2.3 Chemical Industry

2.3.1 Outline of Petroleum Refinery Industry

Petroleum products in I. R. Iran are produced at eight refineries from domestic petroleum, which is produced mainly in the southern oil fields. The National Iranian Oil Company (NIOC), a state-owned company, has been managing monopolistically from drilling crude oil to selling petroleum products.

(1) Trends of petroleum products production

Petroleum products production in I. R. Iran after the cease fire are shown in Table 2.3.1.

Table 2.3.1 Production of Oil Products in Refineries and Extraction from the Other Sources

(unit: 1,000kl/y)

	1988	1989	1990	1991	1992	1993	1994
<Input>							
Crude Oil	39,279	48,558	50,518	57,536	57,638	66,017	73,335
Liquid Gas	28	424	655	677	892	861	534
Gas Oil	0	303	460	498	257	81	0
Motor Oil	162	166	167	162	150	148	156
Total Input (A)	39,469	49,451	51,800	58,873	58,937	67,107	74,025
<Products>							
Liquid Gas	1,473	1,808	1,839	2,031	2,077	2,330	2,595
Gasoline	5,659	7,006	7,150	8,194	8,224	9,082	10,442
Kerosene	4,625	6,812	6,063	7,090	7,756	8,722	9,159
Gas Oil	10,720	12,753	13,805	15,230	14,594	16,790	19,436
Fuel Oil	11,551	15,227	15,790	18,320	18,437	20,617	22,029
Motor Oil	162	143	133	232	409	497	540
Aircraft Fuel	662	470	637	742	765	734	890
Tar	1,603	1,590	1,644	1,963	2,187	2,873	2,878
Others	394	727	775	865	798	1,564	2,456
Total Products (B)	36,849	46,536	47,836	54,667	55,247	63,209	70,425
Fuel & Waste (A-B)	2,620	2,915	3,964	4,206	3,690	3,898	3,600
(A-B)/A	6.64%	5.89%	7.65%	7.14%	6.26%	5.81%	4.86%

Source : The Energy Balance Sheet of 1373

According to Table 2.3.1, production of petroleum products exceeded 70,000,000 kl in 1994 due to the restoration of the Abadan Refinery and establishment of the Arak Refinery.

During the period, due to the disproportionate production pattern and composition of domestic consumption, the balance of supply and demand have been provided by imports of gasoline, kerosene, gas oil, and lubricating oil and export of fuel oil, light/heavy naphtha from Abadan Refinery or Lavan Refinery,

The trends of imports and exports of petroleum products are shown in Table 2.3.2.

Table 2.3.2 Petroleum Products Trade of I. R. Iran

(unit: 1,000kl)

	1988	1989	1990	1991	1992	1993	1994
Imports Total	184	7,809	7,176	7,436	10,189	8,979	6,578
Gas oil	103	4,628	4,664	4,298	6,049	5,031	3,763
Kerosene	50	2,397	2,279	2,309	3,047	2,274	2,032
Engine Gasoline	31	614	99	635	1,014	1,674	780
Liquid Gas		170	44	0	0	0	0
Other Products			90	194	79	0	3
Exports Total	0	0	3,501	5,744	5,626	7,165	7,893
Fuel Oil			3,501	5,744	5,270	6,896	
Others					356	269	

Source : SCI Statistical Yearbook

Petroleum product production in the future is expected to reach approximately 90,000,000 kl in 1999, based on the projected commissioning of Bandar Abbass Refinery and Taheri Refinery according to the 2nd Five Year Plan. (ref. Table 2.3.3)

Table 2.3.3 Production Plan of Oil Products in the Second Plan

(unit: 1,000kl/y)

	1995	1996	1997	1998	1999
<Input>					
Crude Oil	75,074	83,387	85,882	88,436	88,678
Liquid Gas to B. Abbass Refinery		508	696	696	698
Liquid Gas to Taheri Refinery				3,477	3,486
Total Input (A)	75,074	83,895	86,578	92,609	92,862
<Products>					
Liquid Gas, Household	2,661	2,897	2,977	3,333	3,342
Liquid Gas, Industry	233	232	232	232	233
Gasoline	9,963	11,828	12,213	14,317	14,344
Kerosene	8,618	10,191	10,518	11,453	11,428
Gas Oil	19,812	22,795	23,422	24,346	24,413
Fuel Oil	23,934	26,188	27,130	28,056	28,133
Motor Oil	443	430	402	443	444
Light Jet Fuel	276	281	287	293	299
Heavy Jet Fuel	807	845	887	931	981
Others	4,794	4,907	5,065	5,179	5,208
Total Products (B)	71,541	80,594	83,133	88,583	88,825
Fuel & Waste (A-B)	3,533	3,301	3,445	4,026	4,037
(A-B)/A	4.71%	3.93%	3.98%	4.35%	4.35%

Source : The Energy Balance Sheet of 1373

(2) Outline of Petroleum Refinery

Petroleum refineries in I. R. Iran are currently located in eight places including six metropolises and two coastal areas on the Persian Gulf as shown in Table 2.3.4.

Table 2.3.4 Outline of Oil Refinery in I.R. IRAN

		Abadan	Lavan	Tehran	Kermanshah	Shiraz	Tabriz	Esfahan	Arak
<Start up Year>		1913	1968	1968	1971	1973	1978	1980	1993
<Product Ratio (Design)>									
Liquid Gas	(%)	3.8	0.0	2.9	3.0	2.0	3.0	2.5	4.5
Gasoline	(%)	13.8	0.0	13.2	19.8	19.0	15.0	14.0	12.7
Kerosene	(%)	7.1	0.0	14.8	20.6	23.0	20.0	21.0	17.9
Gas Oil	(%)	25.2	26.1	21.8	20.3	19.0	25.0	23.0	31.0
Fuel Oil	(%)	43.2	41.0	32.8	27.7	25.0	26.0	31.0	24.8
Others	(%)	4.4	28.4	6.5	0.0	6.2	2.7	2.4	7.3
Fuel & Waste	(%)	2.5	4.5	8.0	8.6	5.8	8.3	6.1	1.8
Total	(%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source : The Energy Balance Sheet of 1373

Oil refineries are classified into the following four groups.

a. To export petroleum products, refineries were constructed at the Persian Gulf coast: Abadan Refinery and Lavan Refinery.
   Abadan Refinery was constructed by BP in 1913, and is the oldest and the biggest refinery. Located near the border with Iraq, it suffered war damage, but resumed operations in the second half of 1989 after restoration.
   Lavan Refinery is a small-scale oil refinery with only an atmospheric distillation facility used for exporting fuel oil.

b. To satisfy increasing demand for petroleum products since the latter half of the 1960s, refineries were constructed for the domestic market: Tehran Refinery, Kermanshahr Refinery, and Shiraz Refinery.
   Tehran Refinery was constructed to cope with demand in the capital area, which accounts for about 15% of the population. It consists of two trains of 100,000 bbl/d class refining facilities following the Abadan Refinery.

c. Planned to meet domestic demand, refineries were constructed by NIOC without help: Tabriz Refinery, and Esfahan Refinery. Esfahan Refinery is smaller than Tehran Refinery by 10 percent in nominal capacity, but actual production exceeded capacity and its operation rate is the highest.

d. After the war, refineries were constructed or are under construction by Japanese firms under the First-five Years Plan: Arak Refinery and Bandar Abbass Refinery.
   Arak Refinery came on stream in 1993. Bandar Abbass Refinery will begin operation in the near future.
   (ref. Table 2.3.5)

Table 2.3.5 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

Total refining capacity increased nominally from 575,000 bbl/d in 1988 to the current 1,105,000 bbl/d. Production of petroleum products shows a similar tendency.

When Bandar Abbass Refinery is completed, the nominal domestic refining capacity will be 1,285,000 bbl/d.
Establishment of Taheri Refinery and expansion of Tehran Refinery, etc., are now being planned.

2.3.2 Present Situation of Energy Consumption

Most of the energy consumed in the petroleum refinery generates heat, hydrogen, and electricity, all of which are necessary for the distillation of petroleum and other refining reactions.
The following circumstances must be considered when evaluating the energy intensity of the individual petroleum refineries:

a. It is difficult to simply allocate energy consumption for each product, as the petroleum refining industry involves the manufacture of more than just one petroleum product, making it different from an industry which produces a single kind of product.

b. Because a variety of products are produced from petroleum, petroleum refineries utilize a combination of various secondary equipment for treating heavy petroleum, product demand of light fraction, and for environmental measures. Efficiency of energy consumption declines by the usage of secondary facilities.

Nelson's Complexity Factor is used worldwide as the way of evaluating equipment composition for the petroleum refinery. A list of Complexity Factors of the petroleum refining industry in Japan is shown in Table 2.3.6.

This sets the base coefficient of the atmospheric pressure distillation equipment at 1.0 and decides the coefficient of each secondary equipment based on equipment composition.
This is known that the Complexity Factor and has a strong empirical correlation with energy consumption. The relation between actual fuel consumption in 1994 and Complexity Factors for 42 petroleum refineries of Japan is shown in Figure 2.3.1 for reference.

The generally used parameter for measuring energy intensity in the petroleum refining industry is energy efficiency (η), computed using the following formula.

$$\eta = F_R \;/\; (A * (CF)_R) \qquad \text{(unit : l/kl)}$$

Where,

F_R : Total energy consumption of the refinery (Crude oil equivalent, L)

A : Crude oil feed to atmospheric pressure distillation equipment (kl)

$(CF)_R$: Complexity Factor of the refinery

Table 2.3.6 List of Complexity Factor (1/2)

(Rev.1994.4.27)

Name of Unit	Complexity Factor	Rev. Complexity Factor	Remark
(Refinery Process Unit)			
Crude Distillation	1.00	1.00 (*1)	Feed bbl/Feed bbl
Vacuum Crude Distillation	2.00	2.00 (*1)	
Vacuum Flasher	1.00	1.00 (*1)	
Visbreaker	2.00	2.00 (*1)	
Thermal Cracking	3.00	3.00 (*1)	
Delayed Coker	5.50	5.50 (*1)	
Fluid/Flexicoking	5.50	11.00 (*1)	
Coke Calcining	98.00	120.00 (*2)	Feed bbl/Product Coke t
Catalytic Cracking	6.00	-- (*1)	
VGO FCC	--	6.00 (*1)	
RFCC	--	12.00 (*1)	
Hydrocracking	6.00	6.00 (*1)	
Catalytic Naphtha Reforming	5.00	5.00 (*1)	
Hydrogen Production	1.20	3.00 (*3)	Feed bbl/Product M scfd
Hydrogen Recovery	0.70	0.70 (*3)	
Polymerization	9.00	9.00 (*4)	Feed bbl/Product bbl
Alkylation	11.00	7.00 (*4)	
MTBE	11.00	11.00 (*4)	
Isomerization	3.00	3.00 (*4)	
Hydrotreating			
Naphtha	1.70	1.70 (*1)	
Kerosene	1.70	1.70 (*1)	
Distillate	1.70	-- (*1)	
Light Gas Oil	--	2.20 (*1)	
Heavy Gas Oil	--	2.50 (*1)	
Desulfurization			
Cracking Feed	3.00	3.00 (*1)	
Vacuum Gas Oil	3.00	3.00 (*1)	
Residual Desulfurization			
AR low metal	5.00	4.00 (*1)	
AR high metal,VR low meta	6.00	4.00 (*1)	
VR high metal	7.00	5.00 (*1)	
Solvent Deasphalting	5.00	5.00 (*1)	
Acid Regeneration Units	75.00	40.00 (*5)	Feed bbl/Spent acid t

Continued

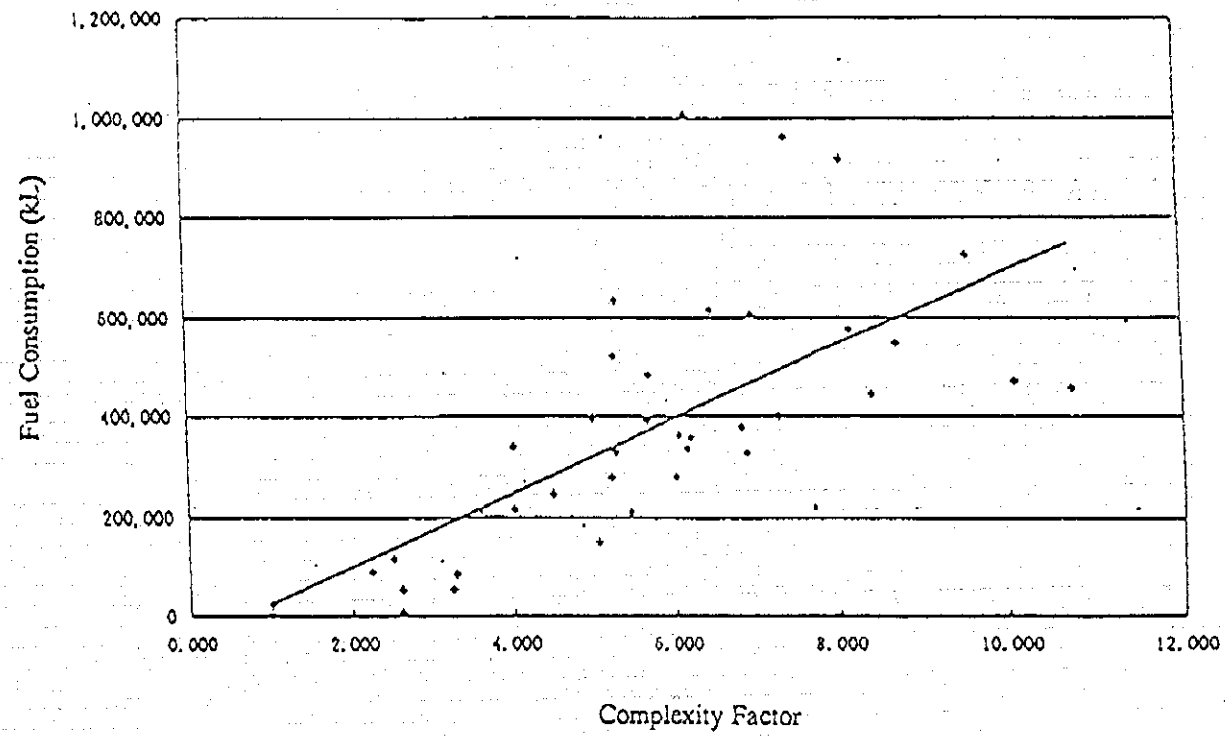
Table 2.3.6 List of Complexity Factor (2/2)

(Rev.1994.4.27)

Name of Unit	Complexity Factor	Rev. Complexity Factor	Remark
Special Fractionation Units			
Propane Splitter	3.00	3.00 (*1)	Feed bbl/Feed bbl
Deisobutanizer	3.00	3.00 (*1)	
Reformate Splitter	1.50	1.50 (*1)	
Secondary Cat.	1.50	1.50 (*1)	
Naphtha Splitter	--	1.50 (*1)	
H-oil, LC Fining	7.00	7.00 (*1)	
Asphalt Manufacture(blown)	2.00	2.00 (*1)	
Normal Paraffin(Molecular Sieve)	--	14.00 (*1)	
Total Isomerization Process	--	5.80 (*1)	
(Lube Process Units)			
Solvent Extraction(Furfural)	4.50	3.00 (*1)	
Dewaxing(MEK-TOL)	9.00	9.00 (*1)	
Hydrofinishing, Hydrotreating	3.00	3.00 (*1)	
(Aromatics Process Units)			
p-Xylene(Molecular Sieve)	16.00	16.00 (*4)	Feed bbl/Product bbl
Hydrodealkylation	8.50	4.00 (*1)	
Extraction (Sulfolane)	8.00	5.00 (*1)	
Aromatics Fractionation	2.00	4.00 (*1)	
Aromatics Separation	2.00	2.00 (*1)	

Note : Calculation Base
(*1) Per (Feed bbl/d)
(*2) Per (Product Coke t/d)
(*3) Per (Product Hydrogen M scfd)
(*4) Per (Product bbl/d)
(*5) Per (Spent Acid t/d)
Original Complexity Factor(Oil & Gas Journal, Vol.87 No.40 P.90, 1989)
Source Petroleum Association of Japan

Figure 2.3.1 Relation between Fuel Consumption and Complexity Factor



Source : Petroleum Association of Japan

Complexity Factor of the refinery is calculated by totaling the Complexity Factor of each equipment multiplied by the processing quantity of each equipment, If the processing quantity of each equipment cannot be accurately obtained, the design capacity of each equipment can be used as a temporary measure. (ref. Table 2.3.7)

Table 2.3.7 Example of Calculation Method for Complexity Factor

Name of Unit		Complexity Factor	Operation (Feed KL)	Complexity	Energy Consumption (kcal)
Atm. Crude Distillation		1.0	A	1.0	AA
Vac. Crude Distillation		2.0	B	B/A*2.0	BB
Hydrotreating	(Naphtha)	1.7	C	C/A*1.7	CC
	(Kerosene)	1.7	D	D/A*1.7	DD
	(Gas oil)	2.2	E	E/A*2.2	EE
Catalytic Reforming		5.0	F	F/A*5.0	FF
Desulfurization					
Gas Oil from Vac. D.		3.0	G	G/A*3.0	GG
Res. Oil from Crude D.		4.0	H	H/A*4.0	HH
Res. Oil from Vac. D.		5.0	I	I/A*5.0	II
Catalytic Cracking		6.0	J	J/A*6.0	JJ
--		--	--	--	--
--		--	--	--	--
--		--	--	--	ZZ
Total				$(CF)_R$	F_R

Note ; Nelson's Complexity Factor
The factor was proposed by Nelson (Oil & Gas Journal Vol.87.No.40 1989) in order to assess the unit of the petroleum refinery.

Trends of energy efficiency for all Japanese petroleum refineries are shown in Table 2.3.8 for reference.

Of eight refineries currently operating in I. R. Iran, only the energy consumption of Tehran Refinery could be derived. Neither data about energy consumption nor any information about the equipment composition could be obtained from NIOC on the other seven refineries. Therefore, it assumed that the actual situation of energy consumption in all Iranian refineries is equivalent to that of Tehran Refinery. Energy consumption of all Iranian refineries was thus roughly estimated based on the data and information on Tehran Refinery.

