Japan International Cooperation Agency (JICA)

No. 2

Plan and Budget Organization (PBO)
The Islamic Republic of Iran

TECHNICAL COOPERATION ON ANALYSIS OF ENERGY CONSERVATION AND RATIONAL USE OF ENERGY IN THE SOCIAL AND ECONOMIC SECTORS OF THE ISLAMIC REPUBLIC OF IRAN

FINAL REPORT

Summary

September 1997

The Energy Conservation Center, Japan (ECCJ)
The Institute of Energy Economics, Japan (IEEJ)

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DESCRIPTION OF THE STUDY

1. DESCRIPTION OF THE STUDY

1.1 Background of the Study

(1) In the Islamic Republic of Iran, it is now an issue of great concern, which may influence the future economic growth, to establish a reliable, efficient and economical energy supply system in good harmony with the social development and environment. In this regard, it is vitally important to work out a comprehensive energy policy.

(2) Plan and Budget Organization of the Islamic Republic of Iran (hereinafter referred to as "PBO") decided to formulate a "Comprehensive Energy Development Plan" which aims at providing a rational and scientific basis and organizing the data in order to establish a long-term energy strategy, along with the 1st 5-year Economic, Social, and Cultural Development Plan (March 1989 to March 1994) drawn up in July 1989. Hence PBO consulted "Institute for Research in Planning and Development" (hereinafter referred to as IRPD) about drafting the plan.

(3) In response to the request of the Government of the I.R. Iran for the development and study for providing technical and theoretical recommendations, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), conducted "A Study of the Comprehensive Energy Development Plan of the Islamic Republic of Iran" with IRPD as the counterpart for the period of February 1992 to March 1994.

The purpose of this study was to establish a scientific basis for formulating a comprehensive energy development plan through the Iranian-Japanese joint work as well as to improve the technical capability of the Iranian counterpart.

The following were mainly studied:

a. Development of energy database
b. Analysis of economic development
c. Analysis of energy demand
d. Analysis of the energy supply system
e. Review of the energy market
f. Consideration of energy conservation potentials
g. Consideration of environmental problems involved in energy supply and consumption

(4) As a result of this study, the following were suggested to be important for attempting the rational use of energy.

a. To optimize the energy supply cost
b. To reduce the environmental load as much as possible
c. To preserve the resources necessary for acquisition of foreign currency to continue the development
d. To optimize energy intensities

e. To establish the policy for controlling the energy supply and demand
f. To proceed with energy-related research and development activities

Specifically, optimization of energy consumption intensity among these is one of the important items for I.R. Iran where energy prices are relatively low, and the quantification has been found to be vitally important for promoting the rational use of energy in the social and economic sectors. The necessary data and information available are, however, not so sufficient, thus making it difficult to plan a fully reliable and practical measure at present.

(5) Hence, the Government of the I.R. Iran requested the Government of Japan to conduct a more detailed study on the current situation of energy use in I.R. Iran, and concurrently to carry out the survey related to the planning of an energy policy based on the foregoing study.

(6) JICA dispatched the preliminary study team in October 1994 to discuss various necessary issues which would be involved in the implementation of this study. After necessary study and discussion, a Scope of Work (S/W) was concluded between PBO, the counterparting organ of the requesting country for this study and the Japanese study team.

1.2 The Objectives of the Study

The objectives of the study are:

(1) to analyze the use of energy at micro level in the main energy consuming sectors, such as industrial sector, in order to provide detailed information for identifying the potentials of energy conservation and rational use of energy,

(2) to help expand the energy data and information system and

(3) to provide a scientific basis for evaluation of the potentials of energy conservation and identification of appropriate measures for improving energy management in the I.R. Iran.

1.3 Counterparts

(1) Plan and Budget Organization (PBO)
(2) Institute for Research in Planning and Development (IRPD)
(3) Sharif University of Technology (SUT)

1.4 Japanese Organization Responsible for Implementation of the Study

The study was conducted jointly by The Energy Conservation Center, Japan (Representative) and The Institute of Energy Economics, Japan.

1.5 Organizations and Factories to be Studied

(1) Interview survey (Ministries, industrial organizations and Japanese enterprises operating in I.R.Iran)

a. Institute for Research in Planning and Development
b. Plan and Budget Organization (Library)
c. Ministry of Industry
d. Ministry of Mines and Metals
e. Central Bank of the Islamic Republic of Iran
f. Iran Statistics Center
g. Association of Iran Textile Industries
h. Sugar Factories Syndicate
i. State Sugar Organization
j. Iran Cement Engineering Center
k. Oilseed Research and Development
l. Cement Research Center
m. Consulting Office for Sugar Industries
n. JETRO, Tehran Office
o. Marubeni, Iran
p. Nikki Engineering

(2) Interview survey (Factories)

(Steel Industry)	a.	Mobarakeh Steel
	b.	Khouzestan Steel
(Chemical Industry)	c.	Razi Petrochemical
(Glass Industry)	d.	Mina Glass
	e.	Saveh Jam Glass
(Textile Industry)	f.	Aliaf
	g.	Yazd Baf
(Food Industry)	h.	Esfahan Sugar
	i.	Shiraz Vegetable Oil

(3) Factory survey

(Steel Industry)	a.	Esfahan Steel
(Chemical Industry)	b.	Tehran Refinery
(Cement Industry)	c.	Sephahan Cement
	d.	Tehran Cement
	e.	Soufian Cement
(Glass Industry)	f.	Ghazvin Glass
(Textile Industry)	g.	Polyacryl Iran
	h.	Kashan Velvet & Rayon Mills, Ltd.
(Food Industry)	i.	Behshar Industry
	j.	Karun Cane
	k.	Abkouh Sugar

(4) Interview survey and observation at organizations and factories in Japan

a. Japan Sugar Refiners' Association
b. Petroleum Association of Japan
c. Japan Chemical Fibres Association
d. Japan Oilseed Processors Association
e. Japan Cement Association
f. The Japan Iron and Steel Federation
g. Association of Japan Beet Sugar Manufacturers
h. Japan Spinners' Association
i. Kawasaki Heavy Industries
j. Kobe Steel
k. Nisshin Sugar Manufacturing
l. Nisshin Plant Engineering
m. Nihon Cement
n. Nippon Beet Sugar Manufacturing, Memuro Sugar Beets Factory
o. Higashi Nihon Sugar Manufacturing, Chiba Plant
p. Hokuren Federation of Agricultural Cooperatives, Shimizu Sugar Beets Factory
q. Meiji Sugar Manufacturing

1.6 Description of the Study

The study was conducted with regard to the following points according to the "IV. Scope of the Study" in the Scope of Work signed on October 18, 1994.

(1) Upgrading the existing energy database

a. Confirmation of the existing energy database
b. Identification of data necessary for microanalysis of energy conservation
c. Upgrading of energy database based on the data obtained through the factory diagnosis

(2) Study on the present status of energy use in the 6 main industries

a. To study the current situation and the future perspective of energy use in the energy consuming sectors, and to investigate the present situation and the future plan of the laws, regulations, activities relevant to energy conservation
b. To investigate the current situation of energy utilization in the steel, cement, glass, food, textile, and chemical industries
c. To investigate the energy management situation in the above-mentioned industries

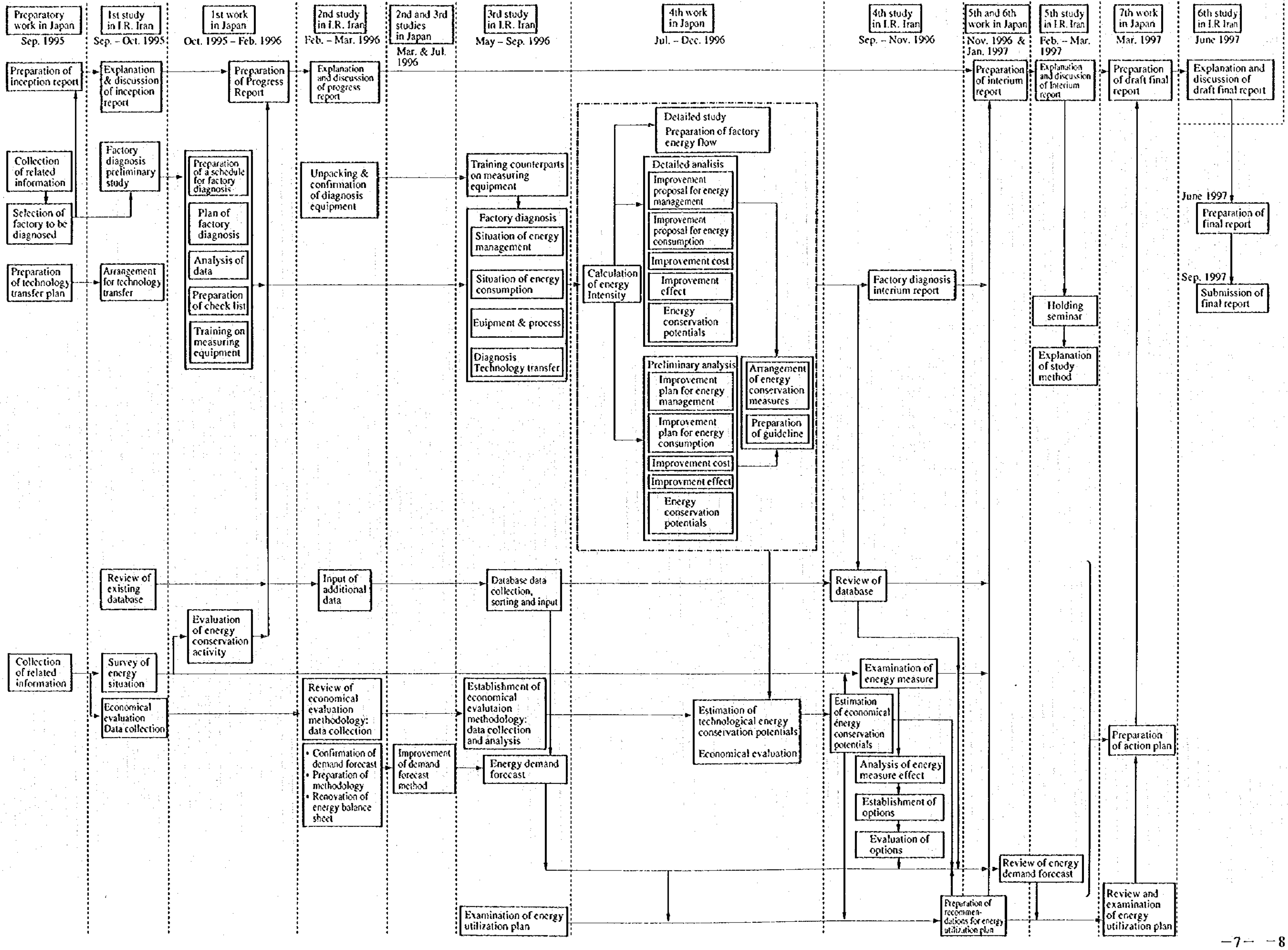
(3) Consideration of energy conservation measures and estimation of energy conservation potentials

a. To examine the energy conservation technical measures in the main 6 industries
b. To estimate the technical potentials for energy conservation after implementation of energy conservation measures
c. To review the energy conservation technological measures in terms of economical efficiency
d. To investigate the optimization of energy intensities in the economic and social sectors
e. To formulate the framework for energy management measures through establishing energy prices, modernization of technology, improvements of various systems, etc.

1.7 Methodology of the Study and the Implementation Status

The overview of the study is illustrated in Figure 1.1.

Figure 1.1 Overview of the Study



1.8 Members of the JICA Team

No	Name	Assignment
1.	Mr. Mitsuo Iguchi	Team leader
2.	Mr. Toru Kimura	Deputy team leader, Energy policy A
3.	Mr. Shin-ya Udou	Energy policy B
4.	Mr. Norio Fukushima	Energy conservation potential analysis
5.	Mr. Kaoru Yamaguchi	Database and energy utilization plan
6.	Mr. Hisao Kibune	Energy demand forecasting A
7.	Mr. Hiroyuki Ishida	Energy demand forecasting B
8.	Mr. Shigeaki Kato	Economic evaluation
9.	Mr. Akihiro Koyamada	Measuring equipment
10.	Mr. Jiro Konishi	Energy management (Heat)
11.	Mr. Kazuo Usui	Energy management B (Electricity)
12.	Mr. Yukio Nozaki	Energy management C (Heat)
13.	Mr. Ken-ichi Nakayama	Energy management D (Electricity)
14.	Mr. Katsuhiko Kaburagi	Energy management E (Heat)
15.	Mr. Toshio Sugimoto	Energy management F (Electricity)
16.	Mr. Seiichiro Maruyama	Factory management A (Steel process)
17.	Mr. Takashige Taniguchi	Factory management B (Textile process)
18.	Mr. Hisashi Ikeda	Factory management C (Cement process)
19.	Mr. Masami Kato	Factory management D (Glass process)
20.	Mr. Shiro Honda	Factory management E (Food process)
21.	Mr. Teruo Anzai	Factory management F (Chemical process)
22.	Mr. Kenji Kazuma	Factory management G (Chemical process)

1.9 Counterpart Members

Dr. Saboohi	Manager
Mr. Ali Mazhari	Energy conservation
Mr. Saeed Akhavan	Energy conservation
Mr. Fereidoun Mianji	Micro level energy management
Mr. Kasra Azizi	Macro level energy management
Mr. S. Mehdi Sajadifar	Factory management
Mr. Abolghasem Schayesteh	Instrumentation
Mr. Hossein Moosavi	Macro level energy management
Mr. Tohangchi	Micro level energy management
Mr. Seid-Reyhani	Micro level energy management
Ms. Zarvani	Macro level energy management

FACTORY ENERGY DIAGNOSIS

1. THE OBJECTIVE OF THE STUDY

The study was carried out on the typical factories selected from 6 industrial sectors with a view to investigating their energy use in order to make the results available as data for estimating the energy conservation potential of each industry as a whole.

This study was conducted also to recommend effective measures for implementing energy conservation activities as well as to transfer technology for the use of factory diagnosis equipment and methods to the counterpart personnel.

2. FACTORIES TO BE STUDIED

The study was carried out on 11 factories in 6 types of industries, including 1 factory in the iron and steel industry, 1 factory in the chemical industry, 3 factories in the cement industry, 1 factory in the glass industry, 2 factories in the textile manufacturing/processing industry and 3 factories in the food processing industries.

3. METHODOLOGY OF THE STUDY

During the 3- to 5-day study period, the following tasks were carried out: interview survey on the process, energy consumption and energy management situation; factory tours to observe equipment and operation; measurement of the main equipment and exchanging of opinions with the factory management about the results of our factory survey and measurement.

Measurement was conducted using nearly 40 types of diagnosis equipment brought in from Japan. These portable equipment included measuring/recording devices for temperature, temperature distribution, pressure, flow rate, gas composition, water quality, electricity, etc., and data processors. The technological knowhow required for using the equipment was transferred to the counterpart personnel in the course of the study. However, it took long time for the bus to clear the customs; therefore, the equipment had to be transported by air and taxi. Table 2.1 shows the equipment used for factory diagnosis.

Table 2.1 Equipment List

No.	Name	Set (s)
1.	Energy Audit Bus	1
2.	Ultrasonic liquid flow meter	3
3.	High temperature anemometer for gas	6
4.	Pitot type flow meter	4
5.	Voltex type flow meter	3 × 3
6.	Oxygen meter for exhaust gas	4
7.	Carbon dioxide and monoxide meter for exhaust gas	4
8.	Pretreatment unit for sampling exhaust gas	4
9.	Sampling tube for exhaust gas	1
10.	Thermometer for surface	2
11.	Thermocouple with compensate cable for gas	50
12.	Suction pyrometer	2
13.	Radiation thermometer (low range)	2
14.	Radiation thermometer (high range)	2
15.	Glass thermometer	5
16.	Hygrometer	10
17.	Thermal video system	1
18.	Portable hybrid recorder	6
19.	Desk-top type personal computer	1
20.	Note type personal computer	2
21.	SC meter	2
22.	pH meter	2
23.	Digital low pressure indicator	2
24.	Pressure transmitter for steam	3 × 3
25.	Clamp-on power meter	5
26.	Clip-on AC power meter	3
27.	Tacho meter	2
28.	Lux meter	2
29.	Tester	2
30.	Low voltage detector	5
31.	Heat-proof gloves	5
32.	Cobalt glass	10
33.	Camera	1
34.	Insulation rubber gloves	5
35.	Cord reel and others	1
36.	Stopwatch	2
37.	Carrying cart	4
38.	Long table	3
39.	Transducer for electricity (5 kinds)	2 × 5
40.	Training unit for combustion	1
41.	Training unit for liquid flow	1
42.	Training unit for gas flow	1

4. ENERGY MANAGEMENT SITUATION

Although the energy use efficiency may differ depending on the performance of the equipment and devices, it is more likely to be affected by the consciousness and behavior of each personnel involved in operation and maintenance.

Therefore, in order to implement energy conservation effectively, it is vitally important to build up the framework to respond quickly to the request of the factory management along with adequate provision of equipment. It is also necessary to set up the framework which will allow all employees to make concerted efforts for achieving the target for energy conservation.

4.1 Top Management's Policies for Energy Conservation

No single step can be taken toward energy conservation in the factory unless the management demonstrates its positive willingness or motivation for energy conservation. This factory survey revealed that only about half of all surveyed factories had management or administration staff who showed a strong interest in energy conservation. This is probably because the energy prices stay still at a low level though they are gradually being raised, and thus are not yet considered as an important item in terms of management.

Even in factories showing a more positive interest in energy conservation, none have set up a specific goal with regard to the target date and degree of energy conservation to be achieved. Therefore, they have no framework where all the company members are allowed to exert a united effort for systematic implementation of energy conservation.

4.2 Activities of the Energy Conservation Committees

Energy conservation committees have been set up in industries excluding textile and food industries since 1995 partially under the guidance of the Ministry of Industry. Some of these committees make efforts such as setting up an activity plan to collect data, inspecting steam leakages, inspecting a trap and so forth. First of all, it is important to get started with the energy conservation activities. In this regard, having set up energy conservation committees is regarded as a significant step toward energy conservation. This effort as a core is expected to gradually develop into company-wide activities. To this end, it is advisable to have the activities implemented not only by the technical staff but also the operators. Hence arises the need to take some appropriate measures for employee education, an improvement proposal system, and encouragement for autonomous management.

4.3 Grasping the Actual Energy Consumption Situation

In order to implement energy conservation activities, it is essential to grasp the energy consumption level for each process or for each main equipment and the fluctuation trend. This allows us to figure out the level of energy conservation to be achieved or to know the area remaining to be improved. It is indispensable as well to provide energy measuring instruments in order to review the results of implemented energy conservation measures.

