Promotion of Energy Conservation Activities in Factories (Electricity)

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1. Promotion of "Energy Conservation Activity"

2. Viewpoint of Power-saving

3. Methods of power-saving of major electric facilities

4. Power-saving Examples of existing facilities in Japan

1. Promotion of “Energy Conservation Activity”

1.1 Significance of “ Energy Conservation ”

“ Energy Conservation Activity ”
has contributed to “ Cost Down of each factory ”
moreover, Improvement of “ Cost ” and “SEC”
(“SEC” is Specific Energy Consumption and defined as energy conservation divided by production)

&

“ Energy Conservation Activity ”
has contributed to “ Reduction of the global warming ”

- Estimation in oil：0.252 [kL／MWh]
- Estimation in CO_2：0.555 [t-CO_2／MWh]

1.2 Control of Energy Conservation

① Establish organization control

- Management has to keep consciousness of employees.
- All staffs have to be involved in the project.

② Set the goal

Establishment of Criteria :
Energy management, operation, inspection, maintenance, and budget

③ Grasp the circumstances

Preparation of reference data and document

Setup of measuring and recording devices

④ Perform

⑤ Make an improvement plan

Implementation of energy conservation by
1. Small group activity
2. day-to-day business of staff
3. General development

⑥ Implement revised plans

⑦ Assess the results

Repeat PDCA cycle of energy management

1.3 3 steps for Promotion of Energy Conservation

1st step: Reinforce energy management and increase efficiency of operations

- To avoid wastefulness
- To optimize use of existing equipment
- To avoid unscheduled stop of operations

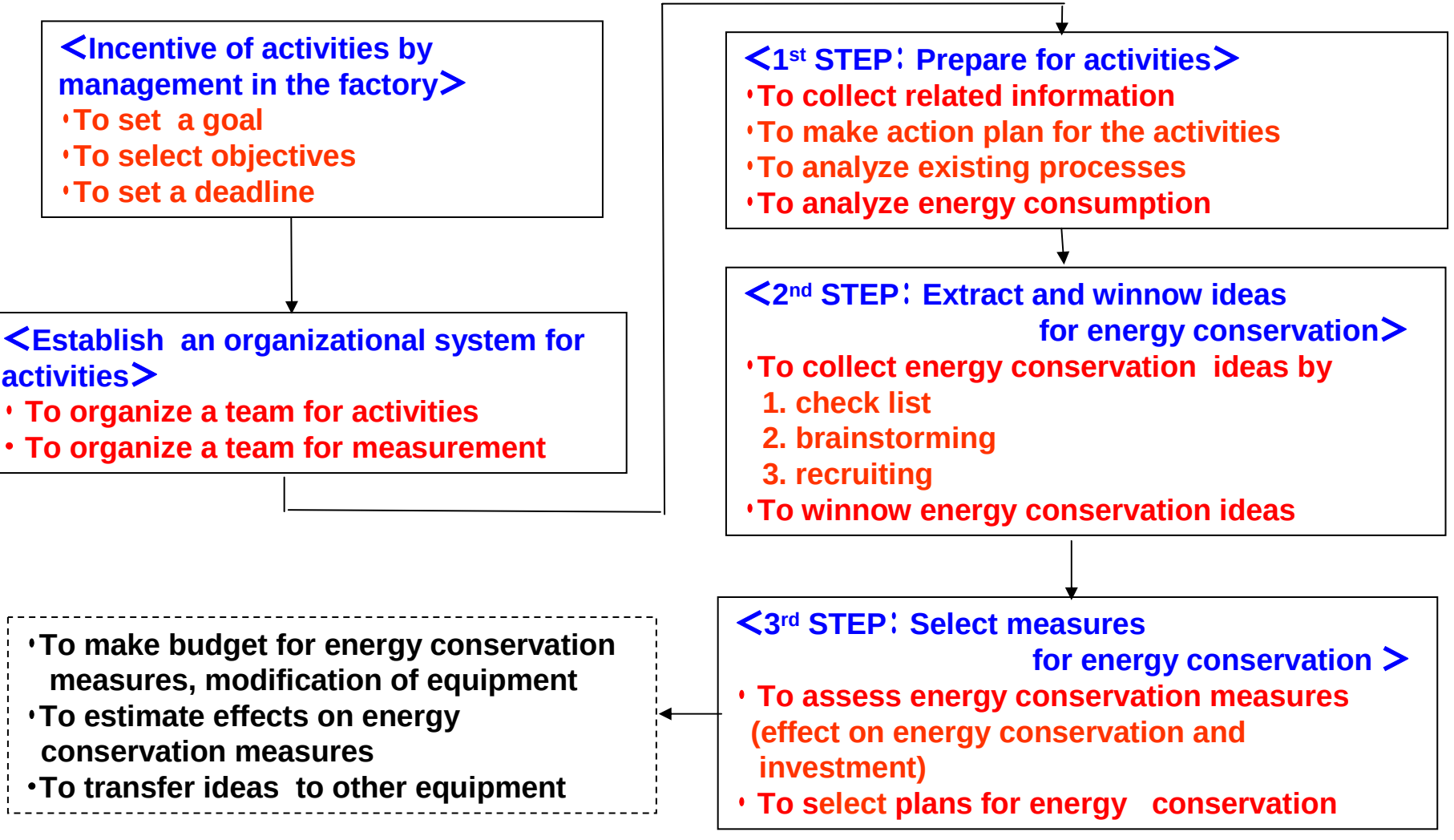
2nd step: Modify and/or add equipment

- Modification and/or addition of equipment (It will be ineffective if main facilities are renewed or replaced)
- Introduction of energy-saving devices

3rd step: Introduce new processes and high efficiency equipment

- It is necessary to develop and introduce new processes.

1.4 Work Flow of Energy Conservation Activity in Factory



1.5 Energy Audit

To fill out questionnaire about situations of energy conservation in a factory

Brief Audit

Hearing from staffs in a factory

Inspection of a factory

- **Identification of basic problems in a factory**
- **Proposal for overcoming (probability, latency and directions)**

Detailed Audit

Cooperation with specialists in energy conservation

Investigation in detail: understanding of present situation, making guideline, and assessment of results

- **Identification of quantitative issues on energy usage**
- **Proposal of definite guidelines (effect of investment for equipment and control)**

