Country	: Syrian Arab Republic
Project	: Banias Power Station Extension Project
Borrower	: Government of Syrian Arab Republic
Executing Agency	: Public Establishment of Electricity (PEE) PEE was divided into PEEGT and PEDEEE
Date of Loan Agreement	: February 1987
Loan Amount	: ¥27,544 million
Local Currency	: Syrian Pound
Report Date	: March 1998 Field Survey: February 1998)

Distant view of Banias Power Station

［**Reference**］

1.Abbreviations

(Organizations)

SPC .... State Planning Commission
MOE .... Ministry of Electricity
PEE .... Public Establishment for Electricity
PEEGT .... Public Establishment of Electricity Generation and Transmission
PEDEEE......................... Public Establishment for Distribution and Exploitation of Electric Energy

2.Terminology

Peak Demand (Load)
Energy Consumption

(Fuel etc.)

DO .... Diesel Oil
NG .... Natural Gas
HFO .... Heavy Fuel Oil
ST .... Steam Turbine
GT.................................. Gas Turbine
CC.................................. Combined Cycle
HT.................................. Hydro Turbine

1. Project Summary and Comparison of Original Plan and Actual Result

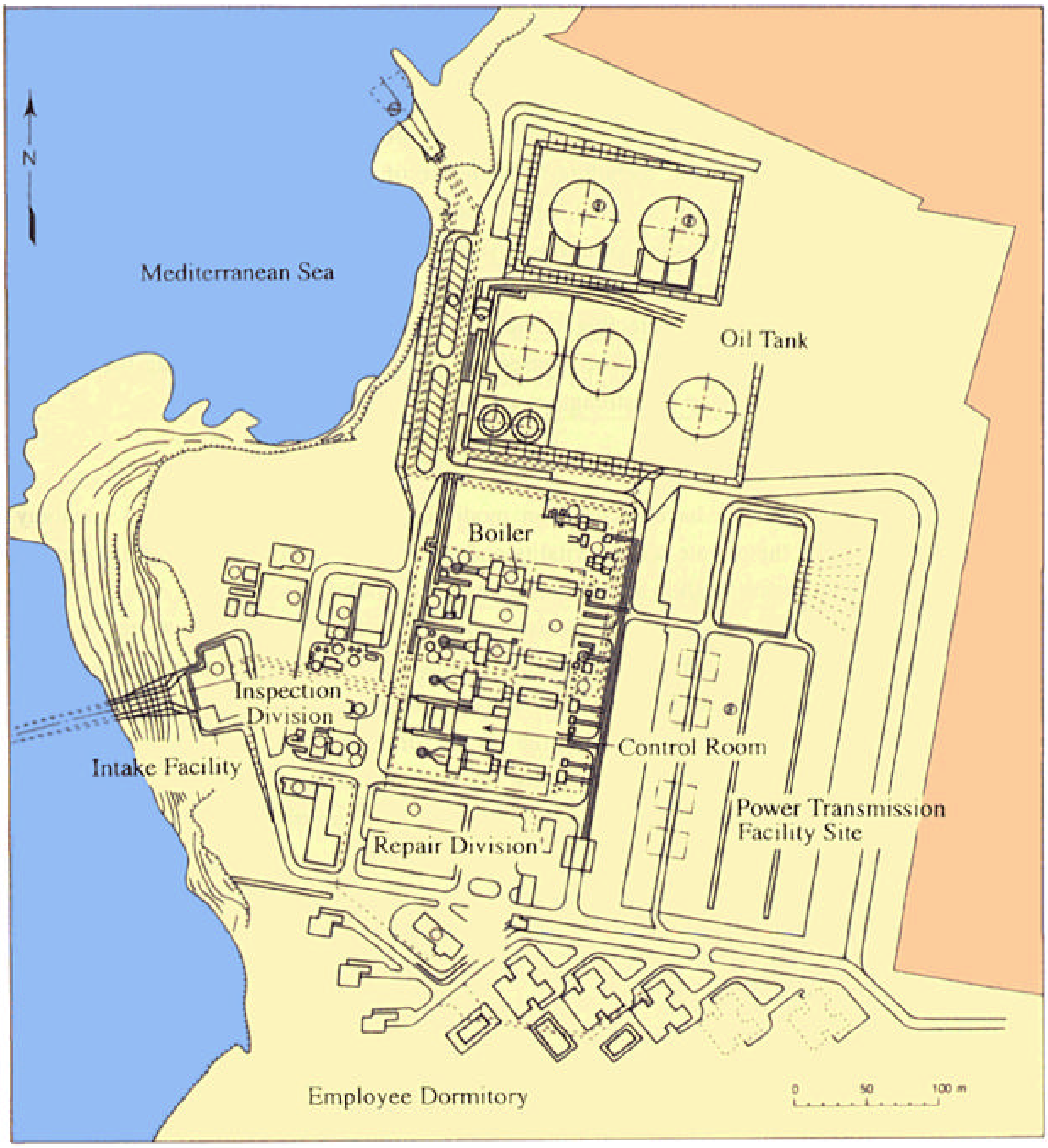
1.1 Pr4oject Location

The project location is in the south of Banias City in the Syrian Arab Republic, located in the coast of the Mediterranean Sea (see following map). This project location was selected for a number of reasons, which include the fact that it is located between Lattakia and Tartus, major cities on the coast of Mediterranean Sea that are consumers of generated electrical power; the fact that fuel (petroleum) can be obtained from the neighboring Banias Refinery; the fact that cooling water can be obtained from the sea; and the fact that soft water for steam production can be obtained from ground water and nearby rivers.

Project Location Map

Layout of Banias Power Station

The Banias Power Station faces the Mediterranean Sea. A building containing four generators is located in the central part of the site, and on the western (sea) side, 4 sets of boilers and stacks are aligned. Between the No. 1 and No. 2 generators, and between the No. 3 and No. 4 generators, there are two control rooms, which are connected to the building of the generators. Glass walls separate the control buildings from the generators, so that the generators can be observed from the control rooms. There are also various facilities between the generators and the sea, including repair shop, hydrogen production facility, water demineralizers, analysis facilities, and intake facilities of cooling water. Petroleum tanks are lined up to the north. On the eastern side, there are power transmission facilities and power transmission towers. In the south of the power station employee dormitories stand close by, but separated by a concrete wall from the power station.



1.2 Project Summary

This project (Banias Power Station Expansion Project) is to double the output capacity of the Banias Power Station (No. 1 and No. 2 generators, with a total capacity of 340 MW), which was completed in 1984 with loans from Arab states including Kuwait and Saudi Arabia (and also the World Bank partly), by adding two more generators (No. 3 and No. 4, with a combined capacity of 340 MW). This project is Syria's first funded by an ODA loan. Following this project, two additional large-scale power stations projects, the Jandar Power Station Project and the Al-Zala Thermal Power Plant Project, also received ODA loans.

1.3 Background

1.3.1 Economic Situation in Syria

(1) Economic Policies

Syria's economic policies have focused on greater use of the private sector's vitality and the introduction of foreign capital, but the private sector still remains small in scale as most large-scale industries. Banking, insurance, and power, still remain state-owned, and tourism and oil development are operated with a combination of national and foreign capital. However, under investment regulations implemented to stimulate the economy, Syria has established policies in the direction of liberalizing the economy, such as allowing the use of foreign capital for the development of agriculture, industry, and transportation, profit tax deductions, and the import of cars and agricultural and industrial equipment owned by Syrians residing abroad.

【Table 1　Outline of Syrian Five-Year Plans】

Five-Year Plan	Planned Investment amount (100 million S￡)	Targeted Growth Rate (Actual) %	Development Points	Remarks
1st (60-65)	27.2	8.0 (8.4)	Primarily economic infrastructure projects including irrigation, land development, transportation, and communications.	Stagnation in Western European loans
2nd (66-70)	56.5	7.7 (3.8)	Primarily economic infrastructure projects including agriculture, irrigation, mining, transportation, and communications	none
3rd (71-75)	80.8	8.2 (13.2)	Mining, power, Euphrates River works, public works projects, and housing, with emphasis on industrial development	Plan stopped temporarily due to Fourth Middle East War, but satisfactory progress marked in latter half. High growth rate of private sector.
4th 76-80)	541.7	12.0 (4.3)	Mining, power, public works projects, and housing, with emphasis on heavy chemicals	none
5th (81-85)	1,014.5	7.7 (2.9)	Emphasis on agricultural development, service industry, and housing	Efforts to complete existing projects. Cautious approach to new projects and target not achieved.
6th (86-90)	1,252.0	7.2 (2.1)	Strengthening of agricultural and power sectors, promotion of oil development	Agriculture and mining initially progressing satisfactorily, but slowdown caused by drought.
7th (91-95)	2,950.0	Approx. 7% (1.5)	Expansion of irrigation, promotion of oil and gas development	

Source:　APIC "Current State of Syrian Economy and Society"
International Development Center: "Basic Survey on Promotion of Direct Loans to Developing Countries--Syria"

【Table 2　Major Economic Indices of Syria】

	1985	1994	1995	1996
GDP (nominal) S￡ (1 billion)	83.2	496.5	552.4	695.2
GDP (real) growth (%)	3.0	7.6	3.6	5.0
Increase rate of consumer price index (%)	17.2	20.0	22.0	20.0
Population (million)	10.3	13.9	14.4	14.9
Export of products (FOB) ($ million)	1,640.0	3,329.0	3,858.0	4,298.0
Import of products (FOB) ($ million)	3,591.0	4,604.0	4,001.0	4,516.0
Balance of payment ($ million)	146.0	-791.0	367.0	285.0
External debt total ($ billion)	24.5	20.6	21.3	22.5
Paid debt service total ($ million)	330.0	398.0	293.0	501.0

Source:　Central Bureau of Statistics, The Economist Intelligence Unit

(2) Movements by Sector

Development strategies by sector of the Seventh Five-Year Plan are as follows.

