring the operational status of the boiler to alarm at the time of an error, browsing and managing boiler operation data via the Internet network by the IoT technology. Controlling steam loads while maintaining high efficiency is also possible using unit number control, etc.

## 3. Effect estimation

(1) Calculation formula

Current boiler output (GJ/year): Current fuel consumption (kL/year) x Lower heating value of heavy oil A x Current boiler efficiency (GJ/kL)

Improved fuel consumption (1,000 $m^3$/year): Boiler output (GJ/year) / Lower heating value of city gas 13A (GJ/1,000 $m^3$) / Renewed boiler efficiency

(2) Prerequisites for calculation

Current fuel consumption: 600 kL/year (heavy oil A)

Fuel heating value (lower): 37.1 GJ/kL (heavy oil A), 40.5 GJ/1,000 $m^3$ (city gas 13A)

Boiler efficiency (average): 80% (current), 96% (renewed)

## 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | Fuel consumption (current) | 600 | kL/year | Heavy oil A |
| ② | Fuel consumption (improved) | 458 | 1,000 $m^3$/year | City gas 13A |
| ③ | Energy conservation rate | 12.8 | % | Crude oil equivalent basis |
| ④ | $CO_2$ reduction rate | 36.7 | % | 598 / (① x 39.1 GJ/kL x 0.0189 x (44 / 12) t-$CO_2$/GJ) x 100 |
| ⑤ | Saved amount of money | 3,684 | ¥1,000/year | ① x ¥84/L – ② x ¥102/$m^3$ |
| ⑥ | Reduction in crude oil equivalent | 75.9 | kL/year | (① x 39.1 GJ/kL – ② x 44.8 GJ/1,000 $m^3$) x 0.0258 kL/GJ |
| ⑦ | $CO_2$ reduction | 603 | t-$CO_2$/year | (① x 39.1 GJ/kL x 0.0189 – ② x 44.8 GJ/1,000 $m^3$ x 0.0136) x (44 / 12) t-$CO_2$/GJ |

### [Reference] Small once-through boiler

As shown in Fig. 1, feed water pressurized by a pump is heated, evaporated and overheated in a generating tube, flows into a steam-water separator, and is separated into steam and water. A start-up time is short because of a structure retaining less water. In the case of the state-of-the-art model, followability to load fluctuations has been enhanced by advanced control, in which an operable range is expanded (load factor: 20% to 100%) due to, for example, the turndown ratio expanded to 1:5 and a shift from unit number control and multi-position control systems to a proportional control system is achieved.

Small once-through boilers, which are provided with a SUS economizer preheating feed water with exhaust gas, have high efficiency, and some gas-fired boilers, which particularly have almost no sulfur content in their fuel, recover the waste heat until the exhaust gas temperature drops below a dew point and exceed 98% in terms of rated boiler efficiency.

An evaporation volume is about 2 to 3 t/h. They are newly introduced and widely used as a replacement for a large water-tube boiler, by installing them more than 10 units.

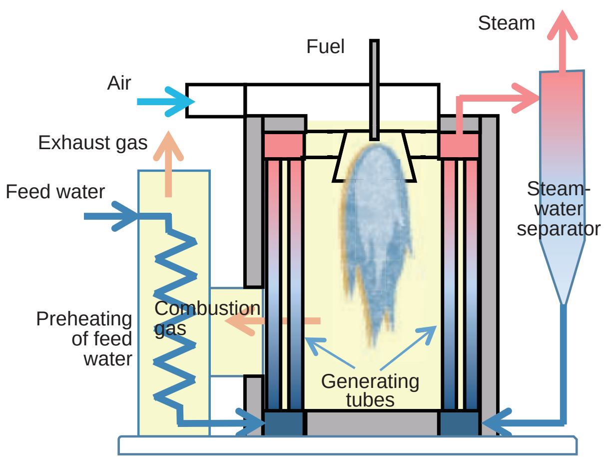



Fig. 1 Small once-through boiler

# Case D-3: Recovering the Steam Drain

## 1. Current problem

Drain discharged from a mold steam heater is supposed to be returned into a tank via the piping. However, the drain is not recovered because impurities flowing out of the heater accumulated in the tank.

## 2. Improvement measure

Clean inside of the drain tank, the mold, and the drain recovery piping in order to remove the impact of the impurities, apply the high-temperature-resistance coating inside the tank to prevent rust, and implement the continuous drain recovery.

## 3. Effect estimation

(1) Calculation formula

Current fuel consumption: Heavy oil A 340 kL/year, Lower heat quantity of heavy oil A 37.1 MJ/L

Boiler evaporation volume (= Steam consumption): Current fuel consumption x Lower heating value of fuel x Boiler efficiency / (Main-steam temperature rise specific enthalpy)

Drain recovery rate: Drain recovery volume (t/year) / Boiler evaporation volume (t/year)

Effective drain recovery heat quantity (GJ/year): Drain recovery volume x (Recovered drain specific enthalpy – Feed water specific enthalpy) x (1 – Blow rate)

Fuel reduction (kL/year): Effective drain recovery heat quantity / (Boiler efficiency x Lower heating value of fuel)

(2) Prerequisites for calculation

Boiler evaporation volume: 340 kL/year x 37.1 MJ/L x 0.8 x 1000 / (2768.4 kJ/kg – 83.9 kJ/kg) = 3759.1 t/year (Major steam pressure: 0.7 MPa-G, Boiler efficiency: 80%, Feed water temperature: 20°C, Specific enthalpy: 83.9 kJ/kg)

