Promotion of Energy Conservation Activities in Factories (Electricity)

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November 24, 2006

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 ”

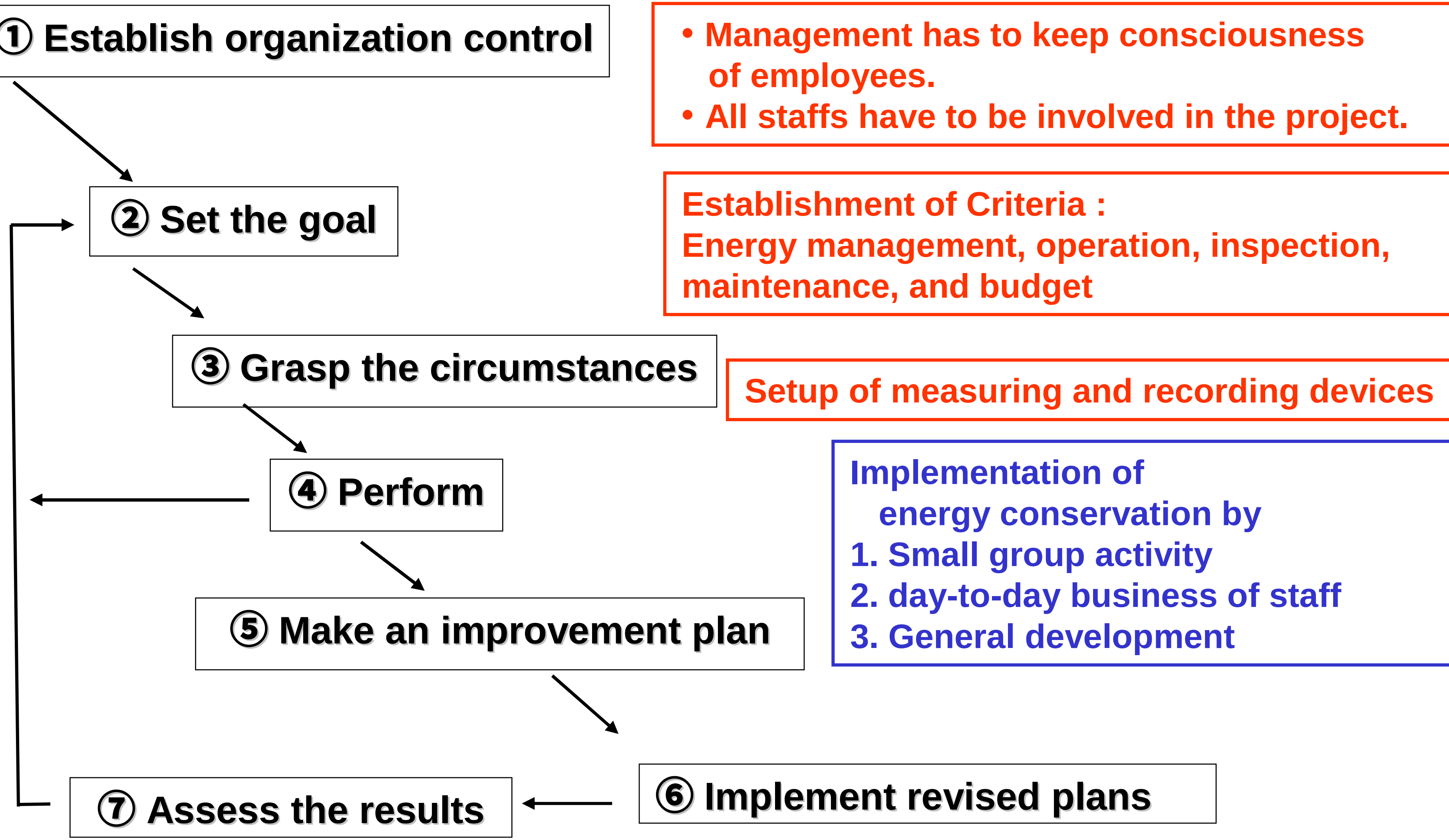
“ Energy Conservation Activity ”
has contributed to “ Cost Down of each factory ”
moreover, Improvement of “ Cost ” and “SEC”
(“SEC” is Specific Energy Consumption and defined as energy conservation divided by production)

