REPORT ON THE STUDY
ON
ENERGY CONSERVATION PROJECT
IN
THE KINGDOM OF THAILAND

— SUMMARY OF PHASE I —

JANUARY, 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

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1. Significance of Phase I Study

Phase I Study was undertaken in accordance with the Scope of Work for the Study on Energy Conservation Project in the Kingdom of Thailand, signed on March 26, 1982 between the Japan International Cooperation Agency and the National Energy Administration of the Kingdom of Thailand, aiming at the promotion of energy conservation in the field of manufacturing industry in the Kingdom of Thailand.

Phase I)	• Diagnosis of the 55 factories of the 6 industries for ceramics/glass, paper, textile, metals, chemicals/plastics, and foods. • Collection of information relative to energy conservation in the manufacturing industry sector. • Transfer of measuring/diagnosis technology to the counterparts of the Kingdom of Thailand.
Phase II)	• Formulation of a draft of standards for rationalization of energy use per type of industry. • Recommendation of measures to promote energy conservation in the field of manufacturing industry. • The framework for the study is as per attached data-1. • A study team of members of the Energy Conservation Center (refer to attached data 2) was dispatched three times in August 1982, and January and June 1983, for 35 days each time.

2. Study Method

(1) Factory Diagnosis

- Preliminary study through Questionnaire
- Interviews with executives and managers
- Overall inspection of factory
- Surveys and measurement
- Discussions

(2) Technology Transfer to Counterparts

- Guidance on how to handle measuring equipment
- Explanation on the important items of diagnosis and guidance on how to make an entry in the check list
- Explanation of diagnosis results

(3) Collection of related information

- Collection of information from NEA, TPA and factory managers

3. Diagnosed Factories

(1) Items manufactured and capital group classification

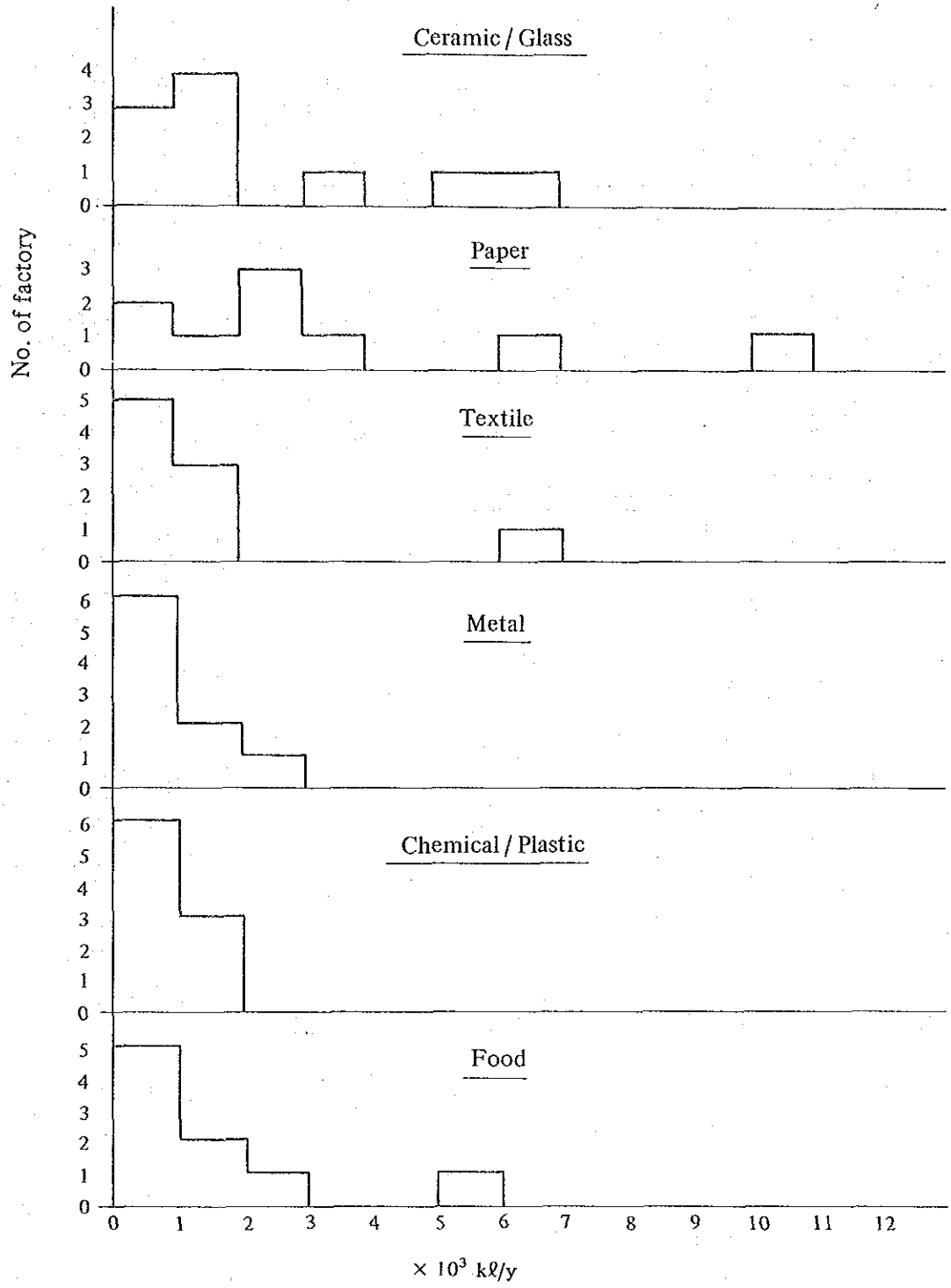
Items manufactured \ No. of factory	Joint venture with foreign co (s)	Belonging to Group	Others	Total
Ceramic/Glass				
Glass bottle, glass	1	0	3	4
Tile	0	0	2	2
Sanitary ware / Insulator	1	0	1	2
Others	0	0	2	2
Subtotal	2	0	8	10
Paper				
Paper	0	3	5	8
Corrugated cardboard	0	0	1	1
Subtotal	0	3	6	9
Textile				
Spinning / Cloth weaving	2	1	3	6
Nylon polymerization/Spinning	1	1	0	2
Socks	1	0	0	1
Subtotal	4	2	3	9
Metal				
Steel bar for concrete	1	2	0	3
PC Wire	1	0	0	1
Wire	1	0	0	1
Foundry	0	0	2	2
Tractor parts	0	1	0	1
Nail, screw, bolt/nut	0	1	0	1
Subtotal	3	4	2	9
Chemical/Plastic				
Organic chemicals	1	0	3	4
Inorganic chemicals	0	1	2	3
Gas separation	1	0	0	1
Plastic moulding	0	1	0	1
Subtotal	2	2	5	9
Food				
Marine product canning	0	1	2	3
Oil and fat	1	0	1	2
Feed	0	3	0	3
Alcoholic drinks	0	0	1	1
Subtotal	1	4	4	9
Total	12	15	28	55