Drain recovery rate and temperature: 50%, 75°C (Specific enthalpy: 314.0 kJ/kg)

Effective drain recovery heat quantity: 3759.1 t/year x 0.5 = 1879.6 t/year, Blow rate 10%

Fuel reduction: 389246 / (0.8 x 37.1) = 13115 L/year ≒ 13.1 (kL/year)

## 4. Effects

| | | | | | |
|---|---|---|---|---|---|
| ① | Fuel consumption (current) | | 340 | kL/year | |
| ② | Reduced fuel consumption | | 13.1 | kL/year | |
| ③ | Energy conservation rate | | 3.85 | % | ② / ① x 100% |
| ④ | Saved amount of money | (Heavy oil A volume) | 1,100 | ¥1,000/year | ② x ¥84/L |
| | | (Feed water volume) | 940 | ¥1,000/year | Saved feed water volume: 1,880 kL/year x Unit price of tap water: ¥500/kL |
| | | (Total) | 2,040 | ¥1,000/year | |
| ⑤ | Reduction in crude oil equivalent | | 13.2 | kL/year | ② x 39.1 GJ/kL x 0.0258 kL/GJ |
| ⑥ | $CO_2$ reduction | | 35.5 | t-$CO_2$/year | ② x 39.1 GJ/kL x 0.0189 x (44 / 12) t-$CO_2$/GJ |

## Case D-4: Improvement of Combustion Air Ratios of Industrial Furnaces

### 1. Current problem

A steel heating furnace uses a city gas as a fuel. Currently, the air ratio is excessive (high oxygen concentration in an exhaust gas) and an exhaust gas volume increases, resulting in large energy losses.

### 2. Improvement measure

Strengthen combustion control to adjust the air ratio to an appropriate value and enhance energy conservation.

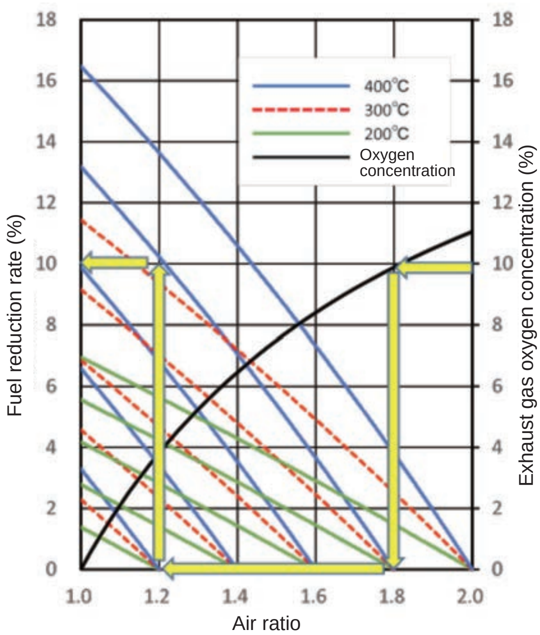



Fig. 1 Air ratio reduction effect (13A city gas)

<Reading the graph>
The current exhaust gas has 9.8% oxygen concentration and its temperature is 400°C.

①Read the air ratio 1.8 on the horizontal axis of the graph from the exhaust gas oxygen concentration 9.8% on the right axis of the graph.

②Read the fuel reduction rate 10% on the left axis of the graph corresponding to the air ratio 1.2 in the fuel reduction rate curve of the exhaust gas temperature 400°C, which starts from the air ratio 1.8 on the horizontal axis of the graph.

### 3. Effect estimation

(1) Calculation formula

Fuel reduction = Current fuel consumption (m³/year) x Fuel reduction rate (%)

(2) Prerequisites for calculation

Current fuel consumption: City gas 50,000 m³/year

Exhaust gas oxygen concentration: Currently 9.8% (air ratio 1.8), After improvement 3.7% (air ratio 1.2) according to Fig. 1, Exhaust gas temperature 400°C

Fuel reduction rate: 10% according to Fig. 1

### 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | Fuel consumption (current) | 50,000 | m³/year | |
| ② | Reduced fuel consumption | 5,000 | m³/year | |
| ③ | Energy conservation rate | 10 | % | See Fig. 1. |
| ④ | Saved amount of money | 510 | ¥1,000/year | ② x ¥102/m³ |
| ⑤ | Reduction in crude oil equivalent | 5.8 | kL/year | ② x 44.8 GJ/1,000 m³ x 0.0258 kL/GJ |
| ⑥ | $CO_2$ reduction | 11.2 | t-$CO_2$/year | ② x 44.8 GJ/1,000 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 ratios as listed in Table 1 as to combustion management of the industrial furnaces.