&

“ 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

Setup of measuring and recording devices

④ Perform

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

⑤ Make an improvement plan

⑥ Implement revised plans

⑦ Assess the results

Repeat PDCA cycle of energy management

1.3 3 steps for Promotion of Energy Conservatio

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

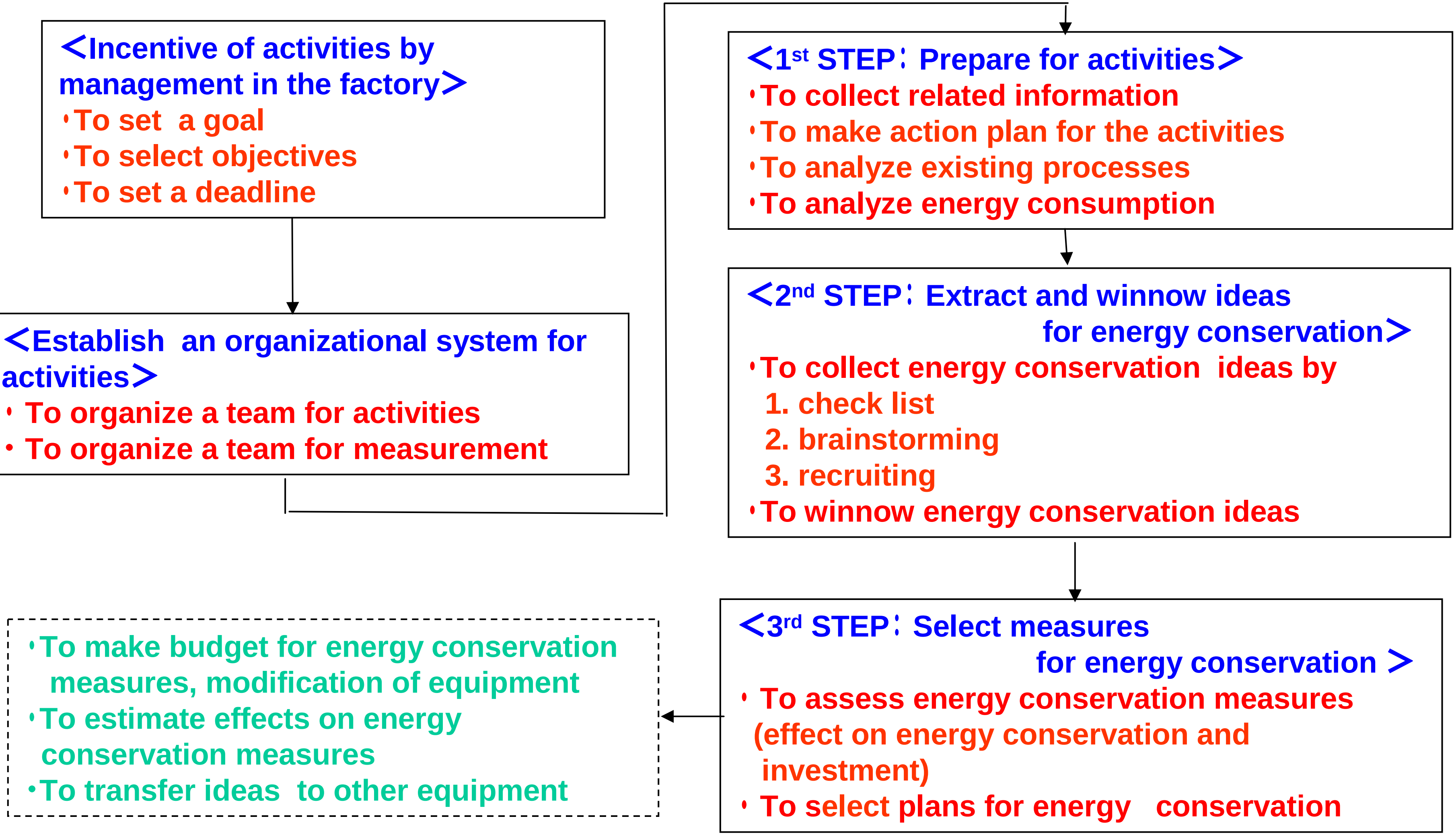
2nd step: Modify and/or add equipment

- 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



<Incentive of activities by management in the factory>
- To set a goal
- To select objectives
- To set a deadline

<Establish an organizational system for activities>
- To organize a team for activities
- To organize a team for measurement

<1st STEP: Prepare for activities>
- To collect related information
- To make action plan for the activities
- To analyze existing processes
- To analyze energy consumption

<2nd STEP: Extract and winnow ideas for energy conservation>
- To collect energy conservation ideas by
  1. check list
  2. brainstorming
  3. recruiting
- To winnow energy conservation ideas

<3rd STEP: Select measures for energy conservation >
- To assess energy conservation measures (effect on energy conservation and investment)
- To select plans for energy conservation

- To make budget for energy conservation measures, modification of equipment
- To estimate effects on energy conservation measures
- To transfer ideas to other equipment

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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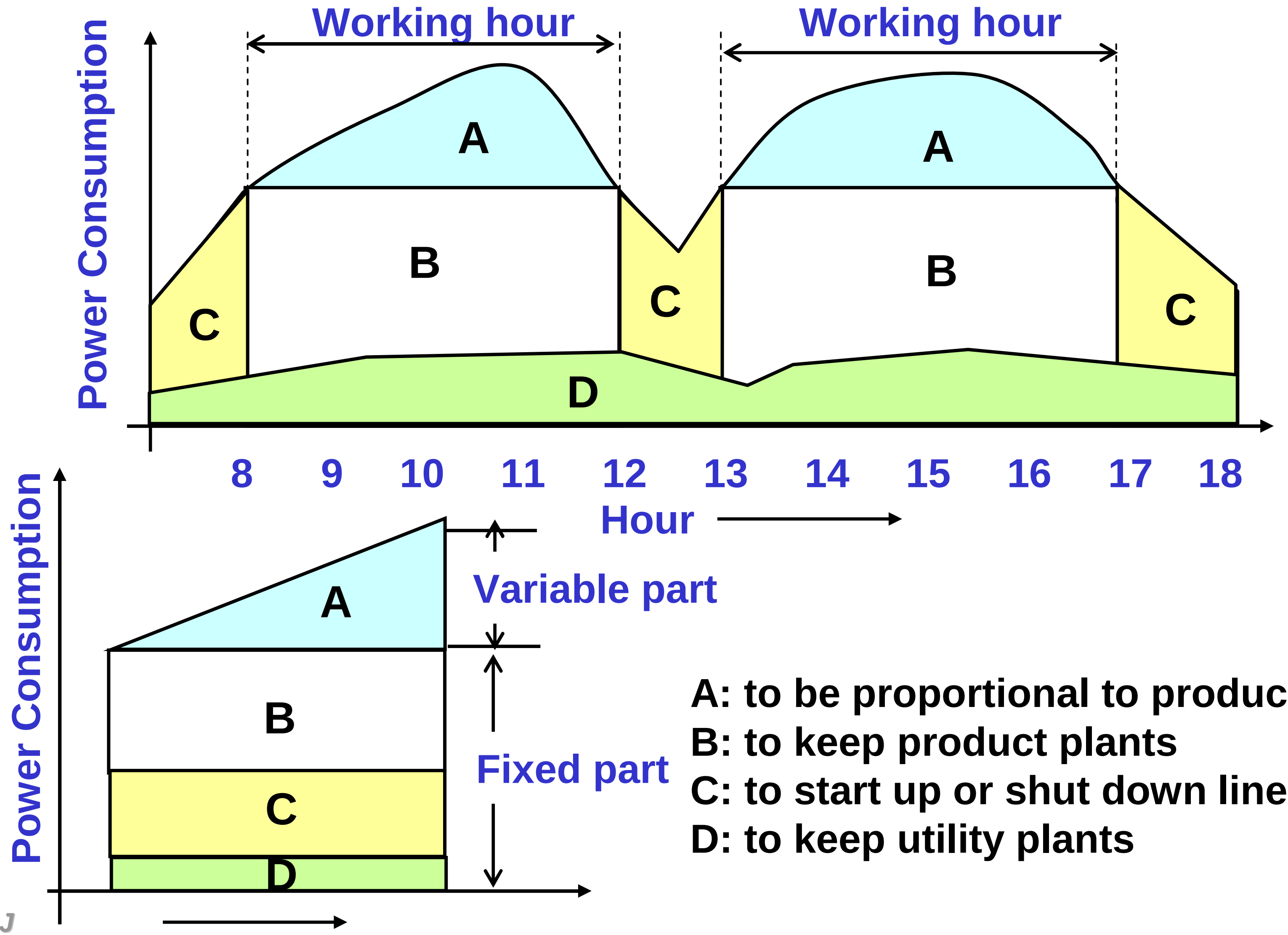
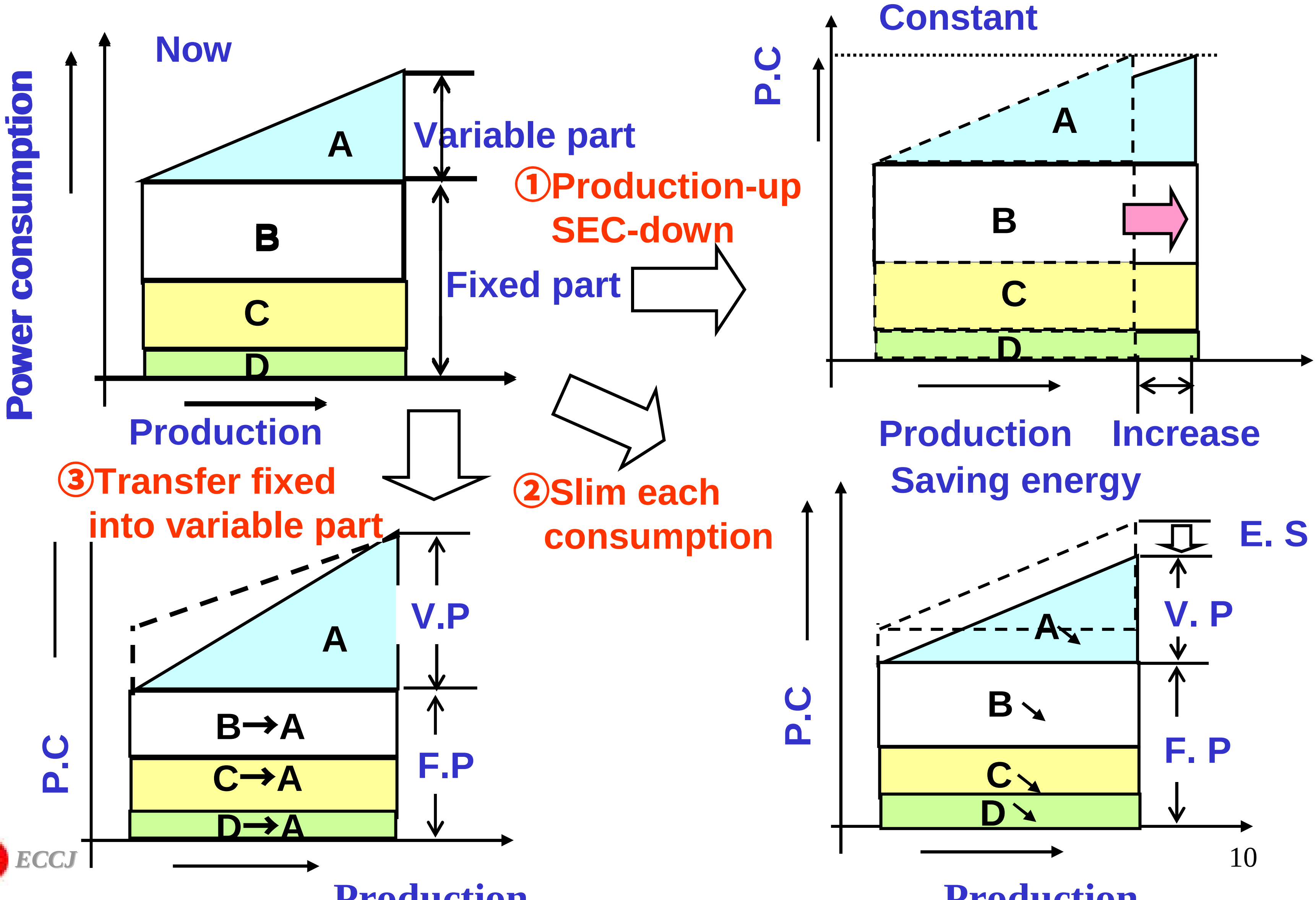
2. Viewpoint of Power-saving