Table 2.3.8 Progress of Energy Conservation in the Japanese Petroleum Refineries

	Amount of Production (A)	Input Crude Oil (B)	Complexity Factor (A)/(B)	Fuel Consumption (C)	Purchased Electricity (D)	Crude Oil Equivalent (E)	Total Energy (F)=(C)+(E)	Energy Efficiency (F)/(A)	Energy Conservation Progress
	1,000kl	1,000kl		1,000kl	GWh	1,000kl	1,000kl	l/kl	%
1973	943,600	250,798	3.762	11,767	2,192	533	12,300	13.03	100.0
1980	982,768	218,294	4.502	10,783	2,792	678	11,461	11.66	89.4
1981	953,373	200,353	4.758	10,053	2,763	671	10,724	11.25	86.3
1982	943,024	186,008	5.070	9,614	2,715	660	10,274	10.89	83.5
1983	972,855	189,608	5.131	9,848	2,702	657	10,505	10.80	82.8
1984	986,730	188,960	5.222	9,830	2,910	707	10,537	10.68	82.0
1985	976,280	176,791	5.522	9,354	2,781	676	10,030	10.27	78.8
1986	933,578	168,095	5.554	9,591	2,419	588	10,179	10.90	83.6
1987	968,790	164,819	5.878	9,702	2,286	555	10,257	10.59	81.2
1988	1,036,075	174,230	5.947	10,542	2,372	576	11,118	10.73	82.3
1989	1,090,433	186,111	5.859	10,820	2,046	497	11,317	10.38	79.6
1990	1,163,726	204,971	5.678	11,529	2,064	502	12,031	10.34	79.3
1991	1,227,473	215,875	5.686	12,189	2,135	519	12,708	10.35	79.4
1992	1,312,995	228,541	5.745	13,122	2,138	520	13,642	10.39	79.7
1993	1,516,614	234,573	6.465	14,111	2,580	627	14,738	9.72	74.5
1994	1,603,663	246,414	6.508	14,935	2,843	691	15,626	9.74	74.7
1995	1,630,282	247,394	6.590	15,109	2,973	722	15,831	9.71	74.5

Note : (E)=(D)*2250(kcal/kWh)/9250(kcal/l)

Electricity Consumption (In-house Generation + Purchased)

in 1993	8,386,439 MWh	5.53 kWh/kl-Prod.	35.75
in 1994	9,141,508	5.70	37.10
in 1995	9,536,913	5.85	38.55

Source : Petroleum Association of Japan

In this case, the Complexity Factor of Tehran Refinery of 6.734 in the factory diagnosis report is the value calculated using nominal capacity base instead of actual quantity processed by each equipment. It is bigger than the true value, and the energy efficiency of 15.2 is rather small. Energy efficiency for all Iranian refineries was set at 16.0, and Complexity Factor of all Iranian refineries at 5.0.
The estimated result is shown in Table 2.3.9.

Table 2.3.9 Rough Estimation of Total Energy Consumption for Petroleum Refining

				<Source>
Estimation Basis :	Total Feed of Crude Oil in 1955		75,074 *1,000kl/y	(Ref. Table 2.3.3)
	Complexity Factor			
	Tehran Refinery	(Apparent)	6.7	(Ref. Vol.3, Table 2.8)
	8 Refineries	(Estimated)	5.0	
	Energy Efficiency			
	Tehran Refinery	(Apparent)	15.2 l/kl	(Ref. Vol.3, P.2-14)
	8 Refineries	(Estimated)	16.0 l/kl	
Energy Consumption:	Total Energy Consumption		55,555 Tcal/y	

According to this, total energy consumption of all Iranian refineries in 1995 is estimated at 55,555,000 Gcal/y, or a crude oil equivalent of 6,006,000 kl/y. That is, 8% of the petroleum processing quantity is consumed, approximately 1.6 times the Japanese level.

2.3.3 Energy Conservation Potential and Cost of Countermeasures

In Japanese refineries, various energy conservation measures have been implemented since the first oil crisis, all designed for crude oil with heavy rich petroleum, product demand for light fraction, and environmental protection measures.
Total energy conservation investment cost has reached about 150 billion yen,
about 70% of which was spent for "rationalization of heat transfer, recovery of waste heat, and rationalization of heat transformation to power" .
With these countermeasures, energy savings of 6,000,000-kl/y(crude oil equivalent) have been attained compared to 1973, with an achievement rate of conservation of 74.5% in 1995 as shown in Table 2.3.8.
The breakdown of energy conservation measures for seven years since 1987 are shown in Table 2.3.10.

Table 2.3.10 Energy Conservation Countermeasure in Japanese Petroleum Refineries

(1987-1993)

Energy Conservation Countermeasure	Investment Cost (M ¥)	Saved Energy (Fuel Oil, 1,000kl)
1 Rationalization of fuel combustion	2,619.4	61.3
2 Rationalization of heating, cooling and heat transfer	13,558.7	243.0
3 Prevention of heat loss due to heat radiation and transfe	2,074.9	36.9
4 Waste heat recovery and reuse	8,562.2	114.4
5 Rationalization in conversion of heat into power	22,833.9	174.1
6 Prevention of electric heat loss due to resistance	95.1	3.9
7 Rationalization in conversion of electricity into power	1,825.3	23.4
8 Others	17,841.5	293.1
Total	69,411.0	950.1

Source : Petroleum Association of Japan

Typical examples for each energy conservation measure given in Table 2.3.10, are shown below.

(1) Rationalization of combustion of fuel
- a. O_2 control of heating furnace/boiler
  - Installation of O_2 meter
  - Process control by computer

(2) Rationalization of heating, cooling and heat transfer
- a. Optimization of heat exchanger arrangement
- b. Prevention of heat exchanger fouling
  - On stream cleaning facilities
  - Anti-fouling agent
- c. Preheater of boiler feed water
- d. Direct charging to distillation column (hot charge)

(3) Loss prevention of heat due to radiation, heat transfer, etc.
- a. Reinforcement of insulation
  - Insulation of tank, column and vessel, and piping
- b. Exchange to energy conservation-type steam trap

(4) Recovery of waste heat
- a. Installation of air preheater for heating furnace/boiler
- b. Installation of steam generator
- c. Installation of FCC gas expander

(5) Rationalization of transformation of heat into power or others
- a. Reduction of bypass steam of the generator turbine
- b. Installation of combined cycle turbine

c. Installation of power recovery

(6) Loss prevention of electricity due to resistance

a. Power factor improvement of the generator

(7) Rationalization of transformation of electricity to power or heat

a. Impeller-cut of pumps

(8) Others

a. Energy conservation operation

Low-pressure operation, low mole ratio operation

Change of solution/solvent and concentration-up

b. Reduction of reflux ratio

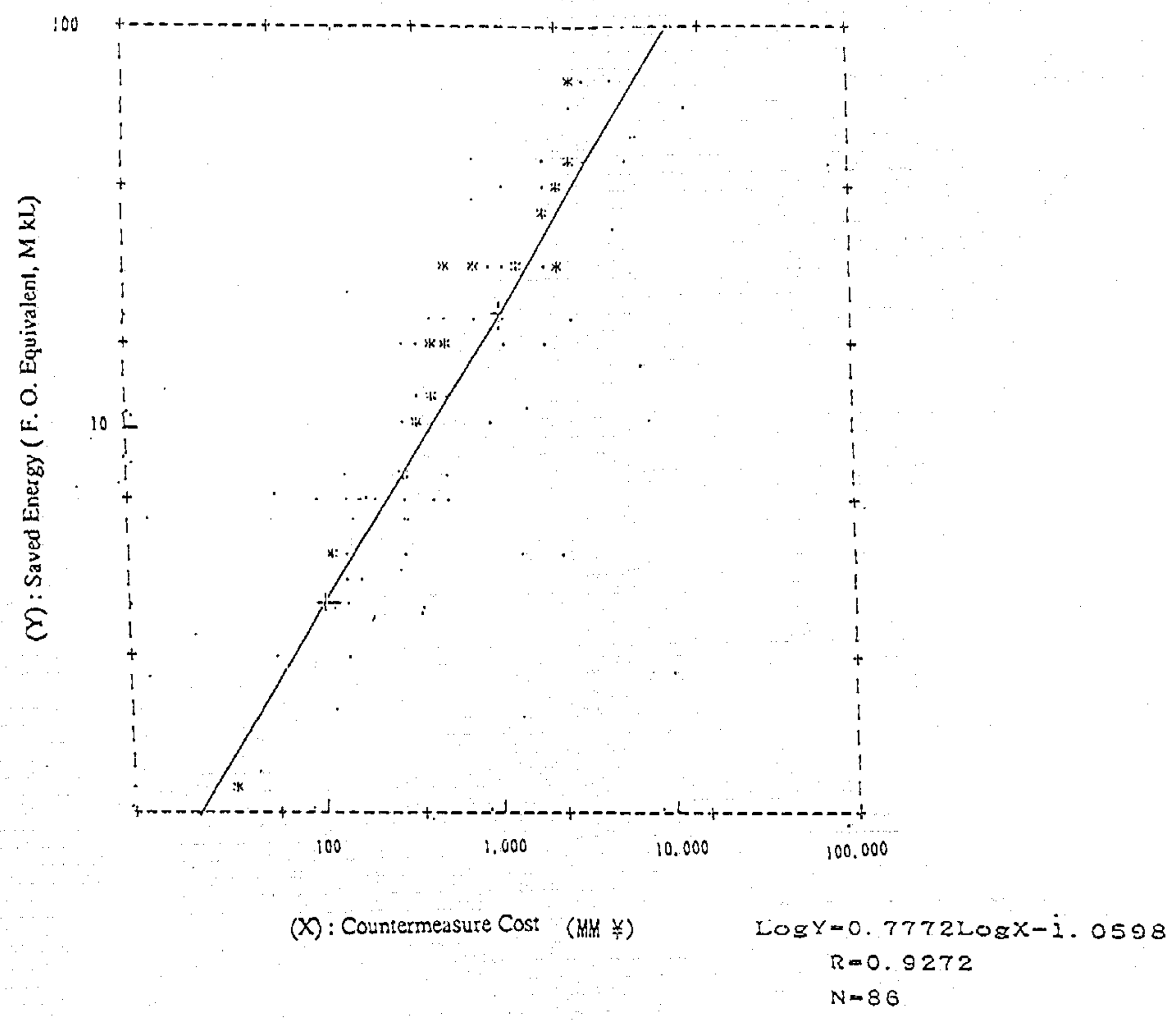
c. Reduction of stripping steam

d. Optimizing operation by computer control

With energy conservation measures mostly in place, only those with a low investment efficiency are left, which have been decreasing every year.

The relation between energy conservation investment and amount of energy saving is shown in Figure 2.3.2.

Figure 2.3.2 Relation between Saved Energy and Countermeasure Cost (1982-1992)



As discussed in the previous paragraph, energy efficiency of all refineries in I. R. Iran, in spite of their low Complexity Factor, seems to exceed 60%, compared to the level of all refineries in Japan.

But energy consumption is an important consideration in the case of plant design, because the petroleum refining industry was originally a process industry starting from the atmospheric distillation column.

Because energy conservation measures are selected using the relative standards of energy price and investment cost, energy conservation measures implemented in Japan were hardly implemented in I. R. Iran where the price of energy is low.

Experience and results at refineries in Japan are nonetheless considered applicable to refineries in I. R. Iran. During the factory audit of Tehran Refinery these were proposed as concrete measures. The expected effects and costs of the measures are shown below.

However, because the equipment composition of all the refineries in I. R. Iran is not clear, it is difficult to develop other refineries in I. R. Iran using the case of Tehran Refinery.

(A) Improvement of operation and maintenance management

a. Improvement of operation management values/process conditions
<energy conservation operation, reduction of reflux ratio, reduction of stripping steam>

b. Optimizing operation by computer control

c. Reduction of air ratio for heating furnace/boiler

(Tehran Refinery)	Energy conservation effect	f.o.e	16,983 kl/y
	Cost of measure		1,575 M Rial

d. Impeller-cut of pumps

(Tehran Refinery)	Energy conservation effect	electricity	899 MWh/y
	Cost of measure		53 M Rial

e. Insulation of tank, column and vessel, and pipings

(Tehran Refinery)	Energy conservation effect	f.o.e	1,789 kl/y
steam valve	Cost of measure		2,013 M Rial

f. Prevention of heat exchanger fouling

g. Turning off unnecessary lights

(Tehran Refinery)	Energy conservation effect	electricity	91 MWh/y
	Cost of measure		0 M Rial

(B) Modification of facility

a. Installation of air preheater for heating furnace/boiler

(for heating furnace of Tehran Refinery)

Energy conservation effect	f.o.e	27,053 kl/y
Cost of measure		31,413 M Rial

(for boiler of Tehran Refinery)

Energy conservation effect	f.o.e	21,177 kl/y
Cost of measure		28,858 M Rial

b. Installation of heat recovery equipment of hot exhaust gas
(Waste heat boiler/Economizer)

c. Reinforcing/optimizing heat exchanger
(for cooler of Tehran Refinery)

	Energy conservation effect	f.o.e	1,781 kl/y
	Cost of measure		1,085 M Rial

d. Rotation control of motor
e. Efficiency-up of steam turbine of the existing generator
f. Direct charging to distillation column (hot charge)
g. Improvement of refractory inside reheating furnace

(Tehran Refinery)	Energy conservation effect	f.o.e	538 kl/y
	Cost of measure		350 M Rial

h. Substitution of pump motor

(Tehran Refinery)	Energy conservation effect	electricity	15 MWh/y
	Cost of measure		12 M Rial

(C) Modification of process
a. Introduction of gas turbine cogeneration
b. Installation of diesel engine cogeneration
c. Installation of heat pump
d. Heat integration of refining unit
e. Installation of process turbine

Note : f. o. e. Fuel oil equivalent

2.3.4 Economic Assessment of Energy Conservation Potential

Assuming that the countermeasures for energy conservation potentials mentioned in the previous paragraph are implemented by the year 2000, an economic assessment of the potentials was made using two cases.

Case 1 : A. E. C. case
Case 2 : E. C. case

The basis for the energy price in each case can be seen in Table 2.1.2. The Rial vs. the US$ rate is based on the rate in 1993 (1,750 Rial/US$).
The results of the assessment are shown in Table 2.3.11 and Table 2.3.12.

According to the assessment, the countermeasures in Case 1, which reinforce management of operation and maintenance, are feasible except for insulation of steam valves. Those that require modification of the facilities, meanwhile, are not feasible.
Of the countermeasures in Case 2, which involve reinforcement of operations and maintenance, reduction of air ratio for reheating furnace only becomes feasible when evaluating for 10 years.
As for the countermeasures in the category of process modification, which are not assessed above, they should be evaluated not only in terms of energy conservation effect but also in terms of facility expansion or renewal, because these involve large-scale investments.

Table 2.3.11 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					Countermeasure Cost		Economic Evaluation
		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									
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 2.3.12 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									

2.4 Cement Industry

2.4.1 Outline of Cement Industry

(1) Trends of supply and demand

Based on the Industry Statistics Year Book 1374 published by the Ministry of Industry, the trends on production, import, and export of cement since 1989 are shown in Table 2.4.1.

Table 2.4.1 Production, Import and Export of Cement in I. R. Iran (unit: 1000t)

Year	1989	1990	1991	1992	1993	1994	1995
Production	12,869.0	15,055.0	15,152.0	15,142.0	16,260.0	16,836.0	17,491.0
Import	1.3	2.0	0.0	115.0	47.0		
Export	169.0	60.0	30.0	0.0	25.6		

Source : Ministry of Industry

According to the table, domestic production has exceeded 15,000,000 t/y since 1990. It seems to have been supported by active demand increases due to rehabilitation after the War, and infrastructure arrangement and reinforcement in the First five-year plan.
Exports have been stable so far, with cement exports of 50,000 t/y in 1994, and clinker exports reaching 550,000 t/y. This is, however, expected to increase rapidly within two to three years with the start-up of the new project.
Imports have been limited to special cement for petroleum drilling.

(2) Outline of the factories

Cement production was inaugurated at the 100 t/d plant at the foot of mount Bibisharbanu, 7 km south of Tehran in 1933.
Existing factories were constructed after World War II and most of them were constructed before the revolution.
Location, production start-up time, production capacity, recent production, type of kiln and clinker cooler, and main fuel of the cement factory of these factories are shown in Table 2.4.2.

Twenty factories of 15 companies in I. R. Iran are operating at present, and white cement is produced in one factory.
Most factories are distributed nationwide at the sources of raw materials, as shown in Figure 2.4.1.

Fars and Khouzestan Cement have the greatest capacity with their four factories accounting for 17,400 t/d, or 31% of the entire production capacity.

Table 2.4.2 Cement Factories in I. R. Iran

(1/2)

Company	Factory	Start -Up	Employee	Capacity (t/y)	(t/d)	Production in 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)

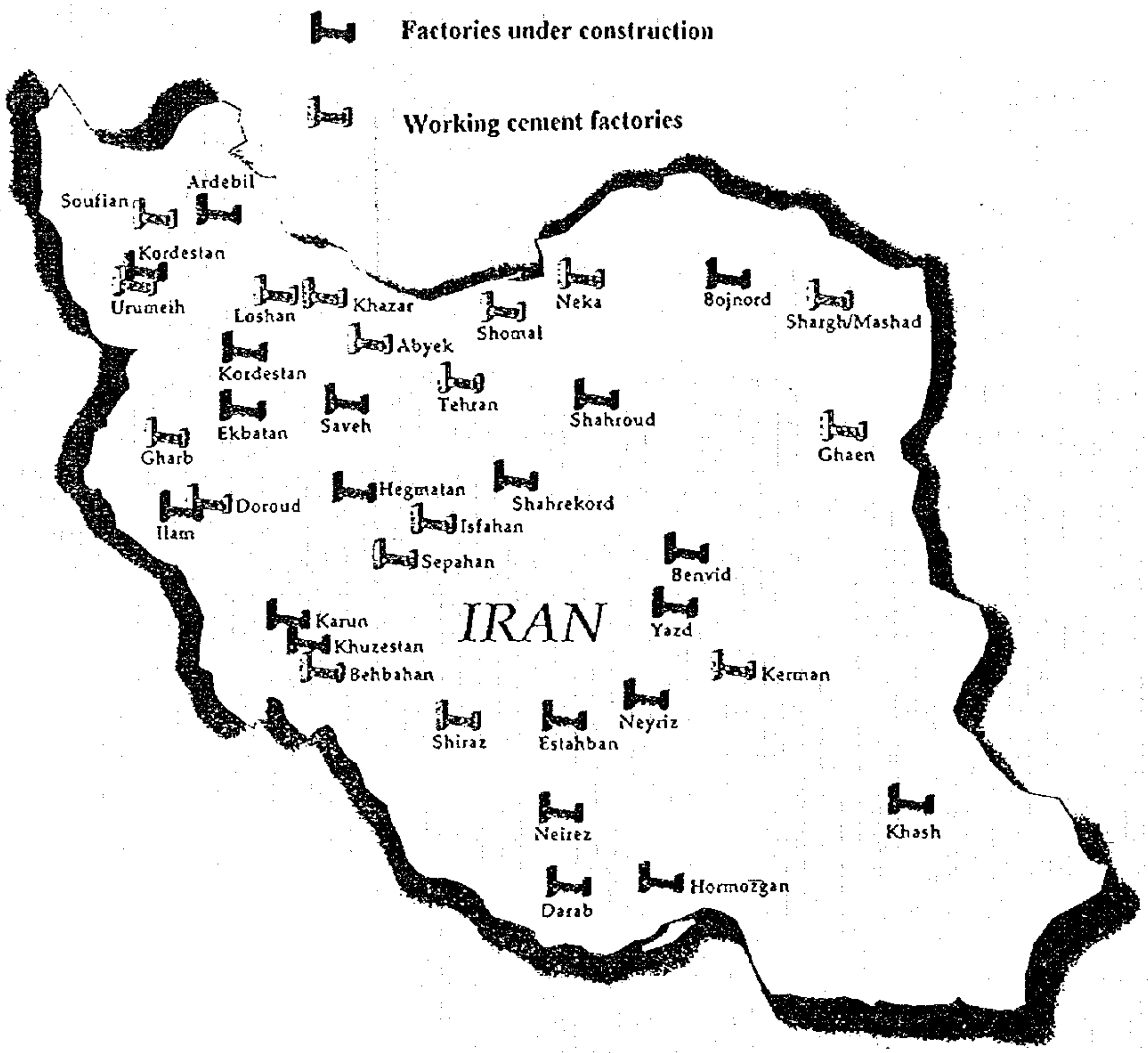
	Company	Factory	Start -Up	Employe	Capacity (t/y)	Production (t/d)	Production 1995 (t/y)	Kiln Type	Cooler	Fuel
10	Soufian Cement	Soufian	1970	1,075	1,428,000	600	1,372,252	3D FLS	4 Planetary	F.O. 100%
			1975			1,000				
			1977			1,000				
			1984			2,000		1SP FLS		
11	Gharb Cement	Gharb	1977	456	600,000	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

Figure 2.4.1 Location of Cement Factories in I. R. Iran



They are followed Tehran Cement 9,600 t/d, Sepahan Cement 6,600 t/d, and Soufian Cement 4,600 t/d.
There are only three factories with new facilities within 10 years after operation start up. Improving processes or facilities is hardly being implemented at the old factories, even in cases where one kiln after another is added.
Among existing plants classified according to type of kiln, which is the center of cement manufacturing facilities, it can be noted that wet process kilns, which consume most energy, and dry process kilns, which have no recovery facilities for waste heat, occupy 22% of all facilities.

a)	Wet kiln (W)	7 set	(4,100 t/d)
b)	Dry process kiln (D)	6 set	(8,400 t/d)
c)	Kiln with suspension preheater (SP)	24 set	(37,250 t/d)
d)	Kiln with suspension preheater and calciner (NSP)	4 set	(8,050 t/d)

As for clinker coolers, planetary-type and rotary-type coolers occupy 52% of total capacity in I. R. Iran, whereas grate-type cooler is more prevalent in Japan,.
As for fuel, fuel oil or natural gas is used as the mainstream and coal is used at only one factory, Esfahan Cement.
The operation rate of the facilities is high due to active domestic demand, and completion of factories under construction is expected to be on time. However, some delays have arisen because of foreign currency circumstances.
An outline of the new establishment plan of the cement factories is shown in Table 2.4.3.