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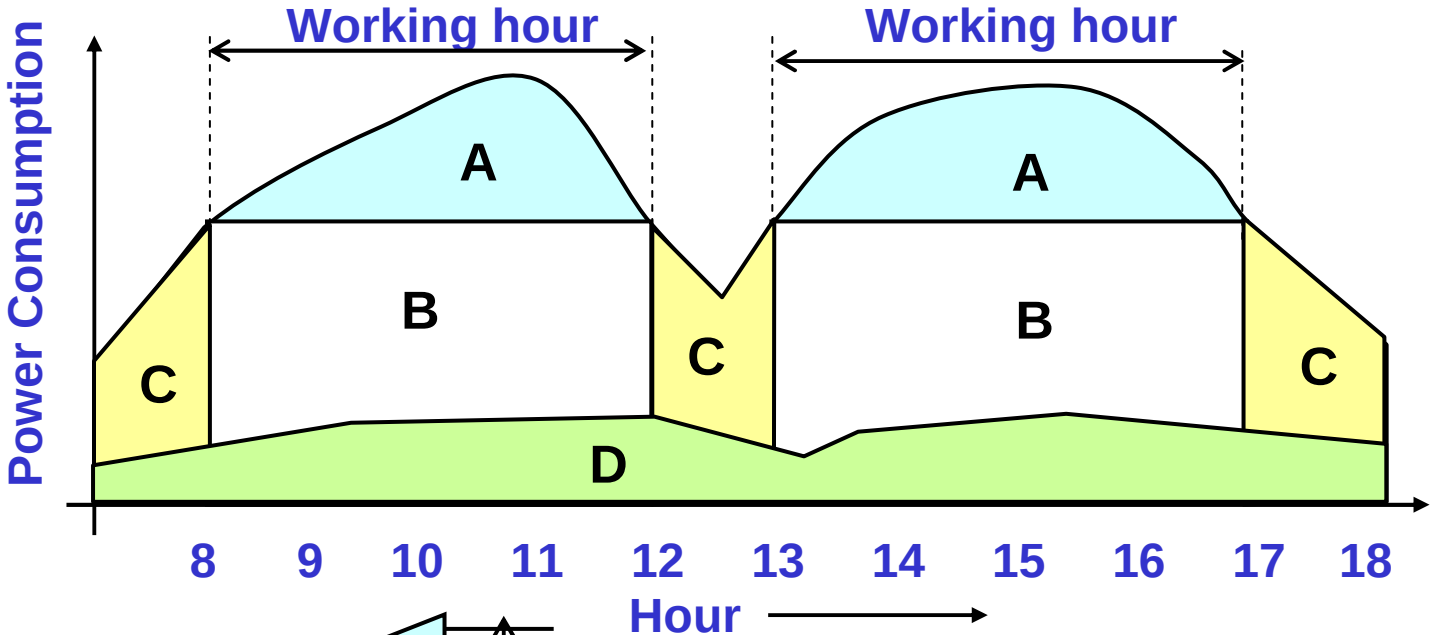
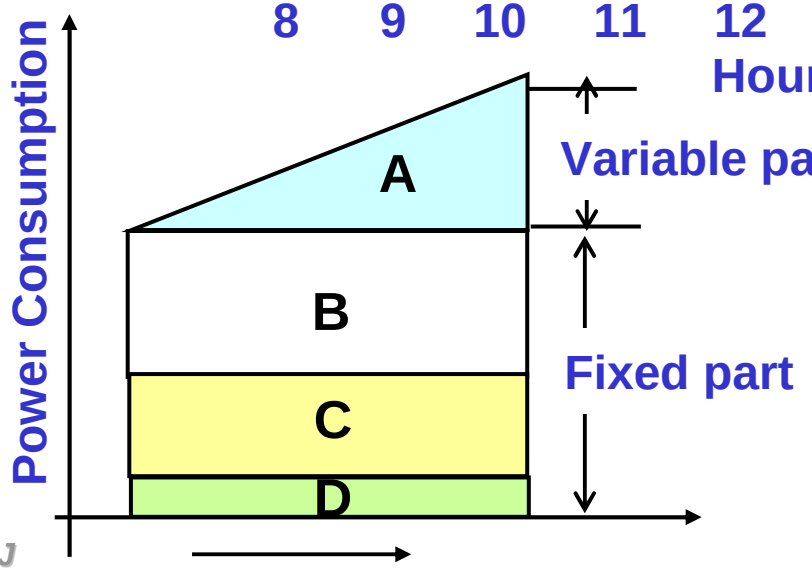
2. Viewpoint of Power-saving

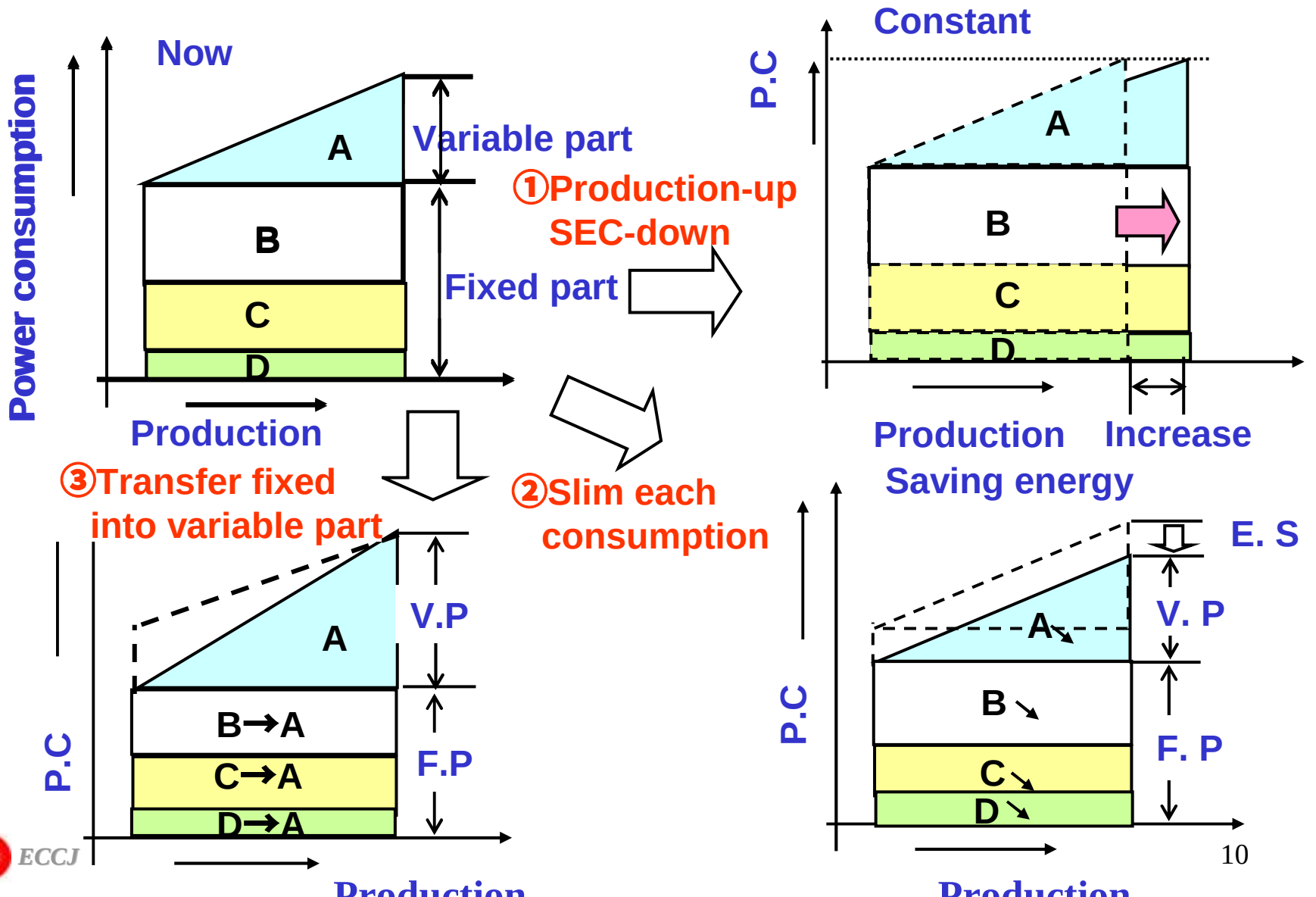
2.1 Breakdown of Energy Consumption by its Usage





A: to be proportional to production
B: to keep product plants
C: to start up or shut down lines
D: to keep utility plants

☆ 3 Viewpoints of Energy Conservation Activity



2.2 Viewpoint of Energy Conservation Activity

① Is a machine paused during a resting period in intermittent operation?

- To pause a coupling of product lines
- To make an automatic ON or OFF

② Is a capacity of equipment too large against requirement?

- To introduce an inverter for pressure regulation in place of valve and damper
- To scale down a capacity

③ Is a fluctuation of workloads properly regulated?

- Automatic control of workloads
- Variable flow control

④ Are inspection and maintenance definitely carried out?

- Guideline on leakage prevention of air and water
- Prevention of pressure loss with cleaning filters etc
- Inspection with regular dismantlement of devices

Awareness in operators and maintenance staff on energy conservation is of primary importance.