Many of the factories surveyed this time had no energy measuring equipment for each process or for each equipment though they had records of the purchased energy amount for the entire factory through contract meters, or purchase slips. Under these circumstances, it is natural that the operators should show little interest in energy consumption.

Even factories equipped with meters do not take prompt action to analyze the data of energy consumption data, investigate the factor for fluctuation and thus control an energy increase. In order to control the trend of energy intensity (energy consumption per unit production) to implement energy conservation efforts, it is advisable to provide an adequate number of energy measuring equipment.

5. ENERGY INTENSITY LEVEL

The energy intensity of any surveyed factory except the synthetic textile factories is higher than that of the Japanese factory: approximately 1.6 times in the iron and steel industry; about 1.5 times in the oil refinery; 1.06 to 1.38 times in the cement factories; 2.1 times in the glass factory; about 6 times in the textile factories except synthetic textile factories; and 1.6 to 3.6 times in the food factory.

These discrepancies arise from not merely the differences in the scale of equipment but also from the methods of equipment management.

6. PROBLEMS IN ENERGY UTILIZATION

The problems common to every industrial sector include the following.

6.1 Combustion Control

In general, air ratio control is not conducted for combustion equipment, and no equipment was provided with an automatic combustion controller.

6.2 Recovery of Waste Heat from Combustion Exhaust Gas

In many cases, the high temperatures of combustion exhaust gas are probably due to insufficient cleaning of the heat transfer surface. Moreover, almost no equipment to recover this waste heat is provided.

6.3 Heat Insulation

Some high-temperature furnaces have inadequate heat insulation. The heat insulation is generally good for steam piping, while such insulation is hardly provided on valves and flanges.

6.4 Power Plant

Many factories are equipped with a private power generator to prepare for a possible power failure due to low reliability of public power distribution line. These power plants are not connected to the public distribution line, and are obliged to operate in inefficient light-load.

6.5 Rotating Devices Including Pumps, Fans and Others

Extremely high pressures and flow rates of pumps and fans result in low-efficiency operation.

6.6 Lighting

Some lights remain unnecessarily lit during the daytime.

6.7 Steel-making Plants

Although the electricity intensity for coke plants is satisfactory, coke ovens still need to be improved and rationalized in terms of operation and steam utilization, respectively. Hence it will be effective to introduce coal moisture control equipment.

In sintering plants requiring improvement of operation to reduce coke intensity, taking an air-leak preventive measure and using a direct-fired burner will allow improvement of both electricity intensity and fuel intensity.

The energy intensity of blast furnace in I.R. Iran shows a significant difference from that of similar equipment in Japan. In order to improve fuel ratio, which is high partially due to the increase in production, it is indispensable to control the material charge distribution.

Steel-making equipment show a significant difference in fuel intensity, thus making it necessary to investigate the equipment consuming natural gas in order to use it more appropriately. Under the present situation, the operation method of the converter boiler needs to be improved, but it is recommended that they should employ the gas recovery method in the future.

Rolling mills require improvements in production/process control, reduction of fuel for holding heat and an improvement in combustion control in order to reduce the fuel intensity of the billet reheating furnace. To this end, the use of hot charge will be effective.

Energy equipment involves energy distribution loss problems such as delays in the modernization of boilers, turbines, generators and oxygen plant and oxygen dissipation. For the countermeasure against blast furnace gas dissipation and coke oven gas distribution loss, it is effective to install gas holders.

6.8 Petroleum Refinery

In the petroleum refinery there are 37 heating furnaces, where combustion control and recovery of waste heat are not sufficiently carried out. Taking such measures as automation of combustion control, recovery of waste heat, etc. will allow fuel intensity to be remarkably improved. Heat exchanging with hot-temperature products is not adequate enough to heat the crude oil. To increase the efficiency of the steam ejector for vacuum distillation towers, it is effective to enforce the temperature control of cooling water.

6.9 Cement Plants

Air leakage of the raw material mill system lead to a poor draft balance of the entire kiln, causing the cooling capacity of the satellite cooler to decline, reducing the production and worsening the energy intensity. In order to improve the fuel intensity of an SP kiln and a kiln with a new suspension preheater (NSP kiln), it is effective to employ a grate cooler which allows changing the volume of cooling air.

Many of the wet-process kilns and dry-process long kilns now in operation have poor fuel intensity. From now on, therefore, their modification into or their replacement by SP kilns or NSP kilns allows fuel intensity to be improved. Electricity intensity is relatively good, but it will be made much better by means of ball size and level control for both raw material mills and finishing mills or replacing them by vertical roller mills.

6.10 Glass Plant

In the glass manufacturing process, the melting furnace is the largest fuel consumer.

The furnace wall of the glass melting furnace has insufficient heat insulation, and the combustion control is not good enough. The inadequate glass pull-up capacity reduces the load of the melting furnace, thereby worsening the energy intensity. The low product yield contributes to poor energy intensity. The introduction of a floating process will allow the size of the melting furnace to be enlarged and the melting load to be increased, leading to a significant improvement of energy intensity and product quality.

6.11 Textile Plants

The polyester and polyacrylic product manufacturing process has good energy intensity due to the use of continuous polymerization and POY system in the polyester spinning process.

The spinning process produces much pneumatic wastes because of yarn end breakage on the spinning frame, affecting electricity intensity adversely. Controlling temperature and humidity will reduce the number of yarn end breakages to a large extent.
In the utility sector, fuel intensity can be improved by increasing the efficiency of the gas turbine and enhancing the boiler combustion control.

The fuel intensity can also be reduced through recovery of steam condensate, use of waste heat of hot water from the dyeing process and recovery of waste heat from diesel generators.

6.12 Vegetable Oil Plants

Ejectors consume too much steam for generating vacuum in the deodorizing process.

The volume of steam can be reduced by adjusting the vacuum degree, the steam pressure of the ejector and the temperature of water for the barometric condenser.

Heat exchange between refined oil and raw material oil allows fuel intensity to be improved.

6.13 Sugar Plant

The yield of cane sugar is poor, thereby increasing energy intensity. Storage management of material cane can prevent the deterioration of sugar content.

Poor control of sugar juice in the crystallizer pan makes the boiling time longer, and therefore the energy intensity gets higher. Automatic control of the crystallizing pan and improvement of the vacuum degree allow energy intensity to be reduced. In addition, much scale forming on the heat transfer surface of the evaporator requires pan cleaning, which further increases energy intensity. Purification of sugar liquid through ion exchange resin improves both product quality and yield, thus reducing energy intensity as well. High steam pressure extracted from the power generating turbine results in loss of power generation amount. Lowering the extraction pressure increases the output of the generator.

7. ENERGY CONSERVATION MEASURES

Most of the equipment-related measures currently implemented in Japan are not applicable in I.R.Iran because of the long payback years due to low energy prices there. Therefore, we proposed measures which would enhance energy management and allow lower investment in equipment. Table 2.2 shows the proposal items for energy conservation measures and the possible saved energy for each factory.
Taking feasible measures may lead to fuel savings of about 10 % and electricity savings of 9 % based on the energy prices in I. R. Iran (energy conservation case).

Even the measures which are described as taking 10 years for payback or as being not feasible in the line "feasibility in energy conservation case" in Table 2.2 can be regarded as being feasible enough if management strategic factors such as production increase, quality improvement, environmental improvement, and others are taken into account. Therefore, such measures are included as well for study. Taking these measures in addition to those mentioned above can be expected to produce fuel savings of about 15 % and electricity savings of about 10 %.

8. GUIDELINE

The guideline for implementation of energy conservation for each industry, which consists of factory diagnosis procedures, energy management, energy conservation technologies and heat calculation worksheet, summarizes technical items useful as references for implementing energy conservation activities. It is recommended that counterpart should utilize this report as a reference to prepare its own guideline and add information, as required, collected through its own future factory diagnosis to make the effort for achieving further substantial results.

Table 2.2 Proposal Items for Energy Conservation Measures and Saved Energy

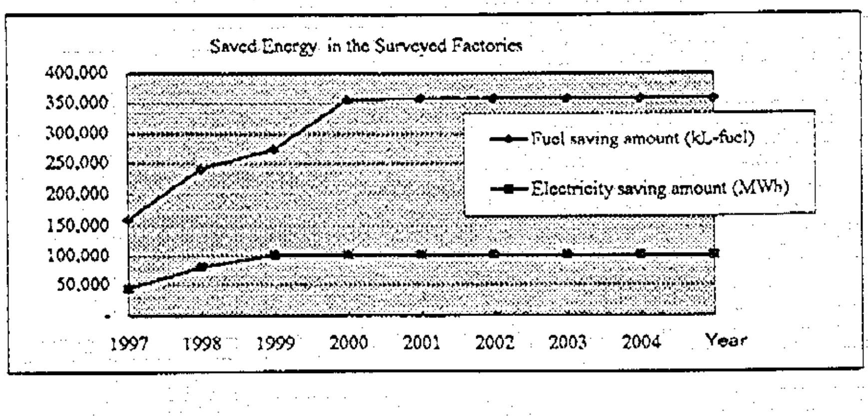
Saved energy is shown in cells from the biginning year of implementation of energy conservation measures

Note 1. Saved energy: Fuel oil(kL), Natural gas(1000m^3) and electricity[MWh]

Note 2. Energy price: Fuel oil = 17.0Rial/L, Natural gas = 22.4Rial/Nm^3, electricity = 40.7Rial/kWh (Average price in 2000-2002)

No.	Industry Factory	Energy conservation measures Feasible measures in accelerated energy conservation case	1997	1998	1999	2000	2001	2002	2003	2004	2005	Saving energy kL-oil 1000m^3-NG [MWh]	Saving money Million Rial	Investment Million Rial	Feasibility in energy conservation case
1	Iron & steel industry														
1.1	Esfahan Steel														
	1) Coke oven	1) Optimization of combustion air ratio	2717	2717	2717	2717	2717	2717	2717	2717	2717	24453	547,747	0	feasible
		2) Optimization of coking temperature			5863	5863	5863	5863	5863	5863	5863	41041	919,318	3,500	not feasible
		3) Review of steam utilization method	7580	7580	7580	7580	7580	7580	7580	7580	7580	68220	1,528,128	0	feasible
	2) Sintering plant	1) Yield increase		10927	10927	10927	10927	10927	10927	10927	10927	87416	1,958,118	1,750	feasible for 10 ys
		2) Installation of high-efficiency burner			12230	12230	12230	12230	12230	12230	12230	85610	1,917,664	3,500	not feasible
		3) Develop. of low coke operation tech.			26002	26002	26002	26002	26002	26002	26002	182014	4,077,114	5,250	not feasible
		4) Prevention of leak air			[7104]	[7104]	[7104]	[7104]	[7104]	[7104]	[7104]	[49728]	1,657,630	525	feasible
	3) Blast furnace	1) Reduction of fuel ratio				81480	81480	81480	81480	81480	81480	488880	10,950,912	8,750	feasible for 10 ys
		2) Low oxygen operation of hot stove			2520	2520	2520	2520	2520	2520	2520	17640	395,136	175	feasible for 10 ys
	4) Steel-making process	1) Reduction of blowing oxygen	[7712]	[7712]	[7712]	[7712]	[7712]	[7712]	[7712]	[7712]	[7712]	[69408]	2,824,906	0	feasible
		2) Reduction of electricity in converter	[7712]	[7712]	[7712]	[7712]	[7712]	[7712]	[7712]	[7712]	[7712]	[69408]	2,824,906	0	feasible
		3) Reduction of fuel in converter process	22117	22117	22117	22117	22117	22117	22117	22117	22117	199053	4,458,787	0	feasible
		4) Reduction of fuel in steel-making plant	41340	41340	41340	41340	41340	41340	41340	41340	41340	372060	8,334,144	0	feasible
		5) Improve. of LD boiler combustion	8268	8268	8268	8268	8268	8268	8268	8268	8268	74412	1,666,829	0	feasible
	5) Rolling process	1) Improvement of production control	47782	47782	47782	47782	47782	47782	47782	47782	47782	430038	9,632,851	0	feasible
		2) Review of reheating furnace operation		30202	30202	30202	30202	30202	30202	30202	30202	241616	5,412,198	875	feasible
		3) Combustion control of reheating f'ce		11269	11269	11269	11269	11269	11269	11269	11269	90152	2,019,405	875	feasible for 10 ys
		4) Improvement of hot charge ratio		15777	15777	15777	15777	15777	15777	15777	15777	126216	2,827,238	875	feasible for 10 ys
		5) Improve. of yield in rolling process	6085	6085	6085	6085	6085	6085	6085	6085	6085	54765	1,226,736	0	feasible
	6)Energy utilization facilities														
	a) Power station	1) Combustion control of boiler & others	4341	4341	4341	4341	4341	4341	4341	4341	4341	39069	875,146	175	feasible
	b) Oxygen plant	1) Improvement of compressor operation	[13167]	[13167]	[13167]	[13167]	[13167]	[13167]	[13167]	[13167]	[13167]	[118503]	4,823,072	0	feasible
	c) Energy distribution	1) Reduction of oxygen supply loss	[11286]	[11286]	[11286]	[11286]	[11286]	[11286]	[11286]	[11286]	[11286]	[101574]	4,134,062	0	feasible
	d) Water pump station	1) Improvement of water pump operation		[13080]	[13080]	[13080]	[13080]	[13080]	[13080]	[13080]	[13080]	[104640]	4,258,848	175	feasible
2	Petroleum refinery														
2.1	Tehran Refinery	1) Improve. of heating furnace refractory			538	538	538	538	538	538	538	3766	64,022	350	not feasible
		2) Improve. of heating furnace air ratio			16983	16983	16983	16983	16983	16983	16983	118881	2,020,977	1,575	feasible
		3) Enhance. of heat recovery from cooler			1781	1781	1781	1781	1781	1781	1781	12467	211,939	1,085	not feasible
		4) Replacement of pump motor		[15]	[15]	[15]	[15]	[15]	[15]	[15]	[15]	[120]	4,884	12	not feasible
		5) Pump impeller cutting		[899]	[899]	[899]	[899]	[899]	[899]	[899]	[899]	[7192]	292,714	53	feasible
		6) Turning off unnecessary light	[91]	[91]	[91]	[91]	[91]	[91]	[91]	[91]	[91]	[819]	33,333	0	feasible
3	Cement Industry														
3.1	Sepahan Cement	1) Capacity up of EP induced draft fan	3780	3780	3780	3780	3780	3780	3780	3780	3780	34020	578,340	168	feasible
		2) Raw mill fan operation control		[5400]	[5400]	[5400]	[5400]	[5400]	[5400]	[5400]	[5400]	[43200]	1,758,240	753	feasible
		3) Total process draft control		9451	9451	9451	9451	9451	9451	9451	9451	75608	1,285,336	105	feasible
		4) Replace of cement mill screen plate		[10000]	[10000]	[10000]	[10000]	[10000]	[10000]	[10000]	[10000]	[80000]	3,256,000	849	feasible
3.2	Tehran Cement	1) No.3 kiln: Modification to NSP					42527	42527	42527	42527	42527	212635	3,614,795	79,625	not feasible
		2) No.4 kiln: Replacement of cooler (fuel)					10385	10385	10385	10385	10385	51925	882,725	39,900	not feasible
		2) No.4 kiln: Replacement of cooler (elec)					[8190]	[8190]	[8190]	[8190]	[8190]	[44550]	1,813,185		
		3) No.6 kiln: Improve. of operation(fuel)			6593	6593	6593	6593	6593	6593	6593	46151	784,567	1,278	feasible
		3) No.6 kiln: Improve. of operation(elec)			[14400]	[14400]	[14400]	[14400]	[14400]	[14400]	[14400]	[100800]	4,102,560		
3.3	Soufian Cement	1) Improvement of kiln operation		4343	4343	4343	4343	4343	4343	4343	4343	34744	590,648	1,663	not feasible
		2) No.3 kiln: Modification to NSP					34286	34286	34286	34286	34286	171430	2,914,310	100,100	not feasible
		3) No.4 kiln: Replacement of cooler			6593	6593	6593	6593	6593	6593	6593	46151	784,567	23,153	not feasible
4	Glass industry														
4.1	Ghazvin Glass	1) Excess air 25% to 15% in melting furnace		2863	2863	2863	2863	2863	2863	2863	2863	22904	389,368	175	feasible
		2) No.2, 3 & 4 furnace light insulation	1320	1320	2640	2640	3955	3955	3955	3955	3955	27695	470,815	875	not feasible
		3) Production yield improvement	1500	1500	3000	3000	4728	4728	4728	4728	4728	32640	554,880	0	feasible
		4) Checker height increase	2500	2500	5000	5000	7910	7910	7910	7910	7910	54550	927,350	3,500	not feasible
		5) Compressed air leakage stop	[217]	[217]	[217]	[217]	[217]	[217]	[217]	[217]	[217]	[1953]	79,487	0	feasible
5	Textile industry														
5.1	Polyacryl Iran	1) Improvement of Dowtherm boiler air ratio	290	290	290	290	290	290	290	290	290	2610	58,464	0	feasible
		2) Review of quench cooling		[2000]	[2000]	[2000]	[2000]	[2000]	[2000]	[2000]	[2000]	[16000]	651,200	350	feasible for 10 ys
		3) Recovery of waste heat in acryl process			2282	2282	2282	2282	2282	2282	2282	15974	357,818	262	feasible for 10 ys
		4) Replacement of chiller system pump			[996]	[996]	[996]	[996]	[996]	[996]	[996]	[6972]	283,760	648	not feasible
		5) Improve. of gas turbine utilization rate	7442	7442	7442	7442	7442	7442	7442	7442	7442	66978	1,500,307	0	feasible
		6) Reduction of supply/waste water		[1818]	[1818]	[1818]	[1818]	[1818]	[1818]	[1818]	[1818]	[14544]	591,941	525	feasible for 10 ys
		7) Optimization of pump capacity		[3000]	[3000]	[3000]	[3000]	[3000]	[3000]	[3000]	[3000]	[24000]	976,800	438	feasible for 10 ys
		8) Rational use of compressed air	[3400]	[3400]	[3400]	[3400]	[3400]	[3400]	[3400]	[3400]	[3400]	[30600]	1,245,420	525	feasible for 10 ys
5.2	Kashan Velvet & Rayon Mills	1) Reduction of pneumatic waste rate	[375]	[375]	[375]	[375]	[375]	[375]	[375]	[375]	[375]	[3375]	137,363	0	feasible
		2) Stopping of return fan	[101]	[101]	[101]	[101]	[101]	[101]	[101]	[101]	[101]	[909]	36,996	0	feasible
		3) Enhence. of condensate recovery rate	360	360	360	360	360	360	360	360	360	3240	55,080	105	not feasible
		4) Recovery of heat of dyeing washing water		1124	1124	1124	1124	1124	1124	1124	1124	8992	152,864	700	not feasible
		5) Improvement of boiler air ratio	147	147	147	147	147	147	147	147	147	1323	22,491	0	feasible
		6) Control of number of air compressor	[65]	[65]	[65]	[65]	[65]	[65]	[65]	[65]	[65]	[585]	23,810	0	feasible
6	Food industry														
6.1	Behshahr Industry	1) Reduction of steam in deodorizing process	5534	5534	5534	5534	5534	5534	5534	5534	5534	49806	1,115,654	0	
		2) Boiler combustion control		1342	1342	1342	1342	1342	1342	1342	1342	10736	240,486	525	not feasible
		3) Recovery of exhaust heat of diesel engine			798	798	798	798	798	798	798	5586	125,126	875	not feasible
6.2	Karun Cane	1) Automatic control of crystallizing pan			2594	2594	2594	2594	2594	2594	2594	18158	406,739	525	not feasible
		2) Adoption of soft type ion exchange resin			4790	4790	4790	4790	4790	4790	4790	33530	751,072	1,750	not feasible
6.3	Ahkouh Sugar	1) Automatic control of crystallizing pan			2217	2217	2217	2217	2217	2217	2217	15519	347,626	350	feasible for 10 ys
		2) Reduction of steam pressure	255	255	255	255	255	255	255	255	255	2295	51,408	0	
		3) Turning of unnnecessary light	[15]	[15]	[15]	[15]	[15]	[15]	[15]	[15]	[15]	[135]	5,495	0	
	Accerelated energy conservation case		1997	1998	1999	2000	2001	2002	2003	2004	2005				
	Total	Fuel saving amount (kL-fuel)	163358	250656	347760	429240	522391	522391	522391	522391	522391	3802969	*1 115,823,857	*1 289,222	Fuel+
		Electricity saving amount (MWh)	44141	80353	102853	102853	111043	111043	111043	111043	111043	885415			Electricity
	Energy saving ratio	Fuel (consumption: 3,498,787 kL/y)	4.7%	7.2%	9.9%	12.3%	14.9%	14.9%	14.9%	14.9%	14.9%				
	(%)	Electricity (consumption: 1,155,133 MWh/y)	3.8%	7.0%	8.9%	8.9%	9.6%	9.6%	9.6%	9.6%	9.6%				
	Saved energy in energy conservation case		1997	1998	1999	2000	2001	2002	2003	2004					
	Total	Fuel saving amount (kL-fuel)	160498	240987	274402	355882	358925	358925	358925	358925	358925	2826394	*1 96,428,578	*1 21,581	Fuel+
		Electricity saving amount (MWh)	44141	80338	101857	101857	101857	101857	101857	101857	101857	837478			Electricity
	Energy saving ratio	Fuel (consumption: 3,498,787 kL/y)	4.6%	6.9%	7.8%	10.2%	10.3%	10.3%	10.3%	10.3%	10.3%				Payback year:
	(%)	Electricity (consumption: 1,155,133 MWh/y)	3.8%	7.0%	8.8%	8.8%	8.8%	8.8%	8.8%	8.8%	8.8%				10 years or less