According to the plan, new facilities of 39,100 t/d, which is equivalent to about 70% of the existing capacity, are expected to come on stream within two years, with the execution of 20 projects including the four white cement projects. Seven factories began operations in the autumn of 1996. Production capacity has been increased for ordinary cement in five factories at 9,100 t/d and for white cement in two factories at 1,000 t/d.
These new factories have a combination of energy saving-type NSP-Grate coolers, except two factories which had already begun operation and the white cement factories.
In any case, due to the operation of these new facilities, disposal of facilities with low productivity will be carried forward, as was the case with Dorud Factory of Fars & Khuzestan Cement. Subsequently, energy conservation will proceed as well.

2.4.2 Present Situation of Energy Consumption

To grasp the present situation of energy consumption at the cement factories in I. R. Iran, energy intensity obtained by the factory audits of three factories, that is, Sepahan Cement, Soufian Cement and Tehran Cement No.1 Factory. The report of an interview survey of Ourmia Cement in 1993 and the average data for 14 factories provided from Cement Research Center of Iran were also reviewed. These are shown in Table 2.4.4.

Table 2.4.3 Cement Projects in I.R. IRAN

	Name of Company	Location	Product	Capacity (t/d)	Anticipated Commissioning	Process	Kiln	Cooler	Intensity (Design) Fuel	Electricity
									kcal/kg-cl.	kW/t-cem
1	Estahban Cement	Fars	Gray	500	Jun.'96	PSP	SP	Rotary	850	95
2	Ekbatan Cement	Hamedan	Gray	500	Operation	PSP	SP	Rotary	850	95
3	Ilam Cement	Ilam	Gray	2,000	Apr.-Jun.'97	ABB/O+K	NSP	Grate	750	95
4	Ardabil Cement	Ardabil	Gray	2,300	Operation	Onoda	NSP	Grate	750	95
5	Yazd Bohrouk C.	Yazd	Gray	3,600	Oct.-Dec.'97	KHD	NSP	Grate	750	95
6	Bojnurd Cement	Khorasan	Gray	2,000	Apr.-Jun.'98	Uzine	NSP	Grate	750	95
7	Khuzestan Cement	Khuzestan	Gray	3,000	Jul.-Sep.'98	FCB	NSP	Grate	750	95
8	Khash	Sistan & Baluch	Gray	2,000	Operation	KHD	NSP	Grate	750	95
9	Shahrud Cement	Semnan	Gray	2,300	Apr.-Jun.'97	FLS	5-stage NSP	FOLAX grate	750	95
10	Khorasan Cement (East Expansion)	Khorasan (Qaen)	Gray	2,000	Operation	FLS	5-stage NSP	FOLAX grate	750	95
										95
11	Kurdestan Cement.	Kurdestan Bijar	Gray	2,300	Operation	FLS	5-stage NSP	FOLAX grate	750	95
12	Karun Cement	Khuzestan	Gray	3,000	Jul.-Sep.'98	FCB	5-stage NSP	Grate	750	95
13	Hegmatan Cement	Hamedan	Gray	2,300	Apr.-Jun.'97	FLS	5-stage NSP	FOLAX grate	750	95
	Hormozgan Cement									95
14	1st line	Hormozgan	Gray	3,000	Oct.-Dec.'96	FCB	NSP	Grate	750	95
15	2nd line	Hormozgan	Gray	3,000	Apr.-Jun.'97	FCB	NSP	Grate	750	95
16	Shargh Cement	Mashad	Gray	3,300	Apr.-Jun.'98	ABB/FCB	NSP	Grate	750	95
17	Banvid Cement	Esfahan	White	500	Apr.-Jun.'98	O+K	SP	Rotary	1,450	125
18	Saveh Cement	Markazi	White	500	Operation	FCB	SP	Rotary	1,450	125
19	Asgarabad Cement	West Azarbaijan	White	500	Jul.-Sep.'97	O+K	SP	Water Basin	1,400	125
20	Neiriz Cement	Fars	White	500	Operation	Nihon	NSP	Rotary	1,150	125
	Total			39,100	G 9,100+W 1,000					

Source : Industry and Development Vol. 1 No. 4 Jun.-Jul. P.25, 1995
Global Cement Report P.96-97, World Cement Apr. 1995 P.47

Table 2.4.4 Energy Intensity of Cement Factories in I. R. Iran

Company	Start -Up	Kiln Capacity (t/d) Wet	Dry	SP	NSP	Cooler	Fuel	Production Cement (t/y)	Intensity Fuel (Mcal/t-cl)	Electr'ty (kWh/t-cem)	Total Energy (Mcal/t-cem)	Remarks
Sepahan Cement	1978			3,300		Planetary	Gas & F.O.	1,556,240	897	132	1,067	in 1989
	1981			3,300		Planetary		1,749,149	863	134	1,042	in 1990
								2,073,624	830	101	939	in 1991
								1,888,943	828	126	994	in 1992
								2,039,740	833	105	951	in 1993
								2,081,203	839	115	979	in 1994
								1,905,798	860	118	1,003	in 1995
Soufian Cement	1970		600			Planetary	F.O. 100%	1,313,839	1,088	104	1,283	in 1990
	1975		1,000			Planetary		1,255,736	1,129	104	1,322	in 1991
	1977		1,000			Planetary		1,329,551	1,079	102	1,270	in 1992
	1984			2,000		Planetary		1,403,147	998	103	1,194	in 1993
								1,337,944	1,013	97	1,195	in 1994
Tehran Cement	1956	300				Planetary	Gas & F.O.					
(No.1 Factory)	1958	300				Planetary						
	1968	600				Planetary						
	1962			2,100		Planetary		570,156	950	118	1,181	No.4 train, in 1995
	1972	300				Rotary						
	1979			4,000		Grate		891,888	843	128	1,101	No.6 train, in 1995
									(1,019)	(118)	(1,248)	Mean V. of No.1 Fac.*
(No.2 Factory)	1984			2,000		Planetary	Gas & F.O.					
Ourmia Cement	1989				2,300	FOLAX Grate	Gas & F.O.		947	113	1,154	in 1992
Mean Value of	11 Factories									125		
	3 Factories (using Natural Gas)								1,135			
	14 Factories (using Fuel Oil)								1,093			

Note : * The data of Intensity in ( ) are estimated value

Source : Sepahan Cement, Soufian Cement, Tehran Cement, Ourmia Cement
Cement Research Center

Differences in energy intensity of the factory which implemented factory audit of as much as 950-1,250 Mcal/t-cem were noted. However, they cannot be compared simply because of the influence of the compounding rate of ingredients, except gypsum (the slag from blast furnace, "pozoran"), which are added to clinker at the milling stage. In particular, it is characteristic that the compounding rate of ingredients at Sepahan Cement is highest at 7-31%.

The fuel intensity, which accounts for the heaviest weight of the energy intensity, is 830-1,120 Mcal/t-cl. The difference seems to be due to type of kiln, scale of facility, and management techniques for operations and maintenance.

In any case, the technical level of these factories is high, judging from the average value the 14 factories received from Cement Research Center.

To estimate the energy consumption of the whole cement industry in I. R. Iran, therefore, the average values of energy intensity provided by the Cement Research Center were used as representative values for the industry.

(ref. Table 2.4.5)

Table 2.4.5 Estimation of Total Energy Consumption for Cement Production

Estimation Basis :	Total Production of Cement in 1!	17,491 * 1,000t/y	
	by Fuel Oil(incl.Coal)	13,957 * 1,000t/y	
	by Natural Gas	3,534 * 1,000t/y	
	Overall Energy Intensity		
	Fuel Oil(incl.Coal)	112 l/t-cl.	1,051 Mcal/t-cem
	Natural Gas	116 Nm3/t-cl.	1,091 Mcal/t-cem
	Electricity	115 kW/t-cl.	249 Mcal/t-cem
Energy Consumption	Total Energy	22,872 Tcal/y	
	Fuel Oil(incl.Coal)	14,664 Tcal/y	1,496 M kl/y
	Natural Gas	3,856 Tcal/y	393 M m^3/y
	Electricity	4,352 Tcal/y	1,934 GWh/y

2.4.3 Energy Conservation Potential and Cost of Countermeasures

To determine the energy conservation potential of the cement industry in I. R. Iran, it is helpful to examine energy consumption trends of the Japanese cement industry.
Each cement manufacturer in Japan has been pursuing process improvement, conversion of fuels and energy conservation to improve productivity and reduce manufacturing costs. This is mainly due to severe cost competition in the industry along with almost total fuel dependence on imports from foreign countries.
The trends are introduced in Vol. 4, Figure 6.16, Figure 6.18, Figure 6.19, Figure 6.20, Figure 6.21, the contents of which are summarized below.

(1) Concerning the cement manufacturing process, conversion to the dry process, particularly to the NSP process from the wet process, has been rapidly carried out. The current composition is NSP 79%, SP and the others 21%.

(2) Concerning fuel, conversion to coal from fuel oil was completed in 1982 immediately after the second oil crisis. At present, fuel savings are carried out using industrial waste and by-products such as slug of blast furnace, coal ash, and waste tires.

(3) As a result, energy intensity has decreased by 24% over the past 20 years, as shown below

1975		1,145 Mcal/t-cement
1995		871 Mcal/t-cement
	Fuel (Coal)	107.3 kg/t-cement
	Electric power	95.1 kWh/t-cement

(4) Consumption rate of energy use

fuel.	: for calcination	87.9 %
	for generation of electricity	11.8
	for drying raw materials, and so on	0.3

(heat of the kiln exhaust gas used for drying raw materials is calculated as calcination.)

electric power	: for raw material preparation	27.2 %
	for calcination	27.7
	for finishing	39.0
	for others	6.1

On the other hand, the present situation of the cement industry in I. R. Iran, as shown in Table 2.4.4, shows a big allowance for energy conservation, judging from energy intensity. Therefore, if the process or the facilities are the same, it is technically possible to apply the Japanese experience in implementing energy conservation measures.
This is shown in Table 2.4.6 entitled, "Main Energy Conservation Technology of the Cement Industry in Japan", which was prepared by a study committee to tackle basic problems in the cement industry.

Table 2.4.6 Main Energy Conservation Technology of Cement Industry in Japan

Energy Conservation Technology		Introduction	Rate of Diffusion	Rate of Energy Conservation
			%	%
1. NSP Kiln		1973	79	16
2. Power Generation Utilizing Waste Heat		1975	25	25
3. Vertical Mill	Raw Materials	1980	34	64
	Coal	?	80	64
	Clinker/Slag	1986	18	64
4. High Efficiency Separator		1980	45	25
5. Preliminary Mill	Finishing Sec.	1987	16	38
6. High Efficiency Clinker Cooler		1992	1	40

Source : Basic Problem Study Committee of Cement Industry in Japan

Concerning the facilities of cement factories in I. R. Iran, only the calcining kiln and the clinker cooler are known, as shown in Table 2.4.2 (existing) and Table 2.4.3 (under construction).
For energy conservation measures such as vertical mill, high-efficiency separator, or preliminary mill, it is difficult to estimate how much will they can be applied to cement factories in I. R. Iran.
Similarly, for energy conservation measures to be carried out through audits of three factories, it is also difficult to estimate how much will they can be applied to the other cement factories in I. R. Iran.

Energy conservation measures for cement factories in I. R. Iran, mainly those proposed as the result from audits of three factories, are classified on the basis of facility investment, and the expected effects and costs of the measures are shown below.

(A) Improvement of management for operation and maintenance

a. Capacity-up of EP IDF

(Sepahan C.)	Energy conservation effect	f.o.e	3,780 kl/y
	Cost of measure		168 M Rial

b. Improvement of raw materials mill fan operation

(Sepahan C.) Energy conservation effect

		electricity	5,400 MWh/y
	Cost of measure		753 M Rial

c. Draft control for whole process

(Sepahan C.)	Energy conservation effect	f.o.e	9,451 kl/y
	Cost of measure		105 M Rial

d. Renewal of screen plate.

(Sepahan C.)	Energy conservation effect		
		electricity	10,000 MWh/y
	Cost of measure		849 M Rial

e. Operation improvement of No.6 kiln

(Tehran C.)	Energy conservation effect	f.o.e	9,451 kl/y
		electricity	14,400 MWh/y
	Cost of measure		1,278 M Rial

f. Air sealing, Combustion Control of kiln burner
Capacity-up of EP IDF, Utilization of kiln exhaust gas

(Soufian C.)	Energy conservation effect	f.o.e	4,343 kl/y
	Cost of measure		1,663 M Rial

(B) Modification of facility

a. Conversion to grate cooler from satellite cooler.

(Tehran C.)	Energy conservation effect	f.o.e	10,385 kl/y
		electricity	8,190 MWh/y
	Cost for measure		39,900 M Rial
(Soufian C.)	Energy conservation effect	f.o.e	6,593 kl/y
	Cost of measure		23,153 M Rial

b. Vertical type mill for raw materials

(300 t/h)	Energy conservation effect		
		electricity	16,000 MWh/y
	Cost of measure		3,500 M Rial

c. Vertical type mill for clinker

(150 t/h)	Energy conservation effect		
		electricity	12,000 MWh/y
	Cost of measure		3,500 M Rial

d. High efficiency separator

(100 t/h)	Energy conservation effect		
		electricity	4,000 MWh/y
	Cost of measure		1,750 M Rial

e. Preheating of 1ry air

(3,000 t/d)	Energy conservation effect	f.o.e	3,024 kl/y
	Cost of measure		1,225 M Rial

(C) Modification of process

a. Conversion to NSP from wet kiln (No.3 kiln)

(Tehran C.)	Energy conservation effect	f.o.e	42,527 kl/y

	Cost of measure		79,625 M Rial
b. Conversion to NSP from SP (No.3 kiln)			
(Soufian C.)	Energy conservation effect	f.o.e	34,286 kl/y
	Cost of measure		100,100 M Rial
c. The automatic operation by conputerization			
(6,000 t/d)	Energy conservation effect	f.o.e	6,048 kl/y
		electricity	4,140 MWh/y
	Cost of measure		8,750 M Rial

2.4.4 Economic Assessment of Energy Conservation Potential

Assuming that countermeasures for energy conservation potentials mentioned in the previous paragraph are implemented by the year 2000, an economic assessment of the potentials was made using two cases.

Case 1 : A. E. C. case
Case 2 : E. C. case

The basis of the energy price for each case can be seen in Table 2.1.2, and the Rial vs. US$ rate is based on the rate in 1993 (1,750 Rial/US$).
The results of the assessment are shown in Table 2.4.7 and Table 2.4.8.

According to the study, more than 10% energy conservation can be accomplished in Case 1, not only because of improved management of operations and maintenance, but also because of some modifications of facilities such as adoption of vertical mill, adoption of high-efficiency separator, and preheating of 1ry. air are feasible.
Modifications of processes, however, are not feasible at this point.
In Case 2, more than 10% energy conservation seems to be difficult to accomplish, because even improving management of operations and maintenance is not always feasible, unless there are added merits of production increases.

**Table 2.4.7 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 Fuel Oil (kl/y)	Benefit Electricity (MWh/y)	Benefit (M Rial/y)	Benefit for 3 years (M Rial)	Benefit for 10 years (M Rial)	Countermeasure Cost (M ¥)	Countermeasure Cost (M Rial)	Economic Evaluation	Note
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 Sealing				+ 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)
1ry 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 2.4.8 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	Factory	Benefit: Fuel Oil (kl/y)	Benefit: Electricity (MWh/y)	Benefit (M Rial/y)	Benefit for 3 years (M Rial)	Benefit for 10 years (M Rial)	Countermeasure Cost (M ¥)	Countermeasure Cost (M Rial)	Economic Evaluation	
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)
1ry 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

2.5. Glass Industry

2.5.1 Outline of Sheet Glass Industry

(1) Trends of Production

Production trends of sheet glass for each factory since 1990 are shown in Table 2.5.1.

Table 2.5.1 Sheet Glass Production in I. R. Iran

(unit : t)

	Ghazvin G.	Abguineh G.	Iran G.	Saveh Jam G.	Total
1990	139,361	43,161	11,759	0	194,281
1991	136,533	45,309	7,794	0	189,636
1992	147,328	76,903	9,199	11,190	244,620
1993	120,304	89,105	7,472	39,359	256,240
1994	117,419	87,051	6,041	48,544	259,055
1995	89,381	71,614	11,193	55,595	227,783

Source : Ministry of Industry

According to the table, domestic production first exceeded 200,000 t/y in 1992 when operation of Saveh Jam Glass started. It seems to have corresponded with the rise in demand caused by rehabilitation efforts and the accompanying construction boom after the War.