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



①Production-up
SEC-down

②Slim each
consumption

③Transfer fixed
into variable part

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

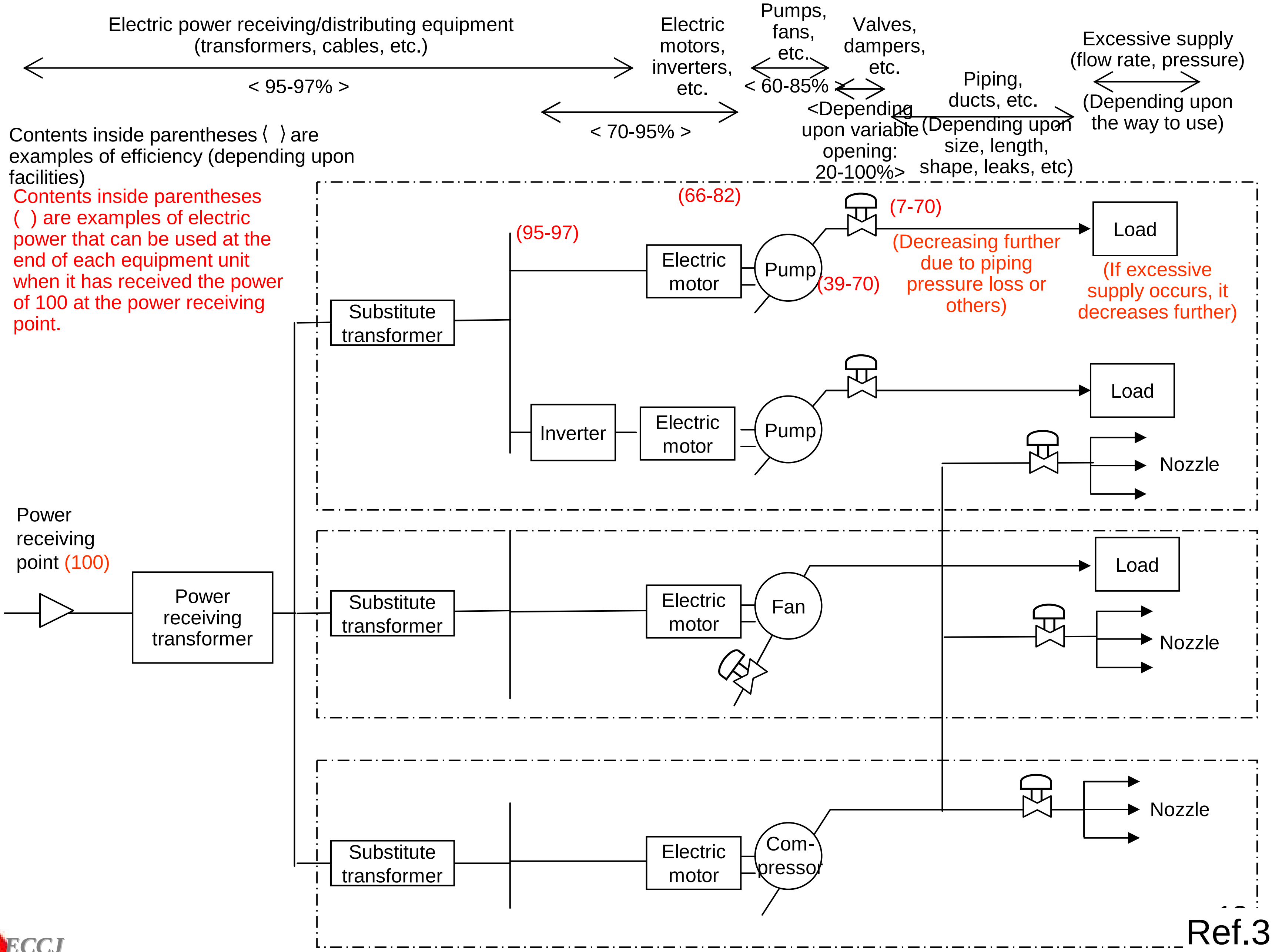
① Equipment (electric motor, transformer, cable） is subject to be audited only when they are established or renewed.

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



Electric power receiving/distributing equipment (transformers, cables, etc.)

< 95-97% >

Electric motors, inverters, etc.

< 70-95% >

Pumps, fans, etc.

< 60-85% >

Valves, dampers, etc.

<Depending upon variable opening: 20-100%>

Piping, ducts, etc.

(Depending upon size, length, shape, leaks, etc)

Excessive supply (flow rate, pressure)

(Depending upon the way to use)

Contents inside parentheses〈 〉are examples of efficiency (depending upon facilities)

Contents inside parentheses ( ) are examples of electric power that can be used at the end of each equipment unit when it has received the power of 100 at the power receiving point.