- Almost a half of the diagnosed factories belong to the groups of joint ventures with foreign companies or influential domestic enterprises.
- The names of the diagnosed factories are as shown in attached data-3.

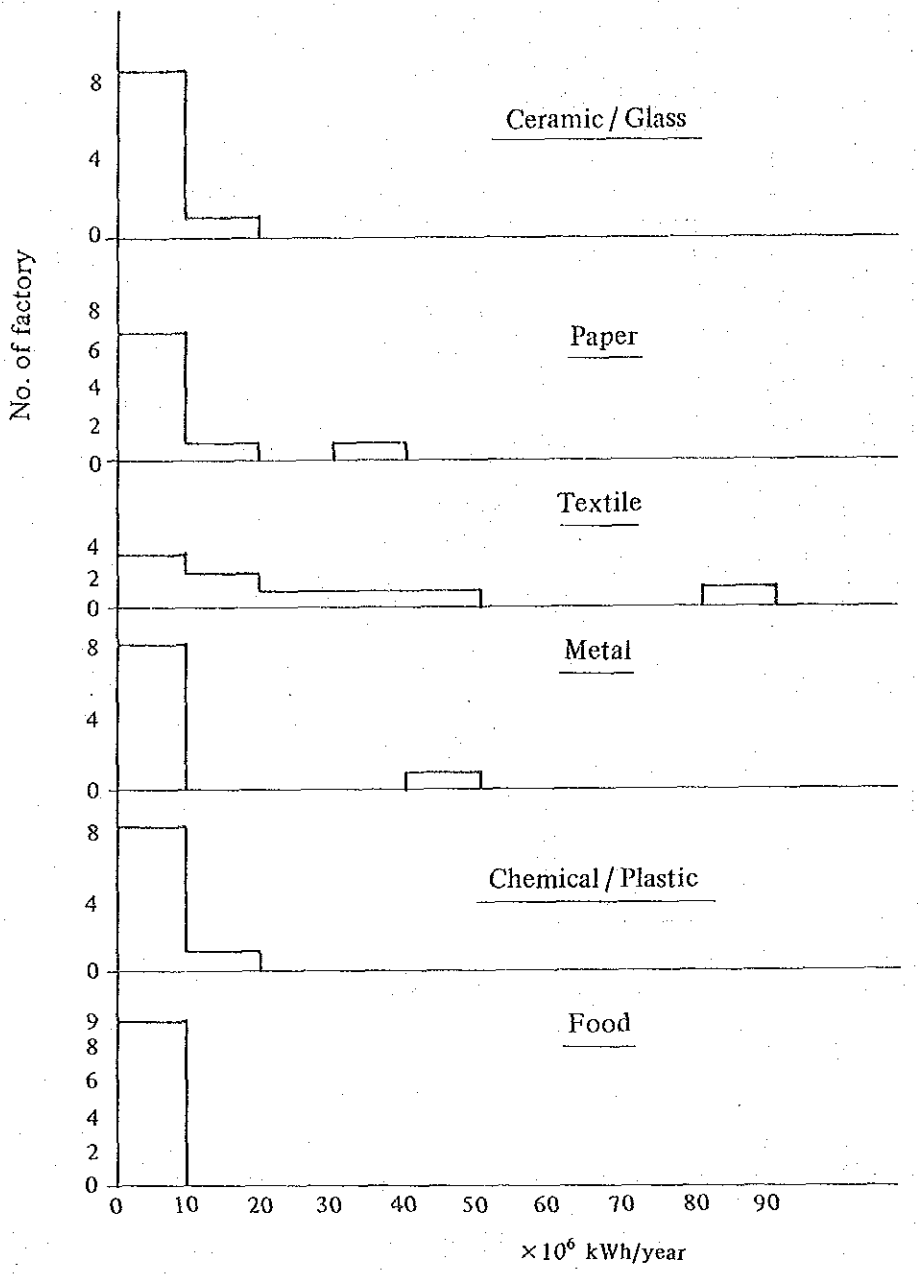
(2) Fuel oil cosumption per factory

(Lignite is in heavy oil equivalent. Excludes LPG and fuel for power generation)