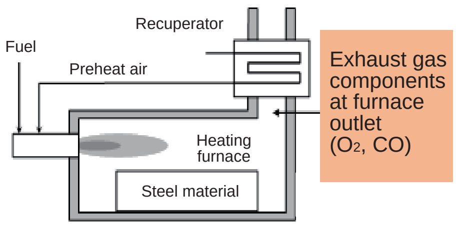
Table 1 Standard air ratios on industrial furnaces (excerpts*1)

| Category*2 | Gaseous fuel | | Liquid fuel | | Remark |
|---|---|---|---|---|---|
| | Continuous | Intermittent | Continuous | Intermittent | |
| Metal casting melting furnaces | 1.25 | 1.35 | 1.30 | 1.40 | |
| Continuous steel billet heating furnaces | 1.20 | — | 1.25 | — | |
| Metal heating furnaces other than the above | 1.25 | 1.35 | 1.25 | 1.35 | |
| Metal heat treatment furnaces | 1.20 | 1.25 | 1.25 | 1.30 | |
| Oil heating furnaces | 1.20 | — | 1.25 | — | |
| Pyrolyzers and reforming furnaces | 1.20 | — | 1.25 | — | |
| Cement combustion furnaces | 1.30 | — | 1.30 | — | Liquid fuel value in case of pulverized coal-fired type |
| Lime combustion furnaces | 1.30 | 1.35 | 1.30 | 1.35 | Liquid fuel value in case of pulverized coal-fired type |
| Drying furnaces | 1.25 | 1.45 | 1.30 | 1.50 | Burner combustion part only |

*1 Public notice by METI: Excerpted from EC Guideline of Business Operators for Rationalization of Energy Use at Factories, etc., Appendix Table 1(A), (2). 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.

*2 See "Remarks" of Appendix Table 1(A) (2) because the following applications may be excluded.
- Those with a rated capacity (burner's fuel combustion performance) of less than 20 L/hr. (in crude oil equivalent)
- Those requiring a specific atmosphere for oxidation or reduction
- Those requiring the diluted air for maintaining a heat pattern or uniformizing the furnace internal temperature
- Those combusting flammable waste

And so on




<Example of the adjustment method>
Automatic: Change the air ratio.
Manual: Fix a fuel flow rate and minimize an air flow rate (adjust a link mechanism, etc).

Fig. 2 Air ratio adjustment of industrial furnace (heating furnace)

(2) Tuning points

Combustion air may be used more than standard values for purposes such as securing combustion stability. Reduce the air ratio while confirming exhaust gas oxygen concentration at the furnace outlet. In order to prevent incomplete combustion, it is particularly important to confirm that there is no CO. Also, pay heed to the fluctuations of the furnace internal pressure.

(3) Measurement items

① Exhaust gas components at the furnace outlet (oxygen ($O_2$) concentration, CO concentration)
② Exhaust gas temperature
③ Fuel flow rate
④ Combustion air flow rate (if possible)

(4) Tuning procedure

① Measure the exhaust gas oxygen concentration to confirm the current air ratio.
Example: $O_2$ = 9.8% → Air ratio = 1.8
② Set an adjustment target value.
Target air ratio = 1.2 ($O_2$ = 3.7%)
③ Adjust the air ratio in a phased manner.
Step 1. Air ratio: 1.8 → 1.4 ($O_2$ = 6.3%)
Step 2. Air ratio: 1.4 → 1.2 ($O_2$ = 3.7%)

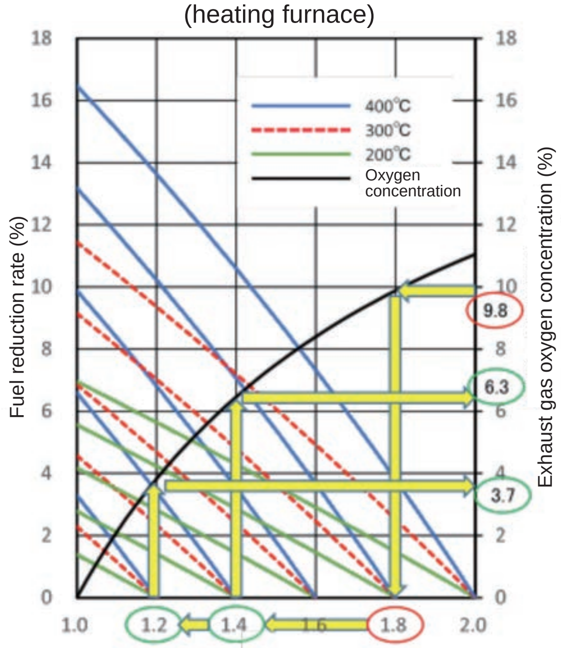



Fig. 3 Example of air ratio adjustment

# E. Lighting Facilities, Power Leveling Facilities, etc.

## Case E-1: Replacing the Mercury Lamps of the Factory Warehouse with the LED Lighting

### 1. Current problem

A factory warehouse has a high ceiling and uses old-fashioned mercury lamps*.
* By adoption of the "Minamata Convention on Mercury", it was banned to manufacture, export or import mercury lamps on Jan. 1, 2021.

### 2. Improvement measure

Replace the mercury lamps with the high-ceiling LED lighting which has been enhanced on the performance and product lineup these days. The LED consumes less power than the mercury lamp for the same illuminance, allowing lower power consumption by renewing the facilities.

Table 1 LEDs with equivalent illuminance to mercury lamps

| Mercury lamp | Power consumption including stabilizer | LED | Power consumption including the DC power supply (luminous flux) |
|---|---|---|---|
| 250 W (HF250X) | 250 + 10 = 260 W | Equivalent to 250 W mercury lamp | 78 W (9,300 lm) |
| 400 W (HF400X) | 400 + 15 = 415 W | Equivalent to 400 W mercury lamp | 117 W (14,000 lm) |

(Source: Catalog of Company H)

### 3. Effect estimation

(1) Calculation formula

Current power consumption: Σ {Current power consumption (kW/unit) x No. of lighting fixtures (unit) x Lighting time (h/year)}

Improved power consumption: Σ {Improved power consumption (kW/unit) x No. of lighting fixtures (unit) x Lighting time (h/year)}