Decrease of production in 1995 is due mainly to scheduled shut-down maintenance of Ghazvin Glass, No.1 furnace. This decline is expected to continue for the time being, provided there is no substantial production increases by the other factories, as Ghazvin Glass No.4 and No.3 furnaces are also to be shut-down for overhauls until 1997.

(2) Outline of the factories

Location, production start-up time, nominal production capacity, estimated glass melting capacity, recent production, the production method of sheet glass and main fuel are shown in Table 2.5.2.

Four factories of four sheet glass producers are operating in I. R. Iran at present.
Total production capacity is approximately 300,000 t/y.
Ordinary sheet glass is the main product, although figured glass is also produced by Ghazvin Glass and Abguineh Glass. With the delay in the introduction of the Float process, which has spread rapidly worldwide in recent years, high-quality products with no deflection necessary for car use, etc. depend on imports.

Table 2.5.2 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) Liva Glass ?	Liva		(project)				–		Glaverbel to Float
Total				1,285		302,000	227,783		

Source : MOI, Ghazvin Glass, & Saveh Jam Glass

Ghazvin Glass has the biggest production capacity at 120,400 t/y. It accounts for about 40% of total production capacity in I. R. Iran. The company has plans to introduce of the Float method as its fifth production line

Similarly, Abguinch Glass and Saveh Jam Glass have their own expansion plans. Moreover Azar Glass and Liya Glass have newly joining plans. After four to five years, a significant change in the industry is expected.

2.5.2 Present Situation of Energy Consumption

To determine the present situation of energy consumption in the sheet glass industry in I. R. Iran, energy intensity, which was obtained by factory audit of Ghazvin Glass and interview survey at Saveh Jam Glass are shown in Table 2.5.3.

Abguinch Glass and Saveh Jam Glass have been using natural gas as fuel, whereas Ghazvin Glass has been using mainly fuel oil. Conversion from fuel oil to natural gas has been promoted as a policy of the Ministry of Industry. In Ghazvin Glass, the conversion of No.1 furnace was completed during scheduled shut-down maintenance in 1995. The conversion of No.4 and No.3 furnaces of the factory, is scheduled to be completed by 1997.

According to the table, there was a big difference in energy intensity in 1995 between Ghazvin Glass (7,233 Mcal/t) and Saveh Jam Glass (4,170 Mcal/t).

However, considering that 1995 was the year of the scheduled shut-down maintenance for Ghazvin Glass No.1 furnace, the normal energy intensity of the factory should be the value in 1994 during which operations were normal. The two other factories seem to be near the normal value of Ghazvin Glass in terms of operation start-up time and degree of product diversification.

As for the breakdown of energy intensity, fuel for glass melting accounted for 84%, fuel for forming and annealing, 9%, and electricity, 7%, in Ghazvin Glass. Meanwhile, fuel for melting accounted for 82%, fuel for forming and annealing, 2%, and electricity, 16%, in the country where introduction of the Float process has been completed.

The main cause of this difference is the electric heater used for forming and annealing in the Float process.

For energy consumption in 1994, which recorded peak production in recent years, therefore, the normal value of Ghazvin Glass shown in Table 2.5.4 is used for estimation.

It is necessary to pay attention to natural gas consumption, because No.1 furnace of Ghazvin Glass has already been converted to natural gas.

Table 2.5.3 Energy Consumption of the Representative Sheet Glass Factories

Company Name	Production Capacity	Production	Fuel Consumption Kind	Quantity		Intensity	Electricity Consumption Kind	Quantity		Intensity	Total Energy Intensity
<Sheet Glass>	(t/y)	(t/y)			(Gcal/y)	(Mcal/t)		(MWh/y)	(Gcal/y)	(Mcal/t)	
Ghazvin Glass	120,400	105,700	N.Gas	8,570	81,415	770	Purchased	12,700	31,115	294	
	(Nominal)	(in 1995)	Fuel Oil	66,650	626,510	5,927	Generated	9,000	22,050	209	
			Gas Oil	3,010	25,471	241					
			(S-total)		733,396	6,938					7,233
		130,100	N.Gas	7,260	68,970	530	Purchased	12,700	31,115	239	
		(in 1994)	Fuel Oil	75,390	708,666	5,447	Generated	10,200	24,990	192	
			Gas Oil	3,360	28,432	219					
			(S-total)		806,068	6,196					6,435
		125,700	N.Gas	8,170	77,615	617	Purchased	12,700	31,115	248	
		(in 1993)	Fuel Oil	73,740	693,156	5,514	Generated	11,100	27,195	216	
			Gas Oil	2,790	23,609	188					
			(S-total)		794,380	6,320					6,567
		153,900	N.Gas	8,500	80,750	525	Purchased	12,700	31,115	202	
		(in 1992)	Fuel Oil	72,760	683,944	4,444	Generated	11,400	27,930	181	
			Gas Oil	3,230	27,332	178					
			(S-total)		792,026	5,146					5,349
Saveh Jam Glass	60,000	55,595 (in 1995)	N.Gas	22,982	218,329	3,927	Purchased	5,506	13,490	243	4,170

Note : Unit of Energy Consumption for Quantity

N. Gas	$1,000m^3/y$
Fuel Oil	kl/y
Gas Oil	kl/y
Electricity	MWh/y

Source : Ghazvin Glass, Saveh Jam Glass

Table 2.5.4 Estimation of Total Energy Consumption for Sheet Glass Production

Estimation basis :	Overall Energy Intensity			6,435 Mcal/t	
	(Ghazvin Glass 1994)				
	Fuel for glass melting		84%	5,405 Mcal/t	
	Fuel for forming & annealing		9%	579 Mcal/t	
	Electricity		7%	450 Mcal/t	
	Total Production of Sheet Glass in 1994			259,055 t/y	
	Glass Melting using Fuel Oil			135,745 t/y	
	Glass melting using Natural Gas			123,310 t/y	
Energy Consumption :	Total Energy			1,667,019 Gcal/y	
in 1994		Fuel Oil			78,059 kl/y
		Natural Gas			85,955 km^3/y
		Electricity			47,629 MWh/y
	Fuel for glass melting			1,400,296 Gcal/y	
		Fuel Oil	52%		78,059 kl/y
		Natural Gas	48%		70,162 km^3/y
	Fuel for forming & annealing			150,032 Gcal/y	
		Natural Gas			15,793 km^3/y
	Electricity			116,691 Gcal/y	47,629 MWh/y

2.5.3 Energy Conservation Potential and Cost of Countermeasures

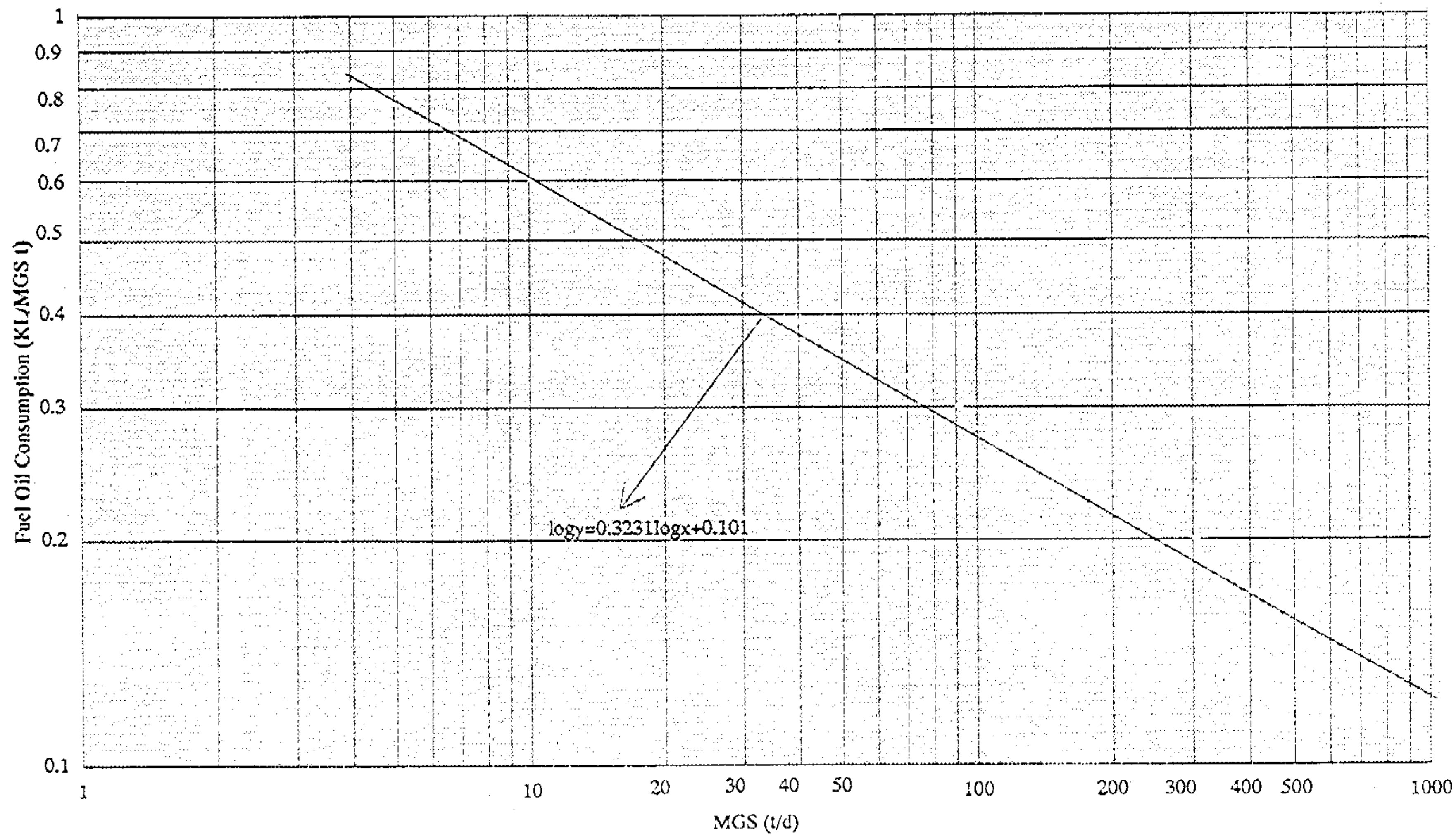
Energy Conservation Potential is shown in Table 2.5.5 by analyzing the difference of fuel oil consumption between the normal value of Ghazvin Glass and the model value of the advanced factory (Japan, 1989).

Table 2.5.5 Energy Conservation Potential of the Sheet Glass Factory in I. R. IRAN

		Ghazvin Normal(N)	Excellent F.(E)	(E-N)/N
F.O. Consumption	(kl/d)	51.6	67.2	
MGS	(t/d)	130	365	
Product	(t/d)	89	274	
F.O. Intensity				
	(kcal/kg MGS)	3,731	1,731	-53.6%
	(kcal/kg Prod.)	5,450	2,305	-57.7%
1 Furnace Scale	(MGS t/d)	214	365	
	(kL/t MGS)	0.223 *(1)	0.188 *(1)	-15.7%
2 Furnace Load	(t/d)	130	214	
	(Calc. Oil kL/d)	52.3	67.5	
	(kL/t MGS)	0.402	0.315	-21.6%
3 Production Yield		68.5%	75.1%	
	(Reciprocal)	1.461	1.332	-8.8%
Sub Total				
	(1-0.157)*(1-0.216)*(1-0.088)-1			-39.7%
4 Insulation		None	Heavy	
Conductivity	(kcal/mh degC)	1.0	0.8	
Heat loss from wall	(kl/d)	29.3	23.4	
	(Calc. Oil kL/d)	52.3	43.0	-17.8%
5 Regenerator				
(Heat recovery)		64.0%	71.5%	
	(Reciprocal)	1.563	1.399	-10.5%
6 Combustion Control				
(Heat Efficiency)		64.0%	66.5%	
	(Reciprocal)	1.563	1.504	-3.8%
7 Others				
				-1.0%
Sub Total				
	(1-0.178)*(1-0.105)*(1-0.038)*(1-0.010)-1			-29.9%
Total	(1-0.397)*(1-0.299)-1			-57.7%

Note : *(1) Refer to Figure 2.5.1

Figure 2.5.1 Relation between Fuel Oil Consumption
and Capacity of Melting Furnace in Sheet Glass Production



According to the table, the differences between the two are mainly accounted for by six factors, that is, scale of glass melting furnace, load of glass melting furnace, yield of products, degree of insulation, efficiency of regenerator, and combustion control.
Among these factors, scale of glass melting furnace and load of glass melting furnace cannot be treated as simple energy conservation potential, because there are restrictions due to products demand, while merits due to increased sales can add to profit due to energy conservation. In particular, the scale of conventional glass melting furnaces shall be assumed to be the status quo as a premise, when considering the above-mentioned technical trend. The other factors are more quantitatively described as the energy conservation potentials as follows.

(1) Improvement of management technology

Main countermeasures for this potential are as follows:

a. To implement energy conservation education for all employees to develop consciousness for energy conservation.
b. To implement quality control education for all employees in the operation division to improve product yield.
   If the product yield is improved to 75%, and assuming the present yield to be 68.7%, fuel savings will be 3,614 kl/y of fuel oil.
c. To implement maintenance education for operation and maintenance personnel to improve operation rate of production facility.
d. To establish energy conservation promotion organization in the office unit, the factory unit, the company unit, and the industry unit.
e. To install measuring instruments at important positions in each process and the factory to get data necessary for energy management.
f. To monitor flame and analyze exhaust gas regularly to control combustion.
   If excess air ratio is reduced to 15%, and assuming the present excess air ratio to be 25%, the fuel saving will be 7,340 kl/y as fuel oil.
g. To seal thoroughly openings of the furnace to prevent flame blowing out flame, radiation of heat, and entry of chilled air.

In principle, the above countermeasures can be implemented without substantial investments in the production facilities. However, for items e and f, investment cost for instrumentation will be 350,000,000 Rial (1,750 Rial/$ base).
Total energy conservation of items b and f will be 10,954 kl/y fuel oil. About 10% energy conservation can be achieved.

(2) Improvement of productivity

Although the melting load of the furnace becomes high when accelerating the forming machine, there is still some allowance for the maximum temperature, which is as low as 1500℃.
By remodeling the roll, a 50% speed increase will be possible for the figured sheet glass machine of Ghazvin Glass, and a 20% speed increase will be possible for the Colburn

machine.
Improving raw materials and furnace operation management is indispensable for maintaining product yield and quality, and maintaining furnace life.

Speed increases of Ghazvin Glass No.1, No.3, and No.4 furnaces, judging from the operational status of the forming machine, can be certainly expected, and are considered targets.

Melting load improvement	from 475 t/d to 555 t/d (17 %)
Fuel oil intensity improvement	from 0.331 kl/t to 0.308 kl/t.
Fuel oil saving	4,659 kl/y
Investment cost	875,000,000 Rial (1,750 Rial/US$)

(3) Light insulation

As the temperature will rise when insulation of the furnace wall is reinforced to reduce radiation from the furnace wall, upgrade the internal furnace material is necessary. But light insulation of the inner furnace materials to a degree which does not require upgrading internal furnace materials, can be done while the furnace is operating.
Ghazvin No.1 furnace and Saveh Jam No.1 furnace, which have already been completed, are excluded from the estimation.
Estimated merit and countermeasure costs are as follows:

Fuel saving	9,576 kl/y
Investment Cost	1,558,000,000 Rial(1,750 Rial/US$)

(4) Heavy insulation

As explained above, the work can be implemented only during the scheduled maintenance shut-down, because upgrading internal furnace materials would be necessary.
Considering the specifications of the four factories, Saveh Jam No.1 furnace, which has already been finished, is excluded from the estimation.
Estimated merit and countermeasure costs are as follows:

Fuel saving	8,505 kl/y
Investment Cost	14,228,000,000 Rial(1,750 Rial/US$)

(5) Enlargement of heat transfer area of checker brick in the regenerator room

This is roughly classified into two methods.

a. The heat transfer area of the checker brick becomes proportionally larger when increasing the volume of the regenerator room as well as brick quantity. As there are functional restrictions on the length and the width, there is no choice but to increase the height. In this case, the limit is about 1 m. Installing a second regenerator room is possible, but is not recommendable.

b. Modification of the shape of the checker brick by replacing basket-weave type with chimney-box type.

Ghazvin No.1 furnace and Saveh Jam No.1 furnace, which were already been implemented, and Abguineh No.2 furnace, which does not have a regenerator, are excluded.

Estimated merit and countermeasure costs are as follows:

Fuel saving	4,782 kl/y
Investment Cost	6,084,000,000 Rial(1,750 Rial/US$)

2.5.4 Economic Assessment of Energy Conservation Potential

Assuming that the countermeasures for energy conservation potentials mentioned earlier are implemented by the year of 2000, an economic assessment of potential was done using the two following cases:

Case 1 A. E. C. case	
Mean price of fuel oil	75 Rial/l at 2000-2002
	75 Rial/l at 2000-2009
Case 2 E. C. case	
Mean price of fuel oil	17 Rial/l at 2000-2002
	22.7 Rial/l at 2000-2009

In the case study, the rate in 1993 (1,750 Rial/US$) was used as the exchange rate of Rial to US$.

The results of this study are shown in Table 2.5.6

According to the table, heavy insulation and modification of the regenerator are not feasible, while modification of the forming machine is feasible only for ten years even in Case 1. In Case 2, there is no feasible countermeasure except improving management, that is, improving product yield and combustion control.

In addition, if there are sufficient profits due to a sales increase, improving productivity by modifying the forming machine is deemed feasible.

Table 2.5.6 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	as Fuel Oil (kl/y)	Benefit (M Rial/y)	Benefit for 3 years (M Rial)	Benefit for 10 years (M Rial)	Cost (M ¥)	Cost (M Rial)	Economic Evaluation
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	as Fuel Oil (kl/y)	Benefit (M Rial/y)	Benefit for 3 years (M Rial)	Benefit for 10 years (M Rial)	Cost (M Y)	Cost (M Rial)	Economic Evaluation
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

2.6 Textile Industry

2.6.1 Outline of Textile Industry

(1) Trend of production and the facilities

Production trend of textile industry in I. R. Iran is shown in Table 2.6.1, which includes production of fabric, and yarn and chemical fiber since 1976 .