1,000 kl/year or more 51%, 3,000 kl/year or more 15%



(3) Electric power consumption per factory
10×10^6kWh/year or more 20%, 20×10^6kWh/year or more 11%



4. The Results of Factory Diagnosis

(1) State of Energy Management

Item	Ceramic/ Glass	Paper	Textile	Metal	Chemical/ Plastic	Food	Total
Company policy							
• Establishment and notification of target values	–	–	2	2	2	4	10
• Measures hitherto taken	5	6	9	5	7	5	37
Participation of all personnel							
• Setting up of committees	3	2	7	4	4	2	22
• Project team	–	2	–	–	–	1	3
• QC circle	1	–	2	4	1	1	9
• Suggestion System	2	2	2	1	1	6	14
• Appeal to employees	5	2	4	4	4	6	25
Management through data							
• Grasping of daily consumption	8	4	6	3	4	8	33
• Grasping of consumption by process	6	2	6	2	5	6	27
• Calculation of energy consumption rate	5	5	3	4	4	3	24
• Preparation of control chart	1	1	1	1	1	2	7
• Analysis of causes of demand variation	1	1	2	–	2	3	9
Technological leveling-up of employees							
• Participation of staff in external training courses	6	5	6	7	6	9	39
• Education of operators	1	–	3	1	1	–	6
• Information exchange within the same industry	–	–	1	–	–	1	2
Total no. of factories	10	9	9	9	9	9	55

(Note)

1. Under "Setting up of the Committees", the committees include also those other than the committee solely for energy conservation.
2. Under "Calculation of Energy Consumption Rate", the calculation includes the portion calculated on monthly data.

(A) Generally, the management is highly concerned about energy conservation. However, only few factories establish and notify definite policy of enterprise and concrete target values.

(B) The factories which have some energy conservation mesures in force have reached 2/3 of the total number.

(C) The factories which provide an opportunity for discussion of the energy problem have reached approx. 40% of the total number. The majority of these factories make use of a general staff meeting for the discussion. Only three factories have a specialized ad hoc committee for energy conservation. One factory had ever had a committee devoted toward energy conservation, but abolished it because of its lacking know-how for the operation of the committee.

(D) At 9 factories, the QC circles are already off the ground centering around the staff. These circles are also being prepared at another factory. Nevertheless, they have not reached a stage that their QC circles activities are successful with favorable results for energy conservation.

(E) The suggestion system is established at factories eqivalent to approx. 1/4 of the total number, but is actually almost not operated.

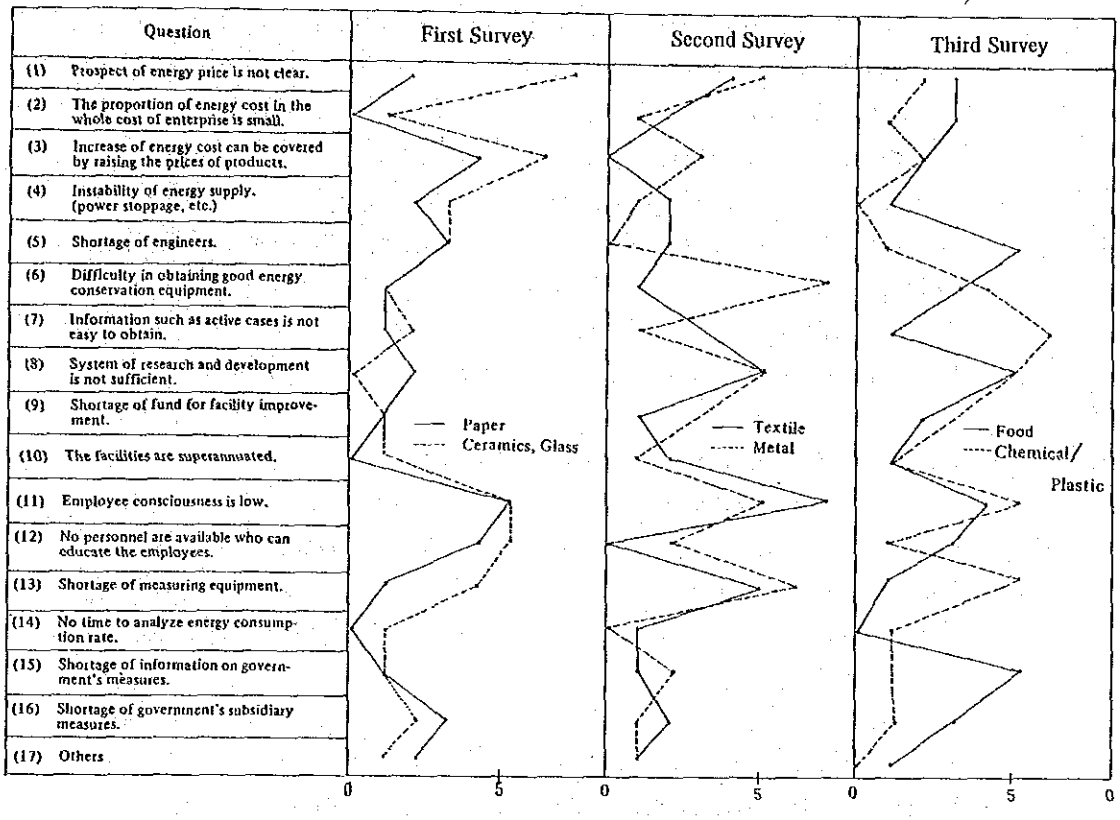
(F) Energy consumption is being recorded by factories equivalent to approx. 60% of the total number.