(2) Prerequisites for calculation

Lighting time: 10 h/day x 242 days/year = 2,420 h/year

Current power consumption (mercury lamps), No. of units

Existing 250 W mercury lamp: 260 W/unit including the power consumption of the stabilizer, 100 units

Existing 400 W mercury lamp: 415 W/unit including the power consumption of the stabilizer, 50 units

Improved power consumption (LEDs), No of units

LED equivalent to 250 W mercury lamp: 78 W/unit including the DC power supply, 100 units

LED equivalent to 400 W mercury lamp: 117 W/unit including the DC power supply, 50 units

### 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | Power consumption (current) | 113,100 | kWh/year | |
| ② | Power consumption (improved) | 33,000 | kWh/year | |
| ③ | Reduced power consumption | 80,100 | kWh/year | ①−② |
| ④ | Energy conservation rate | 71 | % | ③ / ① |
| ⑤ | Saved amount of money | 1,522 | ¥1,000/year | ③ x ¥19/kWh |
| ⑥ | Reduction in crude oil equivalent | 20.6 | kL/year | ③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ |
| ⑦ | $CO_2$ reduction* | 36.3 | t-$CO_2$/year | ③ x 0.453 t-$CO_2$/1,000 kWh |

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

### [Reference] Introduction of new technology: High efficiency LED lighting for high ceiling

High efficiency LED lighting for high ceiling that can be used under a special environment (e.g. with high temperature, powdery dusts, oil smoke, salt damage) and are equipped with a motion detector and a dimmer function are commercialized. A lighting system that can reduce power consumption by dimming the lights and controlling a lighting time for each light and each lighting zone through a tablet are also developed. The system has a function of visualizing low-traffic areas.

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

## 1. Current problem

The contract demand of a ceramics-related factory A is 170 kW, same as the annual maximum power. Main facilities are turned on and off at relatively short time intervals of 1 to 2 hours. Because the maximum power is not managed, however, many facilities are simultaneously operated, boosting the maximum power.

## 2. Improvement measure

Adjust the operation schedule of the main facilities to lower the maximum power. (See "Concept of the operation schedule of the facilities".) Set the target values and try not to exceed them. A demand monitor is useful for monitoring the working power. Set a maximum power reduction target to 10 kW. (See "Concept of the maximum power target value".) Also, utilization of IoT technology allows remote-control operation such as stopping unnecessary facilities according to alarm signals, etc. output from the demand monitoring equipment. This measure corresponds to lowering demand response (DR) in optimization of electricity demand.

### Concept of the operation schedule of the facilities

Fig. 1 shows the operating condition and power consumption of the main facilities A to D. At the times $t_1$ and $t_2$, all the facilities operate simultaneously, maximizing the total power. The maximum power can be lowered by starting the facility D later at $t_1$ and earlier at $t_2$, for example.

### Concept of the maximum power target value

Fig. 2 shows the transition of monthly electric energy and maximum power. The maximum power is 170 kW in October, but it is not proportional to the electric energy. Their relations are made more understandable by preparing a scatter diagram of the electric energy and maximum power. The electric energy is 19,300 kWh in the month with the maximum power of 170 kW, but the maximum power remains at 160 kW in some months even when the electric energy exceeds 20,000 kWh. Based on this graph and other information, set the target value to 160 kW for the moment.

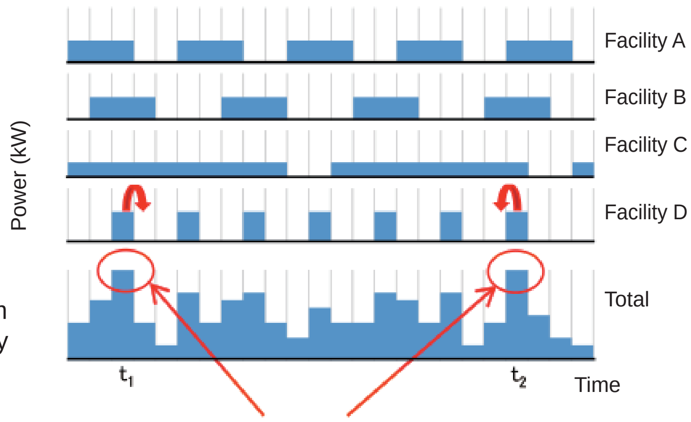



Fig. 1 Operation schedule of facilities (conceptual diagram)