*1: Saved energy and investment for fuel and electricity
Fuel saving amount and electricity saving amount for payback of 10 years or less

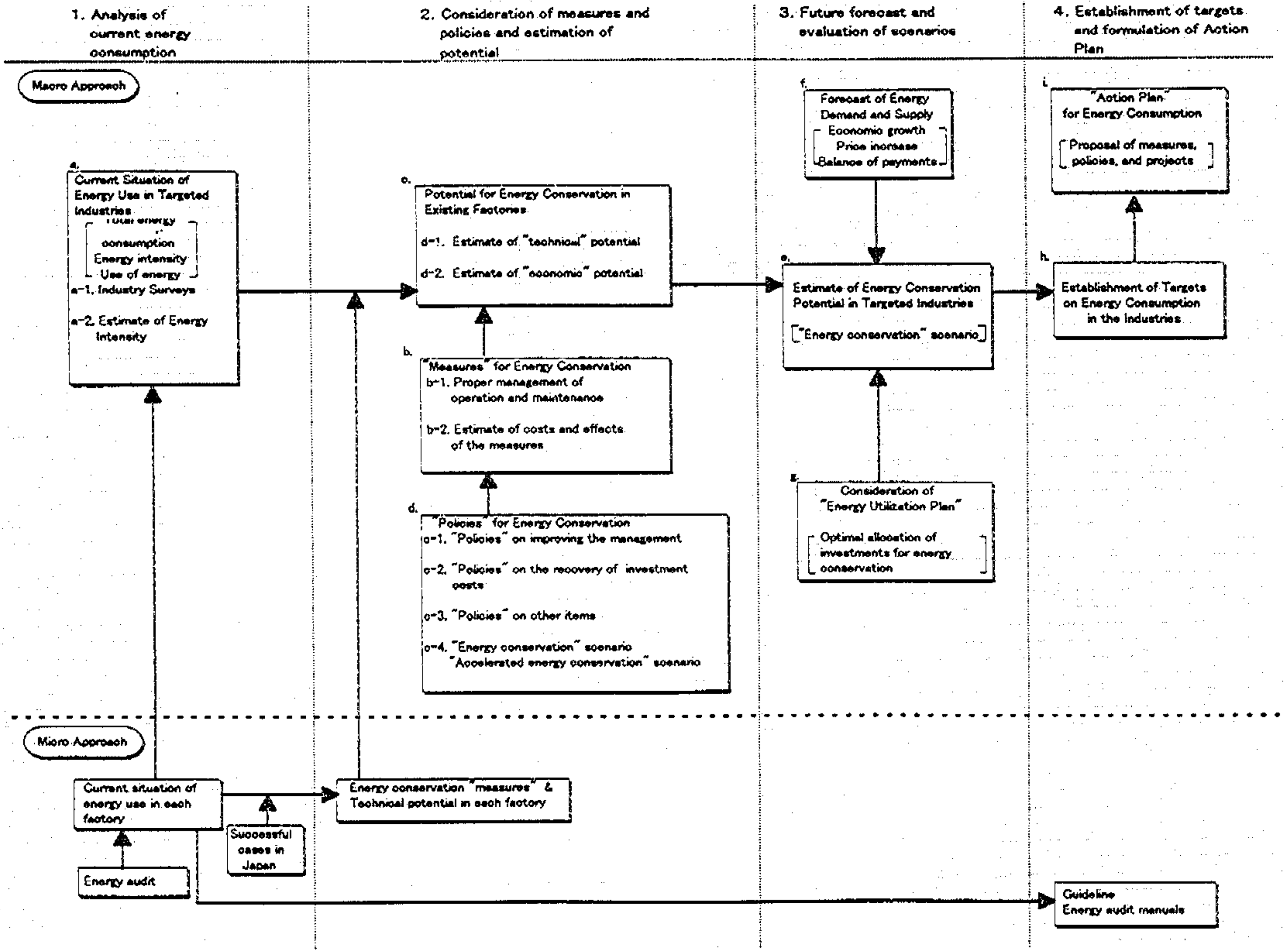


MASTER PLAN FOR ENERGY CONSERVATION IN SIX INDUSTRIES

1. INTRODUCTION

The main task of this part of the study is to formulate a master plan for energy conservation in the six industries targeted. We have carried out the following examinations in formulating it (See Figure 3.1.1):

Figure 3.1.1 The Conceptual Flow of Studying the Master Plan for Energy Conservation in Industries



First, we have tried to grasp the current status of energy use in the seven industries.
Second, we have considered measures for energy conservation based upon our grasp of the current status.
Third, we have estimated how much energy can be saved technically by the measures (estimate of technical potential).
Fourth, we have made an economic evaluation of measures for energy conservation by comparing the costs and the benefits of the measures.

The results of these examinations are described in the next chapter: "2. Current Status of Energy Use in Seven Industries and Economic Evaluation of Measures for Energy Conservation."

Fifth, we have considered various policies for promoting energy conservation in the industries, and established policy scenarios on energy conservation.
Sixth, we have estimated the economic potential of energy conservation in 2000 and 2005 in the industries according to the policy scenarios.
Seventh, we have evaluated the policy scenario and its potential, which is estimated according to the scenarios, from the viewpoint of both the Iranian macro-economy and the optimum investment for energy conservation measures. The former is performed to know the impact of the scenarios on economic growth, prices, government's budget, etc., and the latter is performed to know the optimum investment schedule for energy conservation. In other words, these evaluations are made to identify which scenario is the most desirable for the Iranian economy.

The fifth and the sixth above are described in "3. Establishing Policy Scenarios and Estimate of Potential for Energy Conservation," and the seventh in "4. Evaluation of Policy Scenarios and Investments for Energy Conservation."

Then, methodologies and tools used in this part of the study are explained in "5. Methodologies and Tools used in this Study."

Finally, a summary and a conclusion are given in "6. A Master Plan for Energy Conservation in the Six Industries."

2. CURRENT STATUS OF ENERGY USE IN SIX INDUSTRIES AND ECONOMIC EVALUATION OF MEASURES FOR ENERGY CONSERVATION

2.1 Introduction

Iron and steel, chemical (petroleum refining), (cement and sheet glass), textiles, food (sugar and vegetable oil) industries are targeted in this study.

These industries, excluding petroleum refining, consumed various kinds of energy equivalent to 81,600 Tcal in 1994, according to our estimate. This amount accounted for 32% of total energy consumption in the industrial sector, which was estimated at 255,520 Tcal in 1994. In addition, it accounted for 59% of energy consumed in the sector excluding natural gas used as chemical feedstock.

Petroleum refining belongs to the "energy conversion sector" in the energy balance table, which means it is an energy supply industry, not an energy consuming one, therefore, we consider it appropriate to treat this industry as being different from the other industries. Accordingly, it is described at the end of this chapter.

2.2 Iron and Steel

2.2.1 Outline of the Industry

Demand for steel products is estimated to have shown an annual growth rate of around 10% from the end of the 1980s to the middle of the 1990s in I.R.Iran, while their production increased at an annual rate of around 20% during the same period. The higher increase of production was due to the stabilized production of Ahwaz Steel during this period, as well as the inauguration of Mobarakeh Steel early in 1990s.

Steel production in I.R.Iran started in Esfahan Steel and INSIG (Iran National Steel Group) in 1972, followed by Ahwaz Steel in 1984 and Mobarakeh Steel in 1991. In addition to the four factories, Kavian Steel produces steel products and is a major producer. In 1994 Ahwaz, INSIG, and Kavian, all of which are located in Ahwaz in Khouzestan Province, merged to form Khouzestan Steel.

These factories are divided into the following in terms of production processes:

a. Blast furnace – Basic oxygen furnace process with rolling mills --------- Esfahan Steel

b. Direct reduction furnace – Electric arc furnace process --------- Ahwaz Steel (without rolling) and Mobarakeh Steel (with rolling)

c. Reduced iron & steel scrap – Electric arc furnace process with rolling --------- INSIG

d. Producing final products from semi-products supplied from other factories --------- Kavian Steel (Slabs are supplied from Ahwaz Steel).

Iron and steel factories are shown in Table 3.2.1

Table 3.2.1 Iron & Steel Factories in I.R. Iran

(1/2)

Company Name	Location	Production Start up	Manufacturer	Production Capacity(t/y)		Product (1994 Product Output)		
Esfahan Steel Co.	Esfahan	Phase 1 1972	USSR	(Crude Steel)	2,100,000	Crude Steel	1,881	Mt
				Coke Oven *2	1,150,000	Hot Rolled Prod.		
		Phase 2 1983		Sinter Plant *3	2,516,000	I-beam	936	Mt
				Blast Furnace *2	1,925,000	Bar	703	
				LD Converters *3	3*130t/charge	Billet	229	
				Billet C.C. *7	2,500,000	Channel	28	
				Rolling Mill *6	2,150,000	Angle & rail	13	
				Oxygen Plant *6	11,000NM3/H	(Total)	1,909	
Mobarakeh Steel Complex	Esfahan	1993	Kobe Steel Italimpianti	(Crude Steel)	2,769,000	Sponge Iron	1,624	Mt
				Iron Ore Pelletizing	4,500,000	Crude Steel	1,534	
				D-Reductn. Unit	3,200,000	Hot Coil	1,105	
				Electric Arc Furnaces	8*180-200t /charge	Pickling Coil	341	
						Cold Coil	253	
				C.C. Slab *4	2,700,000			
				Rolling Mill *2				
				Hot Strip Mill	2,500,000			
				Hot Finishing	1,550,000			
				Cold Rolling	986,000			
				Oxygen Plant *3	10,400NM3/H			

continued

(2/2)

Company Name	Location	Production Start up	Manufacturer	Production Capacity(t/y)		Product (1994 Product Output)
Khouzestan Steel Co.						
Ahwaz	Ahwaz			(Crude Steel)	1,550,000	Crude Steel
Steel Complex			Lurgie Chemie	Sinter Plant *2	5,000,000	
		1978	Thyssen(G)	D-Reductn. Unit No.1	330,000	(Purofer 1 set)
		1984	Korf(G)	D-Reductn. Unit No.2	1,200,000	(Midrex 3set)+600,000
		1985	Pullmann Swindell	D-Reductn. Unit No.3	1,000,000	(HYL 3set)
			Lectromelt	Electric Arc Furnaces	6*180t	
					/charge	Main products ;
				C.C. Slab & Billet	1,550,000	Bloom 1 line &
						Slab 2line
Iran National	Ahwaz			(Crude Steel)	150,000	Crude Steel
Steel Indu. G.		1972		Melting 60t/b*4set	360,000	
				Casting 2lines		Beam
		1967-1973		Round & Rod Rolling	505,000	Plain & Ribbed Rounds
		1977		Beam Rolling	385,000	Flange Beams & channels
		1977	Demag	Pipe Mill	190,000	Welded Pipe & Seamless Pipe
		1973	(Germany)	Metal Industry	119,000	Profile,Frame & Electrod
Kavian	Ahwaz	1991	Spezial Stahl	Hot Rolled	Total	mainly Plate,
Steel Co.			(Germany)	Semifinished Products	840,000	Bloom & Slab
				Plate 12%		
				Bloom 43%		
				Slab 55%		

Source : Ministry of Mines and Metals
Metal Bulletin Books 11Ed. P.228-9
Esfahan Steel Complex
Mobarakeh Steel Complex

2.2.2 Process of Producing Steel Products and Energy Consumption

The process of producing steel products is divided into three main parts -- iron making, steel making, and rolling. In the iron making process, iron ore is reduced to iron by coal (coke), natural gas, and others in a blast furnace, a direct reduction furnace, etc. In the steel making process, pig iron from the blast furnace is converted into steel in the basic oxygen furnace, or reduced iron from the direct reduction furnace is converted into steel in the electric arc furnace by removing impurities. In the case of INSIG, reduced iron and steel scrap are input into the electric arc furnace. Finally, in the rolling process, slabs and blooms are rolled into final products by a series of processes including hot rolling, cold rolling, and surface treatment.

Usually, iron making consumes two-thirds or three-fourths of the total energy consumed in the whole blast furnace – basic oxygen furnace process. In particular, the blast furnace consumes around 60 % of the total (in Japanese steel mills). In the direct reduction furnace – electric arc furnace process with rolling, iron making usually consumes nearly 50 % of the total (according to an estimation based on the process model).

2.2.3 Current Status of Energy Use and Measures for Energy Conservation

The energy intensity of Esfahan Steel is 9,140 Mcal/t-crude steel in 1994, which is 66% higher than 5,500 Mcal/t-crude steel of the newest iron and steel mill having a similar product-mix to Esfahan. The reasons are as follows:

a. The mill is heavily inclined to increase production and as a result its blast furnaces are operating with a high fuel ratio.
b. In its operation, there is insufficient coordination between processes.
c. Blast furnace gas, coke oven gas, and basic oxygen furnace steam, which are by-products of production processes, are not effectively utilized.
d. Energy related facilities including power plants are operating less efficiently.

The energy intensity of Mobarakeh Steel is 8,890 Mcal/t, which is nearly 40% higher than the 6,500 Mcal/t standard value of a factory with the direct reduction furnace process. The reasons are supposed to be the following:

a. The capacity factor is still low, which reached 60s % in 1995.
b. There are many problems in operating facilities, partly because the mill has never operated on a regular basis.
c. Energy intensive facilities are installed.

The energy intensity of Ahwaz Steel, which is the core of Khouzestan Steel, was 7,880 Mcal/t in 1994, which is 26% higher than the 6,240 Mcal/t standard value of a factory with a similar process-mix to Ahwaz. The reasons are assumed to be as follows:

a. Seven units of direct reduction furnaces excluding three units of MIDREX originally had a rather high energy intensity. In addition, their capacity factors are low.
b. Productivity of the electric arc furnaces is low.

The energy intensity of INSIG was 1,450 Mcal/t in 1994, which is 65% higher than the 880 Mcal/t standard value of a similar process. The reasons are assumed to be as follows:

a. There are many problems in operating the electric arc furnaces, which are small and originally had a high energy intensity.
b. The capacity factor of the rolling process is low.
c. Combustion in the heating furnaces is not sufficiently managed.

The energy intensity of Kavian Steel is 1,490 Mcal/t in 1994, which is more than twice the 630 Mcal/t standard value of a similar process. The reasons are assumed to be as follows:
a. The energy intensity of the heating furnaces was originally high.
b. Combustion of the heating furnaces is not sufficiently managed.
c. Productivity of the rolling process is low.
d. There are many problems in operating facilities.

Based upon the current status of energy use in the factories mentioned above, we have considered measures for energy conservation in each factory, and evaluated the measures economically. The results of the evaluation are shown in Table 3.2.2, where the measures are categorized into three groups – "improvement in management of operation and maintenance," "modification of facilities," and "modification of process."