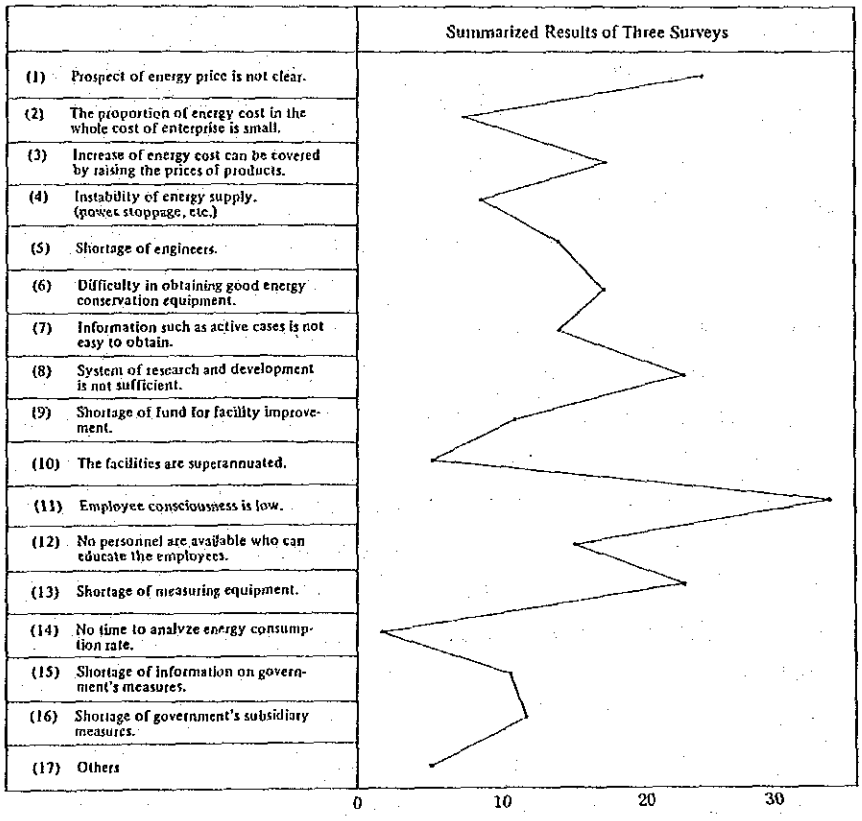
However, any appropriate measures taken whenever necessary through calculation of energy consumption rate, preparation of a control chart, and analysis of causes of demand variation, that is, control through data, are not fully implemented. The same is true about quality and yield.

(G) Staff are often sent to external seminars. However, internal "transfer education" by the staff who have participated in the external seminars is almost not carried.

(2) Answers to questionnaire "Problems Encountered in the Promotion of Energy Conservation".

Replies to Questionnaire "Problems Encountered in the Promotion of Energy Conservation"





5. Problems of Heat Control

5.1 Rationalization of Fuel Combustion

(1) Incorrect Air Ratio
Inadequate adjustment of the air damper
Unsuitable burner capacity and insufficient cleaning
Deterioration of nozzle function
Inappropriate fuel oil temperature
Unsatisfactory adjustment of furnace pressure
Air suction through the opening due to faulty sealing

(2) Incorrect flame direction because of the wrong installation of the burners

(3) Oil leakage from the burners

(4) Shortage of control instruments

(5) No concern about the quality of fuel oil

5.2 Rationalization of Heating, Cooling and Heat Transfer

(1) Insufficient cleaning of the heat transfer surface

(2) Large heat capacity of objects other than those for heating

(3) Exceedingly high steam pressure

(4) Inappropriate furnace design and capacity

(5) Defective charging of objects to be heated

(6) Insufficient utilization of heat obtained through the preceding process

(7) Faulty air purge during steam heating

(8) Room for higher-efficiency equipment for the evaporator, furnace and other equipment

(9) Necessity of reducing dehydrating heat energy through mechanical separation of higher efficiency

(10) High rejection rate of products

(11) Defective boiler feed water treatment
Insufficient water blow-down for the boiler