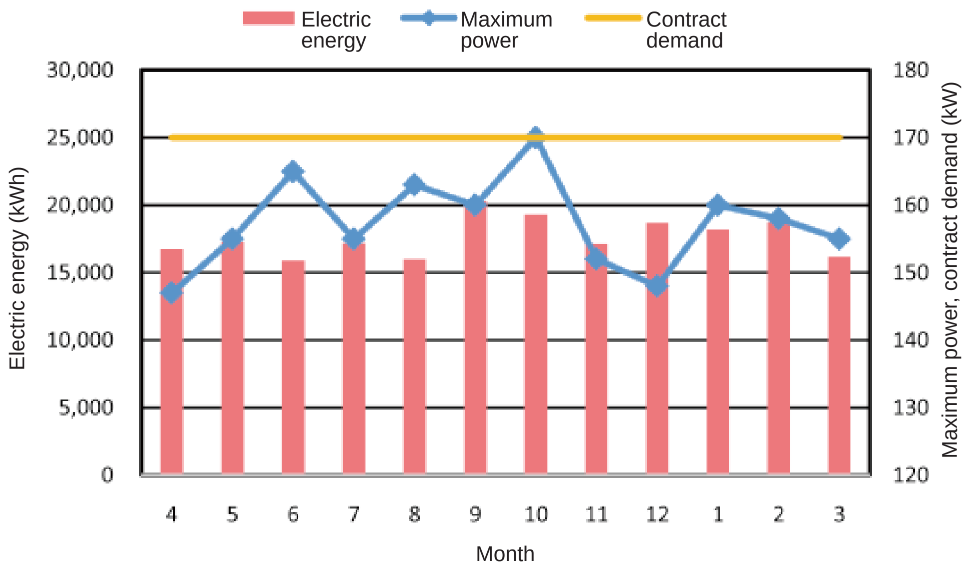



Fig. 2 Transition of electric energy and maximum power

From now on, consider the relations of the production volume and product type with the electric energy and maximum power in details, and organize the operation schedule of the facilities to focus on more accurate and greater reduction. When the electric energy and maximum power fluctuate greatly from one season to another due to the effect of air conditioning, it is necessary to consider them with an emphasis put on the operating condition of the air conditioners.

## 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
Current contract demand: 170 kW
Target contract demand: 160 kW
(Reduced power: 10 kW)
Power factor (pf): 100%
Basic charge rate: ¥1,500/kW･month
(Use the basic charge rate of your contracted power company.)

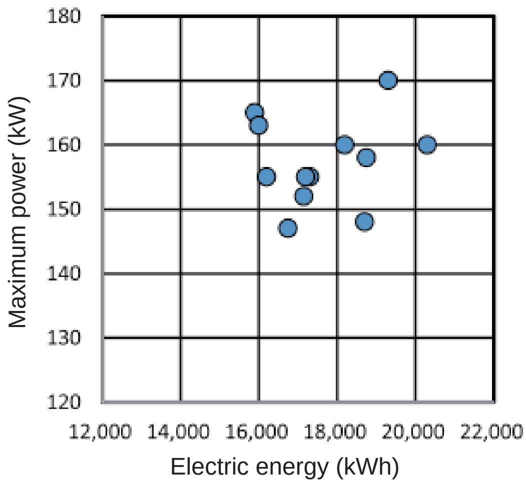



Fig. 3 Relations between electric energy and maximum power

## 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | Contract demand (current) | 170 | kW | |
| ② | Contract demand (improved) | 160 | kW | |
| ③ | Reduced contract demand | 10 | kW | ①−② |
| ④ | Reduction rate | 5.9 | % | ③ / ① |
| ⑤ | Saved amount of money | 153 | ¥1,000/year | ③ x ¥1,500/kW x (185 – 100) / 100 x 12 months/year |

## [Reference] Electricity charge and optimized electricity demand

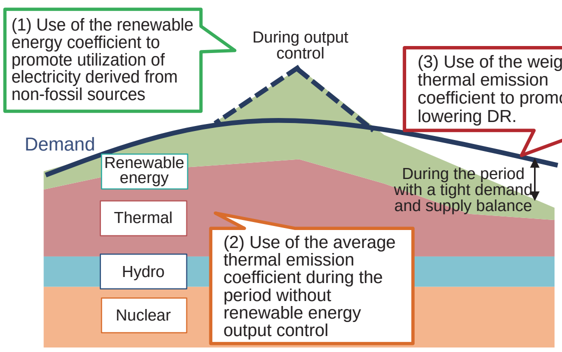
(1) Electricity charge
A demand refers to maximum demand power (= contract demand) and is directly connected to the "basic charge". The electric energy meter installed by a power company memorizes average power consumption every 30 minutes to calculate a monthly maximum value.
An electricity charge consists of a "basic charge", "energy charge" and "renewable energy surcharge". The following table describes them. To reduce the electricity charge, accordingly, you can understand that it is effective to reduce not only ① energy consumption, but ② contract demand.

| Electricity charge = | Basic charge | + | Energy charge | + | Renewable energy surcharge |
|---|---|---|---|---|---|
| Description | Basic charge rate<br>x<br>② Contract demand<br>x<br>Power factor discount and extra | | Energy charge rate<br>x<br>① Energy consumption<br>x<br>Fuel adjustment charge | | Renewable energy surcharge rate<br>x<br>① Energy consumption |

In the case of receiving the high-voltage power of less than 500 kW, calculation of the basic charge uses the highest value among the maximum demand powers (demand values) in that month and past 11 months.

(2) Optimization of electricity demand
In recent years, variable renewable energies such as solar power generation, are significantly increasing, resulting in a surplus of renewable energy.
It is provided in the revised Energy Conservation Act that electricity demand should be optimized by: during the period with the surplus, shifting the demand to the period (raising DR); during the period with tight electricity supply, limiting the demand (lowering DR: corresponding to the conventional measure against demand peak) (Fig. 4).