Table 2.6.1 Production of Textile Products in I. R. Iran

Year	Fabric (km)	Yarn & Chemical Fiber (t)	Imported Fabrics (km)
1976	512,000	130,000	124,000
1977	511,000	125,000	141,000
1978	350,000	95,000	98,000
1979	456,000	100,000	100,000
1980	485,000	100,000	100,000
1981	533,000	105,000	160,000
1982	551,000	115,000	175,000
1983	604,000	125,000	399,000
1984	595,000	126,000	220,000
1985	572,000	122,000	100,000
1986	585,000	129,000	
1987	581,000	138,000	
1988	550,000	120,000	
1989	538,000	100,000	
1990	543,000	108,000	
1991	525,000	115,000	
1992	510,000	142,000	
1993	381,000	122,000	
1994	350,000	115,000	
1995	390,000	135,000	

Source : Association of Iran Textile Industries

In the last 10 years, annual yarn and chemical fiber production has been 100,000 to 140,000 tons, with small fluctuations. Annual fabric production, meanwhile, is 58,000,000 to 35,000,000 m/year, exhibiting a declining tendency.
The facility trends for spinning and weaving are shown in Table 2.6.2-1 and Table 2.6.2-2, respectively.

Table 2.6.2-1 Trend of Spinning Machines in I. R. Iran

	Ring Spinning			O. E. Spinning	
	Installed Number of Spindle		Operation Hour (hr/1-Sp.)	Installed Number of Spindle (Rotor)	Operation Hour (hr/1-Ro.)
	Short Fiber Spinning (Sp.)	Long Fiber Spinning (Sp.)			
1987	1,100,000	-----	-----	38,000	-----
1988	1,100,000	60,000	-----	38,000	-----
1989	1,100,000	60,000	-----	38,000	-----
1990	1,100,000	60,000	-----	38,000	-----
1991	1,200,000	60,000	-----	40,000	-----
1992	1,500,000	60,000	4,500	41,500	5,000
1993	1,550,000	60,000	4,500	41,500	5,000
1994	1,650,000	110,000	4,800	51,500	5,500

Note : Operation Hours Asia/Oceania(1994)
Ring Spinning 8,400-4,800 hr / 1-Sp.
O. E. Spinning 8,400-5,500 hr / 1-Ro.
Japan(1994)
Ring Spinning 6,000 hr / 1-Sp.
O. E. Spinning 6,000 hr / 1-Ro.

Source : Monthly Report of Japan Spinners' Association

Table 2.6.2-2 Trend of Weaving Machines in I. R. Iran

Year (End of the Year)	Shuttleless Loom		Shuttle Loom	
	Installed Number of Cotton Loom	Operation Hour (hr/1-Loom)	Installed Number of Cotton Loom	Operation Hour (hr/1-Loom)
1987	3,200	-----	-----	-----
1988	3,500	-----	-----	-----
1989	3,600	-----	22,000	-----
1990	3,800	-----	20,000	-----
1991	4,000	-----	20,000	-----
1992	7,350	3,800	28,000	4,200
1993	7,850	4,200	28,000	3,900
1994	9,100	5,200	16,000	4,100

Note : Operation Hours Asia/Oceania(1994)
Shuttleless Loom 8,400-5,100 hr/1-Loom
Shuttle Loom 8,200-3,900 hr/1-Loom
Japan(1994)
Shuttleless Loom 5,500 hr/1-Loom
Shuttle Loom 5,500 hr/1-Loom

Source : Monthly Report of Japan Spinners' Association

Use of the ring spinning machine and the rotor type open-end spinning machine(O.E. spinning) worldwide has been decreasing in recent years, resulting in a worldwide facility surplus (ring spinning machine decreased 2.7% at the end of 1993). On the other hand, the installed numbers of ring spinning machines and rotor type open-end spinning machines in I. R. Iran have both increased slightly, but the operation efficiency is not high at 4, 500 hours/1-spindle for ring spinning, and 5,000 hours/1-spindle for O.E. spinning Operation hours in Asia/Oceania and in Japan are shown in the margin of the table for reference.

In I. R. Iran, the installed number of the shuttleless looms increased rapidly from 1992, whereas the installed number of shuttle looms peaked in 1993 and then decreased.
The trend in I. R. Iran has also been taking place worldwide, that is, a shift to the shuttleless loom from the shuttle loom.
However, noting the number of operation hours per loom, the operation efficiency in I. R. Iran apparently is not high. Due to production adjustments, shuttleless loom and related facilities with which production efficiency is higher, do not function sufficiently.

(2) Outline of factories

The main textile factories in I. R. Iran are shown in Table 2.6.3. There are 117 factories at present, which can be classified according to business status as follows:

- a. synthetic fiber factory (3 factories)
- b. spinning factory (44 factories)
- c. weaving factory (58 factories)
- d. dyeing, printing, & finishing factory (12 factories)

Table 2.6.3 shows location, establishment time, product, production capacity, and recent production of the factories.

These factories are interspersed mainly in the metropolis and the suburbs throughout the country.
The operation rate of most factories is below 50%.
The reasons for these include: very few new factories have been constructed within 15 years following start-up with the exception of three synthetic fiber factories; many inefficient facilities are still operating because modification and renewal were not undertaken; and, there remain restrictions on the procurement of raw materials etc., due to foreign currency problems.

Table 2.6.3 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-I>					(km/y)	(km/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 2.6.3 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)			(1,2501)
				(Clothes)		(10,000)	(5,038)
				(Velvet)		(4,460)	(1,851)
				(Carpet)		($1,235km^2$)	($423km^2$)
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 2.6.3 Textile Factories in I. R. IRAN

(3/4)

Factory Name	Location	Estabsh. Year	Products	No. of Machines (R.S.)	(R.O.E.)	Capacity (t/y)	Production in 1995 (t/y)
<Spinning-1>							
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-Ghergherch 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 Ghergherch-ye-Ziba	Tehran	1960	Cot.Syn.Y.& Sp.	35,796		3,500	1,870
23 Gherghere 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 2.6.3 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 :

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 Machine	Capacity	Production in 1995
	<Dyeing, Printing, Finishing>					(km/y)	(km/y)
1	Aba	Tehran	1982	Finished Fabrics		4,000	750
2	Akmal	Esfahan	1968	Finished Fabrics		9,000	5,000
3	Takmil Faraz	Tehran	1978	Finished Fabrics		1,200	800
4	Tehran Gol	Tehran	1968	Finished Fabrics		12,000	5,000
5	Golesorkh Printing	Tehran	1963	Finished Fabrics		2,000	1,000
6	Madbaft Textile	Zanjan	1982	Finished Fabrics		20,000	11,000
7	Golbaft Industrial Group	Esfahan	1969	Finished Fabrics		10,000	6,000
8	Golriz	Esfahan	1964	Finished Fabrics		16,800	8,700
9	Moghaddam	Ghazvin	1959	Finished Fabrics		5,000	3,000
10	Nakh Rang	Hamadan	1984	Finished Fabrics		15,000	9,000
11	Naghshin	Yazd	1983	Finished Fabrics		10,000	7,000
12	Hell	Ghazvin	1973	Finished Fabrics		10,000	4,000
	Total					115,000	61,250

Source : Association of Iran Textile Industries

2.6.2 Present Situation of Energy Consumption

To determine the present energy consumption of the textile industry in I. R. Iran, information was collected not only from an audit of two factories, that is, Polyacryl Iran and Kashan Velvet & Rayon Mills, and interview survey of two factories, that is, Aliaf and Yazd Baf, but also through a questionnaire survey carried out by the Association of Iran Textile Industries.
Energy intensity of each factory is shown in Table 2.6.3

In general, the energy necessary to produce textile products, consists of processing energy, which is used for qualitative changes of the material such as reaction and melting in the chemical fiber process, and change of set condition of fiber such as mixing, orientating, and twisting, direct energy which is used for heating/cooling and driving machines, and indirect energy used for supplementary facilities such as the air-conditioner and lighting equipment.
The energy consumption data, which was collected this time, however, was not broken down according to these categories. Therefore, the energy consumption figures were derived from macro-data.
To avoid a double-counting of energy consumption, only purchased electricity and fuel were included in fuel consumed for the in-house electricity generation plant . Therefore, with regard to electricity, it was difficult to grasp the actual state of consumption.
The present situation of energy consumption for the four categories mentioned above is estimated below.

(1) Synthetic fiber

Synthetic fiber factories in I. R. Iran have a total capacity of 120,900 t/y in three factories. The break-down of these factories are as follows; polyester fiber 54,880 t/y, acryl fiber 40,020 t/y, and nylon-6 fiber 26,000 t/y.
The total production in 1995 was 100,608 t/y and average operation rate was high at 83.2%. The break-down of production was polyester fiber 55,931 t/y, acrylic fiber 24,581 t/y, and nylon-6 fiber 20,096 t/y.
The present status of energy consumption was estimated by totaling the actual data obtained by the factory audit at Polyacryl Iran and the interview survey at Aliaf and the estimated data for Parsilon, as shown in Table 2.6.4.

The figures for Parsilon whose actual situation could not be fully grasped, are based on the energy intensity of Aliaf, which is producing the same nylon-6 fiber as Parsilon. It is possible to assume that energy intensity never exceeds Aliaf, because the scale of the production facility at Parsilon is bigger and newer than that of Aliaf, but the operation rate is not sufficient.

Table 2.6.4 Estimation of Total Energy Consumption for Synthetic Fiber Production in 1995

Factory Name	Products	Capacity	Production in 1995	Fuel Consumption Kind	Fuel Consumption Quantity	Fuel Consumption	Fuel Consumption	Electricity Consumption Quantity	Electricity Consumption	Electricity Consumption	Energy Consumption
		(t/y)				(Gcal/y)	(Mcal/t)	(MWh/y)	(Gcal/y)	(Mcal/t)	(Mcal/t)
1 Polyacryl Iran	Polyester Fiber	30,800	55,931	Fuel Oil	484	4,743	59	3,446	7,754	96	10,302
	Polyester Filament	21,880		Natural Gas	83,362	816,948	10,147				
	Polyester Tops	2,200									
	Acrylic Fiber	23,500	24,581								
	Acrylic Tops	16,520									
2 Parsilon	Nylon 6	16,000	8,596			180,066	20,948	3,274	7,367	857	21,805
3 Aliaf	Nylon 6	10,000	11,500	Gas Oil	6,232	57,334	4,986				
				Natural Gas	18,731	183,564	15,962	4,380	9,855	857	21,805
Sub-total		120,900	100,608			1,242,655		11,100	24,975		

Note : Energy consumption of Parsilon is estimated based on energy intensity of Aliaf

(2) Spinning

The scale of the facilities and the production of the 44 spinning mills, which are surveyed in this study, are shown in Table 2.6.3. The total production of the 44 companies in 1995 was 65,154 t/y.
Among these mills, the total facility scale for which data on energy consumption could be grasped is ring spinning, 311,323 sp., and rotor type open-end spinning, 20,748 drum.
As the composition of the process and the energy consumption mainly depend on the spinning method, the 21 spinning mills are classified into three groups including factories using the ring spinning method, mills using the rotor type open-end spinning method, and mills using both methods. Energy consumption for each group was then examined.

a. Mills Applying Ring Spinning Method
There are 19 ring spinning mills. Of these, the energy consumption of nine mills could be grasped. To estimate the energy consumption of all 19 mills from the nine mills, capacity of facility and production results are also shown in Table 2.6.5.

Number of spindles of the 19 spinning mills totals 344,984 sp. Total production of spinning product in 1995 was 25,369 t/y.
The energy intensity of this group fluctuated wildly, that is, from a maximum of 33,396 Mcal/t to a minimum of 1,586 Mcal/t. The weighted average of the energy intensity for seven mills excluding the maximum and the minimum values of energy intensity is 13,899 Mcal/t.
As a result, the total energy consumption of this group in 1955 was estimated to be 352,598 Gcal/y .

b. Mills Applying the Rotor Type Open-End Spinning Method
There are 12 rotor type open-end spinning mills. Among these mills, the energy consumption of seven mills could be grasped. To estimate the energy consumption of all 12 mills from the seven mills, capacity of the facility and production results are shown in Table 2.6.6.

Number of drum of the 12 spinning factories totals 18,688. Production of spinning product in 1995 was 14,535 t/y.
The weighted average of the energy intensity for seven mills is 12,558 Mcal/t.
As a result, the total energy consumption of this group in 1955 was estimated to be 182,532 Gcal/y.

c. Mills Applying Ring and Rotor Type Open-End Spinning Methods
There are 13 mills using the ring spinning method and rotor type open-end spinning method including two unknown mills. Among these mills, the energy consumption of five mills could be grasped. To estimate the energy consumption of all 13 mills from the five mills, capacity of facility and production results are shown in Table 2.6.7.
Production of spinning product in 1995 was 25,250 t/y.

Table 2.6.5 Estimation of Total Energy Consumption for Ring Spinning in 1995

	Factory Name	Products	No. of Machines (R.S.)	No. of Machines (R.O.E)	Capacity	Production in 1995	Fuel Consumption Kind	Fuel Consumption Quantity	Fuel Consumption	Fuel Consumption	Electricity Consumption Quantity	Electricity Consumption	Electricity Consumption	Energy Consumption
	<Ring Spinning>		(R.S.)	(R.O.E.)	(t/y)	(t/y)			(Gcal/y)	(Mcal/t)	(MWh/y)	(Gcal/y)	(Mcal/t)	(Mcal/t)
1	Ataiyeh	Cotton Yarns	20,304		2,400	819								
8	Khambaf Esfahan	Cot.& PE. Y.	10,000		1,000	700								
9	Khosh Nakh Yazd	Cot.& Syn.Y.	10,000		1,200	700								
10	Douk Nakh	Cotton Yarns	5,000		1,200	600								
13	Riskar Yazd	Cot.& PE. Y.	12,100		1,400	500								
15	Khavar Spinning	Cot.& PE. Y.	27,000		2,500	2,450	Fuel Oil	1,000	9,800	4,000	11,088	24,948	10,183	14,183
17	Seyed Mohammad Agha	Cot.& PE. Y.	10,160		1,200	600								
21	Far Nakh	Cot.& Syn.Y.	32,704		3,000	2,480	Fuel Oil	2,221	21,766	8,777	10,404	23,409	9,439	18,216
22	Ghergherch-ye-Ziba	Cot.Syn.Y.& Sp.	35,796		3,500	1,870	Gas Oil	636	5,851	3,129				
							Fuel Oil	3,596	35,241	18,845	9,493	21,359	11,422	33,396
23	Gherghere Nakhtab Esfahan	Spool Yarns	14,128		1,900	700	Gas Oil	382	3,514	5,021	660	1,485	2,121	7,142
25	Kanaf Esfahan	Cot.& PE. Y.	13,576		2,200	1,500								
29	Mehr Koupa	Cot.& Syn.Y.	10,080		1,300	700	Fuel Oil	210	2,058	2,940	960	2,160	3,086	6,026
30	Mahyaran	Cot.& PE. Y.	20,400		1,800	1,550								
32	Nahid	Cot.& Syn.Y.	15,228		1,500	950								
34	Nakh Rissy Yazd	Cotton Yarns	20,560		2,300	1,200								
35	Nassaji Babakan	Cot.& Syn.Y.	49,392		6,000	3,500	Gas Oil	240	2,208	631				
							Fuel Oil	390	3,822	1,092	22,400	50,400	14,400	16,123
36	Baftehai-e-Kerman	Cot.& PE. Y.	17,760		2,050	2,380	Fuel Oil	310	3,038	1,276	10,368	23,328	9,802	11,078
39	Novin-e-Shahreza	Cot.& Syn.Y.	6,000		900	750	Gas Oil	40	368	491	365	821	1,095	1,586
44	Ghaem Baft Jazeh	Cot.& Syn.Y.	14,796		1,500	1,420	Fuel Oil	100	980	690	7,344	16,524	11,637	12,327
	Sub-total				18,250	13,630			47,186	3,462		142,254	10,437	13,899
	Total		344,984		38,850	25,369			87,826		117,676	264,772		

Note : Unit of Fuel Consumption for Quantity ; Gas Oil kl/y
N. Gas kNm^3/y
Fuel Oil kl/y

Source : Association of Iran Textile Industries

Table 2.6.6 Estimation of Total Energy Consumption for Roter Open End Spinning in 1995

Factory Name	Products	No. of Machines (R.S.)	(R.O.E)	Capacity	Production in 1995	Fuel Consumption Kind	Quantity			Electricity Consumption Quantity			Energy Consumption
<Roter Open End Spinning>		(R.S.)	(R.O.E.)	(t/y)	(t/y)			(Gcal/y)	(Mcal/t)	(MWh/y)	(Gcal/y)	(Mcal/t)	(Mcal/t)
2 Aydin Bonab	Cotton Yarns		400	600	240								
5 Bandhye Pezeshki Iran	C.Y. Hyd.C., G.		768	1,200	900	Fuel Oil	6	59	65	2,832	6,372	7,080	7,145
7 Jahan Nakh	Cotton Yarns		1,344	1,200	900								
16 Natanz Spinning	Cot.& Syn.Y.		1,344	1,200	850	Fuel Oil	112	1,098	1,291	7,036	15,831	18,625	19,916
24 Gheytan	Cotton Yarns		1,728	1,200	900	Fuel Oil	150	1,470	1,633	3,600	8,100	9,000	10,633
26 Golriss	Cot.& PE. Y.		768	1,000	825								
27 Mashad Nakh	Cot.& PE.-A. Y.		1,760	6,000	3,500	Fuel Oil	1,300	12,740	3,640	11,000	24,750	7,071	10,711
31 Nabriss	Cot.& Syn.Y.		1,944	1,350	1,100	Fuel Oil	102	1,000	909	1,100	2,475	2,250	3,159
40 Hamedan Nakh	Cot.& Syn.Y.		960	1,200	700								
41 Yazd Tab	Cotton Yarns		1,344	1,100	420								
42 Khoy Textile	Cot.& Syn.Y.		4,600	2,800	2,700	Gas Oil	100	920	341				
						Fuel Oil	1,700	16,660	6,170	16,764	37,719	13,970	20,481
43 Khameneh Textile	Cot.& PE. Y.		1,728	1,700	1,500	Gas Oil	127	1,168	779				
						Fuel Oil	192	1,882	1,254	5,132	11,547	7,698	9,731
Sub-total				15,450	11,450			36,996	3,231		106,794	9,327	12,558
Total			18,688	20,550	14,535			46,964		60,252	135,568		

Note : Unit of Fuel Consumption for Quantity ;

Natural Gas	kNm^3/y
Gas Oil	kl/y
Fuel Oil	kl/y

Source : Association of Iran Textile Industries

Table 2.6.7 Estimation of Total Energy Consumption for Ring & Roter Open End Spinning in 1995

Factory Name	Products	No. of Machines (R.S.)	No. of Machines (R.O.E)	Capacity	Production in 1995	Fuel Consumption Kind	Fuel Consumption Quantity			Electricity Consumption Quantity			Energy Consumption
<Ring & Roter Open End Spinning>		(R.S.)	(R.O.E.)	(t/y)	(t/y)			(Gcal/y)	(Mcal/t)	(MWh/y)	(Gcal/y)	(Mcal/t)	(Mcal/t)
3 Behriss Esfahan	Cot.& PE. Y.	18,036	436	2,500	1,200								
4 Parvin Esfahan	Cot.& Syn.Y.	26,940	400	3,900	3,100								
6 Nakh-Va-Ghergchereh Gilan	Cotton Yarns	10,720	1,152	3,500	2,700	Fuel Oil	786	7,703	2,853	7,522	16,925	6,268	9,121
11 Rahim Zadeh	Cot.& Syn.Y.	40,076	672	4,700	2,800	--	--			9,000	20,250	7,232	7,232
12 Reshtan	Cotton Yarns	2,656	400	1,500	400								
14 Parnakh Spinning	Cot.& Syn.Y.	1,152	1,152	2,200	1,300	Fuel Oil	1,200	11,760	9,046	2,500	5,625	4,327	13,373
18 Shoukouh	Cotton Yarns	11,396	1,200	1,300	500								
19 Doukriss	Cot.& Syn.Y.			1,500	800								
20 Nakh Semnan	Cot.& Syn.Y.			1,500	700								
28 Mah Nakh	Cot.& Syn.Y.	36,576	3,600	6,000	5,500	Fuel Oil	3,929	38,504	7,001	31,634	71,177	12,941	19,942
33 Nakhtab Firouzan	Cot.& Syn.Y.	15,012	1,344	1,600	1,250								
37 Chookha Textile	Cot.& Syn.Y.	15,216	300	2,000	1,500	Gas Oil	750	6,900	4,600	5,934	13,352	8,901	13,501
38 Qarb Textile	Cot.& Syn.Y.	47,520	768	6,500	3,500								
Sub-total				18,400	13,800			64,867	4,701		127,328	9,227	13,927
Total		225,300	11,424	38,700	25,250			118,688		103,543	232,972		

Note : Unit of Fuel Consumption for Quantity ;

Natural Gas	kNm^3/y
Gas Oil	kl/y
Fuel Oil	kl/y

Source : Association of Iran Textile Industries

The weighted average of the energy intensity for five mills is 13,927 Mcal/t.
As a result, the total energy consumption of this group in 1955 was estimated to be 351,660 Gcal/y.