5.3 Prevention of Heat Loss in Heat Radiation and Transfer

(1) Considerable heat radiation from the furnace wall

(2) Uninsulated steam-using facilities and piping and deteriorated insulation
The following are specially noteworthy of defects
Steam valves, headers, flanges, condensate recovery pipe, feed water pipe, feed water tankage, dyeing device, cookers, hot water tanks

(3) No installation of cover on the hot water of tank

(4) Inadequate provision of enclosures, hoods and lids for drying equipment and melting furnace

(5) Necessity of reinforcement of insulation of the upper surface of a tunnel kiln truck

(6) Unsuitable color of the heat radiation surface

(7) Steam leakage from valves

(8) Inadequate maintenance of steam traps

(9) Unappropriate blow-down quantity of boiler water

5.4 Recovery and Utilization of Waste Heat

(1) Room for the recovery of waste heat

Waste heat of exhaust gas of furnace, electric furnace, tunnel kiln, paper machine

Potential heat of process fluid for the distillation tower and deodorizing tower

(2) Room for the recovery of waste pressure

Steam and high-pressure water

(3) Room for the recovery of condensate

(4) Insufficient utilization of flash steam

(5) Inadequate handling of recovered waste heat

Overflow of recovered condensate

Defective insulation of recovered waste heat transport pipe

6. Problems of Electric Power Control

6.1 Rationalization of Conversion of Heat to Power

Insufficient use of heat of diesel generator for emergency

6.2 Prevention of Electric Power Loss due to Resistance

(1) Room for the improvement of power factor

The condensers are not yet installed or are not arranged satisfactorily

Excess motor capacity

Inadequate speed control method

(2) Insufficient efforts to suppress peak demand

(3) Room for the reduction of loss in the transformer

Integration of load

Cut off of transformer during shutdown

(4) Unbalance of 3-phase current

(5) Insufficient maintenance and shortage of control instruments

6.3 Rationalization of Conversion of Electricity to Power and Heat

(1) Room for the reduction of power for fluid transport, Leakage of compressed air, Release of surplus, Exceedingly high pressure,

Incorrect position of intake port,

Faulty valves,

Room for the integration of low-load equipment, Increase of the number of pumps due to defective layout,

Clogging of filters for air-conditioning,

Increased load on the air-conditioning system attributed to the inflow of atmospheric air,

Throttling loss of the damper on account of excess blower capacity

(2) Excess capacity of some of electric motors

(3) Inadequate maintenance of power transmission belts

Number of pieces

Tension

Material

(4) Room for the rationalization of lighting

Insufficient cleaning of apparatus

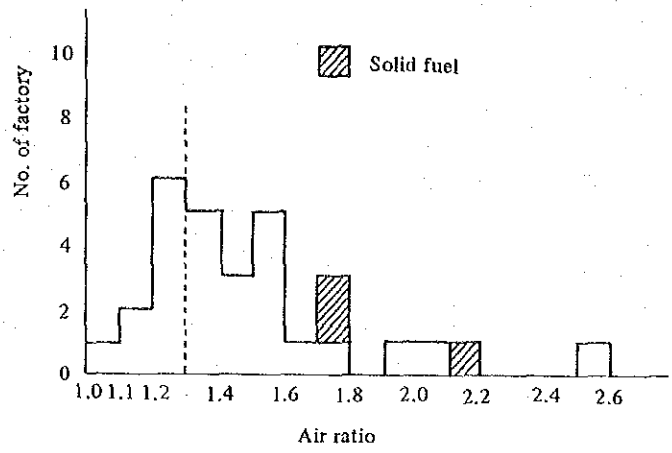
Improper position for installation

Room for the changing of lamps from the existing energy consuming type to the high-efficiency energy conservation type

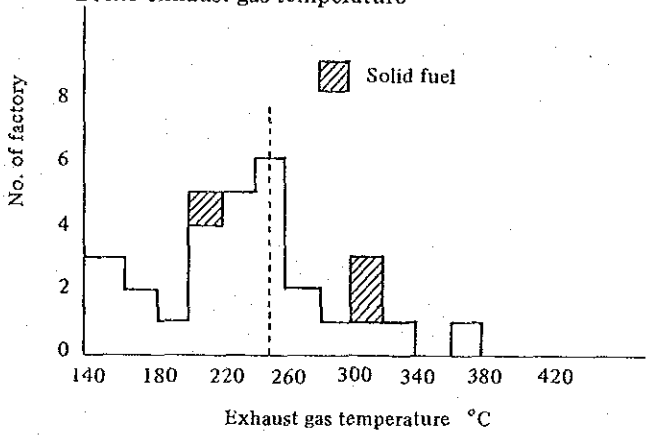
(5) Reinforcement of insulation of electroheating equipment