① Agriculture: Promotion of irrigation and self-sufficiency for food

② Oil and natural gas: Further promotion of oil exploration and active introduction of foreign capital (Al Furat, the state-owned oil company, has signed exploitation contracts with more than 25 foreign corporations and is aggressively promoting oil development). Increase exports of oil and natural gas, for which Syria is achieving satisfactory growth in output, as much as possible to earn foreign currencies.

③ Education: Attempt to increase school attendance.

④ Tourism: Attract large numbers of tourists by developing rich tourism resources.

【Table 3　Gross Domestic Product】

GDP by sector	Composite ratio (%)	
	1985	1996
Agriculture	21.8	20.7
Mining & manufacturing	13.9	28.5
Building & construction	6.8	2.8
Wholesale & retail trade	21.7	18.5
Transport & communications	10.0	11.6
Finance & insurance	5.9	4.7
Governmental Services	17.1	11.7
Social, personal services	2.7	1.5
Total	100.0	100.0

GDP by expenditure	Composite ratio (%)	
	1985	1996
Private consumption	61.5	68.1
Public consumption	24.9	14.3
Fixed capital formation	24.4	15.6
Export of goods & services	11.0	23.1
Import of goods & services	-21.8	-21.1
Total	100.0	100.0

Source:　Central Bureau of Statistics, The Economist Intelligence Unit

(3) Trade

Syria being essentially a self-sufficient agriculture-centered economy (cereals, cotton, etc.) producing handicrafts, its exports consisted principally of handicrafts, food products, and animals. Recently, Syria has actively engaged in oil exploration, with some success, and as a result exports of petroleum and petroleum-derived products are increasing.

Furthermore, there has been a surge in investments for industry, spurring imports of industrial products such as machinery, TVs, and other electric equipment.

【Table 4　Main Exports and Imports】

Main exports	Composite ratio (%)	
	1985	1996
Petroleum, petroleum products	48.5	62.5
Manufacturing products	43.0	16.8
Food, animals	8.5	11.6
Total	100.0	100.0

Main imports	Composite ratio (%)	
	1985	1996
Manufacturing products	53.1	31.8
Machinery, equipment	20.3	31.6
Food, animals	17.1	13.7
Chemical products	9.5	10.2
Others	0.0	12.7
Total	100.0	100.0

Source:　Central Bureau of Statistics, The Economist Intelligence Unit

1.3.2 Power Sector in Syria

(1) State-owned power industry

Syria's power output almost tripled in the 1980s, from 3,720 GWh in 1980 to 9,431 GWh in 1989. The country's power output has continued to increase, and reached 18,328 GWh in 1996 (this figure does not include power generated for self-consumption by hotels, stores, etc.). Electric power supply has been entirely nationalized, with the Ministry of Electricity (MOE) accounting for 13,733 GWh (74.9%), the Ministry of Irrigation for 3,531 GWh (19.3%), and other public sector organizations (private power generation by state-owned refineries, etc.) for 1,064 GWh (5.8%).

Under the supervision of the Ministry of Electricity, the Public Establishment of Electricity (PEE) was responsible for the construction and operation of all power stations in Syria as well as the transmission of their output. However, a presidential order in 1994 split this public power company into two companies, the Public Establishment of Electricity Generation and Transmission (PEEGT) and the Public Establishment for Distribution and Exploitation of Electric Energy (PEDEEE), which have been fulfilling their respective responsibilities up to the present time.

(2) Power output by category

Excluding minor ones, Syria had about 20 major power stations in 1996, including 3 hydraulic power stations and 8 thermal power plants.

As shown in Table 5, power output by category in 1996 was 19.4% hydraulic, 57.6% thermal power, and 23.0% gas turbine. The share of power generation by steam turbine has been declining since 1991, while power generation using natural gas has been rapidly increasing. Hydraulic power stations are limited in their capacity to expand power generation due to restrictions on the quantity of water they are allowed to intake, and as a result they accounted for only 3,550 GWh, or 19.4% of Syria's total power output of 18,328 GWh in 1996. Additional limiting factors are that Syria has only a small amount of precipitation, and Turkey has three large dams upstream of Syria on the Euphrates. As a result, Syria has no alternative but to rely on thermal power plants, which use oil and natural gas, both abundant domestic resources. Natural gas, which has been discovered and developed in Syria from the beginning of the 1990's, is increasingly being used for power generation, so that a greater proportion of oil, which brings in foreign currency earnings, can be exported. And Syria has the policy of maximizing use of natural gas or a combination of heavy oil and natural gas for power generation.

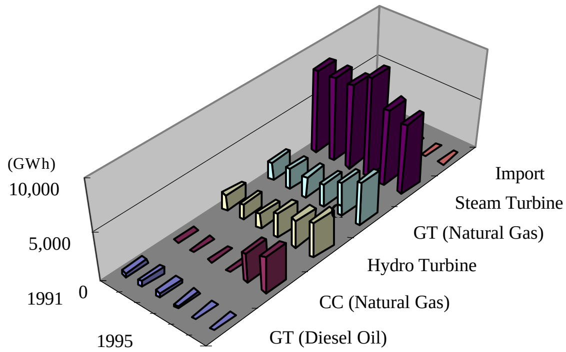
The share of hydraulic power has increased following the completion of the Tishren Dam (600 MW) in 1997. Diesel gas turbines, an uneconomical technology that was used in small power plants, have almost entirely disappeared with the completion of the national power grid. The fact that Syria, which used to import electric power, became a net exporter of electric power from 1995, although by a small amount, is worthy of mention.

【Table 5　 Power Output by Category (Including Others than MOE) 】

(GWh, %)

	1991	Composite Ratio	1992	Composite Ratio	1993	Composite Ratio	1994	Composite Ratio	1995	Composite Ratio	1996	Composite Ratio
GT (Diesel Oil)	410	3.4	585	4.7	503	4.0	212	1.4	19	0.1	9	0.0
CC (Natural Gas)	0	0.0	0	0.0	0	0.0	0	0.0	2,919	17.6	3,555	19.4
Hydro Turbine	1,590	13.0	1,502	12.0	1,538	12.1	2,459	16.5	2,800	16.8	3,550	19.4
GT (Natural Gas)	1,854	15.2	2,051	16.3	2,123	16.7	2,272	15.3	3,304	19.9	4,222	23.0
Steam Turbine	8,372	68.5	8,350	66.5	8,469	66.8	9,937	66.8	7,578	45.6	6,992	38.1
Import	0	0.0	67	0.5	45	0.4	0	0.0	0	0.0	0	0.0
Total	12,226	100.0	12,555	100.0	12,678	100.0	14,880	100.0	16,620	100.0	18,328	100.0

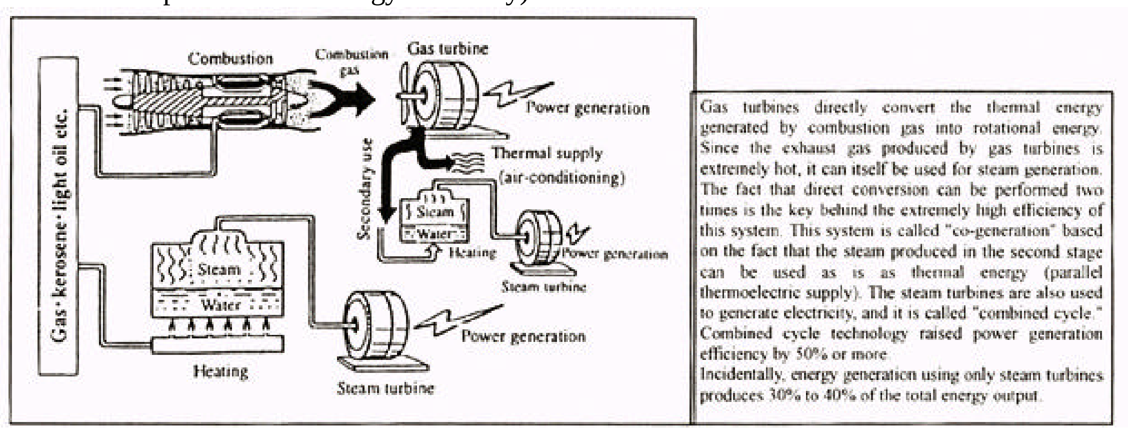
(Source) Ministry of Electricity: "Technical Statistics Report 1996"



【Figure 1　 Power Output by Category】

(3) Major power stations in Syria

Syria's main power stations, as indicated in Table 6, will have a power generation capacity of 7,248 MW in 1999 when they are all completed (the above figure does not include the considerable capacity of refineries). The electric power produced by these power stations will be transmitted to all parts of the country through Syria's power grid. Moreover, Syria plans to raise power generation efficiency by introducing more sophisticated generating equipment such as the combined cycle power generation facilities that can be seen at the Jandar Power Station (which produce steam with the exhaust gas generated by gas power generators, which is then used to generate power, yielding a remarkable improvement in energy efficiency).