Table 3.2.2-1 Economic Evaluation of Measures for Energy Conservation in the Iron & Steel Industry (Esfahan Steel)

A. E. C. Case (Natural Gas 123 Rial/Nm^3, Electricity 100 Rial/kWh)

(1,750 Rial/US$)

(1/2)

Energy Conservation Potential		Factory	Benefit					Countermeasure Cost		Economic Evaluation Note
			N.G. (1,000m^3/y)	Electricity (MWh/y)	(M Rial/y)	for 3 years (M Rial)	for 10 years (M Rial)	(M ¥)	(M Rial)	
<Improvement of Management>										
(C.O.P)	Air Ratio for Combustion	Esfahan Steel	2,549		314	778	1,925	0	0	feasible
	Carbonization Temperature	Esfahan Steel	5,501		677	1,678	4,154	200	3,500	feasible for 10 Ys.
	Steam Utilization Method	Esfahan Steel	7,111		875	2,169	5,371	0	0	feasible
(S.P)	Yield Increase	Esfahan Steel	10,252		1,261	3,127	7,742	100	1,750	feasible
	High Efficiency Burner	Esfahan Steel	11,474		1,411	3,500	8,665	200	3,500	feasible
	Low Coke Operation	Esfahan Steel	24,413		3,003	7,447	18,438	300	5,250	feasible
	Prevention of Air Leak	Esfahan Steel		7,104	710	1,762	4,362	30	525	feasible
(B.F)	Production Increase	Esfahan Steel	76,443		9,403	23,318	57,731	500	8,750	feasible
	Low O2 Operation of Hot Oven	Esfahan Steel	2,364		291	721	1,786	10	175	feasible
(S.M.P)	Converter Yield	Esfahan Steel								
	O2 and Electricity			15,424	1,542	3,825	9,470	0	0	feasible
	Fuel		20,750		2,552	6,330	15,671	0	0	feasible
	Reduction of Fuel	Esfahan Steel	38,785		4,770	11,831	29,291	0	0	feasible
	Boiler Aux. Combustion Method	Esfahan Steel	7,757		954	2,366	5,858	0	0	feasible
(R.P)	Process Management	Esfahan Steel	44,828		5,514	13,674	33,855	0	0	feasible
	Reheating Furnace Operation	Esfahan Steel	28,335		3,485	8,643	21,399	50	875	feasible
	Reheating F. Combustion Control	Esfahan Steel	10,572		1,300	3,225	7,984	50	875	feasible
	Hot Charge Ratio	Esfahan Steel	14,802		1,821	4,515	11,179	50	875	feasible
	Yield	Esfahan Steel	5,709	5,948	1,297	3,217	7,964	0	0	feasible
(C.C.P)	Low O2 Combustion et al.	Esfahan Steel	4,073		501	1,242	3,076	10	175	feasible
(O_2 P)	Operation Method	Esfahan Steel		13,167	1,317	3,265	8,085	0	0	feasible
	Reduction of O2 Supply Loss	Esfahan Steel		11,286	1,129	2,799	6,930	0	0	feasible
	Water Pump Operation Method	Esfahan Steel		13,080	1,308	3,244	8,031	10	175	feasible

continued

(1,750 Rial/US$) (2/2)

Energy Conservation Potential		Benefit					Countermeasure Cost		Economic Evaluation	
		N.G.	Electricity		for 3 years	for 10 years				Note
	Factory	(1,000m³/y)	(MWh/y)	(M Rial/y)	(M Rial)	(M Rial)	(M ¥)	(M Rial)		
<Modification of Facility>										
(C.O.P) Moisture Control Facilities	Esfahan Steel	9,124		1,122	2,783	6,891	1,000	17,500	not feasible	
(S.P) Steam Recovery from Waste Heat	Esfahan Steel	6,592	996	910	2,258	5,590	1,300	22,750	not feasible	
(B.F) Air Preheater for Hot Oven	Esfahan Steel	3,349		412	1,022	2,529	250	4,375	not feasible	
(S.M.P) Exhaust Gas Recovery Equip.	Esfahan Steel	7,757		954	2,366	5,858	5,000	87,500	not feasible	
(C.C.P) Efficiency of the BF Blower	Esfahan Steel	54,687		6,726	16,682	41,301	3,500	61,250	not feasible	
(T.P.P) Multi-Purpose Power G.Turbine	Esfahan Steel			(incl. in the above)						
(O_2 P) Air Compressor Efficiency	Esfahan Steel		39,501	3,950	9,796	24,254	2,500	43,750	not feasible	
(Other) BFG, CDG Holder	Esfahan Steel	97,738		12,022	29,814	73,814	800	14,000	feasible	
<Modification of Process>										
(C.O.P) Introducing CDQ	Esfahan Steel	22,138		2,723	6,753	16,719	5,000	87,500	not feasible	
(B.F) Introducing TRT	Esfahan Steel		50,641	5,064	12,559	31,094	1,000	17,500	feasible for 10 Ys.	

Note : (Abbreviation) Coke Oven Plant (C.O.P), Sintering Plant (S.P), Blast Furnace (BF), Steel Making Process (S.M.P)
Rolling Process (R.P), O_2 Plant (O_2 P), Blast & Power Plant (CPP), Thermal Power Plant (T.P.P)

Table 3.2.2-2 Economic Evaluation of Measures for Energy Conservation in the Iron & Steel Industry (Esfahan Steel)

E. C. Case

(Natural Gas 22.4 Rial/Nm^3, Electricity 40.7 Rial/kWh, for 2000-2002)
(Natural Gas 30.0 Rial/Nm^3, Electricity 54.5 Rial/kWh, for 2000-2009)
(1,750 Rial/US$)

(1/2)

Energy Conservation Potential		Factory	Benefit					Countermeasure Cost		Economic Evaluation
			N.G.	Electricity		for 3 years	for 10 years			Note
			(1,000m^3/y)	(MWh/y)	(M Rial/y)	(M Rial)	(M Rial)	(M ¥)	(M Rial)	
<Improvement of Management>										
(C.O.P)	Air Ratio for Combustion	Esfahan Steel	2,549		57	142	470	0	0	feasible
	Carbonization Temperature	Esfahan Steel	5,501		123	306	1,013	200	3,500	not feasible
	Steam Utilization Method	Esfahan Steel	7,111		159	395	1,310	0	0	feasible
(S.P)	Yield Increase	Esfahan Steel	10,252		230	569	1,888	100	1,750	feasible for 10 Ys.
	High Efficiency Burner	Esfahan Steel	11,474		257	637	2,114	200	3,500	not feasible
	Low Coke Operation	Esfahan Steel	24,413		547	1,356	4,497	300	5,250	not feasible
	Prevention of Air Leak	Esfahan Steel		7,104	289	717	2,377	30	525	feasible
(B.F)	Production Increase	Esfahan Steel	76,443		1,712	4,247	14,081	500	8,750	feasible for 10 Ys.
	Low O_2 Operation of Hot Oven	Esfahan Steel	2,364		53	131	435	10	175	feasible for 10 Ys.
(S.M.P)	Converter Yield	Esfahan Steel								
	O_2 and Electricity			15,424	628	1,557	5,161	0	0	feasible
	Fuel		20,750		465	1,153	3,822	0	0	feasible
	Reduction of Fuel	Esfahan Steel	38,785		869	2,155	7,144	0	0	feasible
	Boiler Aux. Combustion Method	Esfahan Steel	7,757		174	431	1,429	0	0	feasible
(R.P)	Process Management	Esfahan Steel	44,828		1,004	2,490	8,257	0	0	feasible
	Reheating Furnace Operation	Esfahan Steel	28,335		635	1,574	5,219	50	875	feasible
	Reheating F. Combustion Control	Esfahan Steel	10,572		237	587	1,947	50	875	feasible for 10 Ys.
	Hot Charge Ratio	Esfahan Steel	14,802		332	822	2,726	50	875	feasible for 10 Ys.
	Yield	Esfahan Steel	5,709	5,948	370	918	3,042	0	0	feasible
(C.C.P)	Low O_2 Combustion et al.	Esfahan Steel	4,073		91	226	750	10	175	feasible
(O_2 P)	Operation Method	Esfahan Steel		13,167	536	1,329	4,406	0	0	feasible
	Reduction of O_2 Supply Loss	Esfahan Steel		11,286	459	1,139	3,777	0	0	feasible
	Water Pump Operation Method	Esfahan Steel		13,080	532	1,320	4,377	10	175	feasible

continued

(1.750 Rial/US$) (2/2)

Energy Conservation Potential		Benefit					Countermeasure Cost		Economic Evaluation
		N.G.	Electricity		for 3 years	for 10 years			Note
	Factory	(1,000m^3/y)	(MWh/y)	(M Rial/y)	(M Rial)	(M Rial)	(M ¥)	(M Rial)	
<Modification of Facility>									
(Other) BFG, CDG Holder	Esfahan Steel	97,738		2,189	5,430	18,003	800	14,000	feasible for 10 Ys.
<Modification of Process>									
(B.F) Introducing TRT	Esfahan Steel		50,641	2,061	5,111	16,946	1,000	17,500	not feasible

Note : (Abbreviation) Coke Oven Plant (C.O.P), Sintering Plant (S.P), Blast Furnace (BF), Steel Making Process (S.M.P)
Rolling Process (R.P)

Table 3.2.2-3 Economic Evaluation of Measures for Energy Conservation int the Iron & Steel Industry (Mobarakeh/Khouzestan Steel)

A. E. C. Case (Natural Gas 123 Rial/Nm^3, Electricity 100 Rial/kWh)

(1,750 Rial/US$) (1/2)

	Energy Conservation Potential	Factory	Benefit					Countermeasure Cost		Economic Evaluation	Note
			N.G. (1,000m^3/y)	Electricity (MWh/y)	(M Rial/y)	for 3 years (M Rial)	for 10 years (M Rial)	(M US$)	(M Rial)		
<Improvement of Management>											
(P.P)	Increasing of productivity	Mobarakeh		21,240	2,124	5,268	13,041	0	0	feasible	
(DR. P)	Stability of DR plant operation	Mobarakeh	64,984	48,738	12,867	31,910	79,002	0	0	feasible	
(S.M.P)	Stability of EAF operation	Mobarakeh	7,672	122,752	13,219	32,783	81,164	0	0	feasible	
	Improvement of EAF heat loss	Mobarakeh		46,032	4,603	11,416	28,264	0	0	feasible	
	Stability of CC	Mobarakeh	7,376	14,752	2,382	5,908	14,628	0	0	feasible	
(H. R)	Increasing of productivity	Mobarakeh		54,872	5,487	13,608	33,691	0	0	feasible	
	Furnace operation improvement	Mobarakeh	20,577		2,531	6,277	15,540	0.5	875	feasible	
(C. R)	Increasing of productivity	Mobarakeh		12,675	1,268	3,143	7,782	0	0	feasible	
	Furnace operation improvement	Mobarakeh	2,535		312	773	1,914	0	0	feasible	
(Others)	Pump and blower operation	Mobarakeh		26,554	2,655	6,585	16,304	0.1	175	feasible	
(P. P)	Blower and pump efficiency	ASCO		47,512	4,751	11,783	29,172	0.1	175	feasible	
(DR. P)	Stop of old type DR plant	ASCO	150,782		18,546	45,995	113,874	0	0	feasible	
(S.M.P)	Productivity of EAF	ASCO	6,654	133,080	14,126	35,034	86,736	0	0	feasible	
	Increasing productivity of CC	ASCO	6,280	12,560	2,028	5,031	12,455	0	0	feasible	

continued

(2/2)

Energy Conservation Potential		Factory	Benefit					Countermeasure Cost		Economic Evaluation	Note
			N.G. ($1,000m^3/y$)	Electricity (MWh/y)	(M Rial/y)	for 3 years (M Rial)	for 10 years (M Rial)	(M US$)	(M Rial)		
(S.M.P)	Increasing of EAF productivity	INSIG		7,785	779	1,931	4,780	0	0	feasible	
	Stability of EAF	INSIG	973	7,785	898	2,227	5,515	0	0	feasible	
	Productivity increase of CC	INSIG	918	918	205	508	1,257	0	0	feasible	
(P. M)	Pipe mill productivity	INSIG	613	1,886	264	655	1,621	0	0	feasible	
	Furnace operation	INSIG	471		58	144	356	0	0	feasible	
(R.R.M)	Round rolling mill productivity	INSIG	7,397	7,767	1,687	4,183	10,355	0	0	feasible	
	Furnace operation improvement	INSIG	7,397		910	2,256	5,586	0	0	feasible	
(B.R.M)	Beam rolling mill productivity	INSIG	5,749	6,036	1,311	3,251	8,048	0	0	feasible	
	Furnace operation improvement	INSIG	5,749		707	1,754	4,342	0	0	feasible	
(R.M)	Rolling mill furnace operation	Kavian	2,395		295	731	1,809	0	0	feasible	
	Rolling mill productivity	Kavian	6,227	5,029	1,269	3,147	7,791	0	0	feasible	
<Modification of Facility>											
(DR. P)	Waste heat recovery	Mobarakeh	32,492		3,997	9,911	24,539	15.0	26,250	not feasible	
(R.M)	Rolling mill furnace	Kavian	7,185		884	2,192	5,426	0.5	875	feasible	
<Modification of Process>											
(P. P)	Replacement to high eff. P. P	Mobarakeh	121,562	33,767	18,329	45,455	112,539	70.0	122,500	not feasible	

Table 3.2.2-4 Economic Evaluation of Measures Conservation in the Iron & Steel Industry (Mobarakeh/Khouzestan Steel)

E. C. Case

(Natural Gas 22.4 Rial/Nm^3, Electricity 40.7 Rial/kWh, for 2000-2002)
(Natural Gas 30.0 Rial/Nm^3, Electricity 54.5 Rial/kWh, for 2000-2009)
(1,750 Rial/US$)

(1/2)

	Energy Conservation Potential	Factory	Benefit					Countermeasure Cost		Economic	Note
			N.G.	Electricity		for 3 years	for 10 years			Evaluation	
			(1,000m^3/y)	(MWh/y)	(M Rial/y)	(M Rial)	(M Rial)	(M US$)	(M Rial)		
<Improvement of Management>											
(P.P)	Increasing of productivity	Mobarakeh		21,240	864	2,144	7,108	0	0	feasible	
(DR. P)	Stability of DR plant operation	Mobarakeh	64,984	48,738	3,439	8,529	28,279	0	0	feasible	
(S.M.P)	Stability of EAF operation	Mobarakeh	7,672	122,752	5,168	12,816	42,490	0	0	feasible	
	Improvement of EAF heat loss	Mobarakeh		46,032	1,874	4,646	15,404	0	0	feasible	
	Stability of CC	Mobarakeh	7,376	14,752	766	1,899	6,295	0	0	feasible	
(H. R)	Increasing of productivity	Mobarakeh		54,872	2,233	5,539	18,362	0	0	feasible	
	Furnace operation improvement	Mobarakeh	20,577		461	1,143	3,790	0.5	875	feasible	
(C. R)	Increasing of productivity	Mobarakeh		12,675	516	1,279	4,241	0	0	feasible	
	Furnace operation improvement	Mobarakeh	2,535		57	141	467	0	0	feasible	
(Others)	Improvement of pump and blower operation	Mobarakeh		26,554	1,081	2,680	8,886	0.1	175	feasible	
(P. P)	Blower and pump efficiency	ASCO		47,512	1,934	4,796	15,899	0.1	175	feasible	
(DR. P)	Stop of old type DR plant	ASCO	150,782		3,378	8,376	27,774	0	0	feasible	
(S.M.P)	Productivity increase of EAF	ASCO	6,654	133,080	5,565	13,802	45,758	0	0	feasible	
	Increasing productivity of CC	ASCO	6,280	12,560	652	1,617	5,360	0	0	feasible	

(2/2)

Energy Conservation Potential	Factory	Benefit					Countermeasure Cost		Economic Evaluation	Note
		N.G. (1,000m^3/y)	Electricity (MWh/y)	(M Rial/y)	for 3 years (M Rial)	for 10 years (M Rial)	(M US$)	(M Rial)		
(S.M.P) Increasing of EAF productivity	INSIG		7,785	779	1,931	4,780	0	0	feasible	
Stability of EAF	INSIG	973	7,785	339	840	2,784	0	0	feasible	
Productivity increase of CC	INSIG	918	918	58	144	476	0	0	feasible	
(P. M) Pipe mill productivity	INSIG	613	1,886	90	224	744	0	0	feasible	
Furnace operation	INSIG	471		11	26	87	0	0	feasible	
(R.R.M) Round rolling mill productivity	INSIG	7,397	7,767	482	1,195	3,962	0	0	feasible	
Furnace operation improvement	INSIG	7,397		166	411	1,363	0	0	feasible	
(B.R.M) Beam rolling mill productivity	INSIG	5,749	6,036	374	929	3,079	0	0	feasible	
Furnace operation improvement	INSIG	5,749		129	319	1,059	0	0	feasible	
(R.M) Rolling mill furnace operation	Kavian	2,395		54	133	441	0	0	feasible	
Increasing of plate mill productivity	Kavian	6,227	5,029	344	854	2,830	0	0	feasible	
<Modification of Facility>										
(R.M) Improvement of R. mill furnace	Kavian	7,185		161	399	1,323	0.5	875	feasible for 10 Ys.	

2.2.4 Economic Evaluation of Measures for Energy Conservation

An economic evaluation is made for every industry applying the following method:

When

C = Cost of investment (or expenditure) for energy conservation measures at the time of investment or expenditure

B = Effect of the measures (present value of energy saved by the measures for three or ten years

And if

$$B > C$$

Then, the measures are evaluated as economically "feasible". Actually, however, if investment or expenditure for a measure is difficult to finance, the measure will never be implemented. In addition, the following prerequisites are set for the evaluation:

a. Every price is expressed in terms of 1993 prices. Exchange rate is also that in 1993, which was US$1 = 100 yen = 1,750 Rial.

b. Discount rate is 10% for calculating B.

c. Two scenarios are established for energy prices (See Chapter 3 for more details):

   c-1. Energy Conservation (E.C.) Scenario --------- Energy prices will increase at the annual rate of 8% in real terms after 1994.

   c-2. Accelerated Energy Conservation (A.E.C.) Scenario --------- Energy prices will increase to the level reflecting their real costs, and be maintained after that.

d. Evaluation is made assuming that measures will be implemented in 2000 and have an instant effect.

The following are the results of the evaluation including those for the "10 years benefit (effect)" case.

First, there are many "feasible" measures among those belonging to "Improvement of management," apart from those which have no cost, in the iron and steel industry.

Second, many of the measures belonging to "Modification of facilities" and "Modification of process" are evaluated as "not feasible" even in the A.E.C. scenario, although energy prices are much higher than in the E.C. scenario. However, we should note that even the energy prices in the A.E.C. scenario are much lower than in many countries including Japan.

Third, some of the measures belonging to "Improvement in management," which cost much (3.5 or 5.3 billion Rial), are evaluated as "not feasible."

2.3 Cement

2.3.1 Outline of the Industry

Demand for cement is estimated to have increased at an annual rate of around 3% in the first half of the 1990s, and cement production showed almost the same rate of increase during this period to reach 17,500,000 t in 1995.

There were 15 cement companies with 19 factories (excluding those producing white cement) operating in I.R.Iran as of 1995. Table 3.2.3 shows cement factories in I.R.Iran.