2.3 Point of Selection of equipment for Energy Conservation

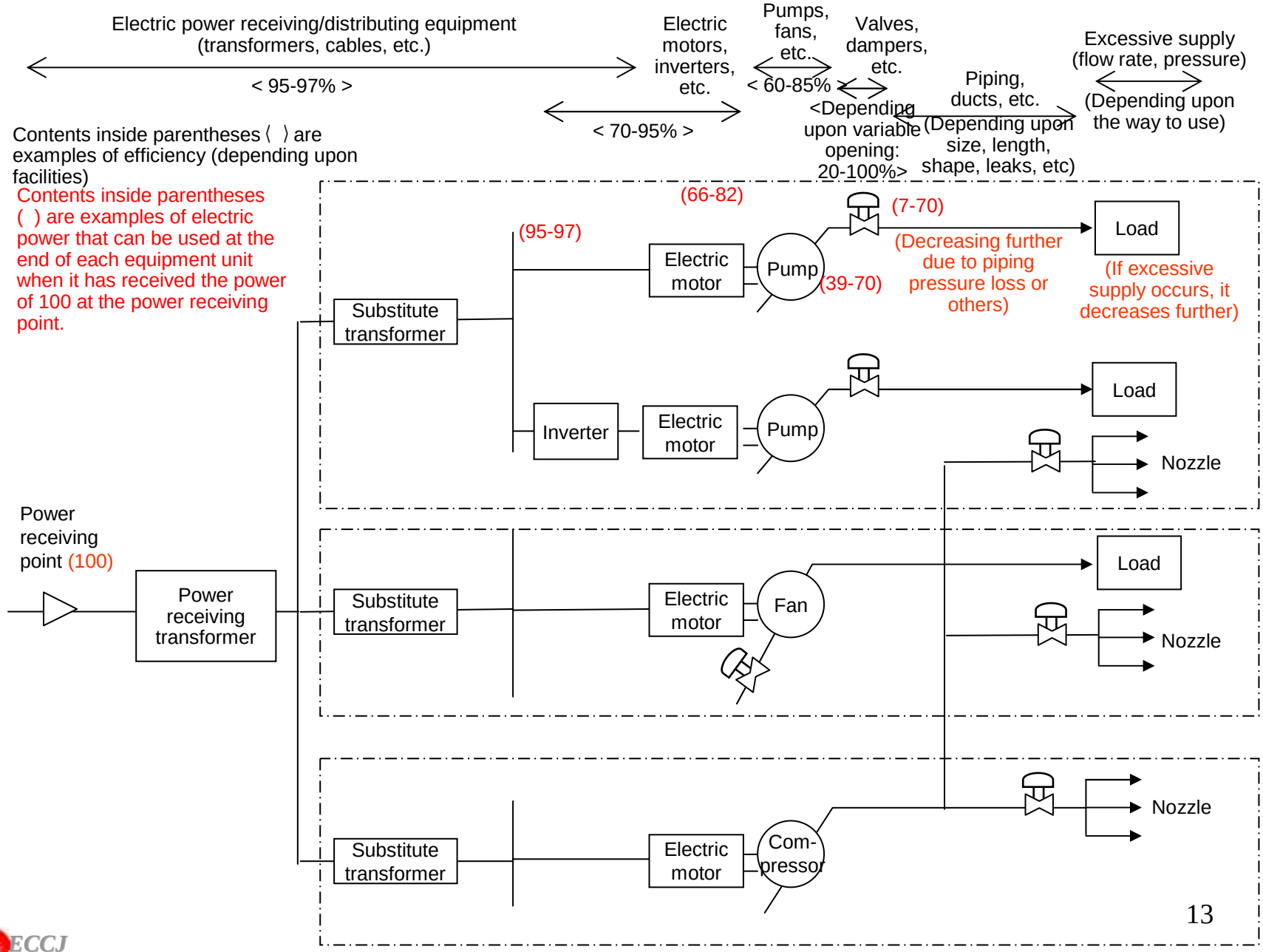
① Equipment (electric motor, transformer, cable) is subject to be audited only when they are established or renewed.

It is difficult to renew electric motor, transformer, and cables except for lighting facility for energy conservation, because these equipment contribute too little to operating efficiency and are too expensive to increase efficiency.

② Main target is motor-powered equipment for energy conservation.

Energy conservation may be expected by avoiding wastefulness and improving efficiency of motor-powered equipment (pump, fan, blower, air-compressor, chiller,etc) because these equipment represent a large portion of energy consumption.

☆ Example of energy flow and electric power consumption



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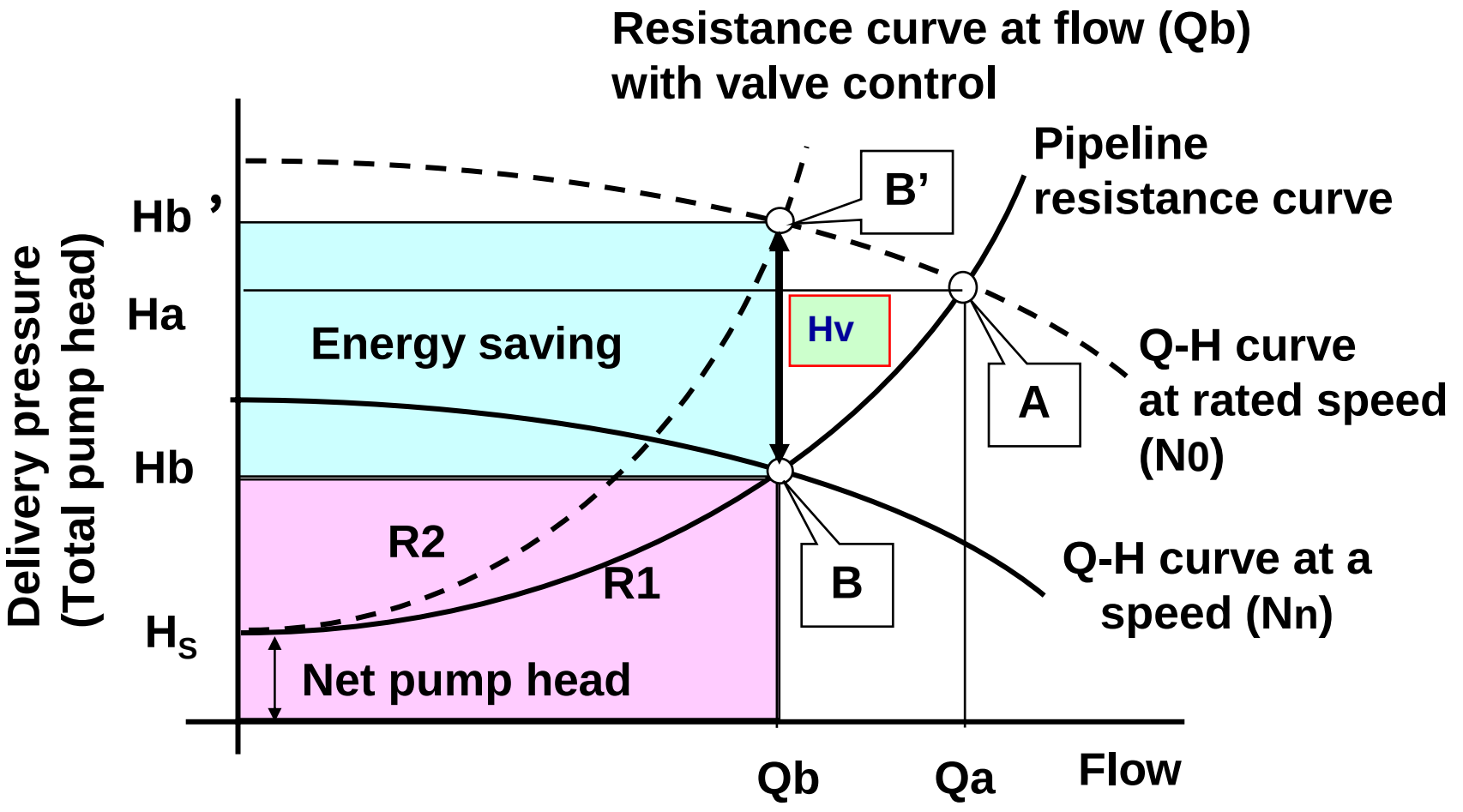
3. Methods of power-saving of major electric facilities