Source:　Kazuma Yamane: "The Age of the Metal Collar" 2, Shogakukan Bunko

【Figure 2　 Conceptual Diagram of Co-Generation Power Generation】

【Table 6　Major Power Stations in Syria】

	Name of Power Station	Type	Kinds of fuel	Year of operation	Rated output (MW)	Real output (MW)	Remarks
1	Gas Tribune (small-scale)	GT	DO	1975/76	280		
2	Hydraulic power	HT	-		21		
3	Thawra	HT	-	1974/77	8000	450	
4	Qatineh	ST ST ST ST	HFO HFO HFO HFO	1969 1969 1969 1980	30 30 30 64	24 24 17 55	
5	Mehardeh	ST ST ST ST GT	HFO/NG HFO/NG HFO/NG HFO/NG DO	1980 1980 1987 1988 1988	150 150 165 165 30	135 134 156 157 30	A major thermal power plant, but with declining output due to maintenance problems
6	Banias	ST ST ST ST GT	HFO HFO HFO HFO DO	1982 1983 1988 1989 1989	170 170 170 170 30	150 150 160 160 30	No. 1 and No. 2 generators were financed by Kuwait and Saudi Arabia. No-3 and No-4 were by ODA loans.
7	Baath	HT	-	1988	75	19	
8	Swedieh (SPC)	GT	NG	1988/89	175	150	
9	Tayem	GT	NG	1989/90	105	90	
10	Homs Refinery	ST	HFO/NG		64	57	
11	Banias Refinery	ST	HFO		48	42	
12	Swedieh	GT	NG		120		
13	Tishren (thermal power)	ST ST GT GT	HFO HFO NG NG	1993 1994 1994 1994	200 200 100 100	200 200 100 100	
14	Al-Nasrie	GT GT GT	NG NG NG	1995 1995 1995	100 100 100	100 100 100	
15	Jandar	GT GT GT GT ST ST	NG NG NG NG HFO HFO	1994 1994 1995 1995 1995 1995	100 100 100 100 100 100	100 100 100 100 100 100	By ODA loans
16	Zezon	GT GT GT	NG NG NG	1996 1996 1996	100 100 100	100 100 100	
17	Aleppo	ST ST ST ST ST	HFO HFO HFO HFO HFO	1997 1997 1997 1998 1998	200 200 200 200 200	200 200 200 200 200	Financed by Saudi Arabia
18	Tishren Dam (hydraulic power)	HT HT HT HT HT HT	- - - - - -	1997 1997 1997 1997 1998 1998	106 106 106 106 106 106	100 100 100 100 100 100	
19	Al-Zala	ST ST	HFO HFO	1999 1999	300 300	300 300	By ODA loans
					7,248	6,190	

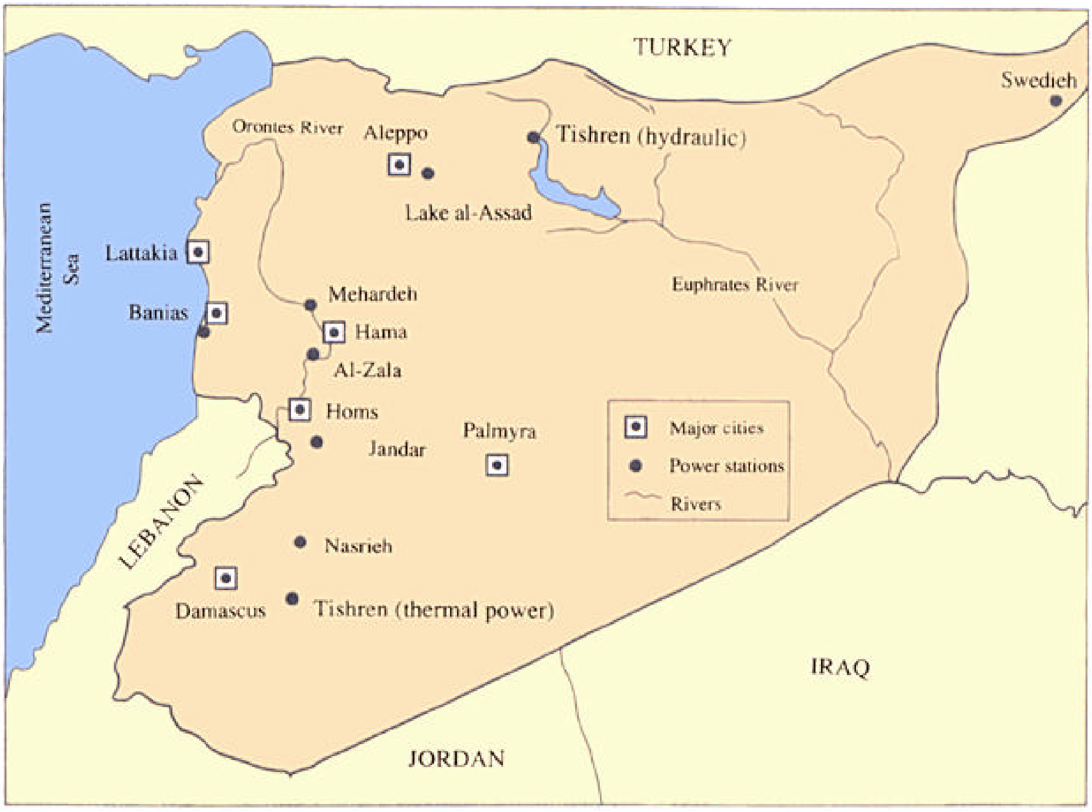
Source:　MOE/PEE

Note 1:　HT = Hydraulic Turbine, ST = Steam Turbine, GT = Gas Turbine

Note 2:　HFO = Heavy Fuel Oil, DO= Diesel Oil, NG = Natural Gas

Note 3:　Power output capacity Refined achieved with ODA loan is 1,570 MW, or 21.7% of total output capacity.

Syria's large power stations are located near major cities, such as the Banias Power Station on the Mediterranean Sea coast, the Nasrie and Tishren Thermal Power Plants on the outskirts of Damascus, the capital, the Jandar and Mehardeh Thermal Power Plants near Hama and Homs in central part of Syria, and the Aleppo Thermal Power Plant in the vicinity of the city of Aleppo. Moreover, the majority of power stations are located along the Orontes and Euphrates Rivers, which is self-explanatory in the case of hydroelectric power stations, and due to the fact that thermoelectric power stations also required vast amounts of cooling water. Power stations in locations where water intake is problematic, like the Jandar Power Station, employ combined cycle power generation and air cooling system instead of water cooling system.



【Figure 3　 Map of Syrian Power Stations (1996) 】

(4) Changes in output capacity of major power stations (under jurisdiction of PEEGT)

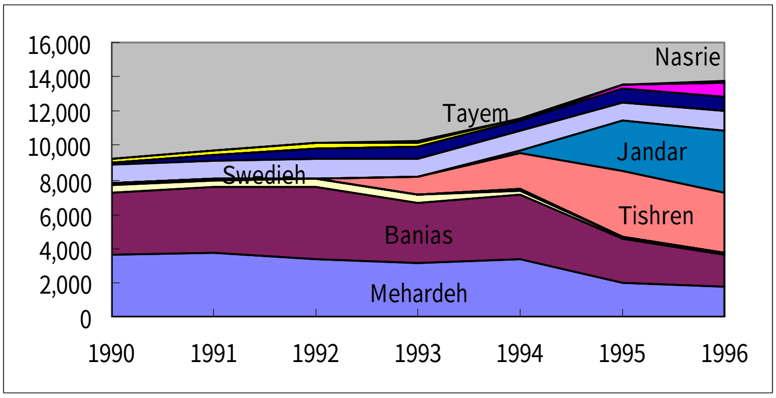
A look at the changes in output capacity of the power stations over which the PEEGT has jurisdiction since 1990 shows that the Mehardeh and Banias Power Stations were the main power stations in 1992-93. Thereafter, the completion and operation of the Tishren and Jandar Power Stations, the number of leading power stations rose to four. Although the output capacity of the Mehardeh and Banias Power Stations is declining due to aging facilities, the Aleppo and Al-Zala Power Stations will greatly improve Syria's power production when they start operating (discussed later).