Table 3.2.3 Cement Factories in I. R. Iran

(1/2)

Company	Factory	Start -Up	Employee -ce	Capacity (T/Y)	(T/D)	Production 1995 (T/Y)	Kiln Type	Cooler	Fuel
1 Abadeh Cement	Abadeh	1995		165,000	500	143,353	SP PSP	Rotary	F.O. 100%
2 Fars & Khouzestan Cement	Abyek	1974		2,250,000	3,500	2,263,412	D Polysius	Planetary	Gas 100%
		1980			4,000		SP Polysius	Grate	
	Behbahan	1979	708	825,000	2,750	717,956	SP IHI	Grate	F.O. 100%
	Dorud	1959	1,404	1,197,000	300	Scrapped	1W Kenedy Vensa	2 Rotary	Gas 100%
		1965			300	Scrapped	2W Polysius		
		1968			400	814,960		Planetary	
		1969			1,000		SP Polysius	1 Grate	
		1980			2,500		NSP IHI	1 Grate	
	Fars	1966	965	1,051,500	300	947,292	2SP Polysius	Planetary	Gas & F.O.
		1967			500			Grate	
		1974			1,250		1SP KHD	Grate	
		1978			1,250		1NSP KHD	Grate	
3 Ourmia Cement	Ourmia	1989		690,000	2,300	768,296	NSP FLS	FOLAX Grate	Gas & F.O.
4 Isfahan Cement	Isfahan	1968	490	679,500	500	642,133	3SP Polysius	2 Planetary	Coal
		1975			700				
		1976			900			1 Grate	
5 Tehran Cement	Tehran	1956	2,096	2,226,000	300	1,803,987	3W FLS	4 Planetary	Gas & F.O.
		1958			300				
		1968			600				
		1962			2,100		1SP FLS		
		1972			300		1W GHH	1 Rotary	
		1979			4,000		1SP Polysius	1 Grate	
	Tehran	1984		600,000	2,000	595,749	1SP Perago Inv.	1 Planetary	Gas & F.O.
6 Khazar Cement	Khazar	1987		600,000	2,000	473,407	Voest Alpine	Grate	F.O. 100%
7 Sepahan Cement	Sepahan	1978	1,375	1,980,000	3,300	1,902,540	2SP Humboldt	2 Planetary	Gas & F.O.
		1981			3,300				
8 Shomal Cement (White)	Shomal	1958	900	660,000	2,000	666,589	1W FLS	2 Planetary	Gas & F.O.
		1967		85,800	200	97,138	1W GHH	1 Rotary	
	Ghani-Abad	1979		99,000	300	97,138	1D KHD		
9 Shargh Cement	Mashad	1970	510	492,740	300	457,041		1 Grate	
		1975			1,250		1SP Polysius	1 Planetary	Gas 100%

continued

(2/2)

Company	Factory	Start -Up	Employe-ee	Capacity (T/Y)	Production (T/D)	Production 1995 (T/Y)	Kiln Type	Cooler	Fuel
10 Soufian Cement	Soufian	1970	1,075	1,428,000	600	1,372,252	3D FLS	4 Planetary	F.O. 100%
		1975			1,000				
		1977			1,000				
		1984			2,000		1SP FLS		
11 Gharb Cement	Gharb	1977	456	600,000	2,000	502,553	D Humboldt	Planetary	F.O. 100%
12 Khorasan C.	Ghaen	1995		660,000	2,000	--	NSP FLS	FOLAX Grate	F.O. 100%
13 Kerman Cement	kerman	1970	920	1,104,000	300	963,000	2SP Polysius	2 Grate	Gas & F.O.
		1974			1,000		1SP Humboldt	1 Planetary	
		1979			2,300				
14 Shimansaz	Loshan	1958		99,000	300	108,142	1SP Polysius	2 Grate	F.O.
15 Gorgan Cement	Neka	1981	530	600,000	2,000	561,656	1SP Humboldt	1 Planetary	Gas & F.O.
Total				18,092,540	59,100	15,898,594			

Note :

Kiln Type		
	W	Wet Process
	D	Dry Process
	SP	Dry Process with Suspension Preheater
	NSP	Dry Process with Suspension Preheater and Calciner

Fuel		
	Gas	Natural Gas
	F.O.	Fuel Oil

Source : Cement Magazine of Iran No.23 Jan. 1996
CEMBUREAU 1991
Global Cement Report P.96-97
World Cement Apr. 1995 P.47

Production lines in the Iranian cement industry can be divided into five groups according to their main components, which are kiln and clinker cooler (Unfortunately, data and information of raw mill and cement mill by factory are not available).

a. Wet kiln – Planetary (Satellite) cooler --------- five lines including No.1, 2, and 3 lines of Tehran Cement (Although one of them installs rotary cooler).
b. Dry kiln – Planetary cooler --------- five lines including Abyek factory of Fars & Khouzestan Cment, and No.1, 2, and 3 lines of Soufian Cement.
c. SP kiln – Planetary cooler --------- 11 lines including Esfahan Cement and Sepahan Cement.
d. SP kiln – Grate cooler --------- 12 lines including Khazar Cement and Kerman Cement.
e. NSP kiln – Grate cooler --------- four lines including Ourmia Cement and Khorasan Cement.

2.3.2 Process of Producing Cement and Energy Consumption

There are three main parts of the process for manufacturing cement – preparing materials, burning, and finishing.

Almost all (more than 90% in Japan) of the fuel required for manufacturing cement is consumed in the burning process, which is the main process in cement manufacturing. In this process, raw materials are burned to form clinker, a semi-product, and the latter is cooled to be moved to the finishing mill. This is the main reason why attention was turned to kiln and clinker cooler when dividing production lines into the groups above. SP kiln (the suspension-preheater kiln) uses waste heat from the kiln for preheating raw materials. The NSP kiln (the new suspension-preheater kiln) has a calciner installed with the preheater. Fuel consumption in the burning process was sharply reduced by adopting SP and NSP in the 1960s and the 1970s, respectively, compared to those of wet and dry kilns.

In addition, the grate type was developed as a more efficient one than the planetary (satellite) type for cooling clinker.

On the other hand, the finishing process consumes around 40% of the total electricity consumption in cement manufacturing, and the burning and raw material process around 30%, respectively, which shows that the difference in electricity consumption by process is not as large as in fuel consumption.

2.3.3 Current Status of Energy Use and Measures for Energy Conservation

The energy intensity of cement manufacturing in I.R.Iran is significantly higher than the level of Japanese factories or the newest factories, as is the case for iron and steel making. For example, the energy intensity of No. 6 line of Tehran Cement (SP kiln ; Grate cooler), which was targeted by the "Factory Energy Audit" is 880 Mcal/t - cement in fuel, and 126 kWh/t - clinker in electricity. Corresponding figures in Japan are 720 Mcal/t, and 95kWh/t, respectively (1995). In this connection, the energy intensities of "NSP kiln - Grate cooler" group mentioned above are 950 Mcal/t, and 125 kWh/t, respectively.

We can point out the following reasons for the energy intensity of the Iranian cement industry being much higher than that of the Japanese cement industry:

First, looking at the management of operations and maintenance, we can find many factors showing insufficient management, including lower yield and leaking air. These are the reasons why a large difference is generated in similar processes.

Second, looking at equipment and facilities, out-dated and aged ones can be seen among wet kilns, dry kilns, and planetary coolers. These are the reasons why a large difference is generated when comparing the Iranian cement industry with the Japanese cement industry.

Based upon the current status of energy use, we considered measures for energy conservation, and made an economic evaluation of the measures. The results of the evaluation are shown in Table 3.2.4 where the measures are categorized into three groups in the same way as for the iron and steel industry.

2.3.4 Economic Evaluation of Measures for Energy Conservation

The results of the evaluation provides roughly the same conclusion as that for the iron and steel industry.

First, many measures belonging to "Improvement in management" are evaluated as "feasible." However, measures with no cost are not listed in Table 3.2.4, which is different from the iron and steel industry. This is because of non-availability of such data and information in the cement industry, not because such measures cannot be found. If this is the case, the potential for energy conservation in the cement industry may be estimated to be relatively smaller than that in the iron and steel industry.

Second, few measures belonging to "Conversion of facilities" are evaluated as "feasible," even in the "Accelerated Energy Conservation" scenario. For example, "Conversion of wet kiln to NSP kiln" and "Conversion of dry kiln to NSP kiln" are "not feasible" even in the "Accelerated Energy Conservation" scenario.

Table 3.2.4-1 Economic Evaluation for Energy Conservation Potential of Cement Industry
A. E. C. Case (Fuel Oil 75 Rial/l, Electricity 100 Rial/kWh, 1,750 Rial/US$)

Energy Conservation Potential	Factory	Benefit					Countermeasure Cost		Economic Evaluation	Note
		Fuel Oil (kl/y)	Electricity (MWh/y)	(M Rial/y)	for 3 years (M Rial)	for 10 years (M Rial)	(M ¥)	(M Rial)		
Improvement of Management										
Capacity-up of EP IDF	Sepahan C.	3,780		284	703	1,741	10	168	feasible	
				+ Merit due to production increase(60,000t/y)						
Raw Mill Fan Operation	Sepahan C.		5,400	540	1,339	3,316	43	753	feasible	
Draft Control for Whole Process	Sepahan C.	9,451		709	1,758	4,352	6	105	feasible	
				+ Merit due to production increase(60,000t/y)						
Renewal of Screen Plate	Sepahan C.		10,000	1,000	2,480	6,140	49	849	feasible	
No.6 Kiln Operation	Tehran C.	6,593	14,400	1,934	4,797	11,878	73	1,278	feasible	
Operation Improvement	Soufian C.	4,343		326	808	2,000	95	1,663	feasible for 10 Ys.	
Air Scaling				+ Merit due to production increase(80,000t/y)						
Combustion Control										
Capacity-up of EP fan										
Utilizing Kiln Exhaust Gas										
Modification of Facility										
Satellite C. to Grate Cooler	Tehran C.	10,385	8,190	1,598	3,963	9,811	2,280	39,900	not feasible	
				+ Merit due to production increase(270,000t/y)						
	Soufian C.	6,593		494	1,226	3,036	1,323	23,153	not feasible	
				+ Merit due to production increase(300,000t/y)						
Vertical Mill for Raw Materials	(300 t/h)		16,000	1,600	3,968	9,824	200	3,500	feasible	*(1)
Vertical Mill for Clinker	(150 t/h)		12,000	1,200	2,976	7,368	200	3,500	feasible for 10 Ys.	*(2)
High Efficiency Separator	(100 t/h)		4,000	400	992	2,456	100	1,750	feasible for 10 Ys.	*(3)
Iry Air Preheating	(3,000 t/d)	3,024		227	562	1,393	70	1,225	feasible for 10 Ys.	*(4)
Modification of Process										
Wet(No.3 Kiln) to NSP	Tehran C.	42,527		3,190	7,910	19,584	4,550	79,625	not feasible	
				+ Merit due to production increase(420,000t/y)						
SP(No.3 Kiln) to NSP	Soufian C.	34,286		2,571	6,377	15,789	5,720	100,100	not feasible	
				+ Merit due to production increase(600,000t/y)						
Automatic Operation	(6,000 t/d)	6,048	4,140	868	2,152	5,327	500	8,750	not feasible	*(5)

Table 3.2.4-2 Economic Evaluation for Energy Conservation Potential of Cement Industry

E. C. Case

(Fuel Oil 17.0 Rial/l, Electricity 40.7 Rial/kWh, for 2000-2002, 1,750 Rial/US$)
(Fuel Oil 22.7 Rial/l, Electricity 54.5 Rial/kWh, for 2000-2009, 1,750 Rial/US$)

Energy Conservation Potential		Benefit					Countermeasure Cost		Economic Evaluation	
	Factory	Fuel Oil (kl/y)	Electricity (MWh/y)	(M Rial/y)	for 3 years (M Rial)	for 10 years (M Rial)	(M ¥)	(M Rial)		
Improvement of Management										
Capacity-up of EP IDF	Sepahan C.	3,780		64	159	527	10	168	feasible for 10 Ys.	
				+ Merit due to production increase(60,000t/y)						
Raw Mill Fan Operation	Sepahan C.		5,400	220	545	1,807	43	753	feasible for 10 Ys.	
Draft Control for Whole Proce	Sepahan C.	9,451		161	398	1,317	6	105	feasible	
				+ Merit due to production increase(60,000t/y)						
Renewal of Screen Plate	Sepahan C.		10,000	407	1,009	3,346	49	849	feasible	
No.6 Kiln Operation	Tehran C.	6,593	14,400	698	1,731	3,876	73	1,278	feasible	
Operation Improvement	Soufian C.	4,343		74	183	605	95	1,663	not feasible	
Air Sealing				+ Merit due to production increase(80,000t/y)						
Combustion Control										
Capacity-up of EP fan										
Utilizing Kiln Exhaust Gas										
Modification of Facility										
Vertical Mill for Raw Material	(300 t/h)		16,000	651	1,615	5,354	200	3,500	feasible for 10 Ys.	*(1)
Vertical Mill for Clinker	(150 t/h)		12,000	488	1,211	4,016	200	3,500	feasible for 10 Ys.	*(2)
High Efficiency Separator	(100 t/h)		4,000	163	404	1,339	100	1,750	not feasible	*(3)
Iry Air Preheating	(3,000 t/d)	3,024		51	127	421	70	1,225	not feasible	*(4)

Note : Calculation Basis of Energy Conservation

*(1)	10 kWh/t * 300 t /h/1.5 * 8000 h /y
*(2)	10 kWh/t * 150 t/h * 8000 h/y
*(3)	5 kWh/t * 100 t/h* 8000 h/y
*(4)	112 l/t * 0.03 * 3000 t/d * 300 d/y
*(5)	112 l/t * 0.03 * 6000 t/d * 300 d /y
	115 kWh/t * 0.02 * 300 d * 6000 t/d

2.4 Sheet Glass

2.4.1 Outline of the Industry

Production of sheet glass recorded an annual growth rate of around 7.5% in the first half of the 1990's reaching slightly less than 230,000 t in 1995.

Sheet glass is produced by four companies (factories). Ghazvin Glass has the largest capacity, followed by Abguineh Glass, Saveh Jam Glass, and Iran Glass. Table 3.2.5 shows sheet glass factories in I.R.Iran.

2.4.2 Process of Producing Sheet Glass and Energy Consumption

There are several steps in manufacturing sheet glass – mixing, melting, refining, forming, annealing, and cutting. Processes for manufacturing sheet glass are divided into several groups according to the technology adopted in the forming process. The float process is the most advanced one and has never been adopted in sheet glass factories in I.R.Iran as can be seen in Table 3.2.5.

The melting process consumes a major part of energy consumed in the whole process, which is estimated to account for 82 - 85% of the total. The differences in the forming process affect energy consumption in the melting process. The float process not only produces better quality products, but also has advantages including lower energy intensity, the large scale of facilities being installed, and production at the full capacity being possible.

Table 3.2.5 Sheet Glass Factories in I. R. IRAN

Company Name	Location	Employee	Start-up Year	Estimated MGS	Process Lines	Production Capacity	Production in 1995	Fuel	Future plan
<Sheet Glass>				(t/d)		(t/y)	(t/y)		
1 Ghazvin Glass	Ghazvin	1,232	1968	95	Roll out	27,700		N. Gas	Float Process
			1970	55	Roll out	16,100		Fuel Oil	
				55	Colburn	10,900			
			1972	150	Colburn	29,700		Fuel Oil	
			1978	230	Colburn	45,600		Fuel Oil	
(Sub-total)				585		130,000	89,381		
2 Abguineh Glass	Ghazvin		1973	100	Glaverbel			N. Gas	Float Process
				45	Roll out			N. Gas	
				20	Roll out				
			1992	230	Colburn			N. Gas	
(Sub-total)				395		98,000	71,614		
3 Saveh Jam Glass	Saveh	300	1992	250	Glaverbel	60,000	55,595	N. Gas	2001? Float Process
4 Iran Glass	Tehran			55	Fourcault	14,000	11,193	Fuel Oil?	
(5) Azar Glass	Tabriz		(project)			(100,000?)	--		Float Process
(6) Liya Glass ?	Liya		(project)				--		Glaverbel to Float
Total				1,285		302,000	227,783		

Source : MOI, Ghazvin Glass, & Saveh Jam Glass

2.4.3 Current Status of Energy Use and Measures for Energy Conservation

According to the results of the "Factory Energy Audit," the energy intensity of Ghazvin Glass fluctuated between 5,350 Mcal/t and 7,230 Mcal/t from 1992 to 1995. The energy intensity of Saveh Jam Glass was 4,170 Mcal/t in 1995. In contrast, the energy intensity of Japanese sheet glass factories is less than 3,000 Mcal/t. The reasons why there are such big differences are as follows, according to the results of the "Factory Energy Audit" and other sources:

First, from the viewpoint of "Improvement in management of operation and maintenance," we can point out the fact that product yield is lower. It is also an important factor that combustion in the melting furnace is not sufficiently managed.

Second, with regard to equipment and facilities, we can point out that the float process has not been adopted, that the melting furnaces have a lower load and smaller scale, and that they have not been insulated.

Based upon the current status of energy use mentioned above, we considered measures for energy conservation and made an economic evaluation as shown in Table 3.2.6.

2.4.4 Economic Evaluation of Measures for Energy Conservation

Looking at Table 3.2.6, we can find that there are many measures which are "feasible" among those belonging to "Improvement in management," but that many measures which need the modification of equipment or facilities are "not feasible."

All of the measures in Table 3.2.6 are for the melting furnace, which we consider important in this study for the reasons mentioned above. In particular, the "Heavy insulation" of the melting furnace and modification of regenerator are "not feasible" even in the "Accelerated Energy Conservation" scenario.

Table 3.2.6 Economic Evaluation of Measures for Energy Conservation in the Sheet Glass Industry

A. E. C. Case

(Fuel Oil 75 Rial/L for 2000-2002 and 2000-2009, 1,750 Rial/$)

Energy Conservation Potential		Benefit			Cost		Economic Evaluation
	as Fuel Oil		for 3 years	for 10 years			
	(kl/y)	(M Rial/y)	(M Rial)	(M Rial)	(M ¥)	(M Rial)	
Improvement of Management							
Improvement of Yield	3614	271	672	1,664	0.0		feasible
Combustion Control	7340	551	1,365	3,380	20.0	350	feasible
Improvement of Productivity	4659	349	867	2,145			
Mod'n. of Forming Machine					50.0	875	feasible for 10 Ys.
Load up of Melting Furnace					0.0		feasible
Insulation							
Light Insulation	9576	718	1,781	4,410	89.0	1,558	feasible
Heavy Insulation	8505	638	1,582	3,917	813.0	14,228	not feasible
Modification of Regenerator	4782	359	889	2,202	202.8	3,549	not feasible

E. C. Case

(Fuel Oil 17.0 Rial/L for 2000-2002, 1,750 Rial/$)
(Fuel Oil 22.7 Rial/L for 2000-2009, 1,750 Rial/$)

Energy Conservation Potential		Benefit			Cost		Economic Evaluation
	as Fuel Oil		for 3 years	for 10 years			
	(kl/y)	(M Rial/y)	(M Rial)	(M Rial)	(M ¥)	(M Rial)	
Improvement of Management							
Improvement of Yield	3614	61	152	504	0.0		feasible
Combustion Control	7340	125	309	1,023	20.0	350	feasible
Improvement of Productivity	4659	79	196	649			
Mod'n. of Forming Machine					50.0	875	not feasible
Load up of Melting Furnace					0.0		feasible
Insulation							
Light Insulation	9576	163	404	1,335	89.0	1,558	not feasible
Heavy Insulation	8505	145	359	1,185	813.0	14,228	not feasible
Modification of Regenerator	4782	81	202	667	202.8	3,549	not feasible

2.5 Textiles

2.5.1 Outline of the Industry

Production of textile products as a whole increased at an annual rate of around 5% from the end of the 1980s to the beginning of the 1990s. Production by textile product, however, showed differences. Production of chemical fibers and yarn showed a small range of fluctuations, while fabric products showed a declining tendency.