3.1 Pumps, Fans, and Blowers

Viewpoint of power-saving	Examples regarding methods of power-saving
a) Reduction of flow rate	Anti-leak measure of air and water, prevention of excessive use, etc
b) Reduction of pressure	Reduction of operating pressure, Reduction of pressure loss (filter, etc)
c) Reduction of excessive specification (reduction to reasonable level)	・To replace to small capacity or machine of less pressure loss ・To change impeller, to cut down impeller diameter, and to decrease stages of rotor impeller ・To change a rotating speed (pole change or pulley, inverter)
d) Addition of variable flow control and multi-unit control	・ Addition of multi-unit control system ・ Selection of big and/or small machines ・ Addition of variable flow control (pole change, pulley, fluid coupling, vane control, inverter)
e) Replace to high efficiency machine	・ To replace to high efficiency machine
f) Pause at a resting time in intermittent load	・ To replace to motor of high frequency start type ・ Addition of soft starter with inverter ・ Addition of fluid coupling

☆Example of Power-saving by Speed Control (1)



$Qb/Qa = Nn/N0$, $Hb/Ha = (Nn/N0)^2$,axis power: $Lb/La = (Nn/N0)^3$

☆Example of Power-saving by Speed Control (2)

System 1:

When the pressure of the feeding side is the same as that of the load side and pumps compensate piping pressure loss:

(1) If there is no valve restriction, pressure is P_{1r} and flow rate is Q_{1r} at a rotation speed of 100%

(2) If an additional valve restriction bears a flow rate of Qa, the pump discharge pressure becomes Pa. Therefore, valve restriction performed until pressure becomes P_1 leads to a flow rate of Qa.

(3) If a further rotation speed change leads to a pressure of P_1 and a flow rate of Qa, valve restriction will result in greater energy saving.

(4) The figures below show the property of the necessary motive power at that time.

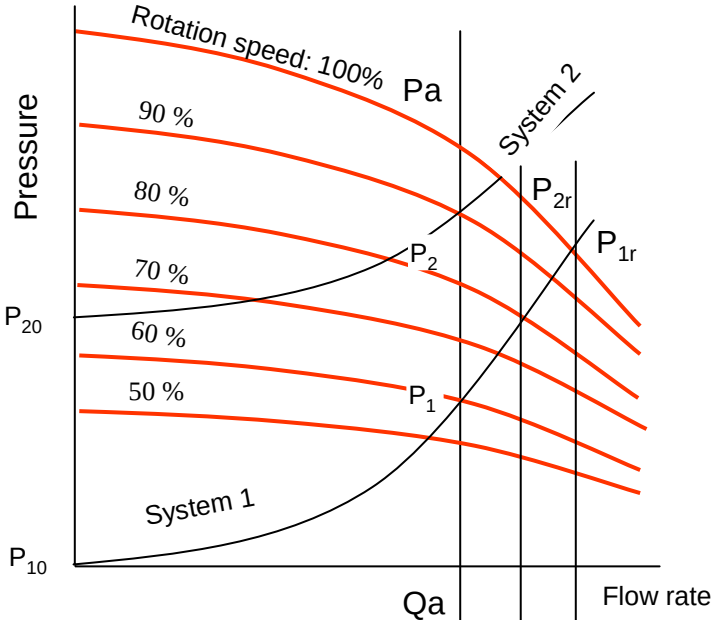
System 2:

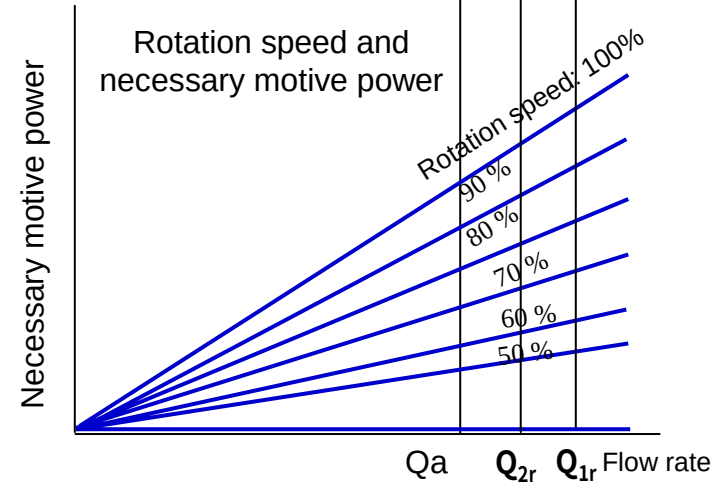
When the pressure of the load side is higher by P_{20} than that of the feeding side, pumps compensate this differential pressure and piping pressure loss.

(1) The principle of reducing the necessary motive power is the same as in item (1) of System 1.

(2) Higher pressure of the load side results in smaller energy saving effect by controlling the rotation speed.

Fan properties and system head curves





☆Pump efficiency and Selection of pump capacity

Figure (a) shows the curves of specific flow rate to pump efficiency for pump A (efficiency : 85%) and pump B (efficiency : 80%).

(1) With respect to the ratio of efficiency at each flow rate, pump A improves by 5% more than pump B.

Figure (b) shows the curves of specific flow rate to pump efficiency for pumps with a capacity of 100, 80, and 50

(1) Employ pumps with appropriate capacity

With respect to pump efficiency at a flow rate of 70%, pumps with a capacity of 80 improve by approx. 10% more than pumps with a capacity of 100.

(2) Quantity control of pumps

With respect to pump efficiency at a flow rate of 40%, pumps with a capacity of 50 improve by approx. 35% more than pumps with a capacity of 100. Controlling the quantity of pumps by installing several small capacity pumps in place of large capacity pumps results in energy savings.