(6) Recovery of fluid pressure

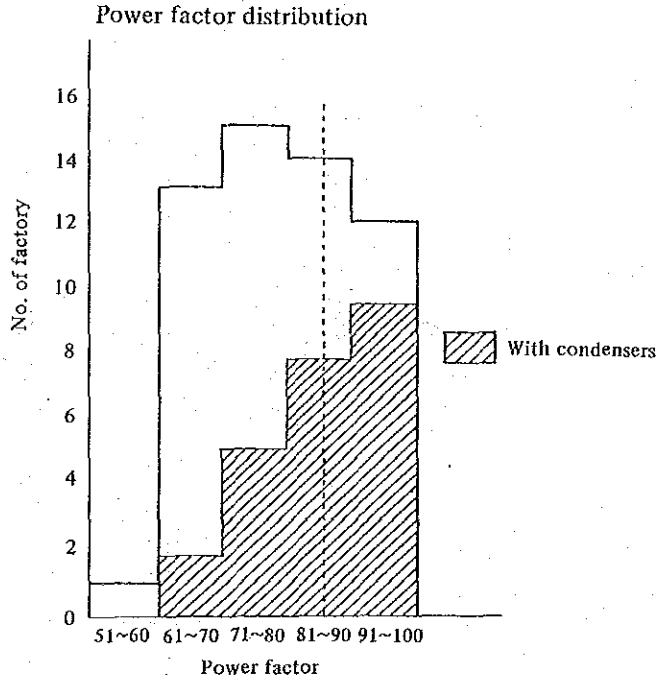
Distribution of Air ratios of boiler



Boiler exhaust gas temperature



Power factor distribution



7. Targets for Improvement and Projected Effects

( ) means ratio in % to consumption.

Classification	Item	Targets for Improvement	Projected Effects of Improvement Heavy oil equiv. kℓ/y						
			Ceramic /Glass	Paper	Textile	Metal	Chemical /Plastic	Food	Total
Rationalization of fuel combustion	Improvement of air ratio. Lowering temperature of exhaust gas.	Air ratio 1.3 max. (Solid fuel: 1.5) Exhaust gas temperature 250°C max.	1,088 (4.5)	1,668 (5.7)	209 (1.6)	165 (2.0)	44 (0.6)	1,026 (7.6)	4,200 (4.4)
Rationalization of heating, cooling, heat transfer	Improvement of production process and heating method.	–	–	2,724 (9.3)	3 (–)	1,495 (18.0)	–	213 (1.6)	4,435 (4.6)
Prevention of heat loss by radiation, convection, and conduction.	Reinforcement of insulation of furnace and carriage.	Surface temperature	1,221		440	180			1,841
	Reinforcement of insulation of facilities using steam.	Newly built glass-melting furnace <200°C		419		10	344	364	1,137
	Installation of cover and hood.			371		20	68	6	465
	Lowering surface emissivity.	Upper surface of firing zone of newly built tunnel kiln. <100°C						10	10
	Optimization of blow water quantity.				31			9	40
	Prevention of steam leakage.			11				8	19
	Smaller radiation area.	Facilities using steam < 60°C					3		3
	Subtotal		1,221 (5.0)	801 (2.7)	471 (3.5)	210 (2.5)	415 (5.8)	397 (3.0)	3,515 (3.7)
Recovery and utilization of waste heat	Recovery and utilization of waste heat of exhaust gas.		648	261	22		131	11	1,073
	Recovery and utilization of waste heat of waste water.				130		166		296
	Heat exchange of process fluid.							280	280
	Recovery of condensate and utilization of flash steam.			761	537		46	81	1,425
	Subtotal		648 (2.7)	1,022 (3.5)	689 (5.1)	–	343 (4.8)	372 (2.8)	3,074 (3.2)
Total			2,957 (12.2)	6,215 (21.1)	1,372 (10.2)	1,870 (22.5)	802 (11.1)	2,008 (15.0)	15,224 (15.8)
Fuel consumption Heavy oil equiv. kℓ/year			24,319	29,397	13,460	8,310	7,201	13,420	96,107

Classification	Item	Targets for Improvement	Projected Effects of Improvement 10^3 kWh/y						
			Ceramic /Glass	Paper	Textile	Metal	Chemical /Plastic	Food	Total
Rationalization of conversion of heat to power, etc.									
Prevention of electricity loss by resistance, etc.	Improvement of power factor.	Receiving power factor 85% minimum	87	11	52	169	73	32	424
	Reduction of transformer loss.		37	209	181	514	44	76	1,061
	Improvement of frequency converter efficiency.					39			39
	Subtotal		124 (0.4)	220 (0.3)	233 (0.1)	722 (1.0)	117 (0.4)	108 (0.4)	1,524 (0.3)
Rationalization of conversion of electricity to power, heat, etc.	Reduction of power for fluid transportation.								
	compressor / refrigerater		227			17	93	287	624
	pump			9					9
	air-conditioning load		7		4,908				4,915
	Improvement of conduction belt/ Change of gear ratio.				470	149			619
	Change of motor capacity / Optimization of motor voltage.		46		147	2	74	473	742
	Reduction of heat loss of electric heating equipment.		57		250	338	119		764
	Rationalization of lighting.		9	15	664	49	22	26	785
	Recovery of waste energy.						964		964
	Application of high efficiency equipment.				525				525
	Subtotal		346 (1.1)	24 (–)	6,964 (3.2)	555 (0.8)	1,272 (4.0)	786 (2.7)	9,947 (2.1)
Total			470 (1.5)	244 (0.3)	7,197 (3.3)	1,277 (1.7)	1,389 (4.4)	894 (3.1)	11,471 (2.5)
Electric power consumption 10^3 kWh/year			30,578	79,919	219,610	73,292	31,874	28,877	464,150