【Table 7　Output Capacity of Major Power Stations Under PEEGT Jurisdiction】

(GWh)

Name of Power Station		1990	1991	1992	1993	1994	1995	1996
Mehardeh	Thermal	3,568	3,579	3,188	2,942	3,306	2,022	1,739
	G/T	92	115	155	179	97	2	0
	Sub-total	3,660	3,694	3,343	3,121	3,403	2,024	1,739
Banias	Thermal	3,525	3,765	4,080	3,554	3,761	2,485	1,849
	G/T	81	111	154	37	0	0	0
	Sub-total	3,606	3,876	4,234	3,591	3,761	2,485	1,849
Qatineh		484	407	489	417	233	182	109
Hama		52	36	20	30	27	12	4
Ain Arutaru		36	23	0	0	0	0	0
Tishren	Thermal	0	0	0	1,013	2,134	3,051	2,737
	G/T	0	0	0	0	34	762	858
	Sub-total	0	0	0	1,013	2,168	3,813	3,595
Jandar	Thermal	0	0	0	0	153	2,508	3,555
	G/T	0	0	0	0	0	411	0
	Sub-total	0	0	0	0	153	2,919	3,555
Swedieh		1,091	1,023	1,102	1,076	1,074	1,106	1,201
Tayem		69	415	660	637	632	823	751
Nasrie		0	0	0	0	0	133	902
Local G/T		210	181	273	284	112	14	9
Seasonal hydraulic power generation		9	16	62	54	38	34	19
Total		9,217	9,671	10,183	10,223	11,601	13,545	13,733

Source: PEEGT



【Figure 4　Output Capacity of Major Power Stations Under PEEGT Jurisdiction】

1.3.3 Electric Power Demand in Syria

(1) Electric power demand

Population of Syrian Arab Republic grew 1.7 times from 1980 to 1996, from 8.704 million to 14.759 million. With a very high average annual population growth rate of 3.5% accompanied by rapidly growing electric power demand as the country enjoyed rapid economic growth, Syria has been experiencing chronic shortages of electric power. Fortunately, Syria is self-sufficient in oil and natural gas, and the Ministry of Electricity (MOE) is actively working to expand the country's power output capacity.

(2) Growth in electric power demand and electric power consumption per capita

Syria's electric power demand, as shown in Table 8, grew 2.24 times from 1980 to 1985, from 3,637 GWh to 8,132 GWh, 1.41 times from 1985 to 1990, to 11,475 GWh, 1.45 times from 1990 to 1995, to 16,500 GWh, and it is predicted to grow again 1.51 times from 1995 to the year 2000, to 24,500 GWh.

In response, the Syrian government is actively promoting the construction of power stations helped by overseas financial support. Already four large-scale power stations project have been completed or are near completion: Three projects funded by the OECF, the Banias project (340-MW capacity increase, this project), the Jandar project (600 MW, the facilities completed with worker training under way as of November 1995), the Al-Zala project (600 MW, order received, foundation work currently in progress, to be completed in1998-1999); and one project funded by Saudi Arabia, the Aleppo project (1,000 MW, under construction, to be completed in 1997-1998).

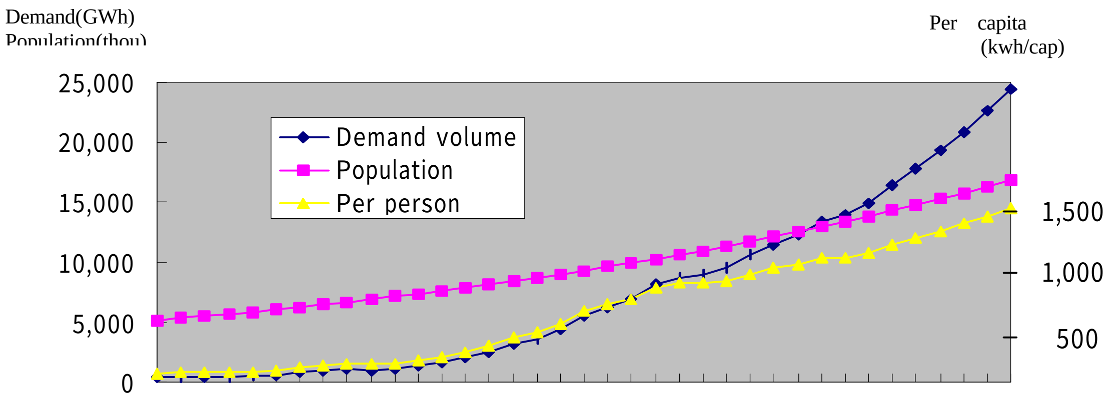
(3) Electric power demand projections

Electric power demand projections should be considered in terms of short-term demand (1 to 5 years), medium-term demand (5 to 10 years), and long-term demand (10 years and more). The MOE and PEE have forecasted the demand, as shown in Table 8 and Figure 5. The chronic shortage of electric power will be overcome in 1998 through the active construction of power stations by the government, and supply and demand are predicted to balance each other for some time. However, demand is also predicted to continue growing at a fast rate, and thus more power stations will need to be built.

【Table 8　Electric Power Demand in Syria】

	Facility capacity (MW)	Power generating volume (Peak Mw)	Demand volume (GWh)	Population (1000pms.)	Per capita (KWh/Cap)	
1964	0	0	370	5,154	72	
1965	171	0	415	5,325	78	
1966	180	0	443	5,500	81	
1967	175	0	450	5,680	79	
1968	173	0	498	5,866	85	
1969	264	0	593	6,059	98	
1970	267	174	777	6,257	124	
1971	164	175	914	6,467	141	
1972	285	190	1,051	6,684	157	
1973	274	192	1,010	6,908	146	
1974	675	255	1,132	7,140	159	
1975	755	292	1,353	7,380	183	
1976	984	302	1,628	7,627	213	
1977	1,134	390	2,009	7,883	255	
1978	1,502	511	2,440	8,148	299	
1979	1,673	635	3,114	8,421	370	
1980	1,715	770	3,637	8,704	418	
1981	1,710	876	4,378	9,046	484	
1982	1,875	1,090	5,515	9,298	593	
1983	2,040	1,132	6,219	9,611	647	
1984	2,047	1,318	6,855	9,934	690	
1985	2,047	1,355	8,132	10,267	792	
1986	2,047	1,294	8,747	10,612	824	
1987	2,556	1,430	9,034	10,969	824	
1988	3,074	1,648	9,485	11,338	837	
1989	3,194	1,870	10,597	11,719	904	
1990	3,268	1,928	11,475	12,116	947	
1991	3,268	2,028	12,331	12,529	984	
1992	3,243	1,982	13,339	12,958	1,029	
1993	3,443	2,032	13,917	13,393	1,039	
1994	3,843	2,470	14,953	13,844	1,080	
1995	4,325	2,847	16,500	14,315	1,153	
1996	4,625	2,994	17,800	14,759	1,206	Actual
1997	5,325	3,220	19,300	15,290	1,262	Projection
1998	5,925	3,460	20,900	15,802	1,323	
1999	6,735	3,720	22,600	16,332	1,384	
2000	7,155	4,000	24,500	16,879	1,452	
(Scale factor)						
80-85	1.19	1.76	2.24	1.18	1.90	
85-90	1.60	1.42	1.41	1.18	1.20	
90-95	1.32	1.48	1.44	1.18	1.22	
95-2000	1.65	1.40	1.48	1.18	1.26	

Source: PEEGT



【Figure 5　Electric Power Demand in Syria】

(4) Electric power demand by sector

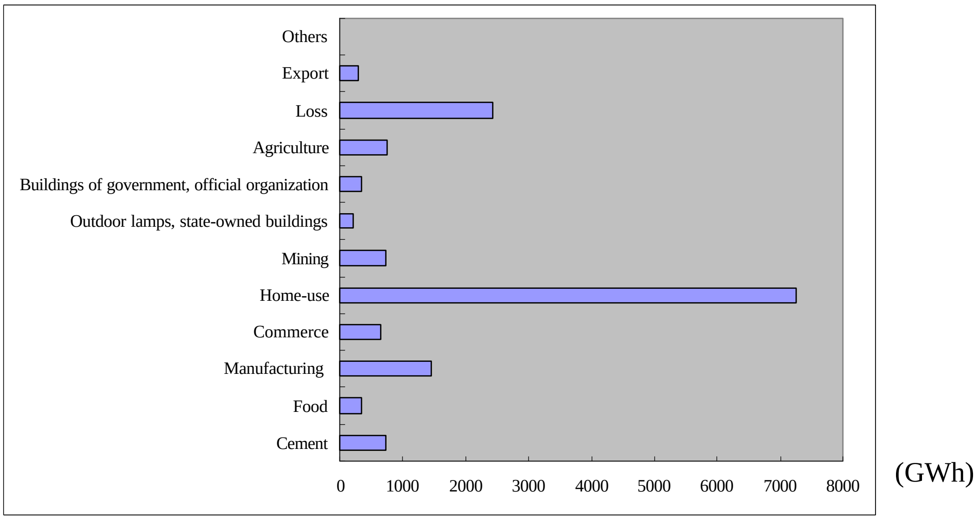
Electric power demand by sector, as shown in Table 9 totaled 15,256 GWh in 1995. House-use demand represents almost half of total demand, while the industrial and commerce sectors account only for about 20% of total consumption.