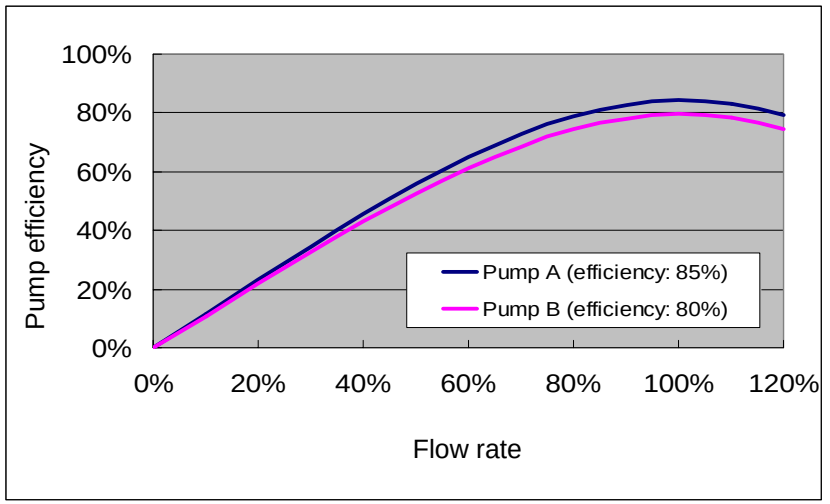


Figure (a) Pump efficiency

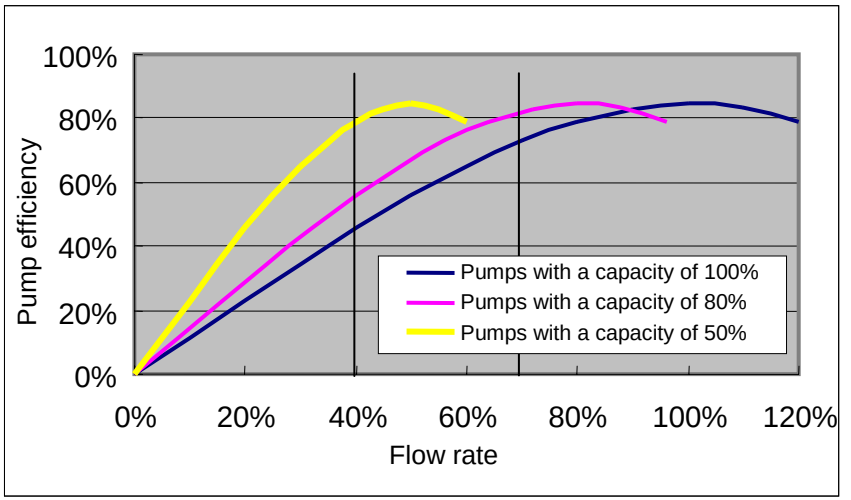
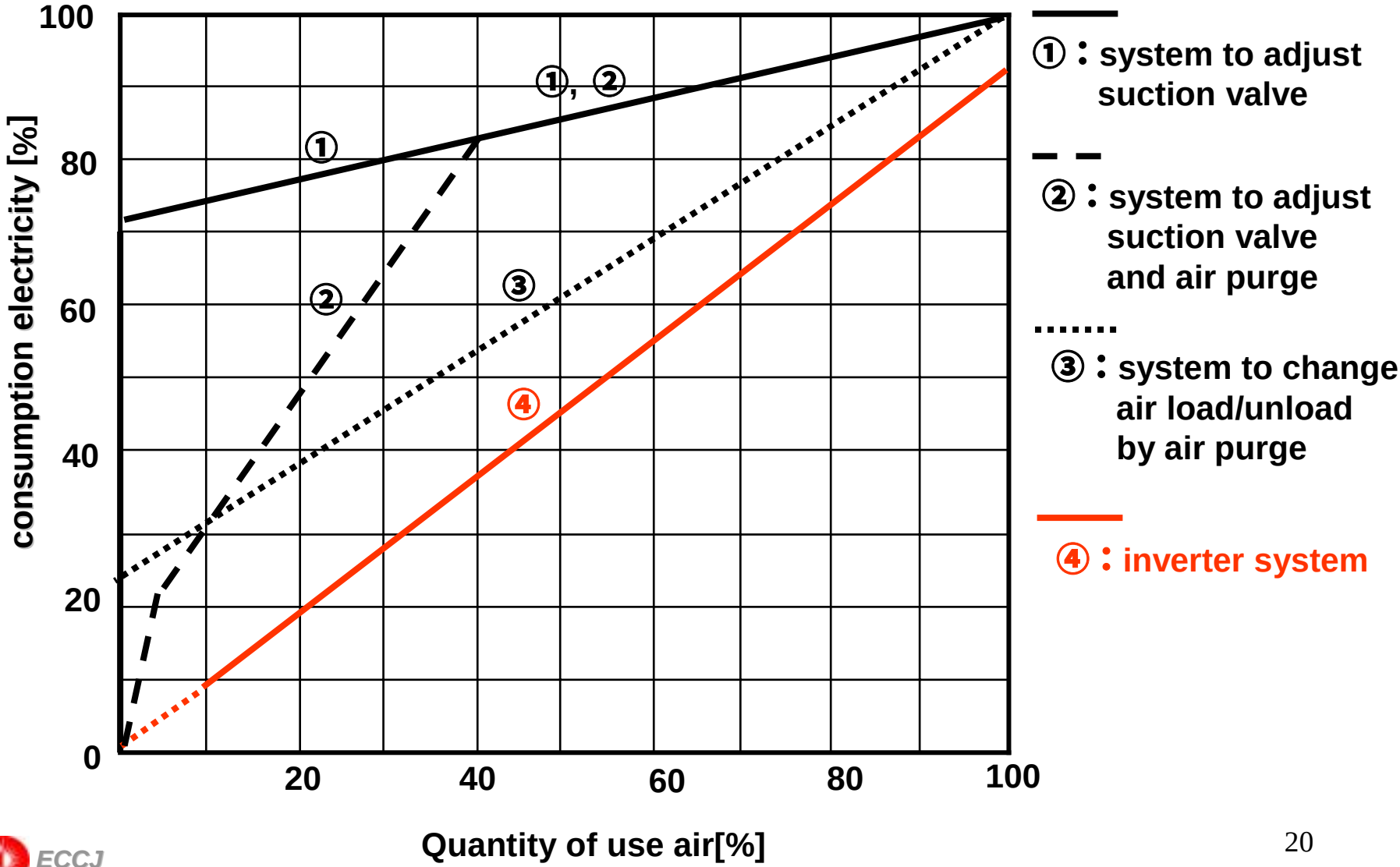


Figure (b) Selection of pump capacity and quantity control

3.2 Air Compressor

Viewpoint of power-saving	Examples regarding methods of power-saving
a) Reduction of necessary air flow rate	• Measures against air leak • ON/OFF control and intermittent operation • Making nozzles smaller and changing to energy- saving nozzles • Employing constant pressure discharge blowers, etc
b) Reduction of pressure loss	• Employing filters with small pressure loss • Making tube diameters larger • Decreasing discharge air pressure, etc
C) Correction of specification on pressure requiring excessive to a more appropriate value	• Making air compressors smaller incapacity and lower in pressure • Adjusting the opening of inlet side vanes
d) Selection of the number of running air compressors or introduction of variable discharge flow-rate control according to the fluctuating load	• Adjusting the number of parallel running air compressor, etc • Selecting small-capacity air compressor and controlling their actual operation • Adjusting the discharge air flow and pressure to appropriate values by controlling the capacity of air compressor • Integrating air compressors • Correcting the capacity of receiver tanks to a appropriate value
e) Enhancement of the function high efficiency air compressor	• changing to high efficiency air compressor • Lowering the temperature inlet side air
f) Reduction of operating time of air compressor	• Shutting down air compressor when operation is unnecessary • Providing air compressor with automatic start/stop functions

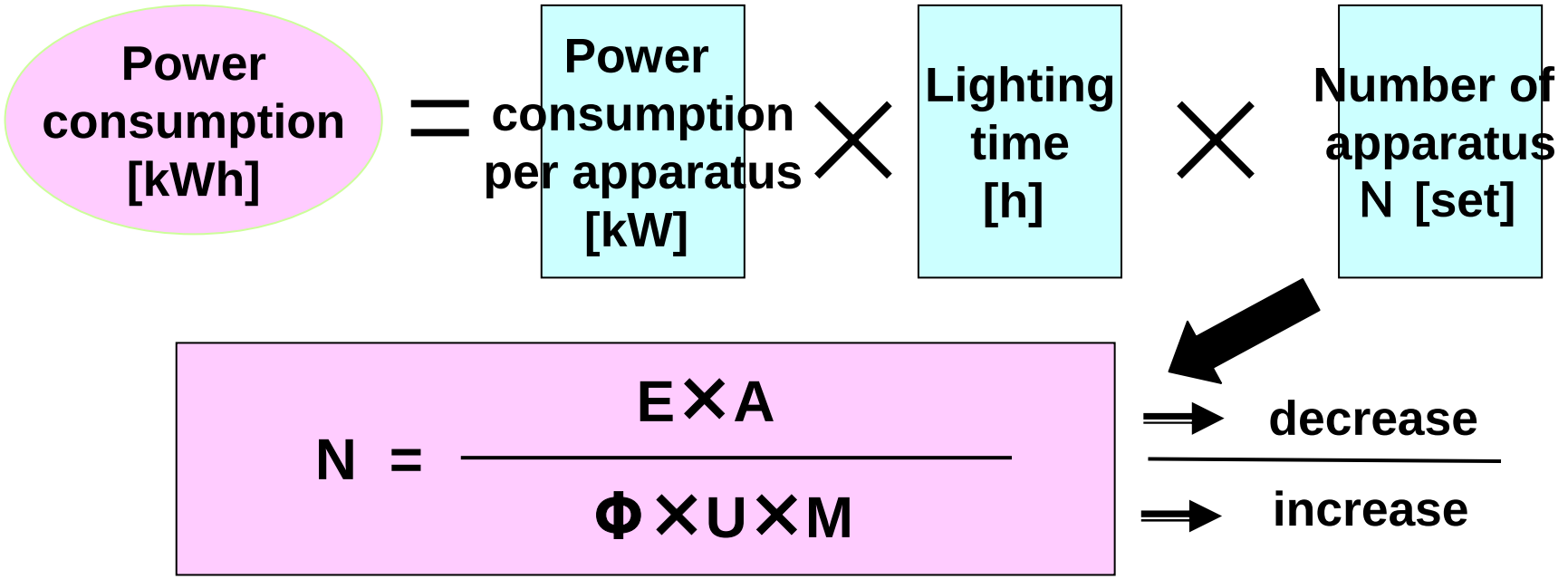
(Examples)
Comparison of electricity consumption of the compressor at variable capacity system