Totaling the estimation results for the three groups, the present energy consumption of the 44 factories is 886,790 Gcal/y.

(3) Weaving

The scale of the facilities and the production of the 58 weaving factories, which were surveyed in this study, are shown in Table 2.6.3. The total production of the 58 companies in 1995 was 372,000 km/y.
As energy intensity of weaving depends greatly on loom type as shown in Table 2.6.8, it is roughly divided into shuttle loom and shuttleless loom. The energy intensity of a shuttle loom is basically larger than that of a shuttleless loom.

Table 2.6.8 Energy Intensity for Inserting Weft Yarn

Method	Type of Loom	Energy Consumption (Wh / m)	(kcal / m)
Shuttle loom	Automatic shuttle loom	238	535.5
	Air jet loom (a)	111-130	250-293
Shuttleless loom	Rapier loom (b)	126-145	284-326
	Gripper loom (c)	110	248
	Water jet loom	44-52	

The 58 factories were classified into four groups, by loom type, such as factories using shuttle loom, factories using shuttleless loom, factories using shuttle loom and shuttleless loom, and unknown factories. Energy consumption was estimated for each group using data from 33 factories on present energy consumption.

a. Factories using shuttle loom

There are 20 weaving factories using only shuttle looms. A total of 7,593 sets of shuttle loom are operating, and produced 101,450-km of cotton cloth and chemical fiber cloth in 1995.
Among these factories, the energy consumption of 13 factories could be grasped. To estimate the energy consumption of all 20 factories from the actual values of 13 factories, production capacity and results are shown in Table 2.6.9.

The weighted average of the energy intensity for 13 factories is 3,690 kcal/m.
As a result, the total energy consumption of this group in 1955 was estimated to be 374,358 Gcal/y.

Table 2.6.9 Estimation of Total Energy Consumption for Weaving by Shuttle Looms in 1995

No.	Factory Name	Products	Shuttle Looms	Shuttle-less Looms	Capacity	Production in 1995	Fuel Consumption Kind	Fuel Consumption Quantity	Fuel Consumption	Fuel Consumption	Electricity Consumption Quantity	Electricity Consumption	Electricity Consumption	Energy Consumption
	<Weaving by Shuttle Looms>				(km/y)	(km/y)			(Gcal/y)	(Mcal/km)	(MWh/y)	(Gcal/y)	(Mcal/km)	(Mcal/km)
1	Azar	Cot. F.	250		3,200	1,700	Fuel Oil	90	882	519	1,200	2,700	1,588	2,107
2	Atlas Baft	Cot.& PE. F.	128		4,000	1,500	Gas Oil	684	6,293	4,195				
							Fuel Oil	192	1,882	1,254	6,169	13,880	9,254	14,703
4	Ettemadieh Boushehr	Cot/PE.Ya & Grey F.	300		9,000	3,500	Gas Oil	185	1,702	486	3,088	6,948	1,985	2,471
11	Brezent Iran	Tarpaulin	32		3,200	1,800	Fuel Oil	616	6,037	3,354	4,364	9,819	5,455	8,809
12	Bafteh Mazandaran	Grey F.	96		2,500	1,500	Gas Oil	168	1,546	1,030	628	1,413	942	1,972
14	Tar-e-Esfahan	Cot.& Syn.F.	50		1,200	500								
15	Khazar Weaving	Grey F.	60		1,200	700								
17	Mohammad Sadegh	Grey F.	35		400	250	Gas Oil	10	92	368	130	293	1,170	1,538
	Khojasteh Weaving	Cot.& PE. F.												
18	Shiraz Weaving	Grey F.	296		6,500	3,500								
26	Chit Behshahr	Cot.& Syn.F.	978		25,000	6,000								
30	Zayandeh Roud	Cot. F.	312		10,000	3,200								
32	Sa-adat Nassajan Yazd	Cot.& Syn.F.	490		18,000	11,000	Fuel Oil	2	20	2	8,468	19,053	1,732	1,734
33	Silkbaf Yazd	Grey F.	500		15,000	9,500	Fuel Oil	1,700	16,660	1,754	11,000	24,750	2,605	4,359
35	Shahreza-ye-Jadid	Cot.& Syn.F.	400		8,000	3,200	Gas Oil	36	331	104				
							Natural Gas	900	8,820	2,756	850	1,913	598	3,457
37	Jahan Industrial	Cot.& Syn.F.	655		25,000	15,000	Gas Oil	4,384	25,760	1,717	2,800	6,300	420	2,137
45	Najaf Abad	Cot.& Syn.F.	810		22,000	11,500	Fuel Oil	30	294	26	10,232	23,022	2,002	2,027
46	Nakh kar	Cot.& Syn.F.	100		2,500	1,600	Gas Oil	1,150	10,580	6,613				
							Fuel Oil	1,000	9,800	6,125	3,072	6,912	4,320	17,058
50	Pars Tehran Textile	Cot.& PE. F.	400		10,000	1,500								
52	Ghaemshahr Textile	Cot.& Syn.F.	580		19,000	8,000	Fuel Oil	4,200	41,160	5,145	4,280	9,630	1,204	6,349
54	Mazandaran Textile	Cot.& Syn.F.	1,121		40,000	16,000								
	Sub-total				131,800	70,050			131,858	1,882	56,281	126,632	1,808	3,690
	Total		7,593		225,700	101,450			190,963		81,509	183,395		

Note : Unit of Fuel Consumption for Quantity :

Natural Gas	kNm^3/y
Gas Oil	kl/y
Fuel Oil	kl/y

Source : Association of Iran Textile Industries

b. Factories using shuttleless loom

There are 12 weaving factories using only shuttleless looms such as rapier loom, and air jet loom, projectile loom. A total of 927 sets of shuttleless loom are operating, and produced 47,100-km of cotton cloth and chemical fiber cloth in 1995.

Among these factories, the energy consumption of seven could be grasped. To estimate the energy consumption of all 12 factories from the actual value of seven factories, production capacity and results are shown in Table 2.6.10.

The weighted average of the energy intensity for the seven factories is 5,854 kcal/m.

As a result, the total energy consumption of this group in 1955 was estimated to be 275,746 Gcal/y.

c. Factories using shuttle loom and shuttleless loom

There are 18 weaving factories using shuttle looms and shuttleless looms such as rapier loom, air jet loom, and projectile loom,. A total of 10,989 sets of shuttle loom and 1,486 set shuttleless loom are operating, and produced 20,450-km of cotton cloth and chemical fiber cloth in 1995.

Among these factories, the energy consumption of 10 factories could be grasped. To estimate the energy consumption of all 18 factories from the actual value of 10 factories, production capacity and results are also shown in Table 2.6.11.

The weighted average of the energy intensity for the 10 factories is 12,778 kcal/m.

As a result, the total energy consumption of this group in 1955 was estimated to be 2,586,963 Gcal/y.

d. Unknown factories

There are eight weaving factories whose weaving machine is unknown. A total of 955 sets of weaving machines are operating, and produced 21,000-km of cotton cloth and chemical fiber cloth in 1995.

Among these factories, the energy consumption in of three factories could be grasped. To estimate the energy consumption of the all eight factories from the actual value of three factories, production capacity and the results are shown in Table 2.6.12.

The weighted average of the energy intensity for 3 factories is 3,615 kcal/m.

As a result, the total energy consumption of this group in 1955 was estimated to be 75,919 Gcal/y.

Totaling the estimation results of the four groups, the present energy consumption at the 58 factories is 3,312,986 Gcal/y.

Table 2.6.10 Estimation of Total Energy Consumption for Weaving by Shuttleless Looms in 1995

	Factory Name	Products	Shuttle Looms	Shuttle-less Looms	Capacity	Production in 1995	Fuel Consumption				Electricity Consumption			Energy Consumption
							Kind	Quantity			Quantity			
					(km/y)	(km/y)			(Gcal/y)	(Mcal/km)	(MWh/y)	(Gcal/y)	(Mcal/km)	(Mcal/km)
	<Weaving by Shuttleless Looms>													
5	Iran poplin	Cot.& Syn.F.		Proj 255	20,000	14,500	Fuel Oil	–	0	0	28,000	63,000	4,345	4,345
				Mali 4										
7	Baresh	Cot.& PE. F.		Air 50	21,000	11,000	Fuel Oil	2,260	22,148	2,013	7,052	15,867	1,442	3,456
10	Baft Harir Semnan	Cot.& PE. F.		Air 96	3,200	2,800	Fuel Oil	1,200	11,760	4,200	600	1,350	482	4,682
21	Zarpood Weaving	Grey F.		Air 44	2,000	1,100								
22	Joulabaf	Grey F.		Mali 4	900	200	Gas Oil	40	368	1,840	155	349	1,744	3,584
31	Zarran Weaving	Cot.& PE. F.		Rapi 36	1,500	450								
38	Sanaye Chahr Mehal-Bakhtiari	Grey F.		Air 26	1,200	400								
39	Kosar Baft	Grey F.		Rapi 30	2,500	1,100								
				Proj 12										
43	Mahbaf Weaving	Grey F.		Rapi 66	5,000	2,100	Fuel Oil	282	2,764	1,316	1,997	4,493	2,140	3,456
47	Ardakan Textile	Cot.& Syn.F.		Proj 124	10,000	4,000								
49	Boroujerd Textile	Cot.& PE. F.		Proj 128	10,000	8,850	Fuel Oil	6,311	61,848	6,988	20,676	46,521	5,257	12,245
56	Khoub Kar Textile	Grey F.		Air 40	1,750	600	Gas Oil	50	460	767				
		Cot.& Syn.F.		Proj 12			Fuel Oil	150	1,470	2,450	922	2,075	3,458	6,674
	Sub-total				61,850	40,050			100,817	2,517	59,402	133,655	3,337	5,854
	Total			927	79,050	47,100			118,564		69,859	157,182		

Note : Unit of Fuel Consumption for Quantity ;

Natural Gas	kNm^3/y
Gas Oil	kl/y
Fuel Oil	kl/y

Abbreviation of Shuttleless Looms ;

Rapi : Rapier	(Total 132)
Air : Air Jet	(Total 256)
Proj : Projectile	(Total 531)
Mali : Malimo	(Total 8)

Source : Association of Iran Textile Industries

Table 2.6.11 Estimation of Total Energy Consumption for Weaving by Shuttle & Shuttleless Looms in 1995

Factory Name	Products	Shuttle Looms	Shuttle-less Looms	Capacity	Production in 1995	Fuel Consumption Kind	Fuel Consumption Quantity			Electricity Consumption Quantity			Energy Consumption
				(km/y)	(km/y)			(Gcal/y)	(Mcal/km)	(MWh/y)	(Gcal/y)	(Mcal/km)	(Mcal/km)
<Weaving by Shuttle & Shuttleless Looms>													
8 Bafkar	Cot.& Syn.F.	491	Proj 153	28,000	12,500								
9 Bafnaz	Cot.& PE. F.	833	Air 50	29,000	10,000								
16 Semnan Weaving	Grey F.	32	Rapi 25	1,000	600								
19 Pakris	Grey F.	1000	Rapi 20	24,000	18,500	Gas Oil	2,763	25,420	1,374				
			Proj 10			Fuel Oil	2,529	24,784	1,340	31,580	71,055	3,841	6,555
20 Pileh	Cot.& Syn.F.	60	Proj 28	3,000	1,950	Gas Oil	1,317	12,116	6,214				
						Fuel Oil	1,768	17,326	8,885	5,483	12,337	6,327	21,425
23 Heydar Esfahan Weaving	Grey F.	45	Rapi 12	2,200	1,000								
25 Jonob Yazd	Cot.& Syn.Y. & F.	48	Rapi 98	5,000	3,500	Fuel Oil	1,711	16,768	4,791	3,894	8,762	2,503	7,294
27 Ray Spinning & Weaving	Cot.& PE. F.	1171	Rapi 150	40,000	18,500	Gas Oil	2,500	23,000	1,243				
			Air 150			Fuel Oil	65	637	34	22,787	51,271	2,771	4,049
28 Khosravi Khorasan	Grey F.	141	Proj 64	4,500	1,400								
29 Kashan Spinning & Weaving	Cot.& Syn.F.	1240	Rapi 156	40,000	18,000	Natural Gas	19,000	186,200	10,344	58,000	130,500	7,250	17,594
34 Simin Esfahan	Cot.& Syn.F.	693	Rapi 30	18,000	10,000	Gas Oil	1,500	165,600	16,560	18,000	40,500	4,050	20,610
36 Sanaye Poshesh Iran	Towel,Denim, Velvet Velvet, Garments	578	Rapi 2	20,000	6,800								
40 Fakhr-e-Iran	Cot.& Syn.F.	728	Proj 30	28,000	16,500	Gas Oil	2,485	22,862	1,386	13,592	30,582	1,853	3,239
41 Faragiur Baft-Balouch	Cot.& PE. F.	643	Rapi 7	28,500	11,500								
			Proj 18										
42 Kashan Velvet & Rayon M.	Cot.& Syn.F.	726	Rapi 73	24,000	9,000	Gas Oil	1,860	17,112	2,333	I 7,378			
					Y 1,290 t	Fuel Oil	1,250	12,250	170	P 18,476			
					C 7,334Mm	Natural Gas	6,943	68,041	9,278	18,476	41,571	5,668	15,116
44 Momtaz	Cot.& Syn.F.	1021	Rapi 18	30,000	11,000								
			Proj 12										
51 Tejarat Textile	Cot.& PE. F.	230	Rapi 20	6,700	4,200	Fuel Oil	1,850	18,130	4,317	3,455	7,774	1,851	6,168
55 Yazd Baf	Cot.& Syn.F.	1309	Proj 360	50,000	47,500	Gas Oil	370	3,404	72				
						Fuel Oil	78,200	766,360	16,134	49,934	112,352	2,365	18,571
Sub-total				238,700	147,650			1,380,011	9,347	225,201	506,702	3,432	12,778
Total		10,989	1,486	381,900	202,450			1,892,199		308,784	694,764		

Note : Unit of Fuel Consumption for Quantity ;

Natural Gas	kNm³/y	Total No. of Shuttleless Looms ;				1,486
Gas Oil	kl/y	Rapier	611	Projectile		675
Fuel Oil	kl/y	Air Jet	200			

Source : Association of Iran Textile Industries

Table 2.6.12 Estimation of Total Energy Consumption for Weaving by Unknown Machines in 1995

Factory Name	Products	No. of Machines	Capacity	Production in 1995	Fuel Consumption Kind	Fuel Consumption Quantity			Electricity Consumption Quantity			Energy Consumption
<Weaving by unknown machines>			(km/y)	(km/y)			(Gcal/y)	(Mcal/km)	(MWh/y)	(Gcal/y)	(Mcal/km)	(Mcal/km)
3 Abbar Brezent	Tarpaulin	24	2,300	1,000	Gas Oil	63	580	580				
					Fuel Oil	134	1,313	1,313	1,679	3,778	3,778	5,671
6 Iran Nou Baft Production	Cot.& PE. F.	11	1,200	700								
13 Foumenat	Cot.& Syn.F.	296	9,000	6,500								
24 Rangin Baft	Grey F.	220	6,000	2,500								
48 Ekbatan Textile	Cot.& Syn.F.	44	4,500	3,000	Fuel Oil	441	4,322	1,441	2,100	4,725	1,575	3,016
53 Nasaji Kordestan	Grey F.	280	10,000	5,800								
57 Kerman Textile	Grey F.	30	1,200	500	Gas Oil	105	966	1,932	260	585	1,170	3,102
58 Ali Tex. & Chem.	Cot.& Syn.F.	50	2,200	1,000								
Sub-total			8,000	4,500			7,181	1,596	4,039	9,088	2,020	3,615
Total		955	36,400	21,000			33,509		18,849	42,410		

Note : Unit of Fuel Consumption for Quantity ;

Natural Gas	kNm^3/y
Gas Oil	kl/y
Fuel Oil	kl/y

Source : Association of Iran Textile Industries

(4) Dyeing, Printing, and Finishing

The scale of the facilities and the production of the 12 dyeing, printing, and finishing factories, which were surveyed in this study, are shown in Table 2.6.3. The total production of the 12 companies in 1995 is 61,250 km/y.
Among these factories, the energy consumption of five factories could be grasped. To estimate the energy consumption of the whole 12 factories from the actual value of five factories, production capacity and results are shown in Table 2.6.13.

The weighted average of the energy intensity for the five factories is 2,865 kcal/m.
As a result, the total energy consumption of this group in 1955 was estimated to be 175,511 Gcal/y.

Totaling the estimation results of the four categories, present energy consumption of the whole textile industry was estimated to be 5,617,942 Gcal/y in 1995, as shown in Table 2.6.14.