【Table 9　Electric Power Demand by Sector in Syria】

(GWh, %)

		Electric power consumption (%)	
Industry	Fertilizer	74	0.5
	Cement	734	4.8
	Food	338	2.2
	Manufacturing	1456	9.5
Commerce		642	4.2
Home-use		7259	47.6
Mining		716	4.7
Outdoor lamps, state-owned buildings		218	1.4
Buildings of government, official organization		340	2.2
Agriculture		752	4.9
Loss		2418	15.8
Export		292	1.9
Others		17	0.1
Total		15256	100

Source: PEEGT



【Figure 6　Electric Power Consumption by Sector in Syria】

(5) Changes in daily electric power demand

Daily electric power demand in Syria is lowest in the early hours, then gradually rises; it is a little higher at lunchtime, then drops a little in the afternoon, and starts rising again toward the evening, peaking between 17:00 and 23:00, as demand rises for lighting and heating. Demand over the week does not change significantly by day of the week.

As for seasonal changes, between October and March, the demand rises for heating.

(6) Electric power demand by region

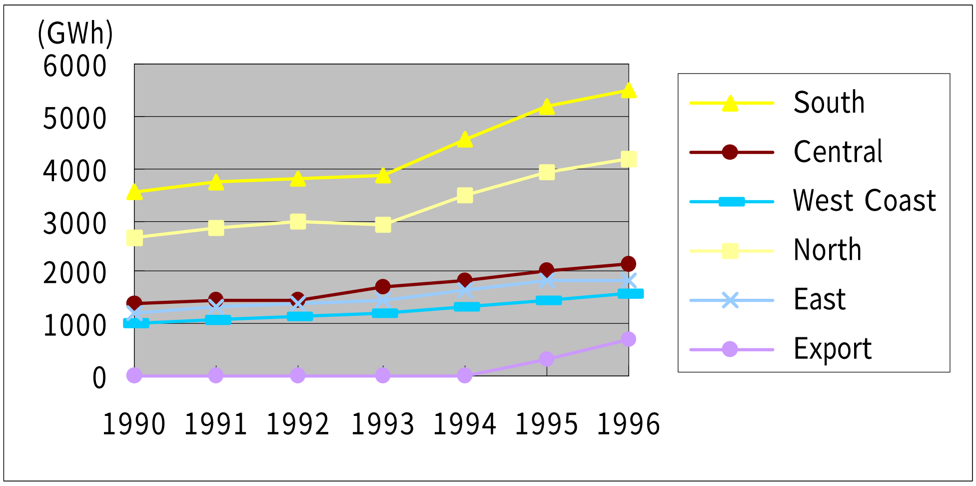
Electric power demand by region is highest for the southern district, which includes Damascus, the capital, followed by the northern district, which includes the industrial cities of Homs and Hama. It is noteworthy that exports have been rising from 1995.

【Table 10　Electric Power Supply by Region】

(GWh)

		1990	1991	1992	1993	1994	1995	1996
South	Damascus	1,641	1,764	1,796	1,845	2,179	2,452	2,380
	Others	1,867	1,963	1,978	2,023	2,393	2,741	3,092
	Sub-total	3,508	3,727	3,774	3,868	4,572	5,193	5,472
Central	Homs	695	728	731	928	1,039	1,133	1,214
	Hama	699	712	715	746	796	869	948
	Sub-total	1,394	1,440	1,446	1,674	1,835	2,002	2,162
West Coast	Tartus	467	473	490	531	584	623	643
	Lattakia	548	619	659	684	772	821	950
	Sub-total	1,015	1,092	1,149	1,215	1,356	1,444	1,592
North	Aleppo	2,252	2,401	2,545	2,474	2,964	3,306	3,526
	Others	392	411	430	428	520	581	646
	Sub-total	2,644	2,812	2,975	2,902	3,484	3,887	4,172
East	Sub-total	1,177	1,306	1,419	1,439	1,639	1,830	1,825
Total		9,738	10,377	10,763	11,098	12,886	14,356	15,223
Export		0	0	0	0	0	292	683

Source: PEEGT Annual Statistics Report 1995



【Figure 7　Electric Power Supply by Region】

(7) Plan to build power stations

Syria is actively building power stations, as previously mentioned. As a result, the country's chronic electric power shortage has been alleviated considerably. Thus there is now time to perform the periodic maintenance of existing facilities, which had to be postponed between 1990 and 1994 when the power shortage was particularly severe. Moreover, the Syrian government is aiming to gradually stop power generation using oil fired gas turbines, which use expensive oil and have a low thermal efficiency. Furthermore, it aims to redirect as much as possible oil used for power generation toward exports, and to make efficient use of the gas that is currently wasted through burning at oil fields. This conversion from oil to gas also has merits from the viewpoint of the environment.

【Table 11　Plan to Increase Power Stations in Syria】

	Name of Power Station	Type	Kinds of fuel	Year of operation	Capacity (MW)	Real output (MW)	1993 Real output	1994 〃	1995 〃	1996 〃	1997 〃	1998 〃	1999 〃	2000 〃	2001 〃	2002 〃	2003 〃
1	Gas Tribune (Small-scale)	GT	DO	1975/76	280		30	30	30	30	30	30	30	30	30	30	30
2	Hydraulic power	HT	－		21		5	5	5	5	5	5	5	5	5	5	5
3	Thawra	HT	－	1974/77	800	450	450	450	450	450	450	450	450	450	450	450	450
4	Qatineh	ST	HFO	1969	30	24	24	24	24	24	24	24	24	24	24	24	24
		ST	HFO	1969	30	24	24	24	24	24	24	24	24	24	24	24	24
		ST	HFO	1969	30	17	17	17	17	17	17	17	17	17	17	17	17
		ST	HFO	1980	64	55	55	55	55	55	55	55	55	55	55	55	55
5	Mehardeh	ST	HFO/NG	1980	150	135	135	135	135	135	135	135	135	135	135	135	135
		ST	HFO/NG	1980	150	134	134	134	134	134	134	134	134	134	134	134	134
		ST	HFO/NG	1987	165	156	156	156	156	156	156	156	156	156	156	156	156
		ST	HFO/NG	1988	165	157	157	157	157	157	157	157	157	157	157	157	157
		GT	DO	1988	30	30	30	30	30	30	30	30	30	30	30	30	30
6	Banias	ST	HFO	1982	170	150	150	150	150	150	150	150	150	150	150	150	150
		ST	HFO	1983	170	150	150	150	150	150	150	150	150	150	150	150	150
		ST	HFO	1988	170	160	160	160	160	160	160	160	160	160	160	160	160
		ST	HFO	1989	170	160	160	160	160	160	160	160	160	160	160	160	160
		GT	DO	1989	30	30	30	30	30	30	30	30	30	30	30	30	30
7	Baath	HT	－	1988	75	19	19	19	19	19	19	19	19	19	19	19	19
8	Swedieh (SPC)	GT	NG	1988/89	175	150	150	150	150	150	150	150	150	150	150	150	150
9	Tayem	GT	NG	1989/90	105	90	90	90	90	90	90	90	90	90	90	90	90
10	Home Refinery	ST	HFO/NG		64	57	57	57	57	57	57	57	57	57	57	57	57
11	Banias Refinery	ST	HFO		48	42	42	42	42	42	42	42	42	42	42	42	42
12	Swedieh	GT	NG		120		150	150	150	150	150	150	150	150	150	150	150
13	Tishren	ST	HFO	1993	200	200	200	200	200	200	200	200	200	200	200	200	200
		ST	HFO	1994	200	200		200	200	200	200	200	200	200	200	200	200
		GT	NG	1994	100	100		100	100	100	100	100	100	100	100	100	100
		GT	NG	1994	100	100		100	100	100	100	100	100	100	100	100	100
14	Al-Nasrie	GT	NG	1995	100	100		100	100	100	100	100	100	100	100	100	100
		GT	NG	1995	100	100		100	100	100	100	100	100	100	100	100	100
		GT	NG	1995	100	100		100	100	100	100	100	100	100	100	100	100
15	Jandar	GT	NG	1994	100	100		100	100	100	100	100	100	100	100	100	100
		GT	NG	1994	100	100		100	100	100	100	100	100	100	100	100	100
		GT	NG	1995	100	100			100	100	100	100	100	100	100	100	100
		GT	NG	1995	100	100			100	100	100	100	100	100	100	100	100
		ST	HFO	1995	100	100			100	100	100	100	100	100	100	100	100
		ST	HFO	1995	100	100			100	100	100	100	100	100	100	100	100
18	Zezon	GT	NG	1996	100	100				100	100	100	100	100	100	100	100
		GT	NG	1996	100	100				100	100	100	100	100	100	100	100
		GT	NG	1996	100	100				100	100	100	100	100	100	100	100
19	Aleppo	ST	HFO	1997	200	200					200	200	200	200	200	200	200
		ST	HFO	1997	200	200					200	200	200	200	200	200	200
		ST	HFO	1997	200	200					200	200	200	200	200	200	200
		ST	HFO	1998	200	200						200	200	200	200	200	200
		ST	HFO	1998	200	200						200	200	200	200	200	200
16	Tishren Dam	HT	－	1997	106	100					100	100	100	100	100	100	100
		HT	－	1997	106	100					100	100	100	100	100	100	100
		HT	－	1997	106	100					100	100	100	100	100	100	100
		HT	－	1997	106	100					100	100	100	100	100	100	100
		HT	－	1998	106	100						100	100	100	100	100	100
		HT	－	1998	106	100						100	100	100	100	100	100
17	Al-Zala	ST	HFO	1999	200	200						200	200	200	200	200	200
		ST	HFO	1999	200	200							200	200	200	200	200
		ST	HFO	1999	200	200							200	200	200	200	200
					7248	6190	2575	3475	3875	4175	5175	5975	6375	6375	6375	6375	6375

Source: MOE/PEE

For reference, besides the plants funded by foreign fund, Syria is constructing the following plant by their own fund.