3.3 Lighting apparatus

Viewpoint of Power-saving	Examples regarding methods of power-saving
Choice of high efficiency light sources	Choice of high efficiency lamp such as sodium lamp Choice of Hf fluorescent lamp utilizing inverter Choice of low loss type stabilizer
Reduction of illumination	Adequacy of lighting standards in workshop Reduction of whole illumination and use of part illumination Dimming of lighting through proper lighting control
Reduction of illumination object	Review and reduction of place needing illumination
Choice of high efficiency lamps	Choice of high efficiency lamp, floodlight beams
Improvement of illumination rate	Consideration such as reflection efficiency to lighted location
Improvement of maintenance rate	Periodical cleaning of lamp Appropriate exchange of lamps
Reduction of lighting time	Close lights out Extinguishing of lighting through proper lighting control

Energy Consumption of Lighting Apparatus



N: Number of lighting apparatus installed

E: Average luminance on working place [LX]

Φ: Luminous flux per lighting apparatus [lm]

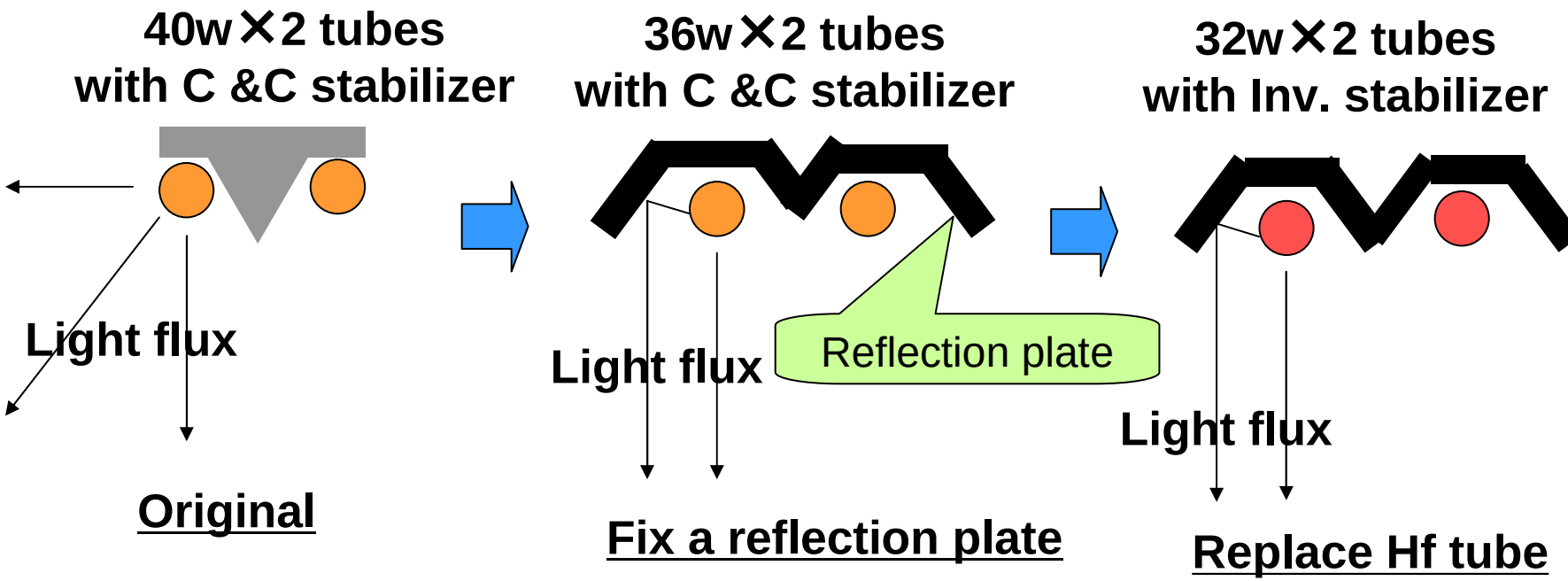
A: Room space [m^2]

U: Utilization factor

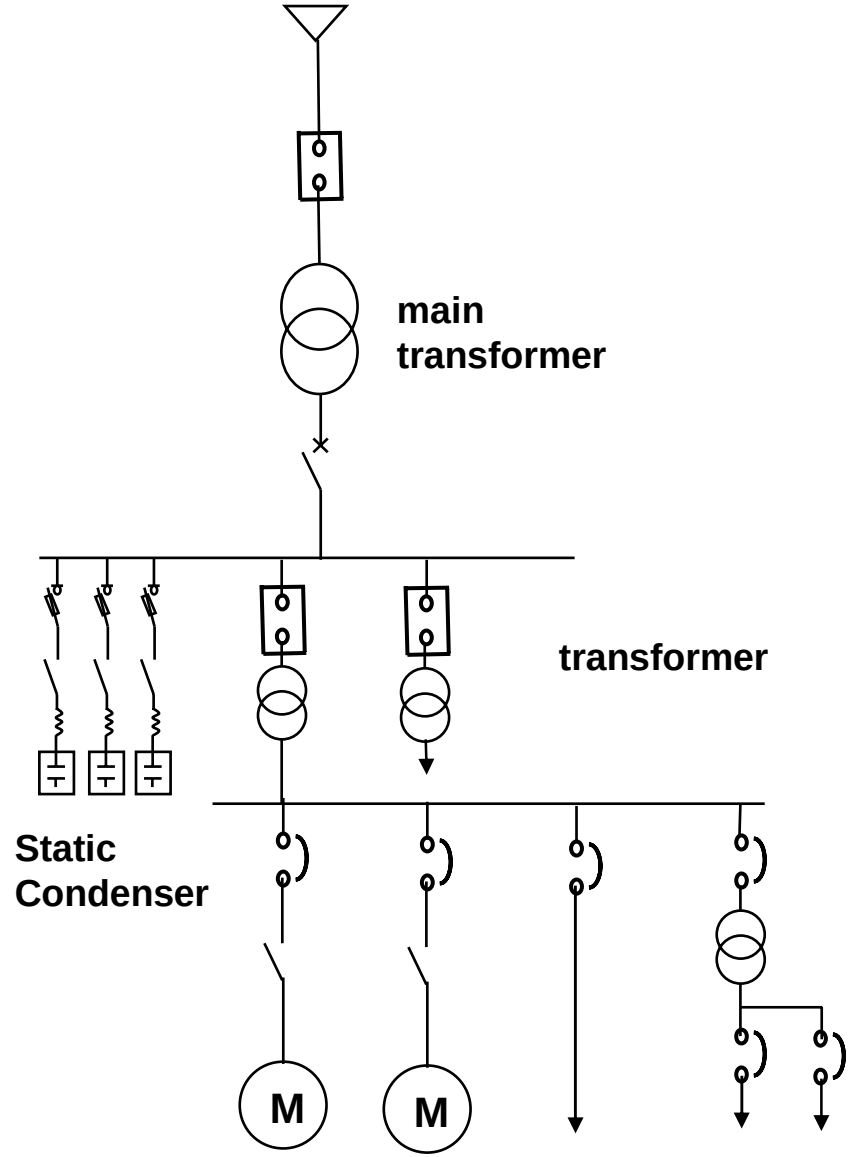
M: Maintenance factor

Lighting standards in workshop in JAPAN : JIS Z9110

Replace with more efficient light



3.5 Electric Power Distribution System



Viewpoint of power-saving	Examples regarding methods of power-saving
Selection of high efficiency apparatus	Selection of high efficiency transformer☆
Improvement of power factor	Addition of condenser for improvement of power factor ☆
	Selection of high power factor apparatus ☆
apparatus with pause at a resting time	Integration and halt of light-load transformers
	Pause of fans for transformers when transformers are loaded lightly and/or not heated