Effects as extended to Thailand's respective entire industries

	Fuel	Electric Power
	kℓ/year	Mwh/year
Ceramic / Glass	6,500 (46%)	1,080 (35%)
Paper	18,600 (33%)	510 (33%)
Textile	10,600 (13%)	55,400 (13%)
Metal	7,500 (25%)	5,100 (25%)
Chemical / Plastic	21,100 (4%)	36,500 (4%)
Food	32,400 (6%)	52,500 (2%)
Total	96,700	151,090

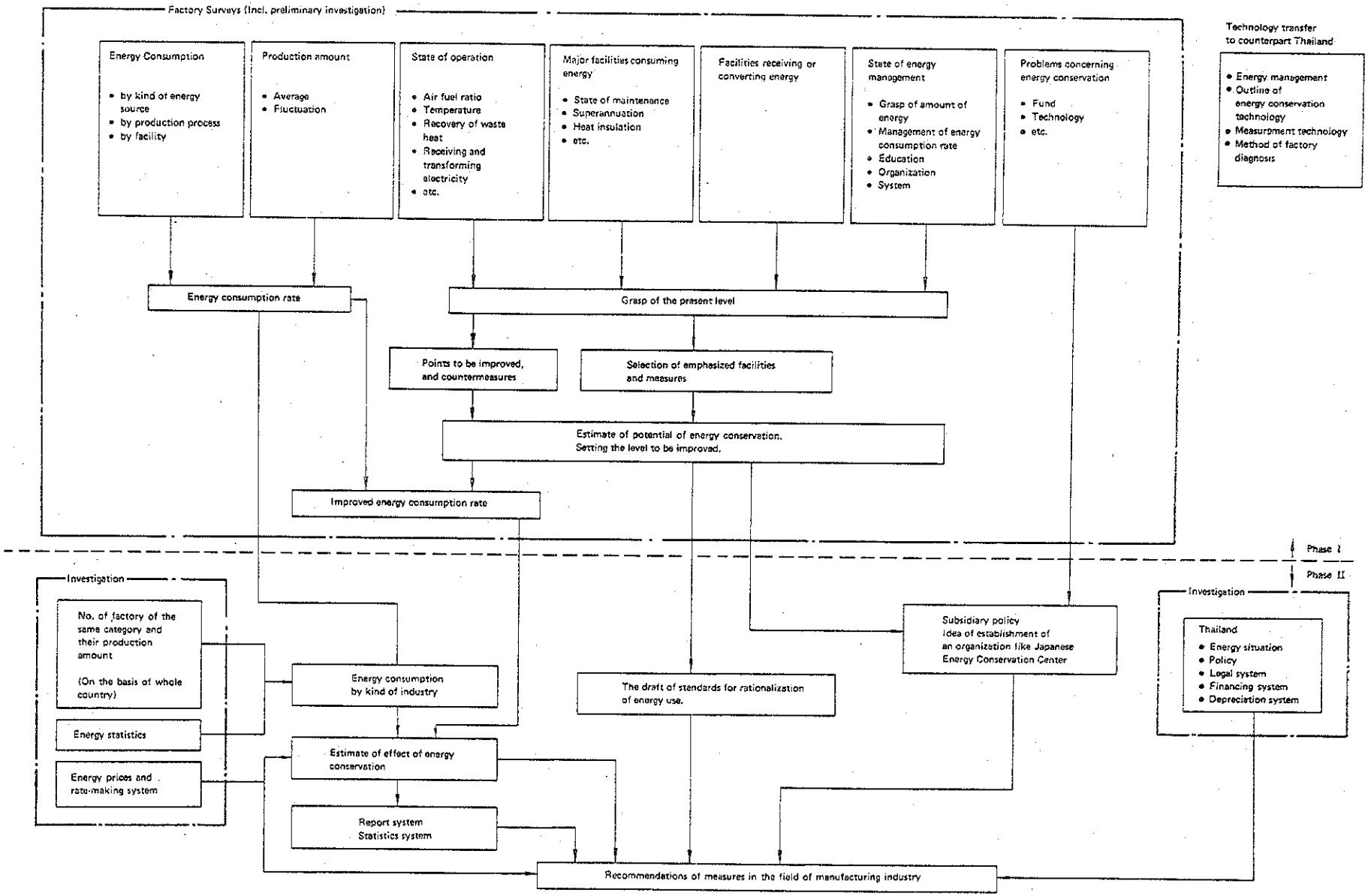
( ) Coverage rate (%)

Calory of the above (A)	kcal/year 0.94×10^{12}	kcal/year 0.13×10^{12}
Total consumption by Thailand's manufacturing industry (B)	$30,557 \times 10^{12}$	$7,709 \times 10^{12}$
A / B	3.1%	1.7%

Note : (B) Thailand Energy Situation 1981~82

Attached Data-1

Framework of Thailand's Manufacturing Industry Energy Conservation Investigation



Attached Data-2 Survey Team Members & Survey Schedule

(1) Survey Team Members

First Survey

Part	Name	Present post
Leader	Masakazu Ue	Executive Director, ECC
Deputy leader	Mitsuo Iguchi	Managing Director, ECC
Ceramics group		
Heat	Mazumi Ito	Director General, ECC's Chugoku Branch
Heat	Yoshio Ohno	Registered diagnoser, ECC
Electric	Toshio Sugimoto	Registered diagnoser, ECC
Paper group		
Heat	Akira Koizumi	Assistant Director General, ECC's Hokkaido Branch
Heat	Kaoru Nakao	Registered diagnoser, ECC
Electric	Kenichi Kurita	Registered diagnoser, ECC