Power receiving point (100)

Power receiving transformer

Substitute transformer

Substitute transformer

Substitute transformer

(95-97)

Electric motor

(66-82)

Pump

(39-70)

(7-70)

(Decreasing further due to piping pressure loss or others)

Load

(If excessive supply occurs, it decreases further)

Inverter

Electric motor

Pump

Load

Nozzle

Electric motor

Fan

Load

Nozzle

Electric motor

Com-pressor

Nozzle

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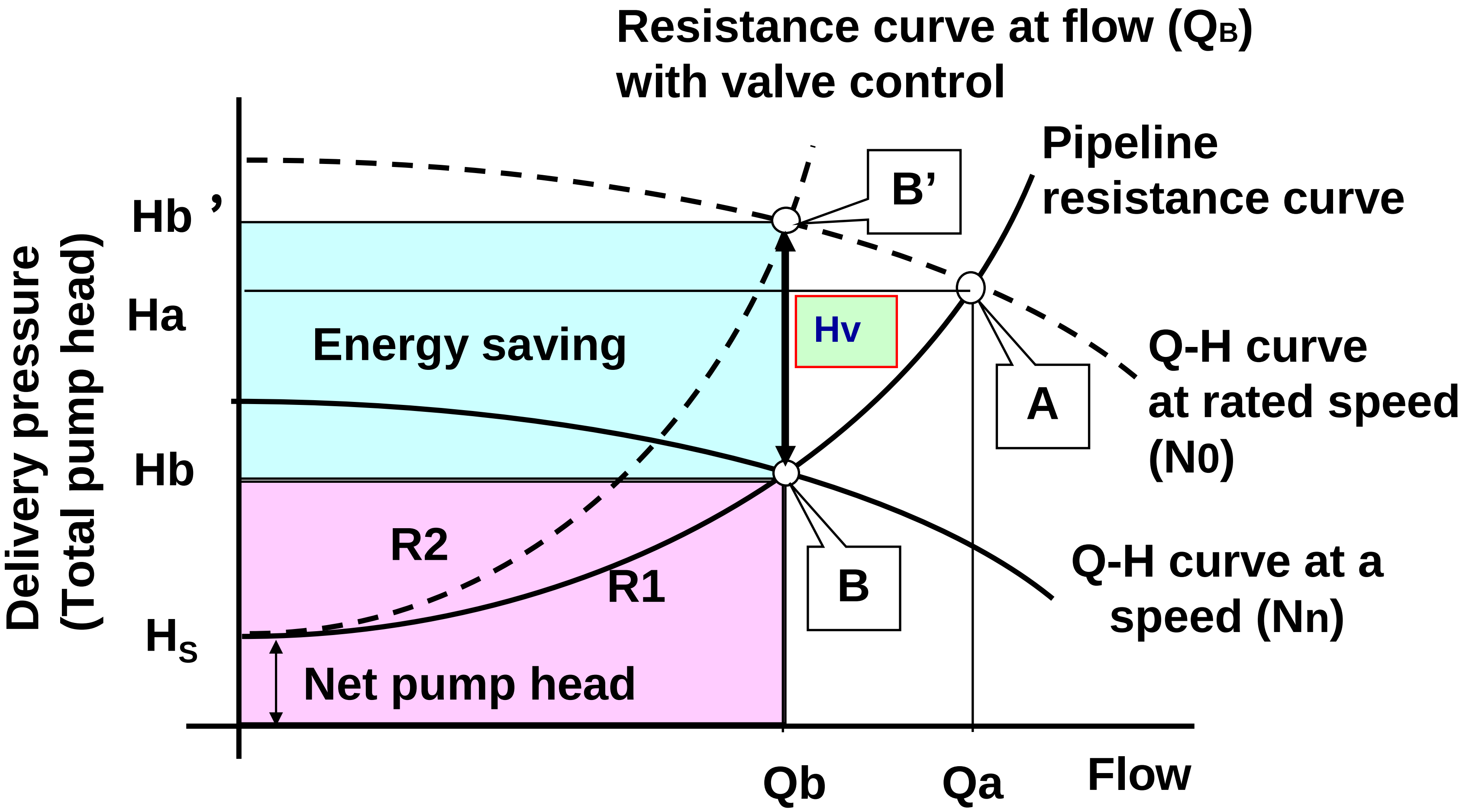
3.1 Pumps, Fans, and Blowers

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.

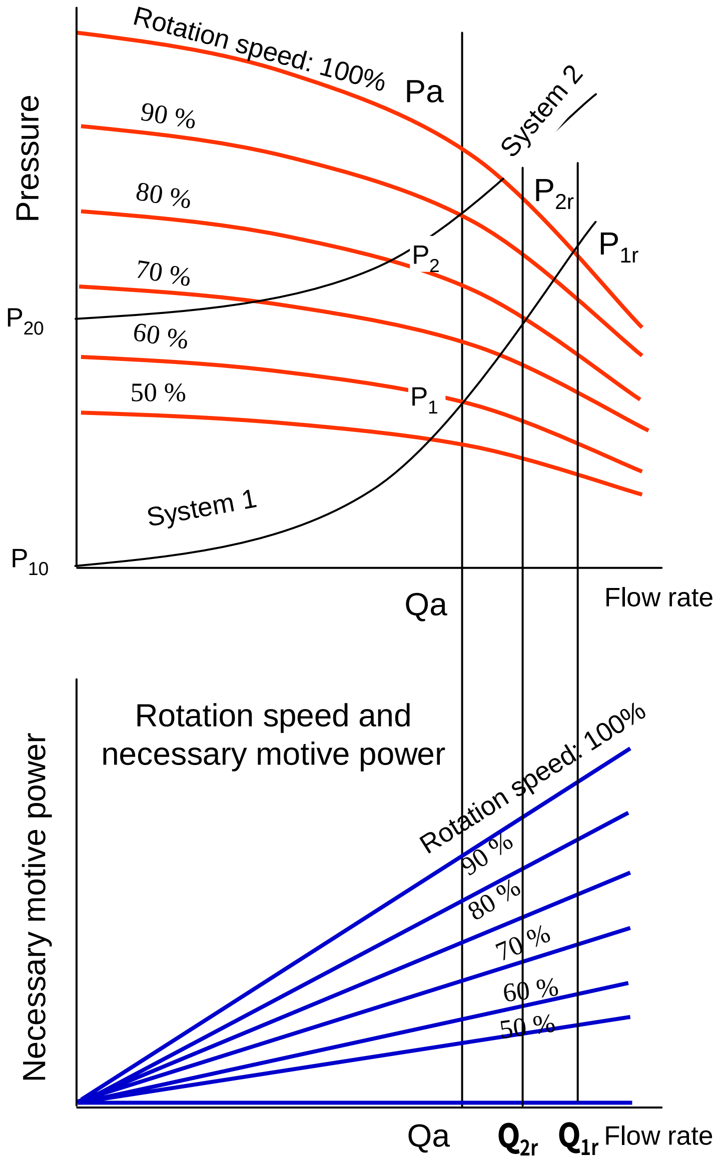
(4) The figures below show the property of the necessary motive power at that time.