☆：Consider when facilities will be replaced or equipment will be newly installed

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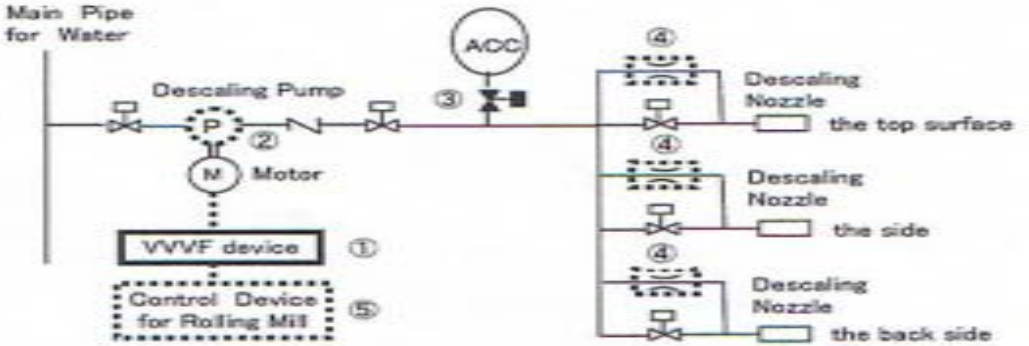
4.1 Example-1 : Power-Saving regarding Pump

Title	Power-saving by rotation speed control of Descaling Pumps
Purpose	Jetting work by descaling nozzles is intermittent and short period is required for the rolling materials surface scale removal. On this account, the rotation speed of the pump at the time of no jetting could be lowered for power-saving.
Plan Summary	a) Figure of facilities summary



b) Facilities remodeling items

①: Introduction of a VVVF Device
2400kVA

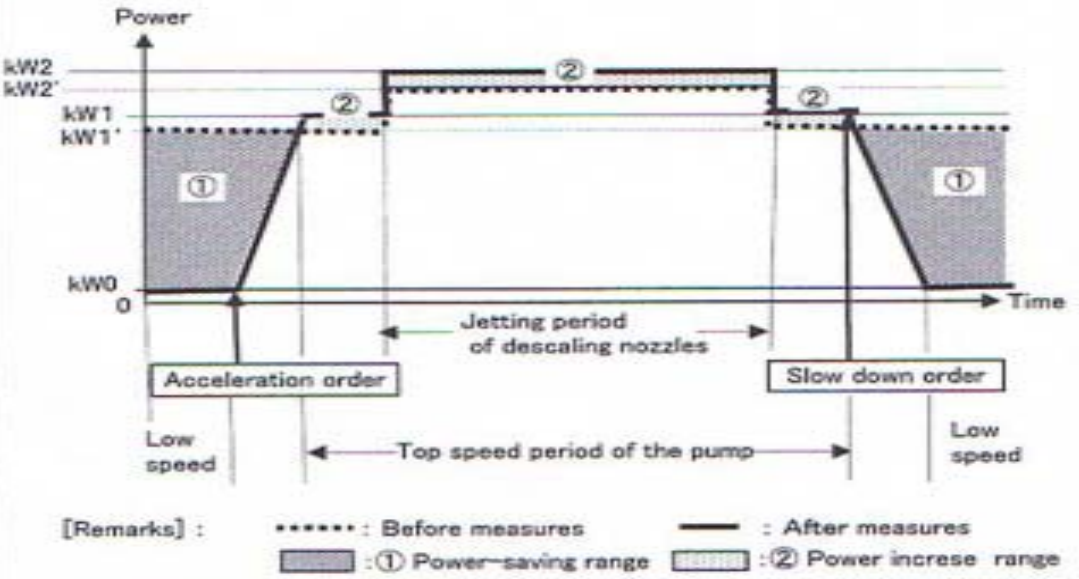
②: Exchange of a Pump Rotor
For mechanical strength improvement

③: Addition of a Accumulator Interception Valve
For low pressure measure

④: Exchange of Bypass Orifices
For low pressure measure

⑤: Remodeling of a Control Device
Addition of an automatic picking up pump speed and slowing down sequence

Object Facilities	Ironworks Rolling Mill
Power −saving Logic Summary	a) Speed pattern of the pump



b)Power−saving logic

①Power−saving by lowering the speed of pump at the time of no jetting.

・Speed of the pump : 100%(Top speed) → 40% (Low speed)

・Power−saving : P_1[kW] (kW1'−kW0)

Furthermore, power−saving by a fine adjustment of the pump terns at the time of jetting work.

・nozzles non−jet time/jet time: T_1 (Low Speed) / T_2 (Top Speed) [h/Y]

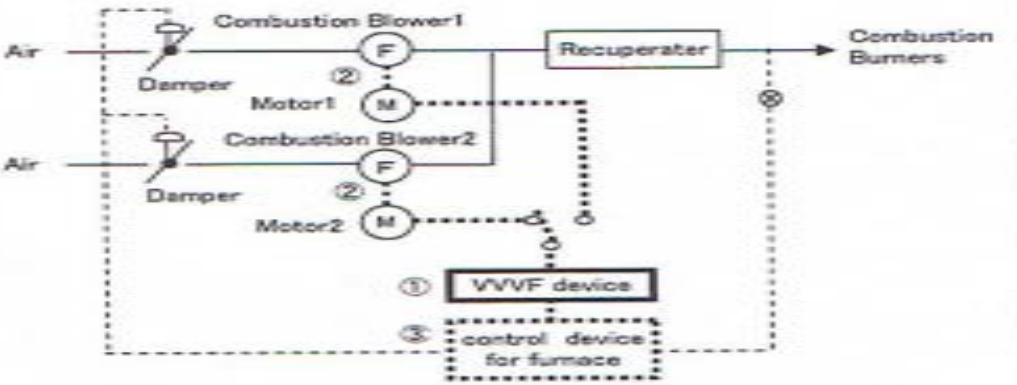
②The incremental power consumption due to efficiency of VVVF device.

・Power increase : P_2[kW] (kW1−kW1' or kW2 − kW2')

☆The power−saving volume : $\Delta kWh = P_1 \times T_1 - P_2 \times T_2$ [kWh/Y]

4.2 Example-2 : Power-Saving regarding Brower

Title	Power-saving by rotation speed control of Heating Furnace Combustion Blowers
Purpose	We introduced a set of VVVF device for load adjustment of heating furnace combu blowers from suction dampers and planed power-saving. In addition, only one set of VVVF device was introduced for two blowers and manages it.
Plan Summary	a) Figure of facilities summary



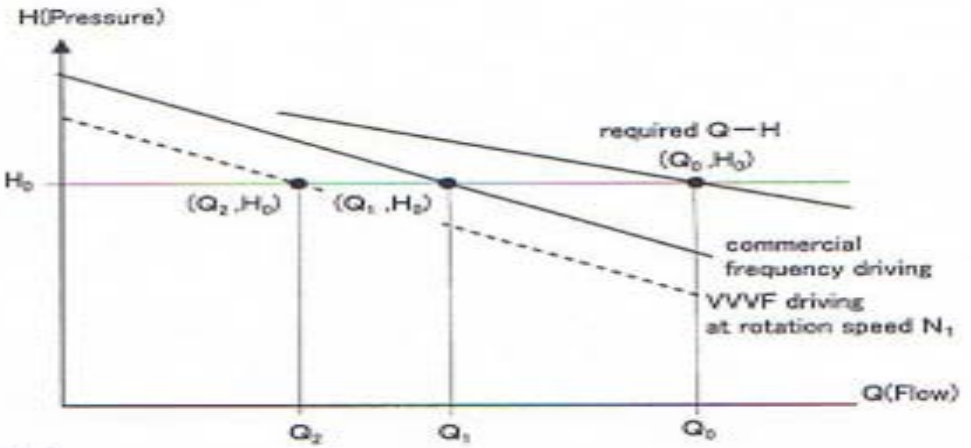
b) Facilities remodeling items

①: Introduction of a VVVF device
350kVA

②: Exchange of Gear Couplings
For mechanical strength improvement

③: Remodeling of a Control Device
Addition of automatic change-over of the VVVF setting function

Object Facilities	Ironworks Rolling Mill
Power -saving Logic Summary	a) Flow Quantity—Pressure Curve (Q-H curve) of blowers A conception diagram when a variable speed runs for one of them at the time of two blower driving.