① Zezon (Northern Syria) gas turbines (3 turbines), 300 MW, operation start in 1996

② Tishren Dam (Euphrates River) hydraulic power generators (6), 630 MW, operation start from 1997 (1 generator) to 1998

Eyeing the completion of the above projects, Syria is also linking its power network to those of neighboring countries. In 1992, Syria also signed the EIJST Agreement (an acronym standing for Egypt, Iraq, Jordan, Syria, and Turkey), a regional pact for the mutual use of excess electric power.

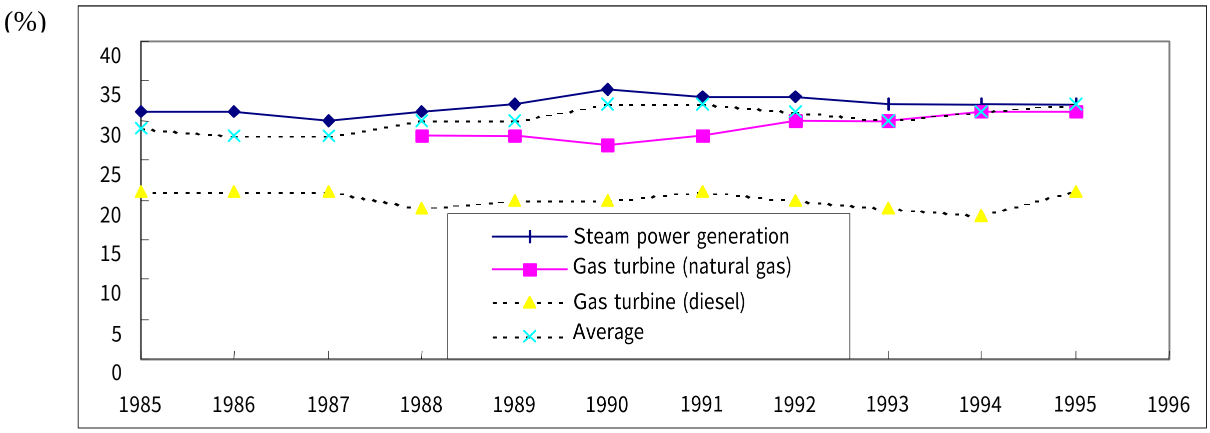
(8) Power generation by efficiency and fuel

The thermal efficiency of thermal power plants under the jurisdiction of the PEEGT is considered to have improved from 31% to 34% between 1985 and 1990 for steam power generation, but had fallen to 32% by 1995 due to the deterioration of power generation facilities. Gas turbines, which use Diesel oil as fuel, are small sized and have a low thermal efficiency of approximately 20%. On the other hand, gas turbines, which use natural gas, have a comparatively high thermal efficiency of about 30%, and as their use is increasing, the overall thermal efficiency of thermal power plants under the jurisdiction of the PEEGT is increasing.

【Table 12　Thermal Efficiency of Thermal Power Plants in PEEGT】　(%)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Steam power generation	31	31	30	31	32	34	33	33	32	32	32	
Gas turbine (natural gas)				28	28	27	28	30	30	31	31	
Gas turbine (diesel)	21	21	21	19	20	20	21	20	19	18	21	
Average	29	28	28	30	30	32	32	31	30	31	32	

Source: PEEGT



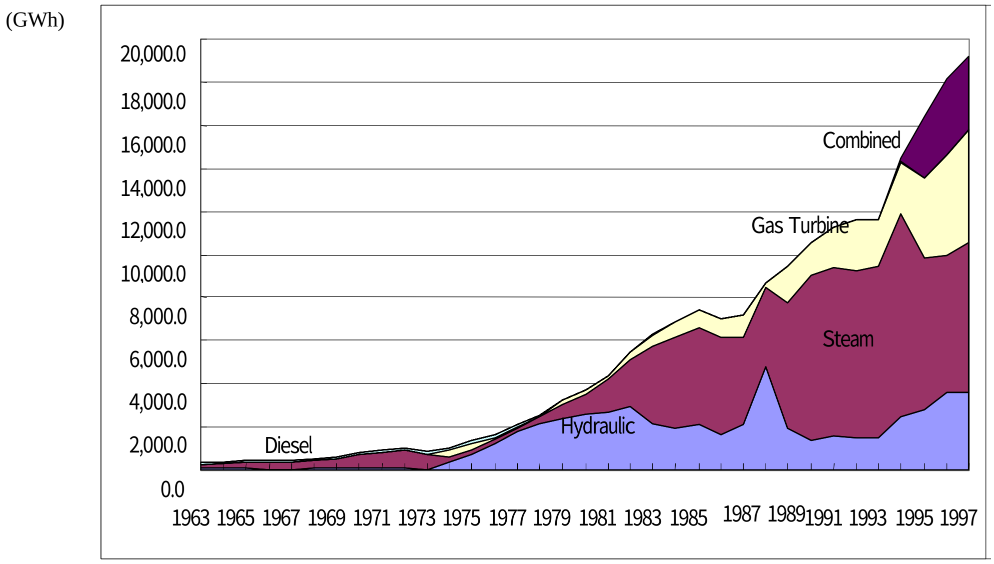
【Figure 8　Thermal Efficiency of Thermal Power Plants in PEEGT】

A look at changes in the electrical power output by power generation type shows that steam turbine power generation and Diesel were the foremost types in the 1960's, while from the mid-1970's, hydraulic power generation took the lead. From the mid-1980's, steam turbine power generation using oil expanded at a rapid pace. From around 1985, the importance of gas power generation was recognized, and the use of gas turbines grew. Then, from around 1995, highly energy efficient combined cycle power generation (a method whereby gas power generation is performed, and the exhaust heat is then used for steam turbine power generation) spread in use. In this way, Syria is achieving a balanced power generation distribution among hydraulic, steam, gas, and combined power generation.

【Table 13　Changes in Electrical Power Output by Power Generation Type (including other than MOE) 】

	Hydraulic		Steam		Gas Turbine		Diesel		Combined		Total
		%		%		%		%		%	
1963	41.5	12.7	193.1	59.1	0.0	0.0	92.4	28.3	0.0	0.0	327.0
1964	55.9	15.3	228.1	62.3	0.0	0.0	81.9	22.4	0.0	0.0	365.0
1965	42.4	10.2	287.2	69.2	0.0	0.0	85.3	20.6	0.0	0.0	414.9
1966	31.1	7.0	316.0	71.3	0.0	0.0	95.9	21.6	0.0	0.0	443.0
1967	30.1	6.7	331.2	73.5	0.0	0.0	89.2	19.8	0.0	0.0	450.5
1968	47.8	9.6	368.0	73.9	0.0	0.0	82.4	16.5	0.0	0.0	498.2
1969	63.5	10.7	447.0	75.3	0.0	0.0	83.4	14.0	0.0	0.0	593.9
1970	52.9	6.8	631.3	81.2	0.0	0.0	93.0	12.0	0.0	0.0	777.2
1971	50.9	5.6	738.5	81.8	0.0	0.0	113.0	12.5	0.0	0.0	902.4
1972	62.4	6.1	850.4	82.7	0.0	0.0	114.9	11.2	0.0	0.0	1,027.7
1973	17.2	1.9	732.2	82.8	2.3	0.3	133.1	15.0	0.0	0.0	884.8
1974	329.5	32.3	266.8	26.1	301.6	29.6	122.5	12.0	0.0	0.0	1,020.4
1975	749.5	55.7	199.5	14.8	255.8	19.0	141.5	10.5	0.0	0.0	1,346.3
1976	1,230.0	75.6	186.0	11.4	111.5	6.9	98.8	6.2	0.0	0.0	1,626.3
1977	1,768.0	86.1	164.0	8.0	48.5	2.4	72.0	3.5	0.0	0.0	2,052.5
1978	2,133.9	85.2	272.0	10.9	50.3	2.0	47.0	1.9	0.0	0.0	2,503.2
1979	2,351.9	72.1	688.0	21.1	186.0	5.7	35.0	1.1	0.0	0.0	3,260.9
1980	2,561.1	68.8	982.0	26.4	149.0	4.0	28.0	0.8	0.0	0.0	3,720.1
1981	2,659.5	60.4	1,596.4	36.2	140.1	3.2	10.3	0.2	0.0	0.0	4,406.3
1982	2,958.7	54.5	2,149.3	39.6	313.2	5.8	10.4	0.2	0.0	0.0	5,431.6
1983	2,165.8	34.4	3,542.6	56.3	563.4	9.0	16.5	0.3	0.0	0.0	6,288.3
1984	1,929.5	28.0	4,247.6	61.6	705.8	10.2	14.9	0.2	0.0	0.0	6,897.8
1985	2,053.8	27.6	4,575.7	61.4	813.7	10.9	10.9	0.1	0.0	0.0	7,454.1
1986	1,632.7	23.2	4,523.1	64.3	860.9	12.2	15.0	0.2	0.0	0.0	7,031.7
1987	2,044.6	28.6	4,153.6	58.0	953.2	13.3	8.7	0.1	0.0	0.0	7,160.1
1988	4,806.3	55.2	3,646.5	41.9	252.4	2.9	2.0	0.0	0.0	0.0	8,707.2
1989	1,934.3	20.5	5,779.7	61.3	1,714.8	18.2	2.3	0.0	0.0	0.0	9,431.1
1990	1,337.0	14.7	7,665.0	72.7	1,543.0	14.6	2.0	0.0	0.0	0.0	10,547.0
1991	1,590.0	14.1	7,810.0	69.4	1,846.0	16.4	3.0	0.0	0.0	0.0	11,249.0
1992	1,502.0	12.9	7,778.0	66.9	2,342.0	20.1	3.0	0.0	0.0	0.0	11,625.0
1993	1,537.0	13.2	7,956.0	68.5	2,113.0	18.2	3.0	0.0	0.0	0.0	11,609.0
1994	2,458.0	17.0	9,428.0	65.2	2,413.9	16.7	3.0	0.0	152.5	1.1	14,455.4
1995	2,799.5	17.0	6,989.2	42.5	3,736.1	22.7	3.0	0.0	2,919	17.7	16,446.9
1996	3,549.7	19.5	6,427.6	35.4	4,624.1	25.5	3.2	0.0	3,555.0	19.6	18,159.6
1997	3,554.0	18.5	7,005.0	36.5	5,214.0	27.2	0.0	0.0	3,425.0	17.8	19,198.0