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

Rotation speed and necessary motive power

☆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.

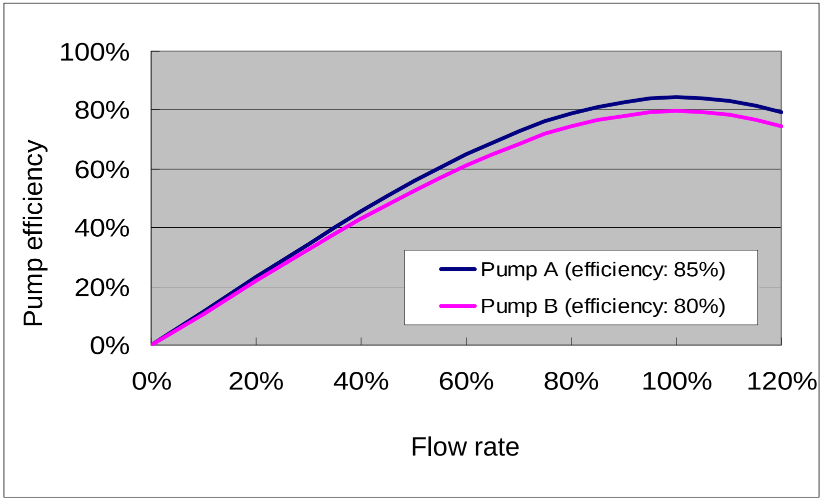


Figure (a) Pump efficiency

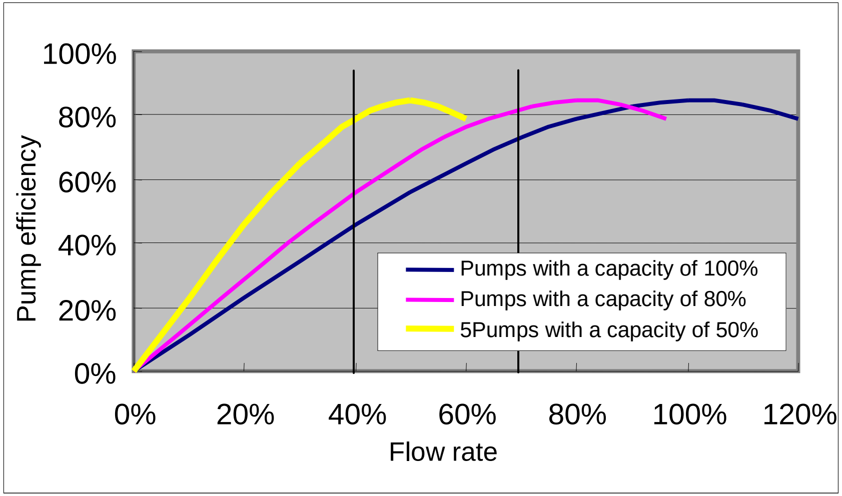


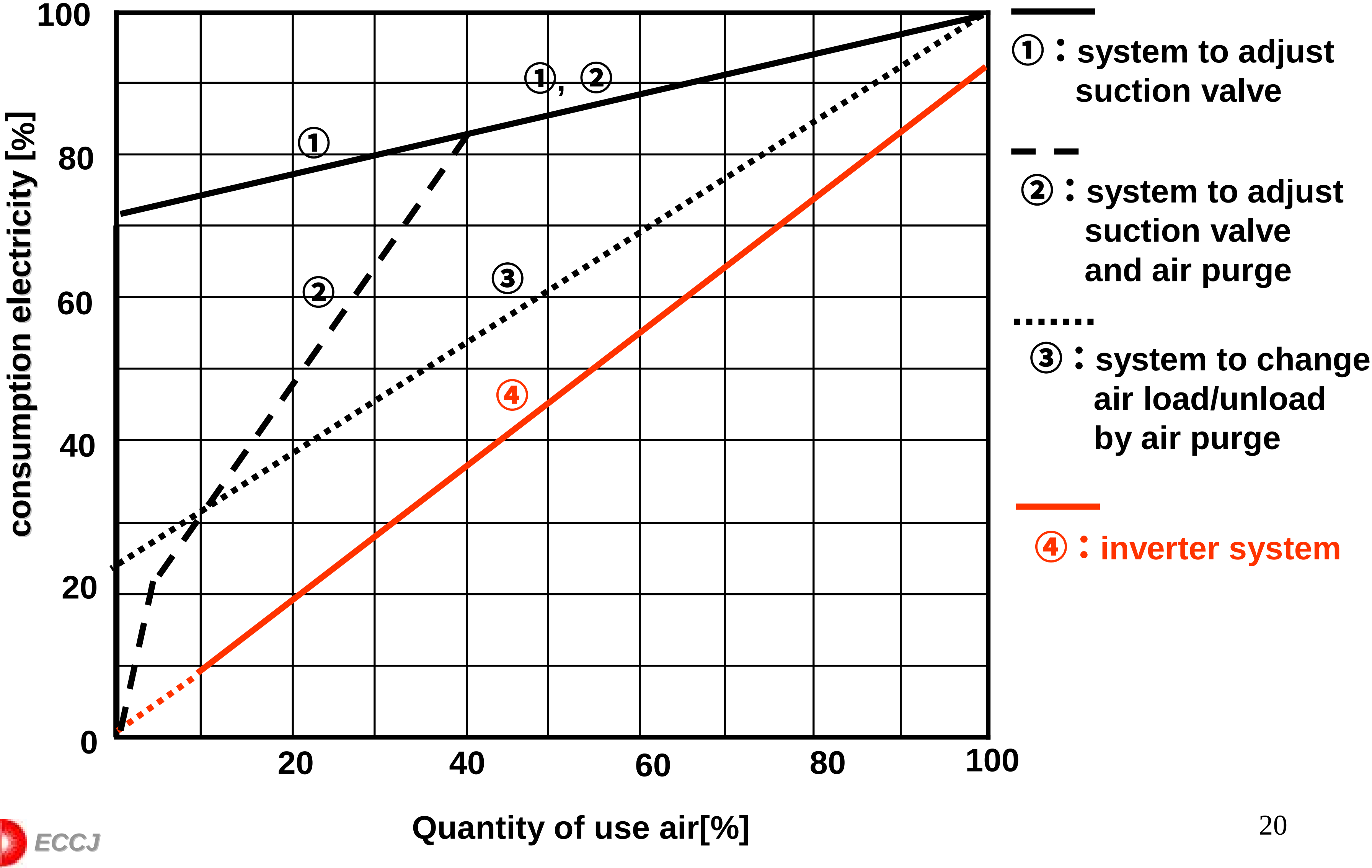
Figure (b) Selection of pump capacity and quantity control

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

Power consumption [kWh] ＝ **Power consumption per apparatus [kW]** × **Lighting time [h]** × **Number of apparatus N [set]**

$$N = \frac{E \times A}{\Phi \times U \times M}$$

→ decrease

→ increase

N: Number of lighting apparatus installed

E: Average luminance on working place [LX]

Φ: Luminous flux per lighting apparatus [lm]