[Remarks] :

$Q_0 = Q_1 + Q_2$

$N_1 = N_1' \times (Q_1 / Q_1')$

★ Flow Quantity Q_1' at rotation speed N_1'

b) Power-saving logic

Driving Cases (VVVF use with all cases)	Proportion [h/Y]	Quantity of Power-saving[kW]
Two Blower driving	T_1	P_1
One Blower driving	T_2	P_2
Maintenance Furnace Temperature	T_3	P_3

☆The quantity of power-saving : $\Delta kWh = P_1 \times T_1 + P_2 \times T_2 + P_3 \times T_3$ [kWh/Y]

4.3 Example-3 : Power-Saving regarding Air compressor

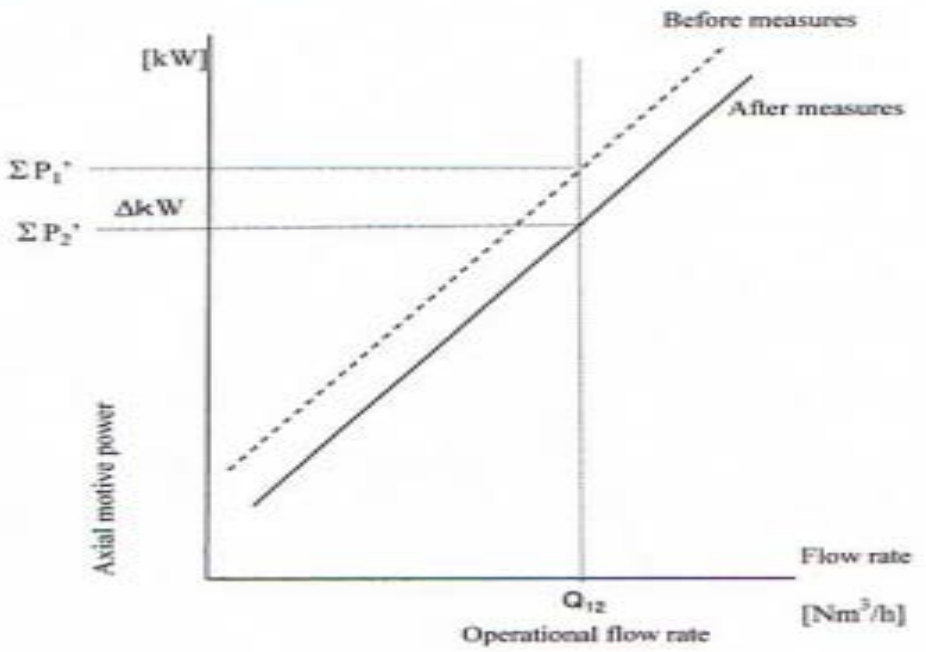
Subject name	**Electric power saving by changing the pressure specification of air compressors and modifying them**
Purpose	Compressed air facilities have been operated according to the designed specifications of a discharge pressure of 0.78 MPa (8kg/cm^2) since they were started, and in recent years, are operated at a lower discharge pressure of 6.4 MPa (6.5 kg/cm^2) after the pressure necessary for terminal equipment was reviewed. Therefore, because the efficiency of air compressors was caused to become lower, their modification has been performed according to the actual load, thereby leading to the achievement of electric power saving thanks to higher efficiency.
Overview of plan	**a) Comparison of the specifications of each facility**

	Initial specification	Before measures	After measures
Discharge air pressure [MPa]	0.78	0.64	0.64
Capacity Q_0 [Nm3/h]	33,000	33,000	33,000
Axial motive power [kW]	P_O	P_1	P_2
Isothermal efficiency [%]	η_0	η_1	η_2
Electric power energy intensity [kW/Nm^3]	P_0/Q_0	P_1/Q_0	P_2/Q_0
Number of air compressors	N	N	N

Differences between the properties: $P_1 > P_0 > P_2$
$(\eta_1 < \eta_0 < \eta_2)$

b) Facility modifications

①: A set of modifications of the existing air compressors (by manufacturers)
- Modifying and replacing diffusers with vanes, impellers, and scrolls

Target factories	Power center of iron works
Overview of electric power saving logic	**a) Property of axial motive power** 
	b) Electric power saving logic (1) Electric power saving by the higher efficiency of air compressors Before measures: P_1(at Q_0) → After measures: P_2(at Q_0) ☆Amount of electric power saving: $\Delta kWh = (P_1/Q_0 - P_2/Q_0) \times Q_{12} \times T$ [kWh/Y] (Explanatory note) T: Hours of operation (24 [h/D] x 365 [D/Y] = 8760 [h/Y])

.4 Example-4 : Power-Saving regarding Lighting Equipment

Subject name	**Electric power saving by changing factory ceiling lighting from the existing lamps to sodium ones**
Purpose	For a long time, all ceiling-mounted lighting in factories consisted of mercury vapor lamps, and electric power saving was attained by changing them to sodium lights.
Overview of plan	**a) Target lighting**

	Rolling	Refining	Warehouse	Total
Mercury vapor lamps 1000W	N1	N2	N3	ΣN

★The lighting not targeted this time is:
(a) Lamps always blacked out by thinning out illumination or otherwise
(b) Lamps lit only during inspections
(c) Lamps that have problems from the standpoint of their color rendering properties during work, even among sodium lamps with high color rendering properties
(product inspection site, etc.)
(d) Mercury vapor lamps left on in mixed-illumination ceilings equipped with both mercury vapor lamps and sodium lamps
(e) Outdoor lamps (lighting-up hours: hours for indoor lamp × approx. 1/2): thereafter, a better plan will be established after consideration of the energy saving effect.

b) Facility modifications

(1) Changing from mercury vapor lamps to sodium lamps and ballast chokes

from HRF1000 to NHR660

★: Price difference between the lamps (one example): Sodium-lamps/mercury-vapor-lamps = approx. 2.6

(2) A set of the exchanged lamps and ballast chokes

Target factories	Rolling factories in iron works
Overview of power saving logic	**a) Comparison of properties between the lamps**

(Values are of reference examples)

	Before measures	After measures
Kinds of lamp	Mercury vapor lamp	Sodium lamp
Lamp model	HRF1000	NHR660
Nominal electric power [W]	1000	660
Light flux [lm]	59500	69000
Average life [h]	12000	12000
Input electric power [W]	1030	700
Electric power rate	100	68

b) Energy saving logic

(1) Electric power saving by changing from mercury vapor lamps to sodium ones

- Input electric power of lamps [kW]: Change from L1 (mercury vapor lamps) to L2 (sodium lamps)
- Electric power saving amount: P [kW] = (L1 - L2) · ΣN

☆Electric power saving amount: ⊿kWh = (L1 - L2) · ΣN · T [kWh/Y]

(Explanatory note)

ΣN: Number of lamps replaced [tubes]

T: Operational hours of lamps (example: 16-24 [h/D]) x 365 [D/Y] = 5840 - 8760 [h/Y])

ECCJ

The END Thank you !