Second Survey

Part	Name	Present post
Team Leader	Mitsuo Iguchi	Managing Director, ECC
Textile Group		
Heat	Kaoru Nakao	Registered Diagnoser, ECC
,,	Yoshio Ohno	,,
Power	Motoki Matsuo	,,
Metal Group		
Heat	Teruo Nakagawa	Manager, International Cooperation Section, ECC
,,	Toshio Noda	Registered Diagnoser, ECC
Power	Kenichi Kurita	,,

Third Survey

Part	Name	Present post
Team Leader	Mitsuo Iguchi	Managing Director, ECC
Chemical Group		
Heat	Hiroo Igarashi	General Manager, International Cooperation Department, ECC
"	Hiroshi Murata	Registered Diagnoser, ECC
Power	Kenichi Kurita	" "
Food Group		
Heat	Akira Koizumi	Assistant Director General, ECC's Hokkaido Branch
"	Shiroo Honda	Registered Diagnoser, ECC
Power	Yuuji Kaneko	" "

(2) Survey Schedule

First Survey
From Aug. 15, 1982
To Sept. 18, 1982 35 days

Second Survey
From Jan. 9, 1983
To Feb. 12, 1983 35 days

Third Survey
From June 26, 1983
To July 30, 1983 35 days

Attached Data-3 The Names of the Diagnosed Factories

First Survey (19 factories)

Name of factory	Product
(Ceramic/Glass)	
Bangkok Glass Industry	Glass bottle
Samutprakan Glass Industry	"
Thai Neutrarn Glass Industry	Cup, Ashtray
Asia Glass Industry	Cup, Glass
Union Mosaic Industry	Tile
Thailand Tile and Pottery	"
Super Fibre Cement	Slate
APA Industry	Injection ampul, Tube
Siam Insulator	High-tension insulator
Armitage Shanks (Bangkok)	Sanitary Ware
(Paper)	
Hiang Seng Fibre Container	Paper
Thai Develop Paper	"
Card Board (Thailand)	"
V. Sang Thai Paper Faotory	"
Industry Krungthai	"
Arkanae Paper Industry	"
New Century Paper	"
Central Paper Industry	"
Sang-Ngam Industry	Corrugated cardboard

Second Survey (18 factories)

Name of factory	Product
(Textile)	
The Thai Durable Textile Co., Ltd.	Spinning, Cloth weaving
Union Thread Industries Co., Ltd.	"
The Thai Textile Co., Ltd.	"
The Phiphatanakit Textile Co., Ltd.	"
Siam Synthetic Weaving Co., Ltd.	"
Thai Warp Knitting Co., Ltd.	"
Hantex Corporation Ltd.	Nylon polymerization, spinning
Toray Nylon Thai Ltd.	"
The Bangkok Nylon Co., Ltd.	Socks
(Metal)	
Bangkok Steel Industry Co., Ltd.	Steel bar for concrete
Sahaviriya Metal Industries Co., Ltd.	"
Union Metal Co., Ltd.	"
Thai Special Wire Co., Ltd.	PC wire
Sinthani Industry Co., Ltd.	Wire rods
Thai Malleable Iron and Steel Co., Ltd.	Castings
Thai Special Steel Co., Ltd.	"
BIS Asia Equipment Industry Co., Ltd.	Tractor parts
Kang Yong Manufacturing Co., Ltd.	Nail, Screw, Rolt, Nut

Third Survey (18 factories)

Name of factory	Product
(Plastic/Chemical)	
Thai Bones Industry Co., Ltd.	Ossein
Citric Acid Industry Co., Ltd.	Citric acid
Custom-pack Co., Ltd.	Plastic container
Thai Industrial Gases Ltd.	Liquid oxygen, Nytrogen
Siam Union Sahamitr Co., Ltd.	Soap, Margarine, Glycerine, Vegetable Oil
Siam Chemical Co., Ltd.	Sulfuric acid, Nytrous oxide, Alum, Sulfur roll
Thai Chemical Corporation Ltd.	Formalin, Plasticizer, Adhesive
Thai Silicate Co., Ltd.	Sodium silicate
The Bangkok Chemical Industrial Co., Ltd.	Sulfuric acid, Cupric sulfate, ferrous sulfate, Alum, Sulfur powder, Sulfur roll
(Food)	
Sang Som Co., Ltd.	Whisky
United Grains Co., Ltd.	Grain storage
Thai Castor Oil Industries Co., Ltd.	Vegetable oil
Thanakorn Vegetable Oil Products Co., Ltd.	Vegetable oil
The Unicord Investment (Thailand) Co., Ltd.	Canned sea-food
Thai Union Manufacturing Co., Ltd.	"
Union Seri Co., Ltd.	"
Star Feedmill Co., Ltd.	Feed
Central Food Products Co., Ltd.	"

JICA