Table 2.6.13 Estimation of Total Energy Consumption for Dyeing, Printing, & Finishing in 1995

Factory Name	Products	Capacity	Production in 1995	Fuel Consumption Kind	Fuel Consumption Quantity			Electricity Consumption Quantity			Energy Consumption
<Dyeing, Printing, Finishing>		(km/y)	(km/y)			(Gcal/y)	(Mcal/Mm)	(MWh/y)	(Gcal/y)	(Mcal/Mm)	(Mcal/Mm)
1 Aba	Finished Fabrics	4,000	750								
2 Akmal	Finished Fabrics	9,000	5,000								
3 Takmil Faraz	Finished Fabrics	1,200	800								
4 Tehran Gol	Finished Fabrics	12,000	5,000								
5 Golesorkh Printing	Finished Fabrics	2,000	1,000								
6 Madbaft Textile	Finished Fabrics	20,000	11,000	Gas Oil	118	1,086	99				
				Fuel Oil	5,017	49,167	4,470	5,241	11,792	1,072	5,640
7 Golbaft Industrial Group	Finished Fabrics	10,000	6,000	Fuel Oil	890	8,722	1,454	1,754	3,947	658	2,111
8 Golriz	Finished Fabrics	16,800	8,700								
9 Moghaddam	Finished Fabrics	5,000	3,000								
10 Nakh Rang	Finished Fabrics	15,000	9,000	Gas Oil	646	5,943	660	874	1,967	219	879
11 Naghshin Yazd	Finished Fabrics	10,000	7,000	Fuel Oil	936	9,173	1,310	438	986	141	1,451
12 Hell	Finished Fabrics	10,000	4,000	Gas Oil	500	4,600	1,150				
				Natural Gas	725	7,105	1,776	683	1,537	384	3,310
Sub-total		65,000	37,000			85,795	2,319	8,990	20,228	547	2,865
Total		115,000	61,250			142,026		14,882	33,485		

Note : Unit of Fuel Consumption for Quantity ;

Natural Gas	kNm^3/y
Gas Oil	kl/y
Fuel Oil	kl/y

Source : Association of Iran Textile Industries

Table 2.6.14 Estimation of Total Energy Consumption for Textile Industry in 1995

Products	No. of Factory	Capacity	Production in 1995	(Unit)	Energy Consumption Gcal/y	Intensity	(Unit)
Synthetic Fiber	3	120,900	100,608	t/y	1,242,655		
Spinning							
Ring	19	38,850	25,369	t/y	352,598	13,899	Mcal/t
Roter Open End	12	20,550	14,535	t/y	182,532	12,558	Mcal/t
Ring & Roter Open End	13	38,700	25,250	t/y	351,660	13,927	Mcal/t
Sub-total	44	98,100	65,154		886,790		
Weaving							
Shuttle Looms	20	225,700	101,450	km/y	374,358	3,690	Mcal/km
Shuttleless Looms	12	79,050	47,100	km/y	275,746	5,854	Mcal/km
Shuttle & Shuttleless Loom	18	381,900	202,450	km/y	2,586,963	12,778	Mcal/km
Unknown	8	36,400	21,000	km/y	75,919	3,615	Mcal/km
Sub-total	58	723,050	372,000		3,312,986		
Dyeing, Printing, & Finishing	12	115,000	61,250	km/y	175,511	2,865	Mcal/km
Total	117	1,057,050	599,012		5,617,942		

2.6.3 Energy Conservation Potential and Cost of Countermeasures

Energy consumption data of the textile industry collected in this study was broken-down into four branches, i.e., synthetic fiber, spinning, weaving, and dyeing and finishing. However, it was difficult to analyze energy consumption because they are macroscopic, and contain neither a detailed breakdown of the product manufacturing process and the energy conversion division, which supplies steam and electricity, nor a detailed breakdown of each kind of energy.
Therefore, energy conservation potential and countermeasures were estimated for each branch of the industry by comparing overall energy intensity of the present situation in I. R. Iran with model values calculated based on the results in Japan.

(1) Synthetic fiber

Energy consumption of synthetic fiber industry generally, depends on differences in the form of raw materials and the product kinds such as the denier, production methods, facilities, and location of the factory, among others.
Because energy consumption is related to process expertise, there are many cases whose details are not clear.
In Japan, 40% of energy conservation was achieved in the last 20 years, and the overall energy intensity of all chemical fibers in 1995 was about 1 kl/t (crude oil equivalent)
Based on this value, energy intensity of each synthetic fiber was estimated considering amount of production, kind of fiber, process characteristics and other factors, as shown in Table 2.6.15.

Table 2.6.15 Estimated Energy Intensity for Synthetic Fiber Production

(in Japan)

Synthetic Fiber	Energy Intensity (Estimated)	
Polyester Filament	8,000 - 10,000	Mcal/t
Polyester Fiber (Staple)	4,000 - 6,000	
Acrylic Fiber (Staple)	9,000 - 11,000	
Nylon 6 Filament	7,000 - 9,000	

Energy intensity of Polyacryl Iran, 10,302 Mcal/t, represents the standard level using present technologies. Polyacryl Iran was established about 20 years ago to introduce the newest facilities of continuous polymerization and direct spinning methods, and has mainly produced products of a fixed gage, including all of domestic production of polyester fiber and acrylic fiber. These facilities function sufficiently at present, especially productivity improvement and high production rate, and help promote energy conservation.

On the other hand, the energy intensity of Aliaf, which manufactures 60% of nylon-6 production in I. R. Iran is 21,805 Mcal/t, more than twice the estimated value in Japan. The scale of the facility seems to have an influence, but the operation rate is very high, exceeding facility capacity.

Energy conservation should be promoted not only for the production process but also for the utility division such as in-house generation facilities.
With reference to the results of the factory audit of Polyacryl Iran, energy conservation measures for nylon-6 factories in I. R. Iran are shown below:

1) Improvement of operation and maintenance management
Energy load on the production facilities and the utility facilities should be calculated and managed based on the process data such as flow rate, pressure, and temperature. In addition, these data should be utilized for evaluating the efficiency of equipment and machinery, as well as optimal operation conditions.
Concerning improvement of utility facilities, in particular, the following items should be checked and acted on:

Gas turbine efficiency for generation of electricity,
Efficiency of waste heat recovery equipment,
Management of compressed air and nitrogen gas,
Reduction of electricity for chiller,
Efficiency improvement of steam and Dowtherm boiler,
Rationalization of water use
Reduction of electricity for water supply and waste water treatment

Energy conservation effect	: 10 % (43,800,000 Mcal/y)	
	N.G.	4,295 * 1,000 Nm^3/y
	Electricity	765 MWh/y
Cost of measure	:	875 M Rials

2) Modification of facility
(Waste heat recovery, Renewal of un-efficient equipment)

Energy conservation effect	: 20 % (87,600,000 Mcal/y)	
	N.G.	8,590 * 1,000 Nm^3/y,
	Electricity	1,530 MWh/y
Cost of measure	:	4,375 M Rials

(2) Spinning

a. Comparison of energy intensity of ring spinning mill
The scale of seven mills excluding two mills with maximum and minimum energy intensities out of nine mills operating solely by the ring spinning method, is about 10,000-30,000sp.
Estimation results of energy intensity based on operation energy for a spinning mill of the same scale are shown as a model value in Table 2.6.16.
The model value includes 23% accounted for by indirect energy consumption such as air-conditioning and lighting as part of total energy consumption.

Table 2.6.16 Energy Consumption of Typical Spinning Factory
(40 S Combed Yarn, 30,000 sp, 8,576 kg/d)

Process	Number of Machines	Operation Hours (h)	Power Consumption (kWh/d)	(kWh/t)	(%)
Blowing	2	17.0	883.7	103.0	3.4
Carding	57	17.0	1,747.3	203.7	6.8
Pre-drawing	4	15.5	185.9	21.7	0.7
Lap Former	5	15.5	203.1	23.7	0.8
Combing	40	15.5	1,805.4	210.5	7.0
Drawing	4 * 2	15.5	342.1	39.9	1.3
Roving	12	15.5	1,212.7	141.4	4.7
Spinning	75	24.0	15,006.2	1,749.8	58.0
Winding	12	21.75	4,160.8	485.2	16.1
Compressor	2	15.5	34.9	4.1	0.1
		21.75	293.6	34.2	1.1
Total			25,875.7	3,017.2 (6,788 Mcal/t)	100.0

Concerning energy intensity, a comparison of the average value of seven mills in I. R. Iran with the model value are shown below.

Average value of seven mills	13,899 Mcal/t		
Model value	8,815 Mcal/t		
		Process facility	6,788 Mcal/t
		Utilities	2,027 Mcal/t

The average value of energy consumption of Iranian ring spinning mills is about 1.58 times that of the model value. one out of two companies which fall below the model value is a spinning mill for spool yarn, and the fall is due to the small energy load of the winding process.

b. Comparison of energy intensity of open end spinning factory

Iranian open end spinning factories are using the rotor type.

The total scale of the seven mills for which energy consumption could be grasped among all of the mills is 13,872 rotors and the weighted average of energy intensity is 12,558 Mcal/t.

It is difficult to accurately analyze and evaluate direct and indirect consumption energy such as energy for operating air-conditioners and lighting equipment on the basis of available data.

Based on energy consumption of a rotor type open-end spinning machine which was developed and announced, the energy intensity of the open-end spinning factory was estimated, and then used for a comparison with those of the seven Iranian open-end spinning mills.

For reference, energy consumption of rotor type open-end spinning machine is shown in Table 2.6.17, in comparison with that of a ring spinning machine.

Table 2.6.17 Energy Intensity of Open End Spinning and Ring Spinning

System	Number of Units/Frame	Spinning Count(s)	Take-up Speed(m/min)	Energy Consumption (kWh/t)	Energy Consumption (Mcal/t)	Remark
Open End Spinning		20	67	1,597	3,593	
	168	30	55	2,919	6,568	Roter : 60,000 rpm
		40	47	4,406	9,914	
Ring Spinning	432	20	14.3	1,156	2,601	Spindle : 11,200 rpm
	400	40	14.9	1,487	3,346	Spindle : 13,500 rpm

Concerning the energy intensity of an open-end spinning mill, a comparison of the average value of seven mills in I. R. Iran with the model value is shown below.
It should be noted that in estimating the energy intensity of a model factory, average spinning gauge of the Iranian products is assumed to be 20 s.

Average value of seven mills factories 12,558 Mcal/t
Model value 7,578 Mcal/t
Process facility 5,551 Mcal/t
(open end spinning machine 3,593 Mcal/t)
Utilities 2,027 Mcal/t

Energy intensity of mills that have comparatively large numbers of spindles is bigger. The reason seems to be that these mills have low production rates compared to the capacity of the facility.

Energy conservation measures for spinning mills in I. R. Iran are shown below.

1) Improvement of operation and maintenance management
   The targeted points for improvement are generally the same as in the case of the synthetic fiber factory. Special points of the spinning factory are shown in Table 2.6.18, as inspection items necessary to maintain the operating conditions of the model factory are shown in Table 2.6.16.

Table 2.6.18 Inspection Items for Energy Conservation at the Spining Factory

Common Items	Special Items for Process
<General>	<Carding>
Adjustment of abnormal machine	Optimum speed of cylinder
Measurement of power of machine	Level up of sliver count
Increase of efficiency with optimum speed	
Adjustment of tension of belt	<Roving>
Adoption of bearing to revolving part	Optimum twist of roving
Efficient use of cleaner	
Efficient use of pneumatic conveyer	<Spinning>
Maintenance and cleaning of apparatus under the most optimum interval	Optimum tension of spindle tape
	Normal revolution of spindles
<Lighting>	Check on quality and quantity of spindle oil
Power Saving	Optimum roller weight
Local control	Small sized package
<Air Conditioner>	
Turn off needless operation	

Because there is a large capacity allowance of facilities in I. R. Iran, low-rotation speed operation of a spinning machine at 13,000 r.p.m is desirable from an energy conservation viewpoint, although the current rotation speed of the machine is unknown. Also, as there seems to be an equipment standstill to adjust production, management of air-conditioners and lighting equipment to cope with the current operation situation should be taken into account.

Energy conservation effect : 10% (88,680,000 Mcal/y)
N.G. 2,586 * 1,000 Nm^3/y
Electricity 28,150 MWh/y
Cost of measure : 770 M Rials

2) Modification of facility (replacement of inefficient equipment)

Desirable energy conservation measures include adoption of energy conservation-type open-end spinning machines. The energy conservation effects of energy conservation-type open-end spinning machines are shown in Table 2.6.19.

The effect and investment cost when 10% of the existing open-end spinning machines, 3,376 rotor, are replaced, are shown below:

Energy conservation effect : Electricity 2,010 MWh/y
Cost for measure : 8,750 M Rials

Table 2.6.19 Estimated Energy Conservation of Energy Saving Type Open End Spinning Machine

Yarn Count	Spinning Speed Roter rpm	Take-up (m/min)	Energy Consumption Conventional Type (kWh)	Save Energy Type (kWh)	Difference (%)	Annual Saving (8,000 h/y) (MWh)
20's	40 * 80,000	100	44.2-46.0	32.2-32.5	25-30	96-108
7's	40 * 80,000	160	49.4-54.4	38.2-38.5	22-30	90-127

Note : Estimated Cost for Energy Saving Type Machine 437.5 M Rial/Frame(168 unit)
1,750 Rials/US$ basis

Source : Producers' Catalogue

(3) Weaving

Estimated example of energy consumption in the weaving factory is shown in Table 2.6.20.

Table 2.6.20 Example of Energy Consumption at the Weaving Factory

Items		Shuttleless Loom (kW)	Shuttle Loom (kW)
Power of Loom/Frame		1.5	
Power of Compressor/Loom		3.7	
Power of Loom/216Frame	(A)	1,123.2	
Lighting(40w/m^2)	(B)	129.6	
Air Condition	(C)	129.6	
Total	(A+B+C)	1,382.4	
Power Consumption(6,000 hour)		8,294,400.0	
Power Intensity	(kw/km)	569 (1,280 Mcal/km)	789 (1,775 Mcal/km)
Woven Fabrics		Polyester Curtain (Warp 20s,24/cm)	
Type of Loom		Air Jet Loom	Loom Winder with Unifil
Reed Space		162 cm	162 cm
Loom Speed		500 rpm	180 rpm
No. of Loom		216 Frame	625 Frame
Output/year		14,580 km	

Source : SENI-GIJYUTU NEWS No.545 p11-18 (1982)

The value derived by multiplying the above estimated value by the revision coefficient 2.8 for the difference from the present operation efficiency, and number of rotations of a loom is assumed to be the standard value.

The model values of energy intensity of weaving machines are shown in Table 2.6.21.

Table 2.6.21 Current Situation of Weaving Machine in I. R. Iran

Type of Loom	No. of Factory	No. of Loom	Production in 1995 (km/y)	Energy Intensity W. Average (Mcal/km)	Energy Intensity Model (Mcal/km)
Shuttle Loom	20	7,593	101,450	3,690	4,970
Shuttleless Loom	12	927	47,100	5,854	3,584
Shuttle Loom &	(A)	10,989			
Shuttleless Loom	18 (B)	1,486	202,450	12,778	
Unknown	8	955	21,000	3,615	
Sub-total	58	21,950	372,000	8,906	

Note : (A) means Number of Shuttle Loom
(B) means Number of Shuttleless Loom
W. Average means weighted average

As shown in Table 2.6.8, the energy consumption of a shuttleless loom is basically less than that of a shuttle loom due to differences in the weft inserting mechanism.
In Iranian weaving factories, the peculiar energy conservation effects of shuttleless looms are not sufficiently utilized, and there is much room for improvement from an energy conservation viewpoint. In I. R. Iran, the transition from using shuttle looms to shuttleless looms is being promoted and the latter now occupies 11.5 % of the total. However, operation efficiency seems to be low. Improving the operation efficiency of shuttleless looms in the Iranian weaving industry is one of the current problems.
Energy consumption of the weaving factory is influenced partly by preparation processes such as sizing, as well as weaving condition.
Because indirect energy consumption is relatively high, more measures such as renewal of obsolete shuttle loom facilities and rationalization of operation environment are desirable.
Most of the factories using shuttleless looms were established long ago (1934 -), and not enough measures were taken to optimize the operating environment. It is thus advisable to improve the operating environment with the introduction of new production management systems. The specific measures for such improvements are as follows:

1) As an overall measure an inspection based on the basic electricity saving items, which is shown in Table 2.6.22,, should be done and weak points improved, if any. Inspection should cover all looms.

Table 2.6.22 General Countermeasure for Energy Conservation at the Weaving Factory

Process/Items	General Countermeasure
Preparation	Thinned-out operation of fans and compressors Shift to multi-cylinder drying system from hot air warping sizer
Weaving	Shift to reasonable loom speed Change to long quiller weft replenishing Thinned-out operation of fans and compressors Adjustment of tension of belt
Lighting	Power saving
Air Conditioner	Turn off needless operation
<Common Items>	
Motor	Inspection and adjustment/exchange of abnormal machine
Machinery load	Adjustment of belt tension Adoption of bearing to revolving parts Cleaning and scheduled maintenance of apparatus Low speed operation for efficiency improvement

Source : SENI-GIJYUTU NEWS No.445 p.26

Assuming the number of shuttle looms requiring improvement is 2,500, or one-fifth of the operation stands, the effects and the costs are shown as follows:

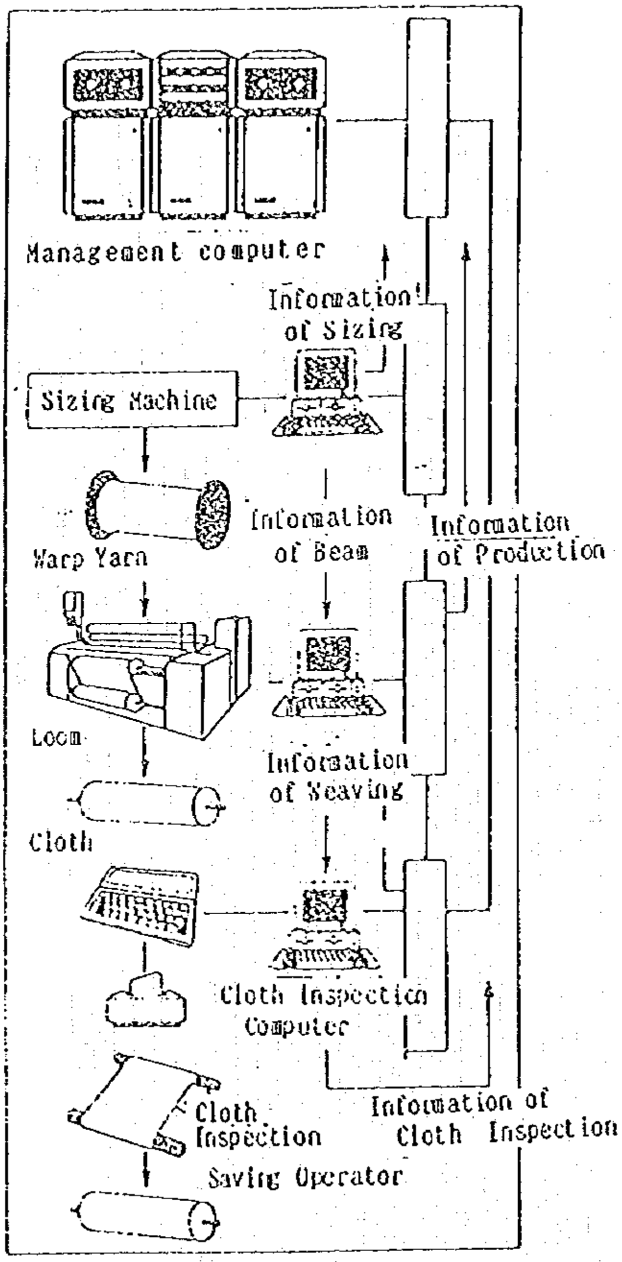
Energy conservation effect : 71,000,000 Mcal/y
Electricity 31,600 MWh/y
Cost of measure : 4,375 M Rials

2) Based on the assumption that the cause of the higher energy intensity of the group using both shuttle looms and shuttleless looms is the complexity of the process and variations in kinds of woven product, reinforcing the main production management system for the weaving process and increase of efficiency should be proposed for six factories having 700 looms, resulting in an energy intensity of more than 7,000 Mcal/km. For this purpose, the establishment of a data base of operation information, maintenance information, weaving length information, etc. and rationalization of transfer and exchange of goods in process including the preparation process should be undertaken.
An example of the production management system using a computer in the weaving factory is shown in Figure 2.6.1.