■Exemplary image of the optimization of electricity demand




■Outline of the system (Draft)

| | |
|---|---|
| Basic concept (Objectives) | • Utilizing surplus power from renewable energy (raising DR)<br>• Limiting demand during the period with a tight demand and supply balance (lowering DR) |
| Specific measures | • Evaluate the demand shift to the period with the renewable energy output control and the reduction of demand during the period with a tight demand and supply balance, such as an improvement in intensity with optimized electricity demand.<br>* Reporting of the intensity with optimized electricity demand is required, and it is evaluated along with the improvement of regular intensity.<br>* The government develops calculation rules and tools for supporting the report.<br>* Study for establishing a simple reporting method. |
| Electricity conversion coefficient | • The coefficient takes account of the situation on the supply side.<br>* For example, the following are applied.<br>(1) A renewable energy coefficient is used during the period with the renewable energy output control.<br>(2) An average thermal emission coefficient is used during other time.<br>(3) A weighted average thermal emission coefficient (×α) is used during the period with a tight demand and supply balance. |

Fig. 4 Optimization of electricity demand
(Source: Agency for Natural Resources and Energy, "Act on the Rational Use of Energy in the Future (Dec. 24, 2021)")

# F. Production Processes, etc.

## Case F-1: Recovering the Waste Heat of the Powder Coating Drying Furnace

### 1. Current problem

Hot blast of a powder coating drying furnace (baking) is produced by heating the outside air with burners (fuel: LPG). Part of the exhaust gas is recirculated to promote energy conservation, but the exhaust temperature is about 210°C, discharging the waste heat into the atmosphere.

### 2. Improvement measure

Recover the waste heat discharged into the atmosphere and preheat the introduced outside air from 20°C to 70°C to reduce LPG consumption.

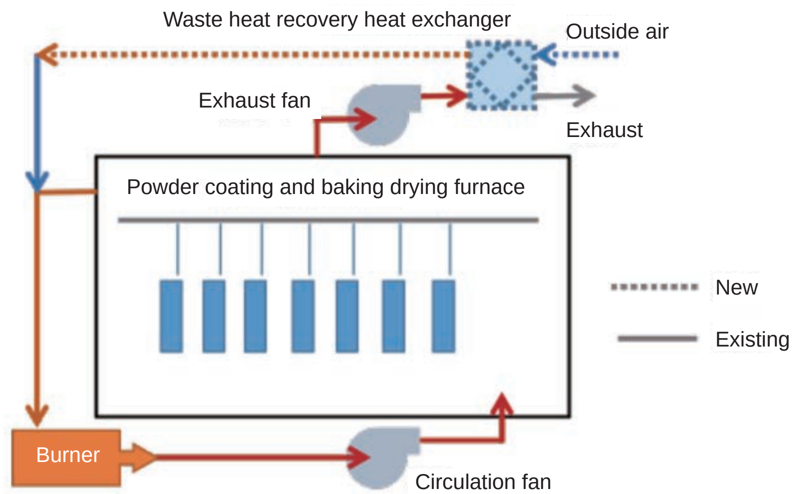



Fig. 1 Waste heat recovery flow diagram

### 3. Effect estimation

(1) Calculation formula

Waste heat recovery temperature difference: {Exhaust gas temperature (°C) – Annual average temperature of outside air (°C)} x Waste heat recovery efficiency (%)

Waste heat recovery heat quantity: Exhaust gas volume ($m^3$/h) x Waste heat recovery temperature difference (°C) x Average specific heat at constant pressure (kJ/$m^3$・K)}

LPG reduction: Waste heat recovery heat quantity (kJ/h) x Coating drying furnace operating time (h/year) / Lower heating value (kJ/kg)

(2) Prerequisites for calculation

LPG consumption (current): 92,700 kg/year

Exhaust gas requirements (volume, temperature): Exhaust gas volume 3,600 $m^3$/h, Exhaust gas temperature 210°C, Annual average temperature of outside air 20°C

Waste heat recovery efficiency: 26.3% (if it is a little less than 30%, preheating is possible by at least 50°C)

Average specific heat at constant pressure: 1.304 kJ/$m^3$・K

LPG lower heating value: 47.0 GJ/t

Coating drying furnace operating time: 9 h/day x 258 days/year = 2,322 h/year

### 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | LPG consumption (current) | 92,700 | kg/year | |
| ② | Reduced LPG consumption | 11,600 | kg/year | |
| ③ | Energy conservation rate | 13 | % | ② / ① |
| ④ | Saved amount of money | 1,508 | ¥1,000/year | ② x ¥130/kg |
| ⑤ | Reduction in crude oil equivalent | 15.2 | kL/year | ② x 50.8 GJ/t x 0.0258 kL/GJ |
| ⑥ | $CO_2$ reduction | 34.8 | t-$CO_2$/year | ② x 50.8 GJ/t x 0.0161 x (44 / 12) t-$CO_2$/GJ |

# Case F-2: Reducing the Radiation Losses from the Opening of the Casting Melting Furnace

## 1. Current problem

A furnace cover at the top of a melting furnace is opened for automatic measurement of the melting temperature, allowing radiant heat losses from this opening during operation hours.

## 2. Improvement measure

Newly install an air cylinder-driven cover over the opening. Close it as much as possible while operating the furnace, and open it only when necessary for temperature measurement, and so on. This will prevent radiant heat losses and shorten a melting time.