As can been seen in Table 3.2.7, main textile factories are 117, and are divided into following four groups according to production process.

a. Chemical fiber ---------- 3
b. Spinning ----------------- 44
c. Weaving ----------------- 58
d. Dyeing, printing, and finishing ---------- 12

Table 3.2.7 Textile Factories in I. R. IRAN

(1/4)

Factory Name	Location	Estabsh. Year	Products	No. of Machines	Capacity	Production in 1995
<Man-made Fiber Production>					(t/y)	
1 Polyacryl Iran	Esfahan	1978	Polyester Fiber		30,800	34,707
			Polyester Filament		21,880	19,896
			Polyester Tops		2,200	
			Acrylic Fiber		23,500	24,581
			Acrylic Tops		16,520	
2 Parsilon	Khoramabad	1979	Nylon 6		16,000	8,596
3 Aliaf	Tehran	1969	Nylon 6		10,000	11,500
<Weaving-1>					(1000m/Y)	(1000m/Y)
1 Azar	Esfahan	1957	Cot. F.	250	3,200	1,700
2 Atlas Baft	Tehran	1956	Cot.& PE. F.	178	4,000	1,500
3 Abhar Brezent	Abhar	1983	Tarpaulin	24	2,300	1,000
4 Ettemadieh Boushehr	Boushehr	1938	Grey F.	300	9,000	3,500
5 Iran poplin	Rasht	1974	Cot.& Syn.F.	259	20,000	14,500
6 Iran Nou Baft Production	Esfahan		Cot.& PE. F.	11	1,200	700
7 Baresh	Esfahan	1957	Cot.& PE. F.	718	21,000	11,000
8 Bafkar	Tehran	1958	Cot & Syn.F.	644	28,000	12,500
9 Bafnaz	Esfahan	1950	Cot.& PE. F.	883	29,000	10,000
10 Baft Harir Semnan	Semnan	1983	Cot.& PE. F.	60	3,200	2,800
11 Brezent Iran	Karaj	1967	Tarpaulin	32	3,200	1,800
12 Bafteh Mazandaran	Ghaemshahr	1982	Grey F.	96	2,500	1,500
13 Foumenat	Rasht	1973	Cot.& Syn.F.	296	9,000	6,500
14 Tar-e-Esfahan	Esfahan	1984	Cot.& Syn.F.	50	1,200	500
15 Khazar Weaving	Ghaemshahr	1982	Grey F.	60	1,200	700
16 Semnan Weaving	Semnan	1983	Grey F.	57	1,000	600
17 Mohammad Sadegh Khojasteh Weaving	Yazd	1977	Grey F.	35	400	250
18 Shiraz Weaving	Shiraz	1948	Grey F.	596	6,500	3,500
19 Pakris	Semnan	1973	Grey F.	911	24,000	18,500
20 Pileh	Tehran	1962	Cot.& Syn.F.	80	3,000	1,950
21 Zarpood Weaving	Saveh	1982	Grey F.	44	2,000	1,100
22 Joulabaf	Ghom	1982	Grey F.	6	900	200
23 Heydar Esfahan Weaving	Esfahan	1985	Grey F.	57	2,200	1,000
24 Rangin Baft	Esfahan	1977	Grey F.	220	6,000	2,500
25 Jonob Yazd	Yazd	1952	Cot.& Syn.F.	162	5,000	3,500
26 Chit Behshahr	Behshahr	1938	Cot.& Syn.F.	978	25,000	6,000
27 Ray Spinning & Weaving	Tehran	1947	Cot.& PE. F.	1,548	40,000	18,500
28 Khosravi Khorasan	Mashad	1968	Grey F.	205	4,500	1,400
29 Kashan Spinning & Weaving	Kashan	1934	Cot.& Syn.F.	1,396	40,000	18,000
30 Zayandeh Roud	Esfahan	1935	Cot. F.	312	10,000	3,200
Sub-Total				10,468	308,500	150,400

continued

Table 3.2.7 Textile Factories in I. R. IRAN

(2/4)

Factory Name	Location	Estabsh. Year	Products	No. of Machines	Capacity	Production in 1995
<Weaving-2>						
31 Zarran Weaving	Ghazvin	1963	Cot.& PE. F.	36	1,500	450
32 Sa-adat Nassajan Yazd	Yazd	1947	Cot.& Syn.F.	490	18,000	11,000
33 Silkbaf Yazd	Yazd	1974	Grey F.	500	15,000	9,500
34 Simin Esfahan	Esfahan	1957	Cot.& Syn.F.	577	18,000	10,000
35 Shahreza-ye-Jadid	Esfahan	1935	Cot.& Syn.F.	400	8,000	3,200
36 Sanaye Poshesh Iran	Rasht	1973	Towel,Denim,Velvet Velvet, Garments	580	20,000	6,800
37 Jahan Industrial	Karaj	1956	Cot.& Syn.F.	655	25,000	15,000
38 Sanaye Chahr Mehal-Bakhtiari	Shahr-e-Kord	1984	Grey F.	26	1,200	400
39 Kosar Baft	Esfahan	1983	Grey F.	30	2,500	1,100
40 Fakhr-e-Iran	Ghazvin	1958	Cot.& Syn.F.	1,148	28,000	16,500
41 Faragiur Baft-Balouch	Iranshahr	1974	Cot.& PE. F.	939	28,500	11,500
42 Kashan Velvet & Rayon M.	Kashan	1950	Cot.& Syn.F.	799	24,000	9,000
			(Spinning)			(1,250t)
			(Clothes)		(10,000)	(5,038)
			(Velvet)		(4,460)	(1,851)
			(Carpet)		(1,235M m2)	(423M m2)
43 Mahbaf Weaving	Yazd	1959	Grey F.	66	5,000	2,100
44 Momtaz	Tehran	1958	Cot.& Syn.F.	1,051	30,000	11,000
45 Najaf Abad	Najafabad	1945	Cot.& Syn.F.	693	22,000	11,500
46 Nakh kar	Tehran	1955	Cot.& Syn.F.	100	2,500	1,600
47 Ardakan Textile	Ardakan	1984	Cot.& Syn.F.	124	10,000	4,000
48 Ekbatan Textile	Hamedan	1983	Cot.& Syn.F.	44	4,500	3,000
49 Boroujerd Textile	Boroujerd	1974	Cot.& PE. F.	128	10,000	8,850
50 Pars Tehran Textile	Semnan	1957	Cot.& PE. F.	400	10,000	1,500
51 Tejarat Textile	Esfahan	1987	Cot.& PE. F.	250	6,700	4,200
52 Ghaemshahr Textile	Ghaemshahr	1930	Cot.& Syn.F.	580	19,000	8,000
53 Nasaji Kordestan	Sanandaj	1986	Grey F.	280	10,000	5,800
54 Mazandaran Textile	Ghaemshahr	1962	Cot.& Syn.F.	1,121	40,000	16,000
55 Yazd Baf	Yazd	1956	Cot.& Syn.F.	1,309	50,000	47,500
56 Khoub Kar Textile	Najafabad	1981	Grey F.	40	1,750	600
57 Kerman Textile	Kerman	1982	Grey F.	30	1,200	500
58 Ali Tex. & Chem.	Saveh	1977	Cot.& Syn.F.	50	2,200	1,000
Total				22,914	723,050	372,000

continued

Note :

Estabsh. ; Establishment
PE ; Polyester
Cot. F. ; Cotton Fabrics
Cot.& PE. F. ; Cotton and Polyester Fabrics
Cot.& Syn.F. ; Cotton and Synthetic Fabrics
Grey F. ; Grey Fabrics

Table 3.2.7 Textile Factories in I. R. IRAN

(3/4)

Factory Name	Location	Estabsh. Year	Products	No. of Machines		Capacity	Production in 1995
<Spinning-1>				(R.S.)	(R.O.E.)	(t/y)	(t/y)
1 Ataiyeh	Saveh	1973	Cotton Yarns	20,304		2,400	819
2 Aydin Bonab	Bonab	1982	Cotton Yarns		400	600	240
3 Behriss Esfahan	Esfahan	1958	Cot.& PE. Y.	18,036	436	2,500	1,200
4 Parvin Esfahan	Esfahan	1957	Cot.& Syn.Y.	26,940	400	3,900	3,100
5 Bandhye Pezeshki Iran	Takestan	1983	C.Y. Hyd.C., G.		768	1,200	900
6 Nakh-Va-Ghergbereh Gilan	Chaboksar	1982	Cotton Yarns	10,720	1,152	3,500	2,700
7 Jahan Nakh	Takestan	1982	Cotton Yarns		1,344	1,200	900
8 Khambaf Esfahan	Esfahan	1975	Cot.& PE. Y.	10,000		1,000	700
9 Khosh Nakh Yazd	Yazd	1982	Cot.& Syn.Y.	10,000		1,200	700
10 Douk Nakh	Abhar	1933	Cotton Yarns	5,000		1,200	600
11 Rahim Zadeh	Esfahan	1933	Cot.& Syn.Y.	40,076	672	4,700	2,800
12 Reshtan	Amol	1973	Cotton Yarns	2,656	400	1,500	400
13 Riskar Yazd	Yazd	1957	Cot.& PE. Y.	12,100		1,400	500
14 Parnakh Spinning	Arak	1983	Cot.& Syn.Y.	1,152	1,152	2,200	1,300
15 Khavar Spinning	Rasht	1976	Cot.& PE. Y.	27,000		2,500	2,450
16 Natanz Spinning	Natanz	1983	Cot.& Syn.Y.		1,344	1,200	850
17 Seyed Mohammad Agha	Yazd	1948	Cot.& PE. Y.	10,160		1,200	600
18 Shoukouh	Esfahan	1958	Cotton Yarns	11,396	1,200	1,300	500
19 Doukriss	Delijan	1983	Cot.& Syn.Y.		1,728	1,500	800
20 Nakh Semnan	Garmsar	1984	Cot.& Syn.Y.		1,920	1,500	700
21 Far Nakh	Ghazvin	1967	Cot.& Syn.Y.	32,704		3,000	2,480
22 Ghergbereh-ye-Ziba	Tehran	1960	Cot.Syn.Y.& Sp.	35,796		3,500	1,870
23 Ghergbere Nakhtab Esfahan	Esfahan	1935	Spool Yarns	14,128		1,900	700
24 Gheytan	Shahroud	1983	Cotton Yarns		1,728	1,200	900
25 Kanaf Esfahan	Esfahan	1971	Cot.& PE. Y.	13,576		2,200	1,500
26 Golriss	Abhar	1982	Cot.& PE. Y.		768	1,000	825
27 Mashad Nakh	Mashad	1980	Cot.& PE.-A. Y.		1,760	6,000	3,500
28 Mah Nakh	Ghazvin	1974	Cot.& Syn.Y.	36,576	3,600	6,000	5,500
29 Mehr Koupa	Esfahan	1969	Cot.& Syn.Y.	10,080		1,300	700
30 Mahyaran	Esfahan	1973	Cot.& PE. Y.	20,400		1,800	1,550
31 Nabriss	Ghazvin	1982	Cot.& Syn.Y.		1,944	1,350	1,100
32 Nahid	Esfahan	1947	Cot.& Syn.Y.	15,228		1,500	950
33 Nakhtab Firouzan	Tabriz	1969	Cot.& Syn.Y.	15,012	1,344	1,600	1,250
34 Nakh Rissy Yazd	Yazd	1931	Cotton Yarns	20,560		2,300	1,200
35 Nassaji Babakan	Amol	1973	Cot.& Syn.Y.	49,392		6,000	3,500
36 Baftehai-e-Kerman	Kerman	1990	Cot.& PE. Y.	17,760		2,050	2,380
37 Chookha Textile	Sari	1976	Cot.& Syn.Y.	15,216	300	2,000	1,500
38 Qarb Textile	Kermanshah	1975	Cot.& Syn.Y.	47,520	768	6,500	3,500
39 Novin-e-Shahreza	Shahreza	1936	Cot.& Syn.Y.	6,000		900	750
40 Hamedan Nakh	Hamedan	1982	Cot.& Syn.Y.		960	1,200	700
Sub-Total				555,488	26,088	91,000	59,114

continued

Table 3.2.7 Textile Factories in I. R. IRAN

(4/4)

	Factory Name	Location	Estabsh. Year	Products	No. of Machines		Capacity	Production in 1995
	<Spinning-2>				(R.S.)	(R.O.E.)	(t/y)	(t/y)
41	Yazd Tab	Yazd	1983	Cotton Yarns		1,344	1,100	420
42	Khoy Textile	Khoy	1984	Cot.& Syn.Y.		4,600	2,800	2,700
43	Khameneh Textile	Khameneh	1984	Cot.& PE. Y.		1,728	1,700	1,500
44	Ghaem Baft Jazeh	Esfahan	1983	Cot.& Syn.Y.	14,796		1,500	1,420
	Total				570,284	33,760	98,100	65,154

Note :

Abbreviation	Meaning
Estabsh.	Establishment
Cot.& PE. Y.	Cotton and Polyester Yarn
Cot.& Syn.Y.	Cotton and Synthetic Yarn
C.Y.Hyd.C.,G.	Cotton Yarns, Hydrophil Cotton, Gauze
Cot.Syn.& Sp.	Cotton, Synthetic and Spool Yarns
Cot.& PE-A.Y.	Cotton and Polyester-Acrylic Yarns
(R.S.)	Ring Spindle
(R.O.E.)	Roter Open End

	Factory Name	Location	Estabsh. Year	Products	No. of Machines	Capacity	Production in 1995
	<Dyeing, Printing, Finishing>					(m/y)	(m/y)
1	Aba	Tehran	1982	Finished Fabrics		4,000,000	750,000
2	Akmal	Esfahan	1968	Finished Fabrics		9,000,000	5,000,000
3	Takmil Faraz	Tehran	1978	Finished Fabrics		1,200,000	800,000
4	Tehran Gol	Tehran	1968	Finished Fabrics		12,000,000	5,000,000
5	Golesorkh Printing	Tehran	1963	Finished Fabrics		2,000,000	1,000,000
6	Madbaft Textile	Zanjan	1982	Finished Fabrics		20,000,000	11,000,000
7	Golbaft Industrial Group	Esfahan	1969	Finished Fabrics		10,000,000	6,000,000
8	Golriz	Esfahan	1964	Finished Fabrics		16,800,000	8,700,000
9	Moghaddam	Ghazvin	1959	Finished Fabrics		5,000,000	3,000,000
10	Nakh Rang	Hamadan	1984	Finished Fabrics		15,000,000	9,000,000
11	Naghshin	Yazd	1983	Finished Fabrics		10,000,000	7,000,000
12	Heli	Ghazvin	1973	Finished Fabrics		10,000,000	4,000,000
	Total					115,000,000	61,250,000

Source : Association of Iran Textile Industries

2.5.2 Process of Producing Textile Products and Energy Consumption

a. Chemical fiber

Among three chemical fiber factories, one is producing polyester and polyacryl fiber, and the other two are producing nylon-6.
Generally, energy used in chemical fiber factories is electricity for electrically-run machines and heating and steam for heating and vacuum devices.

- **Polyester**
  The main methods of manufacturing polyester are the DMT process and the TPA process. Polyacryl Iran's factory, which was targeted for the "Factory Energy Audit," has adopted the DMT process.
  The process of manufacturing polyester is divided into polymerization, spinning, and winding/finishing. Energy is consumed mainly for heating and mixing in the polymerization process, melting and extruding out in the spinning process, and heating and winding in the winding/finishing process.

- **Acrylic fiber**
  The process of manufacturing acrylic fiber is divided into polymerization, stock solution (Polymer is dissolved in solvent and adjusted to uniformly concentrated solution as the original liquid for spinning), spinning, and finishing.
  Energy is used mainly for mixing in the polymerization process, mixing, transferring, and heating in the stock solution process, and heating in the spinning process.

- **Nylon**
  The process of manufacturing nylon is divided into polymerization, spinning, and finishing.
  Energy is used mainly for heating and mixing in the polymerization process, solution and extruding out in the spinning process, and heating and winding in the finishing process.

b. Spinning

Usually, spinning processes are divided into pre-spinning, spinning, and winding.
Energy is used mainly in the spinning process, where around half of the total electricity consumption for production is used. Main methods of spinning are "Open end spinning" and "Ring spinning," and the latter is superior in energy efficiency.
In addition, electricity is used in air conditioners installed for conditioning temperature and humidity in each process, and also is used for the automated operation of waste yarn collection and cleaning in factories.

c. Weaving

The main processes for producing fabric are preparation and weaving. A fabric is made by crossing the weft and the warp at a right angle. Conventionally, a mechanism to drive a shuttle was used to pass the weft. Recently, the shuttle-less loom, in which air or water is jetted instead of a shuttle, has been developed.

The shuttle-less loom offers higher productivity and lower energy intensity than the shuttle loom. Conditioning temperature and humidity are very important in weaving, where electricity is used for the conditioning.

d. Dyeing and Finishing

The process for dyeing and finishing is divided into preparation, dyeing, and finishing, in each of which large amounts of heat and water are used.

2.5.3 Current Status of Energy Use and Measures for Energy Conservation

Sufficient data and information on individual factories have not been available, mainly because there are so many factories in the textile industry. We have analyzed the current status of energy use and considered measures for energy conservation using data and information collected and organized in Japan, in addition to those the PBO Team and the Association of Iran Textile Industries kindly collected and provided us.

a. Chemical Fiber

The energy intensity of Polyacryl Iran, which is producing polyester and polyacryl fibers, is of a standard level in world terms. This company has introduced the newest machines with continuous polymerization and direct spinning, which are assumed to be operated efficiently even at the present time.

On the other hand, the energy intensity for producing nylon is more than twice the estimated value of Japanese factories.

We have assumed that there are many items to be improved not only in producing facilities but also in other plants including power plants from the viewpoint of both "Management" and "Equipment/facilities," although we have not obtained data and information for more specific analyses.

b. Spinning

Iranian spinning factories are divided into three groups by process : "Open end spinning (rotor type)" process, "Ring spinning" process, and both processes.