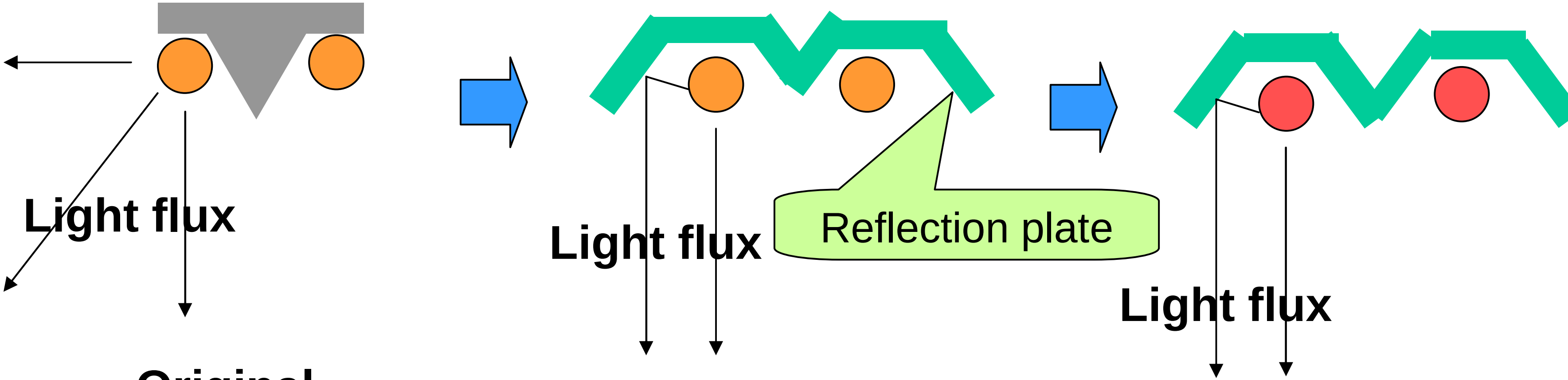
A: Room space [m²]