Source: PEEGT



【Figure 9　Changes in Electrical Power Output by Power Generation Type】

1.3.4 Power Rates in Syria

Syria being an oil producing country, and has enough fuel for power plants, its power rates are generally low, and its policy is to hold down rate increases. However, in 1992, although Syria kept rate increases for small domestic users small, it raised at once power rates between two and three times in order to secure funds for the construction of additional power stations. The details are shown in Table 14.

Yet, despite this rate increase, power stations have long way in achieving financial self-sufficiency. Banias Power Station has never been profitable since it began operations, and its rate of return continues to be -10% to -20%. Furthermore, large-scale repairs in 1995 caused its rate of return to plunge to lower than -40% (for details, refer to section 2.3.2 Quantitative Results". Even Jandar Power Station, which has just begun operating with the most sophisticated facilities, has so far generated zero profits. The upshot of this state of affairs is that, unless rates are hiked up by 30% to 50%, Syria's power plants will not be able to achieve financial self-sufficiency.

【Table 14　Power Rates System in Syria】

（Syria Piastres = 1/100￡）

		1988-1991	1992-	Scale factor
230 KV(for industry)		34	75	2.2
230 KV (for agriculture)		36	80	2.2
230 KV (for commerce)		42	90	2.1
20/04 KV (for industry)		43	120	2.8
20/04 KV (for agriculture)		25	80	3.2
20/04 KV (for commerce)		43	125	2.9
04 KV (for commerce)		75	150	2.0
04 KV (Craft, etc.)		75	140	1.9
04 KV (Outdoor lamps)		15	75	5.0
04 KV (Public organizations)	1-50 KWh/Month	19	75	3.9
04 KV (Public organizations)	50-100 KWh/〃	24	75	3.1
04 KV (Public organizations)	＜100 KWh／〃	35	75	2.1
04 KV (For home-use)	1-50 KWh/Month	19	25	1.3
	50-100 〃	24	35	1.5
	101-200 〃	35	50	1.4
	201-300 〃	35	50	1.4
	301-400 〃	55	150	2.7
	＜400 〃	75	150	2.0

Source: PEEGT

1.4 Objectives

This project aims to increase the absolute output capacity of the existing Banias Power Station completed in 1984 (No. 1 and No. 2 generators with combined output of 340 MW) by doubling its capacity (by adding 340 MW in output capacity with No. 3 and No. 4 generators), in order to reduce the demand-supply gap.

2. Analysis and Evaluation

2.1 Evaluation of Project Implementation

2.1.1 Project Scope

This project for the installation of one gas turbine, two 230 KV power transmission towers, and employee housing, with emphasis on steam power generating equipment, steam turbines, and generators for the No. 3 and No. 4 generators, apart from the later addition of an emergency Diesel generator, was implemented according to plan.

(1) Differences with existing facilities

This project was designed to expand the Banias Power Station by adding a third and fourth generators to the existing No. 1 and No. 2 generators, basically employing the same specifications. In particular, the construction of the new buildings was to be fully based on the structure and design of existing ones.

The major differences with the No. 1 and No. 2 generators are as follows.

① Anti-earthquake design
② Unlike connection pipes from boilers of No. 1 and No. 2 generators, which were buried, surface pipes were employed for the new generators.
③ Unlike the boilers of the No. 1 and No. 2 generators, which were of the pre-boiling type, they were of the in-line boiling type this time.
④ Auxiliary steam is generated from steam exchangers in the No. 3 and No. 4 generators (No. 1 and No. 2 generators have no steam exchangers.)
⑤ In the case of the No. 3 and No. 4 generators, the screen for removing dirt on surface seawater that is used for the circulation system is equipped with an automatic dirt remover (not provided for the No. 1 and No. 2 generators)

(2) Main equipment

The main facilities provided through this project are indicated in ① to ⑤ below. All machines and equipment were of a general nature, and did not employ particularly advanced technology.

① Steam power generating equipment

Unit		2
Type		Radiant reignition natural circulation
Max. serial steam power generating volume		560 t/h
Conditions of steam	Exit from super heater	145kg/cm^{2}g
	Exit from re-heater	541℃
Fuel		Remnants of oil and crude oil
Ventilation type		Forced ventilation type
Set-up position		Outdoor

② Steam turbine and generator

Unit		2 generators
Type		Reheat reactivation condensing (Tandem, Compound)
Max. serial steam power generating volume		
Rated output standard		170,000 kw (by terminal of generator)
		212,500 kVA (80% of power factor)
Main steam pressure		139 kg/ cm^2g (137bar abs)
Steam temperature	Main steam	538℃
	Reheat steam	538℃
Exhaust pressure		722 mmHg VAC
Feed water heater		1 set
Deaerator		1 set
Rotational frequency		3,000 rpm
Generator voltage		15.5 kV
Frequency		50 HZ
Excitation type		Brushless direct excitation equipment
Set-up position		Outdoor

③ Gas turbine

Gas turbines are for backup during peak hours.

Unit		1 generator
Type		PG6461
Kinds of fuel		Gas oil, light oil
Combustor		Multiple
Compressor number of rows		17
Compressor pressure ratio		Approx.11.4 at 20℃
Turbine number of rows		3
Start method		Diesel engine
Real thermal ratio (20℃/1013.6mbar)		3051kcal/kwh (LHV)
Emission temperature (℃)		Refined oil/crude oil 539/563
Max. emission temperature limit (℃)		Refined oil/crude oil 571/571

④ Emergency Diesel power generators

The emergency Diesel power generators provide electric power for the startup of four units in the case of a power failure, and their function is to ensure the safety of the steam generating equipment. This item was not initially part of the project, but after its necessity was recognized, was additionally procured.

Unit		2 generators
Type		380KA12V45(HE 750/38)
Generator		2 x 750KVA/600KW
Power factor		0.8
Rotational frequency		1,500 rpm

⑤ Other facilities

Water supply facilities (2 system)

Seawater cooling facilities (2 system)

Circulating facilities (2 system)

Fuel combustion facilities (2 system)

Main transformer

Power supply facilities for emergency (3)