- Ring spinning
  The energy intensity of factories using only this process is estimated to be 13,900 Mcal/t (1995), which can be compared to the model value of 8,820 Mcal/t, which is nearly 40% lower.
- Open end spinning (rotor type)
  The energy intensity of factories using only this process is estimated 12,560 Mcal/t (1995), which can be compared to the model value of 7,560 Mcal/t, again 40% lower.

We have assumed that there are many items to be improved in both factories from the viewpoints of "Management" and "Equipment/facilities," although we could not obtain sufficient data and information for more specific analyses.

c. Weaving

Iranian weaving factories are divided into three groups by machine type : "Shuttle machine," "Shuttle-less machine," and both machines.

◆ Shuttle machine

The energy intensity of factories using only this process is estimated to be 3,690 Mcal/km (1995), which is lower than the model value of 4,970 Mcal/km.

We cannot clarify the reason why there is such a difference between the two figures, because specific data and information are not available on each factory.

◆ Shuttle-less machine

The energy intensity of factories using only this process is estimated to be 5,850 Mcal/km (1995), which can be compared to the model value of 3,580 Mcal/km, which is much lower than the Iranian figure. As can be seen from the model values, it is natural for the intensity of the Shuttle-less process to be lower than that of the Shuttle process, but the Iranian figures above show the reverse relation.

We have assumed that factories using this process are not operating efficiently, although data and information for explaining the difference more specifically are not available.

d. Dyeing and Finishing

The energy intensity of this process could not be fully estimated for the comparison. If we use data on Kashan Velvet, which was targeted for the "Factory Energy Audit," as Iranian figures, a comparison with Japanese figures is as follows:

	Electricity intensity (Mwh/1,000m^2)	Fuel intensity (Gcal/1,000m^2)
Kashan Velvet	0.59	9.39
Japan	0.13	0.94

As shown in this comparison, the Iranian intensities are significantly higher than the Japanese intensities.

Such big differences imply that there is much room for improving the management of waste hot water, checking insulation, and others.

Based upon the current status of energy use mentioned above, we have considered measures for energy conservation and made the economic evaluation of them in chemical fiber, spinning, weaving, and dyeing/finishing, respectively, as shown in Table 3.2.8.

2.5.4 Economic Evaluation of Measures for Energy Conservation

As stated for iron and steel, cement, and sheet glass above, there are many measures among those belonging to "Improvement in management" which are "feasible," while measures belonging to "Conversion of equipment and facilities" often include those which are "not feasible."

Table 3.2.8-1 Economic Evaluation for Energy Conservation Potential of Textile Industry

A. E. C. Case

(Natural Gas 123 Rial/Nm^3, Fuel Oil 75 Rial/l, Electricity 100 Rial/kWh)
(1,750 Rial/US$)

Energy Conservation Potential		Benefit					Countermeasure Cost		Economic Evaluation	Note
	Factory	N.G., F.O. (km^3/y, kl/y)	Electricity (MWh/y)	(M Rial/y)	for 3 years (M Rial)	for 10 years (M Rial)	(M ¥)	(M Rial)		
Improvement of Management										
Air Ratio for Dowtherm Boiler	Polyacryl Iran	290		36	88	219	0	0	feasible	NG
Quench Cooling	Polyacryl Iran		2,000	200	496	1,228	20	350	feasible	NG
Utilization Rate of Gas Turbine	Polyacryl Iran	7,442		915	2,270	5,620	0	0	feasible	NG
Supply/Waste Water & Aeration	Polyacryl Iran		1,818	182	451	1,116	30	525	feasible	NG
Optimization of Pump Capacity	Polyacryl Iran		3,000	300	744	1,842	25	438	feasible	NG
Rational Use of Compressed Air	Polyacryl Iran		3,400	340	843	2,088	30	525	feasible	NG
Reduction of Pneumatic Waste	Kashan Velvet		375	38	93	230	0	0	feasible	FO
Stopping of the Return Fan	Kashan Velvet		101	10	25	62	0	0	feasible	FO
Combustion Air Ratio of Boiler	Kashan Velvet	147		11	27	68	0	0	feasible	FO
Enhancement of Heat Insulation	Kashan Velvet	238		18	44	110	16	277	not feasible	FO
Control of Air Compressors	Kashan Velvet		65	7	16	40	0	0	feasible	FO
Improve't of Oper'n & Maint'nce	Synthetic F. F.	4,295	765	605	1,500	3,713	50	875	feasible	NG
	Spinning F.	2,586	28,150	3,133	7,770	19,237	44	770	feasible	NG
	Weaving F.		31,600	3,160	7,837	19,402	250	4,375	feasible	NG
Modification of Facility										
Waste Heat Recovery(Acryl P.)	Polyacryl Iran	2,282		281	696	1,723	15	263	feasible	NG
Exchange of Chiller Pumps	Polyacryl Iran		996	100	247	612	37	648	not feasible	NG
Waste Heat Recovery	Kashan Velvet									
Condensate Recovery		360		27	67	166	6	105	feasible for 10 Ys.	FO
from Dyeing Washing water		1,126		84	209	519	40	700	not feasible	FO
from Diesel Engine		712		53	132	328	50	875	not feasible	FO
Modification of Facility	Synthetic F. F.	8,590	1,530	1,210	3,000	7,427	250	4,375	feasible for 10 Ys.	NG
	Spinning F.		2,010	201	498	1,234	500	8,750	not feasible	NG
	Weaving F.		170,000	17,000	42,160	104,380	300	5,250	feasible	NG
Modification of Process										

Table 3.2.8-2 Economic Evaluation for Energy Conservation Potential of Textile Industry

E. C. Case (Natural Gas 22.4 Rial/Nm^3, Fuel Oil 17.0 Rial/l, Electricity 40.7 Rial/kWh, for 2000-2002)
(Natural Gas 30.0 Rial/Nm^3, Fuel Oil 22.7 Rial/l, Electricity 54.5 Rial/kWh, for 2000-2009)
(1,750 Rial/US$)

Energy Conservation Potential		Benefit					Countermeasure Cost		Economic Evaluation	Note
		N.G., F.O.	Electricity		for 3 years	for 10 years				
	Factory	(km^3/y, kl/y)	(MWh/y)	(MRial/y)	(MRial)	(MRial)	(M ¥)	(MRial)		
Improvement of Management										
Air Ratio for Dowtherm Boiler	Polyacryl Iran	290		6	16	53	0	0	feasible	NG
Quench Cooling	Polyacryl Iran		2,000	81	202	669	20	350	feasible for 10 Ys.	NG
Utilization Rate of Gas Turbine	Polyacryl Iran	7,442		167	413	1,371	0	0	feasible	NG
Supply/Waste Water & Aeration	Polyacryl Iran		1,818	74	184	608	30	525	feasible for 10 Ys.	NG
Optimization of Pump Capacity	Polyacryl Iran		3,000	122	303	1,004	25	438	feasible for 10 Ys.	NG
Rational Use of Compressed Air	Polyacryl Iran		3,400	138	343	1,138	30	525	feasible for 10 Ys.	NG
Reduction of Pneumatic Waste	Kashan Velvet		375	15	38	125	0	0	feasible	FO
Stopping of the Return Fan	Kashan Velvet		101	4	10	34	0	0	feasible	FO
Combustion Air Ratio of Boiler	Kashan Velvet	147		2	6	20	0	0	feasible	FO
Control of Air Compressors	Kashan Velvet		65	3	7	22	0	0	feasible	FO
Improve't of Oper'n & Maint'nce	Synthetic F. F.	4,295	765	127	316	1,047	50	875	feasible	NG
	Spinning F.	2,586	28,150	1,204	2,985	9,896	44	770	feasible	NG
	Weaving F.		31,600	1,286	3,190	10,574	250	4,375	feasible for 10 Ys.	NG
Modification of Facility										
Weste Heat Recovery(Acryl P.)	Polyacryl Iran	2,282		51	127	420	15	263	feasible for 10 Ys.	NG
Waste Heat Recovery	Kashan Velvet									
Condensate Recovery		360		6	15	50	6	105	not feasible	FO
Modification of Facility	Synthetic F. F.	8,590	1,530	255	632	2,094	250	4,375	not feasible	NG
	Weaving F.		170,000	6,919	17,159	56,887	300	5,250	feasible	NG
Modification of Process										

2.6 Sugar

2.6.1 Outline of the Industry

Demand for sugar is estimated to have increased at an annual rate of around 7.5% in the first half of 1990s. Sugar production showed an increase of more than 10% annually, reaching one million t in 1995.

As of 1995, there were 41 sugar factories in I.R.Iran, which are divided into four groups according to feed stock.

a. Beet sugar factories ---------- 31
b. Cane sugar factories ---------- 2
c. Refining factories using imported crude sugar ---------- 4
d. Both of a. and c. above ---------- 4

In 1995, 672,000t of beet sugar, 187,000t of cane sugar, and 141,000t of refined sugar were produced by these factories. Table 3.2.9 shows the facilities, production capacities, and others of sugar factories.

2.6.2 Process of Producing Sugar and Energy Consumption

In producing beet sugar, preparation of feed stock (washing and slicing), diffusion (where the sugar content of feed stock is diffused), clarification, evaporation, crystallization, separation, drying and finishing are the main processes.
The process of producing cane sugar basically comprises the same as those for beet sugar. There are, however, at least two differences.
First, "compressing" is usually used instead of "diffusion," because the feed stock is different, although in some cases in other countries "diffusion" is used even for producing cane sugar.
Second, in Iranian cane sugar factories, crude sugar, which has been produced through processes from preparation of feed stock to finishing as mentioned above, is refined once more through basically the same processes as the previous one. For reference, there are sugar factories in south-east Asian countries, for instance, which produce the so-called "plant white sugar" as a final product using only the first half of the process including clarification.
Finally, in sugar refining factories, crude sugar, which is supplied from outside, is refined to produce the final product through the second half of the process mentioned above.

In producing beet sugar, a large volume of heat energy is consumed in the evaporation and crystallization processes. Consumption of heat energy in the two processes accounts for more than half of the total consumed in the whole process. In addition, much energy is consumed for pressing and drying "pulp" produced in the diffusion process to be used as livestock feed. Electricity is consumed mainly for slicing feed stock and powering centrifugal separators.
In producing cane sugar, a large volume of heat energy is also consumed in the two processes above. It is estimated that the crude sugar process consumes around 75% of total heat consumption and the refining process around 25%. Electricity is consumed mainly in compression and in separation.

Table 3.2.9 Sugar Factories in I.R. IRAN

Company	Factory Location	Start -Up	Capacity (T/D)	Ref. Cap. (T/D)	Production in 1995	Fuel
<Beet Sugar>						
1 Abkooh Sugar	Mashad	1935	2,500		22,950	NG/FO
2 Torbat-E-Heydaryeh S.	Torbat-E-Heydaryeh, Khor.	1951	1,200		14,007	F. Oil
3 Torbat-E-Jam Sugar	Torbat-E-Jam, Khor.	1969	1,500		11,992	F. Oil
4 Joveyn Sugar	Joveyn, Khor.	1976	3,000		31,462	F. Oil
5 Chenaran Sugar	Khorassan	1956	1,000		12,858	F. Oil
6 Shirvan Sugar	Shirvan	1960	4,000		31,926	F. Oil
7 Shirin Sugar	Khorassan	1964	2,500		28,014	N. Gas
8 Sabet Khorassan	Fariman, Khor.	1959	2,500		36,009	F. Oil
9 Ghohestan Sugar	Assad-Abad	1961	500		12,235	F. Oil
10 Nelshabour Sugar	Mashad	1965	1,500		21,482	F. Oil
11 *Shahrood Sugar	Shahrood, Semnan	1962	750	220	10,688	F. Oil
12 Ouromeyeh Sugar	Azarbayedjan(West)	1950	700		5,794	F. Oil
13 Pyranshahr Sugar	Pyranshahr, Azar.(W)	1968	1,000		20,432	F. Oil
14 Khoy Sugar	Khoy, Azar.(E)	1966	1,500		8,552	F. Oil
15 Miandoab Sugar	Miandoab, Azar(W)	1936	1,800		32,412	F. Oil
16 Eslam-Abad(West)S.	Kermanshah	1935	1,000		10,742	F. Oil
17 Bissotoon Sugar	Kermanshah	1963	2,000		23,720	F. Oil
18 Lorrestan Sugar	Broudjerd,Lorestan	1968	1,500		15,396	F. Oil
19 *Shazand Sugar	Shazand, Arak	1938	600	50	7,460	F. Oil
20 Ghazvin Sugar	Ghazvin, Zandjan	1966	2,000		22,436	F. Oil
21 Karadj Sugar	Karadj	1932	1,100		10,448	F. Oil
22 Esfahan Sugar	Esfahan	1959	4,000		46,298	NG/FO
23 Naghshe Jahan Sugar	Mobarakeh, Esfahan	1966	1,500		22,836	N. Gas
24 Hekmatan Sugar	Hamedan	1955	1,000		12,825	F. Oil
25 Eghlid Sugar	Eghlid, Fars	1966	1,500		37,723	F. Oil
26 Pars Sugar	Kavar, Fars	1959	1,500		23,308	FO/NG
27 Fassa Sugar	Fassa	1953	800		14,237	F. Oil
28 Marvdasht Sugar	Marvdasht, Fars	1935	1,650		25,702	N. Gas
29 Mamassani Sugar	Noor-Abad,Fars	1965	1,000		8,101	F. Oil
30 Bardsir Sugar	Kerman	1955	1,000		14,716	F. Oil
31 *Ahvaz S. Refinery	Ahvaz	1960	2,500	250		F. Oil
32 *Dezfool Sugar	Dezfool Khuz.	1975	5,000	600	34,508	F. Oil
33 Chahar-Mehal Sugar	Chahar-Mehal Khuz	1971	1,000		11,151	F. Oil
34 Yassodj Sugar	Yassodj	1965	1,000		8,276	F. Oil
35 Moghan Sugar	Moghan Valley, Azar.(E)	1978	5,000		21,016	F. Oil
(Sub-total)					671,712	
<Cane Sugar>						
1 Haft-Tappeh Cane S.	Haft-Tappeh, Khuz.	1959	10,000		81,795	F. Oil
2 Karun Agro Ind.	Dalmcheh, Khuz.	1974	20,000		104,950	F. Oil
(Sub-total)					186,745	
<Refining>						
1 Ferdows S. R.	Meshad	1978		130	35,000	F. Oil
2 Kamyab S. R.	Esfahan	1973		130	32,000	F. Oil
3 Noor-Sepahan S. R.	Esfahan	1973		130	34,000	F. Oil
4 Varamin Sugar R.	Varamin	1935		130	40,000	F. Oil
(Sub-total)					141,000	

Note :

Azar.(E): Azarbayedjan(East) Khor. : Khorassan
Azar.(W): Azarbayedjan(West) Khuz. : Khuzestan

Capacity means treating capacity of feed materials (Beet or Cane)
Ref. Cap. means refining capacity of raw sugar

Source : World Sugar and Sweetener Yearbook 1995
Syndicate of Sugar Factories, The list of Production of Sugar Factories
State Sugar Organization Co.

2.6.3 Current Status of Energy Use and Measures for Energy Conservation

The energy intensity of Iranian beet sugar factories is estimated to be 7,800 Mcal/t-product (1995), which can be compared to the Japanese factories' of 5,060 Mcal/t. The level of Iranian factories is 1.5 times that in Japan.
The energy intensity of Iranian cane sugar factories is estimated to be 9,500 Mcal/t (1995), which can be compared to the standard value of 5,100 Mcal/t. The Iranian level is 1.9 times the standard level.
The energy intensity of Iranian refining factories is estimated to be 4,240 Mcal/t, which can be compared to the Japanese average of 1,200 Mcal/t. The Iranian level is 3.5 times the Japanese level.

The reasons why there are big differences between Iranian and Japanese factories' or standard ones are as follows, according to the results of the "Factory Energy Audit" and other sources:
First, looking at "Improvement in management," there are many items to be improved in Iranian sugar factories, including lower yield caused by longer storage time of feed stock and insufficient insulation of steam pipes.
Second, with regard to "Modification of equipment and facilities," we can point out (a) a mixer has not been installed in the crystallizing process, (b) an ion exchange process has not been adopted in the clarification process (If adopted, the efficiency of the evaporator is improved), and (c) a few automated control systems have been adopted.
Third, there is one disadvantage in Iranian sugar factories, which is to consume a certain amount of energy in manufacturing "corn sugar."

Based upon the current status of energy use in sugar factories mentioned above, we have considered measures for energy conservation and made an economic evaluation of measures, which are shown in Table 3.2.10 below.

2.6.4 Economic Evaluation of Measures for Energy Conservation

In producing sugar, many measures belonging to "Improvement in management" are evaluated as "feasible," as in the four industries mentioned already.
Also, many measures belonging to "Modification of equipment and facilities" are "not feasible." Even in the "Accelerated Energy Conservation" scenario, these measures are evaluated very often as "not feasible."