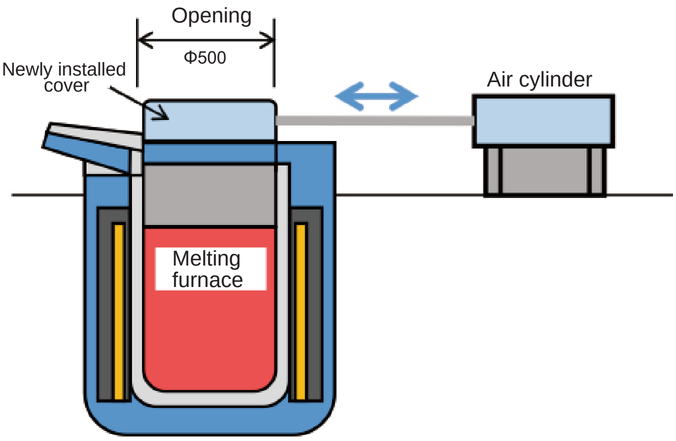



Fig. 1 Installation of driven cover on melting furnace

## 3. Effect estimation

(1) Calculation formula

Radiant heat from the opening: $3.26A \times (T_1 - T_a)^{1.25} + 5.67\ \varepsilon_1 A \times \{(T_1 / 100)^4 - (T_a / 100)^4\}$ (W)

Radiant heat from the furnace cover surface: $3.26A \times (T_2 - T_a)^{1.25} + 5.67\ \varepsilon_2 A \times \{(T_2 / 100)^4 - (T_a / 100)^4\}$ (W)

Where; A: Opening area ($m^2$), $\varepsilon_1$, $\varepsilon_2$: Surface emissivity, $T_1$: Melting temperature (K), $T_2$: Furnace cover temperature (K), $T_a$: Ambient temperature (K)

Operating time considered heat dissipation: Heat dissipation from the opening (kW) x (14 min/batch, 3 batches/60 min)
Reduced electric energy: Operating time considered heat dissipation (kW) x Ratio of furnace cover closable time (%) x Operating time (h/year)

(2) Prerequisites for calculation

Opening area: $A = 0.196\ m^2$, Surface emissivity of the melted casting: $\varepsilon_1 = 0.3$, Surface emissivity of the furnace cover: $\varepsilon_2 = 0.75$
Melting temperature: $T_1$ = 1,573 K (1,300°C), Furnace cover temperature: $T_2$ = 523 K (250°C), Ambient temperature: $T_a$ = 288 K (15°C)
Ratio of furnace cover closable time: 12 min of 14-min operating time → 85%
Furnace operating time: 18 h/day x 20 days/month x 12 months/year = 4,320 h/year
Melting furnace efficiency: $\eta$ = 80%

## 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | Heat dissipation from opening | 17.7 | kW | Operating time considered: (14 min/batch x 3 batches/60 min) |
| ② | Heat dissipation from furnace cover | 0.8 | kW | Operating time considered: (14 min/batch x 3 batches/60 min) |
| ③ | Reduced electric energy | 77,600 | kWh/year | (① – ②) x Ratio of furnace cover closable time x Furnace operating time / $\eta$ |
| ④ | Energy conservation rate | – | % | |
| ⑤ | Saved amount of money | 1,474 | ¥1,000/year | ③ x ¥19/kWh |
| ⑥ | Reduction in crude oil equivalent | 20.0 | kL/year | ③ x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ |
| ⑦ | $CO_2$ reduction* | 35.2 | t-$CO_2$/year | ③ x 0.453 t-$CO_2$/1,000 kWh |

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

# G. Solar Power Generation, etc.

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

### 1. Current problem

Introduction of a solar power generation system is under consideration, however, it involves some issues such as a large initial investment cost, time and expense required for management and maintenance, and time-consuming internal procedures/approvals.

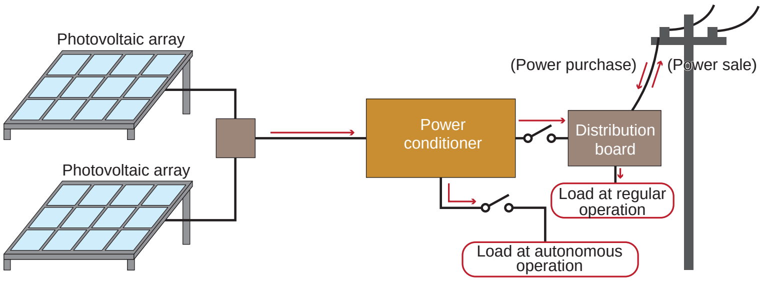



Fig. 1 Example of solar power generation system configuration

### 2. Improvement measure

A general configuration of a solar power generation system is as shown in Fig. 1. A self-consumption solar power generation system is designed in principle to self-consume the entire amount of electricity it generates. However, it is also possible to sell electricity while it has a low power load during a non-business day. The methods of introducing the system are classified as shown on Table 1. In the case of using the on-site PPA model or a lease model, none of the initial investment cost and expenses for management and maintenance during a contract period are needed as a rule.

Table 1 Methods of introducing solar power generation system

| Methods | Advantages | Disadvantages |
|---|---|---|
| Self-investment on the system | ●Best investment recovery efficiency in the long term.<br>●It is possible to dispose or replace the system with internal decisions only.<br>●Surplus electricity exceeding self-consumption can be sold. | ●An initial investment cost is needed.<br>●An impact on the financial indicator occurs due to an increase in fixed assets.<br>●Time and expense for operation, management, and maintenance are required. |
| On-site PPA model | ●No initial investment cost is needed as a rule.<br>●Time and expense for operation, management, and maintenance are not required.<br>●Only self-consuming part of the entire amount of generated power can be purchased.<br>●The system is not considered as an asset and kept off the balance sheet.<br>●Low-price carbon-free power can be used without spending any initial investment costs. | ●A lot of arrangements and coordination with a PPA operator are required.<br>●It is not possible to replace or dispose the system internally.<br>●A long-term contract must be concluded (typically for 17 years or longer).<br>●After expiration of the contract, additional time and expense are required for operation, management, and maintenance of the system. |
| Lease model | ●No initial investment cost is needed as a rule.<br>●Expense for operation, management, and maintenance is not required.<br>●Surplus electricity exceeding self-consumption can be sold. | ●It is not possible to replace or dispose the system internally.<br>●A long-term contract must be concluded.<br>●A lease fee must be paid even when no power is generated.<br>●The system must be managed and recorded as a leased asset. |

### 3. Effect estimation

An effect obtained in a case where a solar power generation system with a 50 kW capacity is introduced in a business establishment with a contract power demand of 200 kW is calculated.