U: Utilization factor

M: Maintenance factor

Lighting standards in workshop in JAPAN : JIS Z9110

Replace with more efficient light



40w×2 tubes with C &C stabilizer

Light flux

Original

36w×2 tubes with C &C stabilizer

Light flux

Reflection plate

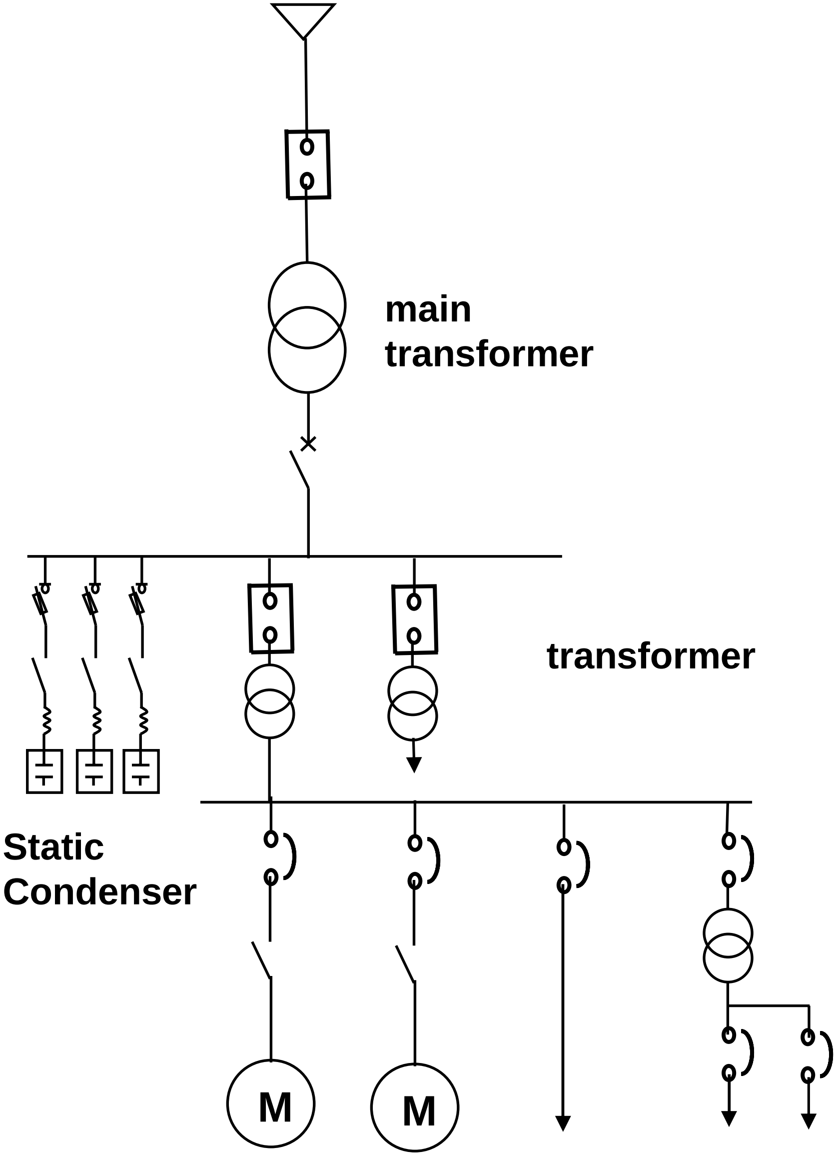
Fix a reflection plate

32w×2 tubes with Inv. stabilizer

Light flux

Replace Hf tube

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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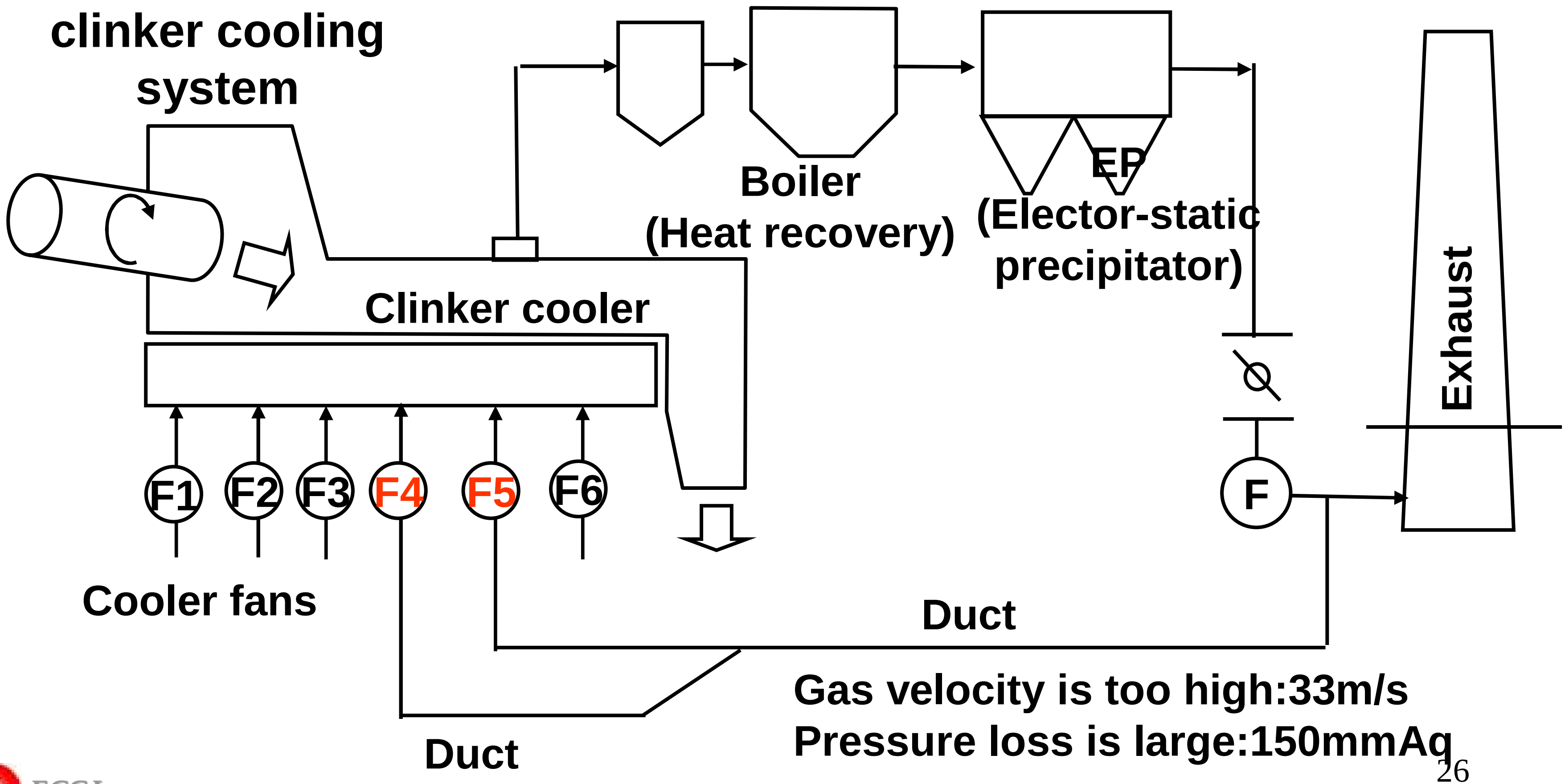
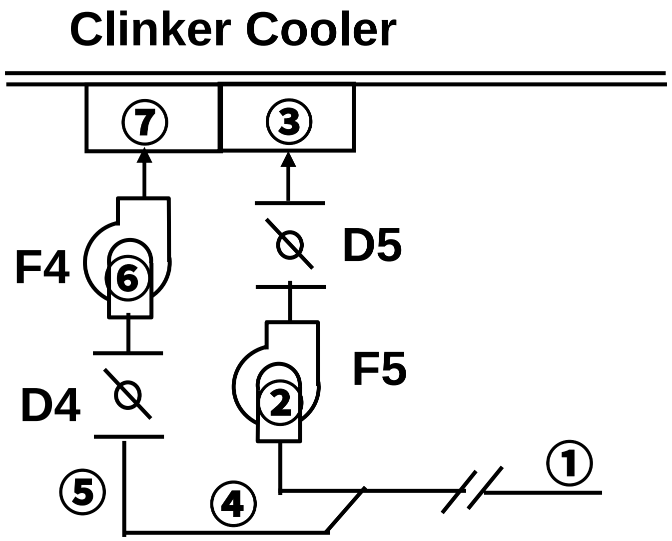
4． Power-saving Examples of Cement Process in Japan

4.1 Power saving on Clinker-cooling-Fan



Gas velocity is too high:33m/s
Pressure loss is large:150mmAq

Measurement Data



Pressure (mmAq)

Position	Pressure
①	-122
②	-135
③	+260

④	-270
⑤	-280
⑥	-250
⑦	+430

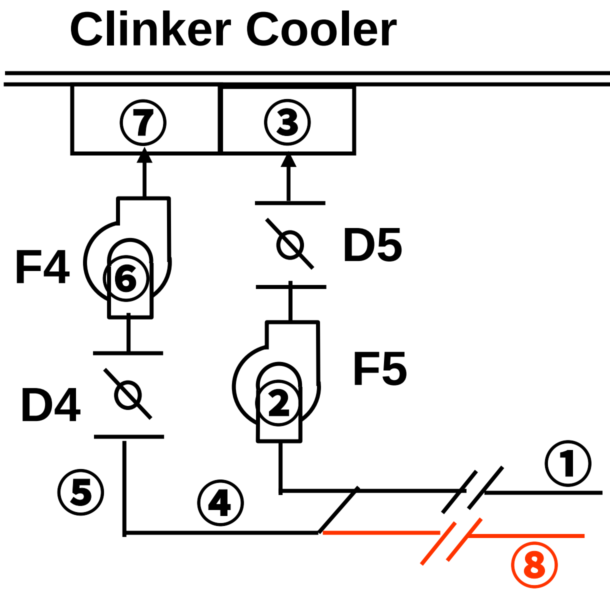
Gas Data at Position #1

Temperature(℃)	115
Velocity (m/s)	Around 33
Flow(m^3/min)	6,550

Fan data

	Flow (m^3/min)	Damper-opening
F4	3,750	78%
F5	2,800	100%

Improvement Measures



1. Place a new duct to reduce gas velocity
   Damper-opening:
   F4:55%, F5:45%
2. Fan-runner cutting

Runner Diameter (mm)

	Original	After cutting	Cut-ratio
F4	1,568	1,506	4.0%
F5	1,348	1,276	5.3%

ECCJ

Evaluation

1.Pressure (mmAq)

Position	Pressure
①	-122 to -60
②	-135 to -70
③	260 to +256
④	-270 to -97
⑤	-280 to -110
⑥	-250 to -203
⑦	430 to +388
⑧	-56