The effects and the costs of implementation at three factories are as follows.

Energy conservation effect : 382,000,000 Mcal/y
Electricity 170,000 MWh/y
Cost of measure : 5,250 M Rials

Figure 2.6.1 Computer Network for Weaving Factory



Source: Monthly Report of Japan Spinning Association No.581 (1995)

(4) Dyeing, Printing, and Finishing

Because the energy consumption values for dyeing, printing, and finishing factories depend on the composition of products, degree of processing and equipment, among others, it is difficult to calculate energy conservation potential quantitatively using only current energy consumption data.
In this section, by focusing on energy conservation technologies for dyeing, printing, and finishing factories, problems and measures of the dyeing industry are described.
Large facilities and large volumes of water are necessary for dyeing. Energy consumption is thus high and there is much emphasis on the management of energy and environment measures such as electricity, steam, waste water, and exhaust gas.

The basic energy conservation measures currently being implemented in the dyeing industry are:

(1) Reduction of energy consumption through heat management in existing facilities

(2) Improving heat efficiency of facilities.

To illustrate:

a. For the batch dyeing process, an improvement to the liquid fluid dyeing machine is contributing to energy conservation through low bathing ratio and rapid dyeing.
Also, use of vapor phase dyeing, which replaces some of the liquid with vapor, is being implemented.

b. For the printing machine, speeding up the rotary printing machine is underway, and automatic color adjustment, reduction of set time, and reduction of washing water, among others are also being developed.

c. To reduce enormous heat losses, development of a continuous dyeing method which does not need intermediate drying is indispensable. In relation to this technology, development of energy and resource conservation technologies which make reaction dyeing of cotton in the vat possible without using an auxiliary agent or chemicals is progressing.

d. A test dyeing machine is being developed to minimize differences between test dyeing and process dyeing, and ensure reproducibility. Flexible production with short delivery periods is an important consideration for the dyeing industry. Technologies which avoid waste, i.e., with no errors and minimal defective products, are very important from the energy conservation viewpoint, too.
These technologies are useful not just for the above-mentioned purposes but also for establishing optimum technology for dyestuff, chemicals and pH or temperature control, etc.
Dyeing factories which have a decisive influence on the evaluation of products such as apparel, shall have the ability to analyze the dyeing process and cope with needs related to energy and resource conservation, shortening of processing time, etc.

2.6.4 Economic Assessment of Energy Conservation Potential

Assuming that countermeasures for energy conservation potential mentioned in the previous paragraph and reported in the factory audit of Polyacryl Iran and Kashan Velvet are implemented by the year 2000, an economic assessment of potential was made using two cases.

Case 1 : A. E. C. case
Case 2 : E. C. case

The basis of energy prices for each case can be seen in Table 2.1.2, and the Rial vs. the US$ rate is based on the rate in 1993 (1,750 Rial/US$).
The result of the assessment are shown in Table 2.6.23 and Table 2.6.24.

Summarizing the results

Total energy conservation potential of the whole textile industry (excluding the dyeing sector), which are feasible in Case 1 are as follows:

Natural Gas	15,471 * 1,000 Nm^3/y.	
Electricity	232,045 MWh/y	
Total Energy	671,467 Mcal/y	(12.3 %)

(Note) The numerical value in parentheses in the above table is the rate of energy conservation (Estimated value).

As for Case 2, almost the same results as Case 1 can be expected, if the feasibility study is made for a period of 10 years. That is, more than 10% of energy conservation can be expected in either case.

Table 2.6.23 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	Factory	Benefit					Countermeasure Cost		Economic Evaluation	Note
		N.G., F.O. (km3/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 2.6.24 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	Factory	Benefit N.G., F.O. (km^3/y, kl/y)	Benefit Electricity (MWh/y)	Benefit (MRial/y)	Benefit for 3 years (MRial)	Benefit for 10 years (MRial)	Countermeasure Cost (M ¥)	Countermeasure Cost (MRial)	Economic Evaluation	Note
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										

2.7 Food Industry(Sugar Industry)

2.7.1 Outline of Sugar Industry

(1) Trends of Production

Trends of demand and supply, i.e., consumption, production and importing of sugar since 1988 in I. R. Iran are shown in Table 2.7.1.

Table 2.7.1 Demand and Supply of Sugar in I. R. Iran

unit : 1,000 t, crude sugar equivalent

	Consumption	Production			Import	Supply
		Beet	Cane	Total(A)	(B)	(A+B)
1988	1,150	500	225	725	280	1,005
1989	1,000	460	140	600	381	981
1990	1,200	450	170	620	606	1,226
1991	1,400	530	180	710	685	1,395
1992	1,500	755	220	975	736	1,711
1993	1,500	710	225	935	500	1,435
1994	1,600	720	230	950	645	1,595
1995		(672)	(187)			

Note : Figures in ( ) are refined sugar base
Source : Japan's Sugar Refiners Association
Syndicate of Sugar Factories

According to the table, domestic consumption has reached 1,500,000 t/y since 1992, whereas production has not reached 1,000,000 t/y, although it is increasing every year. Meanwhile 500,000 t/y or more comes from imports.
Recent developments in production depend mainly on beet sugar. The production of cane sugar is stable at one quarter or less of the entire domestic production (about 220,000 t/y).
Imported sugar seems to be mostly in the form of crude sugar to be refined at the eight factories in the country.
According to Tehran Times (Sep. 9, 1996), domestic consumption of sugar has reached 1,650,000 t/y, and the rate of domestic supply will improve substantially in the future, because eight projects which contain construction plans for cane sugar factories in Khuzestan state in the southern region, are being undertaken aiming at domestic production of 1,700,000 t/y by the final year of the second five-year plan.

(2) Outline of the factories

There are 41 sugar factories in I. R. Iran at present, and they are classified based on industry status as follows:

a. The beet sugar factory in which the main raw material is beet (31 factories)
b. The cane sugar factory in which the main raw material is cane (2 factories)
c. The refining sugar factory which refines imported crude sugar (4 factories)
d. Combined factory, the above "a" + "c", (4 factories)

Location, production start-up time, production capacity, recent production, and main fuel of these factories are shown in Table 2.7.2.

Factories are generally located near the sources of raw materials. Cane sugar factories are located only in Khouzestan state in the southern region, whereas beet sugar factories are distributed throughout the country.
Operation start-up of all factories was before the revolution. There are some renewed facilities, but details of renewal or improvement of facilities are not clear.
As for the scale of the factories, cane sugar factories are about 10,000 to 20,000 t/d with the capacity base to process raw materials, whereas beet sugar factories are much smaller at 500 to 5,000 t/d.

2.7.2 Present Situation of Energy Consumption

To grasp the present situation of energy consumption at the sugar factories in I. R. Iran, a factory audit of Abkooh Sugar and Karun Agro Industry and an interview survey of Esfahan Sugar were conducted. The energy intensity of the factories is shown in Table 2.7.3.

When comparing two beet sugar factories, the energy intensity of Abkooh Sugar has fluctuated rather wildly and in fact has worsened in last three years. The cause is not clear. Therefore, it is not possible to obtain a representative value of the beet sugar factory. Instead, recent values for Esfahan Sugar should be adopted as representative values of the beet sugar factory.
For cane sugar factories, the recent energy intensity of Karun Agro Industry shall be adopted as the representative value. It should be noted that the energy intensity of the factory in the last three years has also fluctuated with the exact cause not being known.
In case of refining sugar factories, the energy intensity could not be obtained in this survey, but it was decided to estimate it using the value for Varamin Sugar, which was obtained in the survey in 1992.
The sugar factories generally have in-house generation facilities for electricity, because a large volume of steam is needed for the sugar production process. Electricity consumption of the sugar factories consists of both in-house generation and purchased electricity, but it is appropriate that only purchased electricity is used for computing energy consumption to avoid double counting.
For example, in the results for Esfahan Sugar in 1995 the purchased electricity intensity is 404 Mcal/t, whereas the total electricity intensity is 1,328 Mcal/t.
In other words, the substantial electricity consumption is as about 3.3 times that shown in Table 2.7.4.

Table 2.7.2 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	Neishabour 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.

Table 2.7.3 Energy Intensity of the Representative Sugar Factories

Company Name	Production (t/y)	Energy Consumption kind	Quantity		(Gcal/y)	(Mcal/t)
Karun Agro Ind.	(1995) 106,590	Natural Gas	95,796	(M Nm³/y)	938,801	8,808
		Electricity	32,105	(GWh/y)	72,236	678
		Total				9,485
	(1994) 107,000	Natural Gas	66,116	(M Nm³/y)	647,937	6,055
		Electricity	17,602	(GWh/y)	39,605	370
		Total				6,426
	(1993) 93,111	Natural Gas	85,749	(M Nm³/y)	840,340	9,025
		Electricity	25,593	(GWh/y)	57,584	618
		Total				9,644
	(1992) 76,153	Natural Gas	67,863	(M Nm³/y)	665,057	8,733
		Electricity	24,031	(GWh/y)	54,070	710
		Total				9,443
	(1991) 88,145	Natural Gas	56,737	(M Nm³/y)	556,023	6,308
		Electricity	26,948	(GWh/y)	60,633	688
		Total				6,996
Abkooh Sugar	(1995) 23,433	Kerosene		(kl/y)		
		Fuel Oil	2,928	(kl/y)	28,694	1,225
		Natural Gas	19,448	(M Nm³/y)	190,590	8,133
		Electricity	12,723	(GWh/y)	28,627	1,222
		Total				10,580
	(1994) 26,458	Kerosene	2	(kl/y)	20	1
		Gas Oil	78	(kl/y)	718	27
		Natural Gas	21,431	(M Nm³/y)	210,024	7,938
		Electricity	18,000	(GWh/y)	40,500	1,531
		Total				9,497
	(1993) 33,887	Kerosene	3	(kl/y)	27	1
		Gas Oil	140	(kl/y)	1,288	38
		Natural Gas	20,694	(M Nm³/y)	202,801	5,985
		Electricity	16,020	(GWh/y)	36,045	1,064
		Total				7,087
Esfahan Sugar	(1995) 46,298	Coal	1,150	(t/y)	8,280	179
		Fuel Oil	5,375	(kl/y)	52,675	1,138
		Natural Gas	28,828	(M Nm³/y)	282,514	6,102
		Electricity	8,318	(GWh/y)	18,716	404
		Total				7,823
	(1994) 39,076	Coal	900	(t/y)	6,480	166
		Fuel Oil	3,250	(kl/y)	31,850	815
		Natural Gas	26,691	(M Nm³/y)	261,572	6,694
		Electricity	5,563	(GWh/y)	12,517	320
		Total				7,995
	(1993) 27,947	Coal	750	(t/y)	5,400	193
		Fuel Oil	3,150	(kl/y)	30,870	1,105
		Natural Gas	16,534	(M Nm³/y)	162,033	5,798
		Electricity	3,785	(GWh/y)	8,516	305
		Total				7,400

Source : Karun Agro Ind.,Abkooh Sugar, and Esfahan Sugar

Table 2.7.4 Estimation of Total Energy Consumption for Sugar Production

Estimation basis :	Total Production of Sugar in 1995			999,457 t/y	
	Beet Sugar			671,712 t/y	
	Cane Sugar			186,745 t/y	
	Sugar from Refining Factories			141,000 t/y	
	Overall Energy Intensity				
	Beet Sugar	(Esfahan Sugar, 1995)		7,823 Mcal/t	
	Natural gas		78%	6,102 Mcal/t	
	Fuel Oil		15%	1,138 Mcal/t	
	Coal		2%	179 Mcal/t	
	Electric power		5%	404 Mcal/t	
	Cane Sugar	(Karun Agro, 1995)		9,485 Mcal/t	
	Natural gas		93%	8,808 Mcal/t	
	Electric power		7%	678 Mcal/t	
	Refining F.	(Varamin Sugar 1992)		4,238 Mcal/t	
	Fuel Oil		88%	3,747 Mcal/t	
	Electric power		12%	491 Mcal/t	
Energy Consumption	Total Energy			7,624 Tcal/y	
(in 1995)	Natural gas		75%	5,744 Tcal/y	586 M m^3/y
	Fuel Oil		17%	1,293 Tcal/y	132 M kl/y
	Coal		2%	120 Tcal/y	17 MM t/y
	Electric power		6%	467 Tcal/y	208 GWh/y
	Beet Sugar			5,255 Tcal/y	
	Natural gas			4,099 Tcal/y	418 M m^3/y
	Fuel Oil			764 Tcal/y	78 M kl/y
	Coal			120 Tcal/y	17 MM t/y
	Electric power			271 Tcal/y	121 GWh/y
	Cane Sugar			1,771 Tcal/y	
	Natural gas			1,645 Tcal/y	168 M m^3/y
	Electric power			127 Tcal/y	56 GWh/y
	Refining F.			598 Tcal/y	
	Fuel Oil			528 Tcal/y	54 M kl/y
	Electric power			69 Tcal/y	31 GWh/y

2.7.3 Energy Conservation Potential and Cost of Countermeasures

Although the energy consumption data which could be collected this time, as mentioned in the previous paragraph, are actual values for two factories among the beet sugar factories, one factory among cane sugar factories, and one factory among refining factories, respectively, they are only macroscopic, contain no details about facility composition, and no breakdown of energy consumption for the production process and energy conversion section, which supply steam and electricity, so it is difficult to analyze energy consumption.
Energy conservation measures for sugar factories in I. R. Iran, thus are mainly those proposed following the factory audit of one cane sugar factory and one beet sugar factory, and are classified on the basis of facility investment, as shown below.

(1) Improvement of management for operation and maintenance

a. Reduction of boiling time by automatic control of the crystallizing pan

(Karun Cane)	Energy conservation effect	n.g.e	2,594 * 1,000m^3/y
	Cost of measure		525 M Rial
(Abkouh Sugar)	Energy conservation effect	n.g.e	2,217 * 1,000m^3/y
	Cost of measure		350 M Rial

b. Reduction of steam pressure

(Abkouh Sugar)	Energy conservation effect	n.g.e	255 * 1,000m^3/y
	Cost of measure		0 M Rial

c. Turning off unnecessary lights

(Abkouh Sugar)	Energy conservation effect	n.g.e	15 * 1,000m^3/y
	Cost of measure		0 M Rial

d. Improvement of product yield and operation condition

In addition to the above measures, improvement of storage condition of raw materials, diffuser efficiency, pulp dehydration rate, concentration of standard syrup, and others are included.

(All factories)	Energy conservation effect (10%)	n.g.e	58,600 * 1,000m^3/y
		electricity	2,080 MWh/y (1%)
	Cost of measure		7,000 M Rial

(2) Modification of facility

a. Adoption of the softening-type ion exchange resin

(Karun Cane)	Energy conservation effect	n.g.e	4,790 * 1,000m^3/y
	Cost of measure		1,750 M Rial
(Abkouh Sugar)	Energy conservation effect	n.g.e	1,108 * 1,000m^3/y
	Cost of measure		1,750 M Rial
(All factories)	Energy conservation effect	n.g.e	45,000 * 1,000m^3/y
	Cost of measure		70,000 M Rial

b. Adoption of the R-Cl type ion exchange resin

(Karun Cane)	Energy conservation effect	n.g.e	2,874 * 1,000m^3/y
	Cost of measure		3,500 M Rial

c. Heat insulation of the steam pipe

(Abkouh Sugar)	Energy conservation effect	n.g.e	107 * 1,000m ^{3}/y
	Cost of measure		403 M Rial

d. Reduction of natural gas by repairing bagasse boiler

It is assumed that part of the bagasse is used as a raw material for paper and the residuals substitute 60% of natural gas.

(2 Cane Sugar factories)

	Energy conservation effect	n.g.e	100,800 * 1,000m ^{3}/y
	Cost of measure		5,250 M Rial

e. Improvement of crystallization efficiency by installing a stirrer on the crystallizing pan

(All factories)

40 cans	Energy conservation effect	n.g.e	23,300 * 1,000m ^{3}/y
		electricity	- 550 MWh/y
	Cost of measure		13,300 M Rial

f. Waste heat recovery of steam discharged from the crystallization stage

(All factories)

40 cans	Energy conservation effect	n.g.e	2,800 * 1,000m ^{3}/y
	Cost of measure		22,400 M Rial

g. Waste heat recovery of boiler exhaust gas

(All factories)

24 cans	Energy conservation effect	n.g.e	1,680 * 1,000m ^{3}/y
	Cost of measure		29,400 M Rial

Note ; n. g. e Natural gas equivalent

2.7.4 Economic Assessment of Energy Conservation Potential

Assuming that countermeasures for energy conservation potential mentioned in the previous paragraph are implemented by the year 2000, an economic assessment of the potentials was made using two cases.

Case 1 : A. E. C case
Case 2 : E. C. case

The basis of energy prices for each case can be seen in Table 2.1.2, and the Rial vs. US$ rate is based on the rate in 1993 (1,750 Rial/US$).
The result of the assessment is shown in Table 2.7.5 and Table 2.7.6.

According to the assessment, because countermeasures that require modifications in facilities or processes (except for two measures, that is, utilization of bagasse for the boiler fuel as the original design, and crystallization efficiency improvement by installing stirrer on crystallization pan, are not feasible in Case 1, promotion of energy conservation will depend largely on improving operation and maintenance of the facility.
In Case 2, as economic restrictions are further increased, simple measures for energy conservation can not be implemented; for instance, the measure for improving crystallization efficiency by installing a stirrer to the crystallization pan, will not be executed.
On the other hand, some factories are undertaking renewal projects for superannuated facilities. As improved product yield, as well as improved operation and maintenance technology, are expected to accompany facility renewal, energy conservation will be achieved.

Table 2.7.5 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 2.7.6 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									