(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))*1 x Total design coefficient*2 / Intensity of solar radiation (1 kW/$m^2$)

*1: NEDO "Solar Radiation Amount Database Browsing System", *2: JIS C 8907:2005 "9. Total Design Coefficient of Photovoltaic Array"

(2) Prerequisites for calculation

Installation condition of photovoltaic array: Location in Chiyoda-ku, Tokyo, Array azimuth 0º (due south), Inclination angle 30º

Operating condition: No. of annual operating days 365, Self-consumption rate 100%

Amount of solar radiation of array surface: 4.39 (kWh/($m^2$•day)), Total design coefficient 0.8

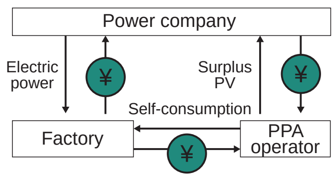
### 4. Effects

| | | | | |
|---|---|---|---|---|
| ① | Reduced power consumption | 64,094 | kWh/year | |
| ② | Energy conservation rate | – | % | |
| ③ | Saved amount of money | 1,218 | ¥1,000/year | ① x ¥19/kWh |
| ④ | Reduction in crude oil equivalent | 16.5 | kL/year | ① x 9.97 GJ/1,000 kWh x 0.0258 kL/GJ |
| ⑤ | $CO_2$ reduction* | 29.0 | t-$CO_2$/year | ① x 0.453 t-$CO_2$/1,000 kWh |

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

### [Reference] What is on-site Power Purchase Agreement (PPA) model?

It is a mechanism, based on a PPA Agreement concluded between an electricity generation utility (PPA operator) and an owner of a facility, in which the PPA operator installs a solar power generation system on-site and is responsible for the entire operation, maintenance, and management of the system, and is also called "third-party-owned model" or "power selling contract model". The power generation system is owned by the PPA operator, and the facility is only required to provide a space for installing the solar power generation system. Without spending any initial investment costs, the facility can purchase the electric power from renewable energy generated by the system at a fixed price from the PPA operator for a long time.



## [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) | x | 39.1 (GJ/kL) | ⇒ | 39.1 | x 0.0258 (kL/GJ) | ⇒ 1.009 |
| LPG | 1 (t) | x | 50.8 (GJ/t) | ⇒ | 50.8 | | ⇒ 1.311 |
| City gas 13A** | 1 (1,000 $m^3$) | x | 44.8 (GJ/1,000 $m^3$) | ⇒ | 44.8 | | ⇒ 1.156 |
| Electric energy (daytime)*** | 1 (1,000 kWh) | x | 9.97 (GJ/1,000 kWh) | ⇒ | 9.97 | | ⇒ 0.257 |
| Electric energy (nighttime)*** | 1 (1,000 kWh) | x | 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. Figures shown in the table are cited from the ministerial ordinance related to calculation of greenhouse gas emissions associated with the business activities of the business operators.
*** : 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 coefficient 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 coefficient* (t-C/GJ) | $CO_2$ emissions (t) | |
|---|---|---|---|---|---|
| Heavy oil A | 1 (kL) ⇒ | 39.1 | x 0.0189 | $\times\left(\frac{44}{12}\right)$ | ⇒ 2.71 |
| LPG | 1 (t) ⇒ | 50.8 | x 0.0161 | | ⇒ 3.00 |
| City gas 13A | 1 (1,000 $m^3$) ⇒ | 44.8 | x 0.0136 | | ⇒ 2.23 |

* Figures shown in the table are cited from the ministerial ordinance related to calculation of greenhouse gas emissions associated with the business activities of the business operators (Ministerial Ordinance No. 3, 2006 by the Ministry of Economy, Trade and Industry/the Ministry of the Environment, Ministerial Ordinance related to Calculation of Greenhouse Gas Emissions associated with the Business Activities of the Business Operators, Appended Table 1).

### [For electric energy]

Multiply the electric energy by the $CO_2$ emission coefficient.

| Electric energy | $CO_2$ emission coefficient* | $CO_2$ emissions | Remark |
|---|---|---|---|
| 1 (1,000 kWh) | x 0.453 (t-$CO_2$/1,000 kWh) | ⇒ 0.453 (t) | The emission coefficient 0.453 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 coefficient and post-adjustment emission coefficient used for reporting should be annual values for each electric utility (**).

For the latest emission coefficient, see "Pages Related to Emission Coefficient by Electricity Utility" (https://ghg-santeikohyo.env.go.jp/calc/denki), etc. The emission coefficient, 0.453 (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 coefficient of utility generation and private power generation in Comprehensive Energy Statistics) in "Emission Coefficient by Electricity Utility (results in FY2020, published by the Ministry of the Environment and the Ministry of Economy, Trade and Industry on Jan. 7, 2022, partially revised on Feb. 17, 2022, partially added and updated on Jul. 14, 2022)".

## 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, postal mail or E-mail.**

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

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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 FY2022".**

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2022.08/7K