2.Gas flow

Position	Speed(m/s)	Flow(m³/min)
①	33 to 18.0	3,565
⑧	17.5	3,104

3.Damper opening

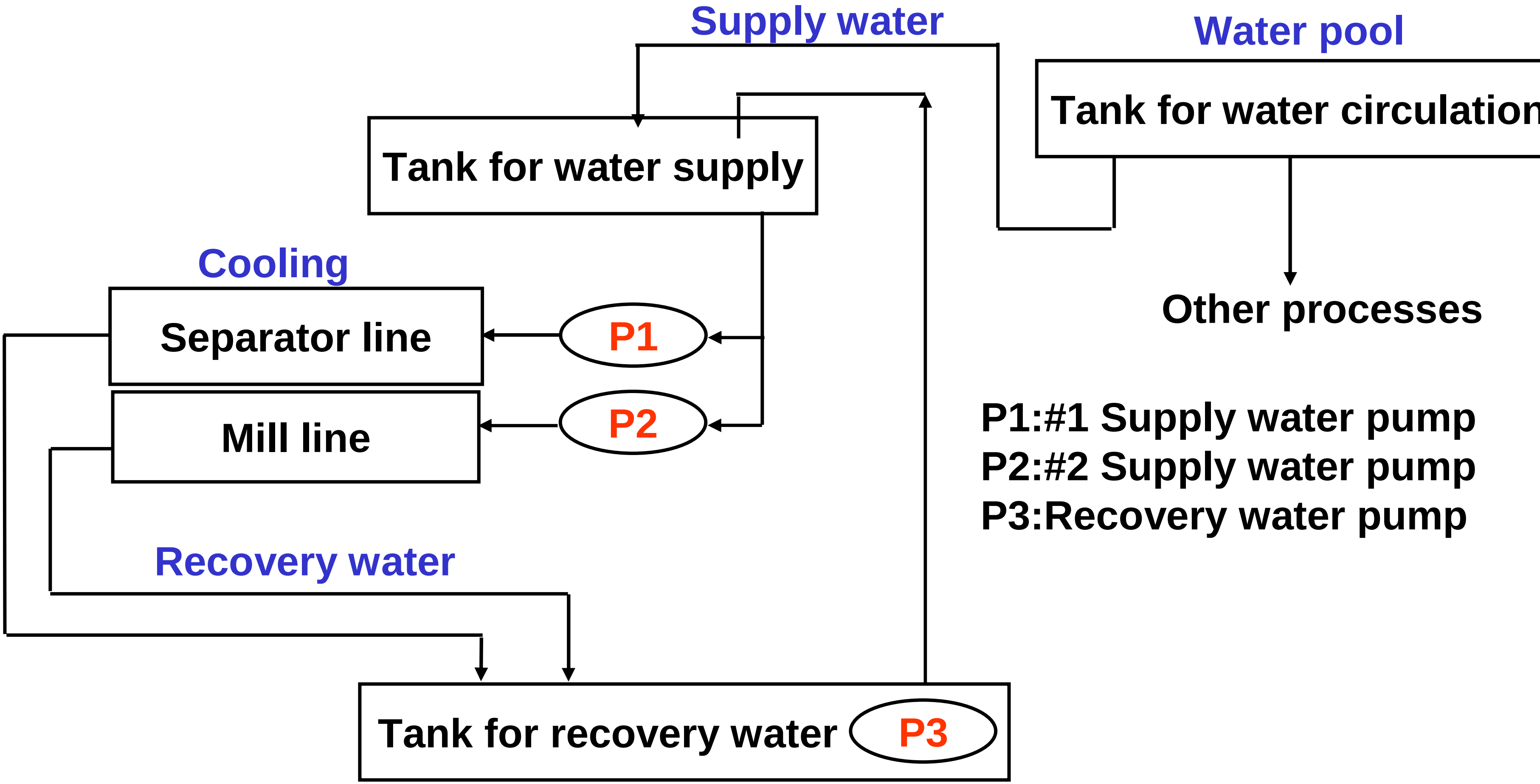
	Lay Duct	Runner-cut
F4	57%	80%
F5	45%	100%

4.Power consumption of Fans (kW)

	Before	New duct	Runner-cut	Saving
F4	550	525	489	61
F5	254	267	205	49

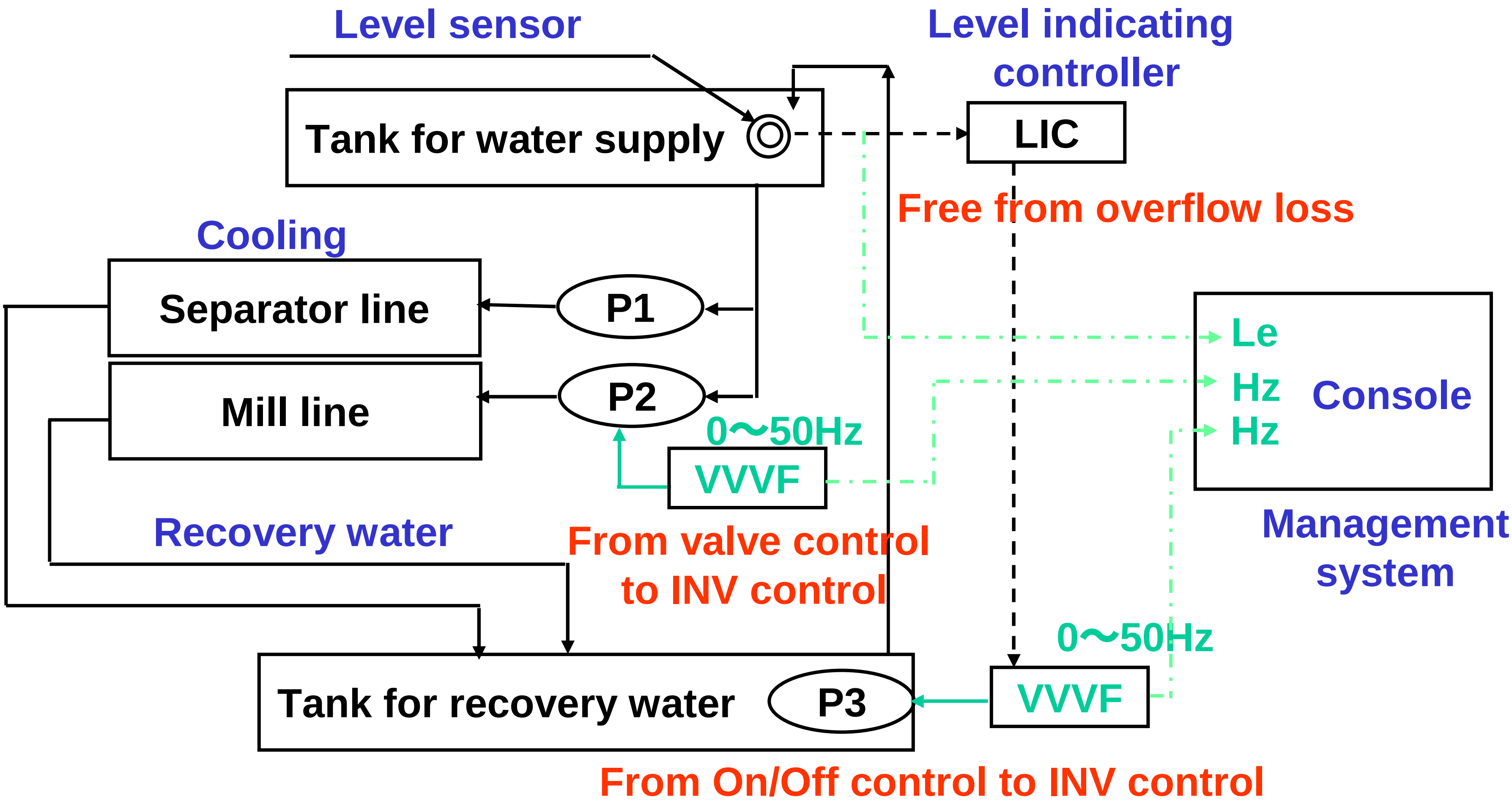
4.2 Power-saving on Cooling Water System

Cooling water circulation in finishing section



P1:#1 Supply water pump
P2:#2 Supply water pump
P3:Recovery water pump

Inverter control and Management system



Evaluation

1.Water Saving

Before	18t/h
After	10t/h
Saving	8t/h

2. Energy Saving

(kW)

	P1	P2	P3	total
Power Consumption	3.7	11	11	25.7
Saving	—	7	2	9.0

3. Conclusion

Saving Water is Saving Power

The End Thank you!