Table 3.2.10-1 Economic Evaluation of Measures for Energy Conservation in the Sugar Industry

A. E. C. Case (Natural Gas 123 Rial/Nm^3, Fuel Oil 75 Rial/l, Electricity 100 Rial/kWh)
(1,750 Rial/US$)

Energy Conservation Potential	Factory	Benefit					Countermeasure Cost		Economic Evaluation Note
		Natural Gas (km^3/y)	Electricity (MWh/y)	(M Rial/y)	for 3 years (M Rial)	for 10 years (M Rial)	(M ¥)	(M Rial)	
Improvement of Management									
Automatic Control									
of the Crystallizing Pan	Karun Cane	2,594		319	791	1,959	30	525	feasible
of the Crystallizing Pan	Abkouh Sugar	2,217		273	676	1,674	20	350	feasible
Reduction of Steam Pressure	Abkouh Sugar	255		31	78	193	0	0	feasible
Turning off Unnecessary Lights	Abkouh Sugar		15	1	4	9	0	0	feasible
Improvement of Management	All Sugar F.	58,600	2,080	7,416	18,391	45,533	400	7,000	feasible
Modification of Facility									
Adoption of									
Softening Type Ion E. Resin	Karun Cane	4,790		589	1,461	3,618	100	1,750	feasible for 10 Ys.
	Abkouh Sugar	1,108		136	338	837	100	1,750	not feasible
	All Sugar F.	45,000		5,535	13,727	33,985	4,000	70,000	not feasible
R-Cl Type Ion E. Resin	Karun Cane	2,874		354	877	2,171	200	3,500	not feasible
Steam Pipe Insulation	Abkouh Sugar	107		13	33	81	23	403	not feasible
Bagasse Fuel for Boiler	Cane Sugar F.	100,800		12,398	30,748	76,126	300	5,250	feasible
Install'n of Stirrer to Crys'r	All Sugar F.	23,300	-550	2,811	6,971	17,259	760	13,300	feasible for 10 Ys.
Heat Recovery									
from Crystallizer	All Sugar F.	2,800		344	854	2,115	1,280	22,400	not feasible
from Boiler Exhaust Gas	All Sugar F.	1,680		207	512	1,269	1,680	29,400	not feasible
Modification of Process									

Table 3.2.10-2 Economic Evaluation of Measures for Energy Conservation in the Sugar Industry

E. C. Case
(Natural Gas 22.4 Rial/Nm^3, Fuel Oil 17.0 Rial/l, Electricity 40.7 Rial/kWh, for 2000-2002)
(Natural Gas 30.0 Rial/Nm^3, Fuel Oil 22.7 Rial/l, Electricity 54.5 Rial/kWh, for 2000-2009)
(1,750 Rial/US$)

Energy Conservation Potential	Factory	Benefit					Countermeasure Cost		Economic Evaluation Note
		Natural Gas (km^3/y)	Electricity (MWh/y)	(M Rial/y)	for 3 years (M Rial)	for 10 years (M Rial)	(M ¥)	(M Rial)	
Improvement of Management									
Automatic Control									
of the Crystallizing Pan	Karun Cane	2,594		58	144	478	30	525	not feasible
of the Crystallizing Pan	Abkouh Sugar	2,217		50	123	408	20	350	feasible for 10 Ys.
Reduction of Steam Pressure	Abkouh Sugar	255		6	14	47	0	0	feasible
Turning off Unnecessary Lights	Abkouh Sugar		15	1	1	5	0	0	feasible
Improvement of Management	All Sugar F.	58,600	2,080	1,397	3,465	11,490	400	7,000	feasible for 10 Ys.
Modification of Facility									
Adoption of									
Softening Type Ion E. Resin	Karun Cane	4,790		107	266	882	100	1,750	not feasible
Bagasse Fuel for Boiler	Cane Sugar F.	100,800		2,258	5,600	18,567	300	5,250	feasible
Install'n of Stirrer to Crys'r	All Sugar F.	23,300	-550	500	1,239	4,108	760	13,300	not feasible
Modification of Process									

2.7 Vegetable Oil

2.7.1 Outline of the Industry

Demand for vegetable oil is estimated to have increased at an annual rate of around 10% in the first half of the 1990s, reaching 780,000 t in 1995.

Some 90-95% of vegetable oil consumed in I.R.Iran is refined from imported crude oil, and only 5-10% is refined from domestically produced feed stock.

Some 90-95% of vegetable production is the hardened oil (solid state oil), and the liquid oil account for only 5-10% (sunflower oil, olive oil, etc.).

In summary, a major part of the vegetable oil consumed in I.R.Iran is hardened oil refined from imported crude oil. We will confine our description below mainly to this type of oil.

Table 3.2.11 shows vegetable oil factories in I.R.Iran.

Table 3.2.11 Vegetable Oil Factories in I. R. IRAN

Company	Location	Start up	Employee (1981)	Capacity	Production (1995)	Fuel	Share
				(t/y)	(t/y)		
1 Behshahr	Tehran	1953		227,500	243,475	NG/Gas Oil	31 %
2 Pars	Tehran		1012	140,000	112,106	N. Gas	14.4%
3 Shiraz Vegetable Oil	Shiraz	1969	966	140,000	80,151	N. Gas	10.3%
4 Jahaan Vegetable Oil	Karadj	1956	417	70,000	67,421	Gas Oil	9.3%
5 Margarin	Tehran	1960	647	140,000	60,121	N. Gas	
6 Naab	Tehran	1963	131	35,000	40,600	Gas Oil	
7 Golnaz	Kerman	1989		37,500	37,892	G.O/F.O	
8 Kesht Va Sanat	Sari			35,000	34,261		
9 Naz-Esfahan	Esfahan			35,000	30,649		
10 Fazle Neishaboor	Neishaboor		195	17,500	20,055		
11 Etka Co.(Processing oil)	Varamin		245	35,000	16,724		
	Shar Ray				15,931		
12 Gorgan Center Cotton	Kordkooy		157	5,250	6,869		
13 Ganje Roodbar	Roodbar	1959		(30T/D)	5,863	Fuel Oil	(Olive oil)
14 Shokufeh Oil Industry	Babol		182	11,900	3,195		
15 Tehran Golnaab	Arak	1995-96	--	3,000	0		
(Sub-total)				932,650	775,313		

Source : Oil Seed Research & Development Co.

2.7.2 Process of Producing Vegetable Oil and Energy Consumption

The process for producing the hardened oil from imported crude oil is as follows:
Crude oil contains phospholipid, free fatty acid, trace metal, and pigments, as well as its unique odorant matter. Refining removes these unnecessary components while retaining useful components as much as possible. The refining process is divided into degumming (removing phospholipid), neutralization (alkali refining), decolorization, dewaxing, hydrogenation (hardening), and deodorization.

2.7.3 Current Status of Energy Use and Measures for Energy Conservation

The energy intensity of Iranian vegetable oil factories is significantly higher than that of Japanese factories. Heat energy intensity in the refining process in I.R.Iran is estimated 3.6 times that in Japan. Electricity intensity in I.R.Iran, however, is almost the same as in Japan.

Such big differences in heat energy consumption imply that Iranian factories have been facing problems in "Improvement in management" and "Modification of equipment and facilities" as we can see in other industries.
According to the results of the "Factory Energy Audit" and other information, we can point out the insufficient recovery of waste oil, problems in the quality and the operation of vacuum makers, and insufficient insulation.

Based upon the current status of energy use mentioned above, we considered measures for energy conservation and made an economic evaluation of measures in the Iranian vegetable oil industry, which is shown in Table 3.2.12 below.

2.7.4 Economic Evaluation of Measures for Energy Conservation

As in other industries mentioned above, measures belonging to "Modification of equipment and facilities" are evaluated as economically "not feasible" in this industry. These measures are evaluated as "not feasible" even in the "Accelerated Energy Conservation" scenario.
Also, the number of "feasible" measures belonging to "Improvement in management" seems to be relatively small.
Needless to say, it is very difficult to consider and evaluate measures for energy conservation at the same level or depth for every industry, mainly because of the availability of data and information.
Consequently, it may be reasonable for us to consider that a fewer "feasible" measures does not necessarily mean a greater difficulty in energy conservation in this industry.

Table 3.2.12-1 Economic Evaluation of Measures for Energy Conservation in the Vegetable Oil Industry

A. E. C. Case

(Natural Gas 123 Rial/Nm^3, Fuel Oil 75 Rial/l, Electricity 100 Rial/kWh)
(1,750 Rial/US$)

Energy Conservation Potential	Factory	Benefit					Countermeasure Cost		Economic Evaluation	Note
		Natural Gas (1,000m^3/y)	Electricity (MWh/y)	(M Rial/y)	for 3 years (M Rial)	for 10 years (M Rial)	(M ¥)	(M Rial)		
Improvement of Management										
Adjustment of	Behshahr Ind.	5,534		681	1,688	4,179	0	0	feasible	
Vacuum Degree										
Ejector Steam Pressure										
CW Temp. for B. Condenser										
	All Veg. Oil F.	13,193		1,623	4,024	9,964	0	0	feasible	
Boiler Combustion Control	Behshahr Ind.	1,342		165	409	1,014	30	525	feasible for 10 Ys.	
	All Veg. Oil F.	3,174		390	968	2,397	120	2,100	feasible for 10 Ys.	
Modification of Facility										
Heat Insulation of Steam V & F	Behshahr Ind.	266		33	81	201	19	333	not feasible	
	All Veg. Oil F.	629		77	192	475	76	1,330	not feasible	
Recovery of Exhaust Gas Heat from Diesel Generator	Behshahr Ind.	798		98	243	603	50	875	not feasible	
	All Veg. Oil F.	944		116	288	713	250	4,375	not feasible	
Modification of Process										

Table 3.2.12-2 Economic Evaluation of Measures for Energy Conservation in the Vegetable Oil Industry

E.C. Case (Natural Gas 22.4 Rial/Nm^3, Fuel Oil 17.0 Rial/l, Electricity 40.7 Rial/kWh, for 2000-2002)
(Natural Gas 30.0 Rial/Nm^3, Fuel Oil 22.7 Rial/l, Electricity 54.5 Rial/kWh, for 2000-2009)
(1,750 Rial/US$)

Energy Conservation Potential	Factory	Benefit					Countermeasure Cost		Economic Evaluation	Note
		Natural Gas (1,000m^3/y)	Electricity (MWh/y)	(M Rial/y)	for 3 years (M Rial)	for 10 years (M Rial)	(M ¥)	(M Rial)		
Improvement of Management										
Adjustment of	Behshahr Ind.	5,534		124	307	1,019	0	0	feasible	
Vacuum Degree										
Ejector Steam Pressure										
CW Temp. for B. Condenser										
	All Veg. Oil F.	13,193		296	733	2,430	0	0	feasible	
Boiler Combustion Control	Behshahr Ind.	1,342		30	75	247	30	525	not feasible	
	All Veg. Oil F.	3,174		71	176	585	120	2,100	not feasible	
Modification of Facility										
Modification of Process										

2.8 Petroleum Refining

2.8.1 Outline of the Industry

Production of petroleum products increased from 47,800,000 kl in 1990 to 70,400,000 kl in 1994. There are eight refineries in I.R.Iran, which are categorized as follows:

a. Abadan and Lavan refineries --------- built for exporting petroleum products in the Persian Gulf.
b. Tehran, Kermanshar, and Shiraz refineries --------- built for supplying petroleum products to domestic demand which increased since the second half of 1960s
c. Tabriz and Esfahan refineries --------- built for satisfying domestic demand by NIOC itself.
d. Arak and Bandar Abbass refineries --------- built or being built by Japanese companies after the war.

Table 3.2.13 shows production, production capacity, and others of petroleum refineries in I.R.Iran.

2.8.2 Process of Producing Petroleum Products and Energy Consumption

Petroleum refining is a process in which various hydrocarbon compounds in crude oil are processed into fuels and other useful products. There are four main processes in petroleum refining, which are separation (distillation), conversion (cracking), reorganization (reforming), and finishing (treating).
Energy consumed in each process of petroleum refining depends upon the type of refinery. In the refineries of Royal Dutch Shell Group in late 1960s, energy consumed in crude oil distillation was 25% of the total in a refinery, and 80% in another. According to a study done by the Office of Technology Assessment, the U. S. Congress, in early 1990s, the distillation process consumed 23% of the total energy consumption in the U. S. refining industry.
There are refineries as Kermanshar and Lavan with only crude distillation units installed. In other refineries cracking and reforming do not have such a big weight. Accordingly, it is assumed that energy consumed in the distillation process accounts for a larger part of total energy consumption than in the U. S. and Japan.
Usually, liquids, gas, and solids generated inside a refinery are used as a fuel for in-house consumption, and, according to some documents, they account for 90-99% of the total input of energy. And, 55-70% of the fuels is consumed in heating furnaces for supplying process heat to the distillation, cracking, and other processes. Around 25-45% is consumed for generating steam to be supplied to equipment and facilities including power plants in the refinery.
Around half or more of the energy generated by fuels in this way is lost for cooling products in the final stage of refining. Accordingly, it is generally very important from the viewpoint of energy conservation for refineries to reduce such heat losses as much as possible by improving and reinforcing the method of heat recovery.

Table 3.2.13 Petroleum Refineries in I. R. Iran

		Tehran	Esfahan	Tabriz	Shiraz	Kermanshahr	Lavan	Abadan	Arak	Total
1988	Capacity (k bbl/d)	220	200	80	40	15	20			575
	Crude Input(M l/y)	13,350	17,568	3,965	2,307	1,099	990			39,279
	Production (M l/y)	12,482	16,791	3,590	2,128	1,039	819			36,849
1989	Capacity (k bbl/d)	220	200	80	40	15	20	130		705
	Crude Input(M l/y)	13,671	17,949	4,701	2,294	1,376	1,251	7,316		48,558
	Production (M l/y)	12,909	17,411	4,402	2,105	1,314	1,211	7,184		46,536
1990	Capacity (k bbl/d)	220	200	80	40	15	20	260		835
	Crude Input(M l/y)	14,126	18,171	5,144	2,137	1,557	1,339	8,044		50,518
	Production (M l/y)	13,154	17,393	4,806	1,976	1,472	1,288	7,747		47,836
1991	Capacity (k bbl/d)	220	200	80	40	15	20	260		835
	Crude Input(M l/y)	13,776	19,282	5,102	2,495	1,659	1,254	13,968		57,536
	Production (M l/y)	13,022	18,408	4,704	2,249	1,579	1,221	13,484		54,667
1992	Capacity (k bbl/d)	220	200	80	40	15	20	260		835
	Crude Input(M l/y)	13,738	20,353	5,020	2,608	1,334	1,333	13,252		57,638
	Production (M l/y)	13,048	19,688	4,711	2,424	1,271	1,288	12,817		55,247
1993	Capacity (k bbl/d)	220	200	110	40	15	20	350	150	1,105
	Crude Input(M l/y)	13,470	19,767	5,725	2,277	1,424	1,309	16,254	5,791	66,017
	Production (M l/y)	13,180	18,757	5,407	2,193	1,364	1,268	15,764	5,246	63,179
1994	Capacity (k bbl/d)	220	200	110	40	15	20	350	150	1,105
	Crude Input(M l/y)	13,981	20,481	6,083	2,474	1,416	1,563	18,742	8,595	73,335
	Production (M l/y)	13,330	20,182	5,723	2,420	1,353	1,468	17,942	8,037	70,455

Source : The Energy Balance Sheet of 1373

2.8.3 Current Status of Energy Use and Measures for Energy Conservation

Depending upon data and information for Tehran Refinery, which was targeted for the "Factory Energy Audit," we have estimated that energy equivalent to around 8% of crude oil throughput is consumed in Iranian petroleum refineries. This is 1.6 times that of Japanese refineries. If this estimate is accurate (although, unfortunately, data and information on other refineries than Tehran are not available), and if we consider that many more cracking and reforming facilities are installed in Japanese refineries, we can conclude there is much room for saving energy in refining in I.R.Iran. Specifically, such items as management of combustion in heating furnaces and boilers, operation and maintenance of heat exchangers, insulation of storage tanks and pipes, recovery of waste heat are to be improved.

Based upon the current status of energy use mentioned above, we have considered measures for energy conservation and made an economic evaluation of the measures. The results are shown in Table 3.2.14.

2.8.4 Economic Evaluation of Measures for Energy Conservation

Many measures belonging to "Improvement in management" are estimated to be "feasible." All measures belonging to "Modification of equipment and facilities," at least those listed in this table, are "not feasible".

Table 3.2.14-1 Economic Evaluation of Measures for Energy Conservation in the Petroleum Refinery
A. E. C. Case (Fuel Oil 75 Rial/L, Electricity 100 Rial/kWh, 1,750 Rial/US$)

Energy Conservation Potential	Refinery	Benefit Fuel Oil (kl/y)	 Electricity (MWh/y)	 (M Rial/y)	 for 3 years (M Rial)	 for 10 years (M Rial)	Countermeasure Cost (Ｍ ¥)	 (M Rial)	Economic Evaluation
Improvement of Management									
Combustion Air for Reheating F.	Tehran R.	16,983		1,274	3,159	7,821	90	1,575	feasible
Insulation of Steam Valves	Tehran R.	1,789		179	444	1,098	115	2,013	not feasible
Pump Impeller Cutting	Tehran R.		899	90	223	552	3	53	feasible
Turning off Unnecessary Lights	Tehran R.		91	9	23	56	0	0	feasible
Modification of Facility									
Reheating F.inside Refractory	Tehran R.	538		40	100	248	20	350	not feasible
Preheating of Combustion Air	Tehran R.								
for Reheating Furnace		27,053		2,029	5,032	12,458	1,795	31,413	not feasible
for Boiler		21,177		1,588	3,939	9,752	1,649	28,858	not feasible
Heat Recovery from the Cooler	Tehran R.	1,781		134	331	820	62	1,085	not feasible
Exchange of Pump Motors	Tehran R.		15	2	4	9	1	12	not feasible
Modification of Process									

Table 3.2.14-2 Economic Evaluation of Measures for Energy Conservation in the Petroleum Refinery

E. C. Case

(Fuel Oil 17.0 Rial/L, Electricity 40.7 Rial/kWh, For 2000-2002, 1,750 Rial/US$)
(Fuel Oil 22.7 Rial/L, Electricity 54.5 Rial/kWh, For 2000-2009, 1,750 Rial/US$)

Energy Conservation Potential		Benefit					Countermeasure Cost		Economic Evaluation
		Fuel Oil	Electricity		for 3 years	for 10 years			
	Refinery	(kl/y)	(MWh/y)	(M Rial/y)	(M Rial)	(M Rial)	(M ¥)	(M Rial)	
Improvement of Management									
Combustion Air for Reheating F.	Tehran R.	16,983		289	716	2,367	90	1,575	feasible for 10 Ys.
Pump Impeller Cutting	Tehran R.		899	37	91	301	3	53	feasible
Turning off Unnecessary Lights	Tehran R.		91	4	9	31	0	0	feasible
Modification of Facility									

2.9 Conclusion of Economic Evaluation

We have made an economic evaluation of measures for energy conservation in seven industries mainly according to the "Energy Conservation" scenario. In summary, many measures which need a certain amount of investment are evaluated as "not feasible" mainly because energy prices in I.R.Iran are much lower than in many countries including Japan even in the "Accelerated Energy Conservation" scenario. Consequently, efforts for promoting energy conservation should be concentrated on measures belonging to "Improvement in management of operation and maintenance" for the time being. As stated later, we have estimated that such measures can accomplish at least around 10% of energy conservation in every industry.

More specifically, our conclusions are as follows:
First, in every industry, we have found many "feasible" measures which belong to "Improvement in management."
Second, also in every industry, many measures among those belonging to "Modification of equipment and facilities" and "Modification of processes" are evaluated as "not feasible."
Third, at least in some industries, we can find that measures belonging to "Improvement in management" sometimes include those evaluated as "not feasible."

In addition, we should notice the following concerning energy prices:
The "Energy Conservation" scenario assumes that energy prices will increase at an annual rate of 8% in real terms through 2005 (As mentioned already, these prices are and will be still much lower than those in many countries including Japan). The trend of energy prices as well as commodity prices since 1995, however, show that the former has been decreasing in real terms, and it is probable that commodity prices will increase at a higher rate than energy prices, at least for a few years in the future. Considering these past and future developments, measures evaluated as "feasible" in the future may be fewer than those evaluated as "feasible" according to the "Energy Conservation" scenario above.