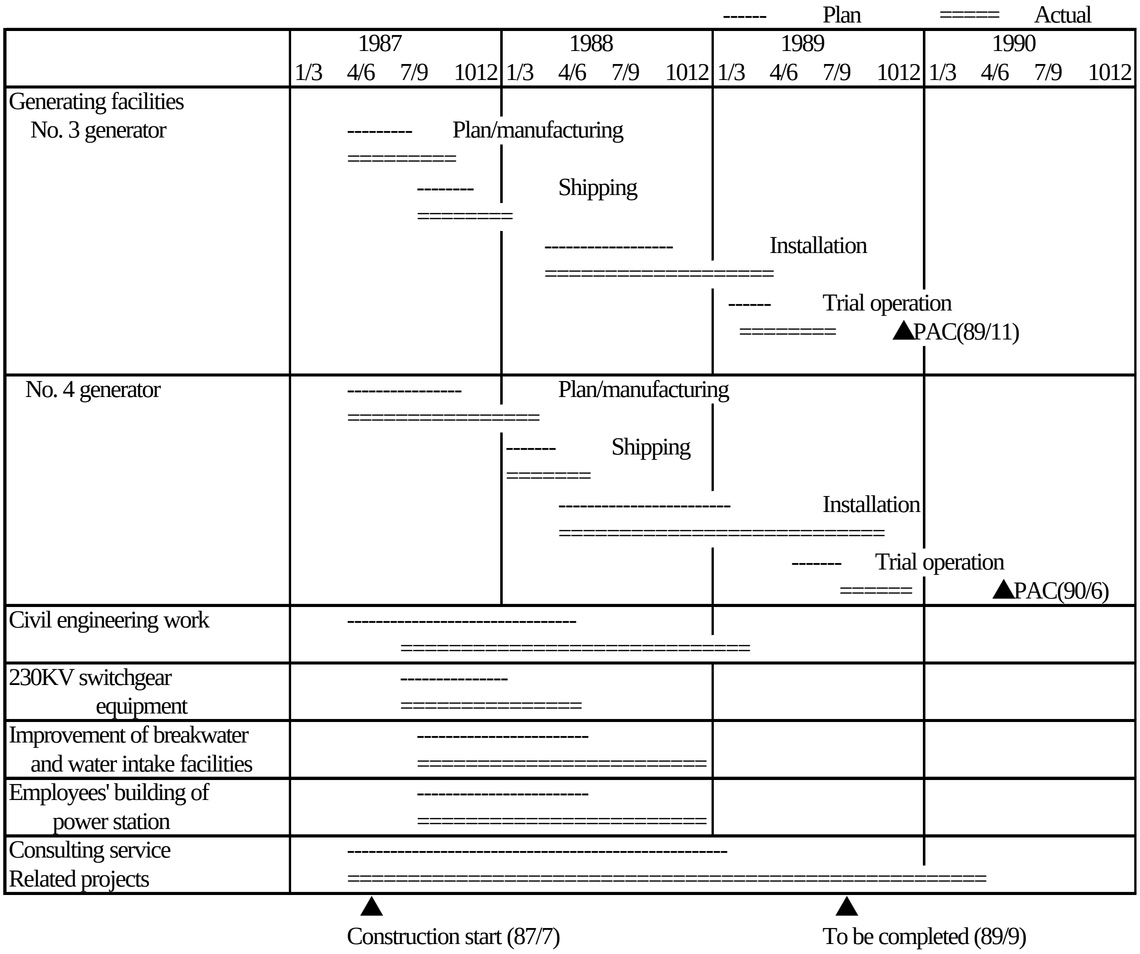
230kV power transmission steel tower

Housing of employees

2.1.2 Implementation Schedule

(1) Planned implementation schedule and difference

As the L/C start was delayed by 4 months, delays occurred in some parts of the project, but overall, the project was implemented nearly on schedule, and in the end trial operation was completed merely 2 months behind schedule.



Source: PCR

【Figure 10 Implementation Schedule at the Time of Appraisal and Actual Result】

(2) Implementation schedule in months

As described above, electric power supply started a mere 26 months after the construction start (July 1987). Moreover, the time for obtainment of PAC (Provisional Acceptance Certificate) was in 6 months for the No. 3 generator and gas turbine, and in 10 months for the No. 4 generator.

【Table 15　 Implementation Schedule in Months】

Unit	Time from construction start to achievement of 100% load (months)	Time from 100% load to obtainment of PAC (months)
U3, GT	23	6
U4	26	10

The reasons why the project could be implemented so smoothly are as follows.

① Preliminary survey... The construction work was expansion work for an existing thermal power plant, and geological conditions were surveyed beforehand.

② Labor...Labor was ample and of good quality. Syrian workers participated in civil engineering work, but for construction work, over half of workers of contractor were experienced Japanese and Filipino workers.

③ Delivery...Although there were many problems with the lack of storage space for delivered materials, these problems were solved with the cooperation of the executing agency.

④ Inspections and trial operation...During the construction period, the contractor adequately conducted inspections and testing of individual equipment units. These inspections and tests were attended by consultants, and as a result, over 3,000 pages of inspection reports were written.

2.1.3 Project Cost

The total project cost was ¥33,308 million, compared to ¥34,958 million planned. The ODA loan (approved amount) covered foreign currency expenses of ¥27,927 million minus consulting expenses, thus a total of ¥27,544 million. The actual loan amount turned out to be ¥26,686 million. Thus, the project cost was nearly as much as planned.

The reason consulting expenses were excluded from the ODA loan was that the Syrian government has the policy of not hiring consultants from countries that supply equipment, and in the case of this project, Japanese company supplied the equipment for the power station, and when it became clear that Japanese companies were excluded from the bidding process, the Japanese government signified during the pledge stage that consulting fees would not be covered by the ODA loan.

【Table 16 Project Cost】

Item		Foreign currency (1 million yen)		Local currency (1 million S£)		Total (1 million yen)	
		Plan	Actual	Plan	Actual	Plan	Actual
Expansion of power stations	Generating facility, equipment	15,750	15,777	0	0	15,750	15,777
	Charges, insurance fees (FOB)	3,430	3,624	0	0	3,430	3,624
	Inland transport cost	480	620	0	0	480	620
	Installation cost	5,230	5,608	17	17	5,247	5,625
	Civil engineering work cost	1,610	909	62	61	1,672	970
	Sub-total	26,500	26,538	79	78	26,579	26,616
230KV switchgear equipment		160	0	1	1	161	1
Water intake and breakwater		175	0	7	14	182	14
Employees' housing of power station		363	148	22	34	385	182
Reserve fund		346	0	4	0	350	0
	Sub-total	27,544	26,686	113	127	27,657	26,813
Consulting fee		383	301	5	3	388	304
Customs				60	23	60	23
	Total	27,927	26,987	178	152	28,105	27,139

Source: PCR

Note 1) Base cost: October 1986

Note 2) Exchange rate: 1 US$ = \155 = 3.925S£

【Table 17 Project Expenditures by Year】

(Units: 1 million yen)

	1987	1988	1989	1990	1991	1992	1993	Total
Generating facility, equipment	1,976	5,927	7,903	3,951	0	0	263	20,021
Installation cost	628	628	3,144	1,887	0	0	0	6,287
Civil engineering cost	330	1,821	497	661	0	0	0	3,309
230KV Switchgear equipment	0	19	28	0	0	0	0	47
Water intake and breakwater	0	164	376	0	0	0	0	540
Employees' housing of power station	0	285	663	0	52	462	16	1,478
Reserve fund	0	0	0	0	0	0	0	0
Sub-total	2,934	8,844	12,611	6,499	52	462	279	31,681
Consulting fee/customs	133	265	464	332	133	0	0	1,327
Total	3,067	9,109	13,075	6,831	185	462	279	33,008

Source PCR

2.1.4 Project Implementation Scheme

(1) Executing agency

The PEE (Public Establishment of Electricity, the executing agency for the project, which was established in January 1965 as a public corporation entirely funded by the government and under the jurisdiction of the MOE (Ministry of Electricity), oversaw power generation and transmission over the entire national territory of Syria.

The PEE, prior to the implementation of this project, had gained experience building a number of power stations of the same scale as this project, notably the Banias Power Station's No. 1 and No. 2 generators, and the Mehardeh Thermal Power Plant's No. 1 and No. 2 generators, with financing from Kuwait and other Arab states (and also the World Bank partly).
It also constructed on its own the Qatineh Thermal Power Plant (180 MW), and as the result of all these activities, had ample experience. Using this know-how, the PEE suitably supervised the implementation of this project.

The PEE was split by a presidential order in 1994 into two companies, the Public Establishment of Electricity Generation and Transmission (PEEGT) and the Public Establishment for Distribution and Exploitation of Electric Energy), as a result, the PEE was dissolved.

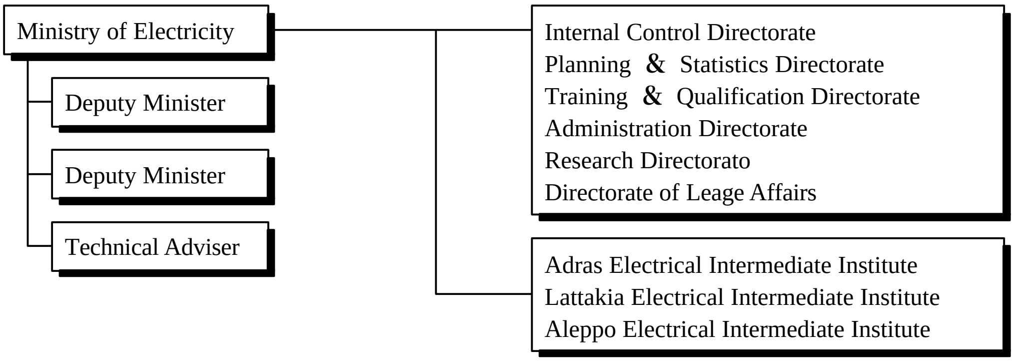
The PEEGT, which has a paid-in capital of 17,500 million Syrian pounds, is headquartered in Damascus, and controls electric power generation and transmission.

Concretely, its responsibilities include the following.

① Determination of demand for power stations and transmission network, and planning to fulfill demand
② Construction of power stations, the transmission network, and transforming stations (230 to 400 kV)
③ Operation, management, and maintenance of power stations, the transmission network (230 kV and 400 kV), and major regulation centers.
④ Operation, management, and maintenance of transforming stations (230/66/20 kV and 400 kV)
⑤ Follow-up of electric power transmission network links within Arab states and Turkey.

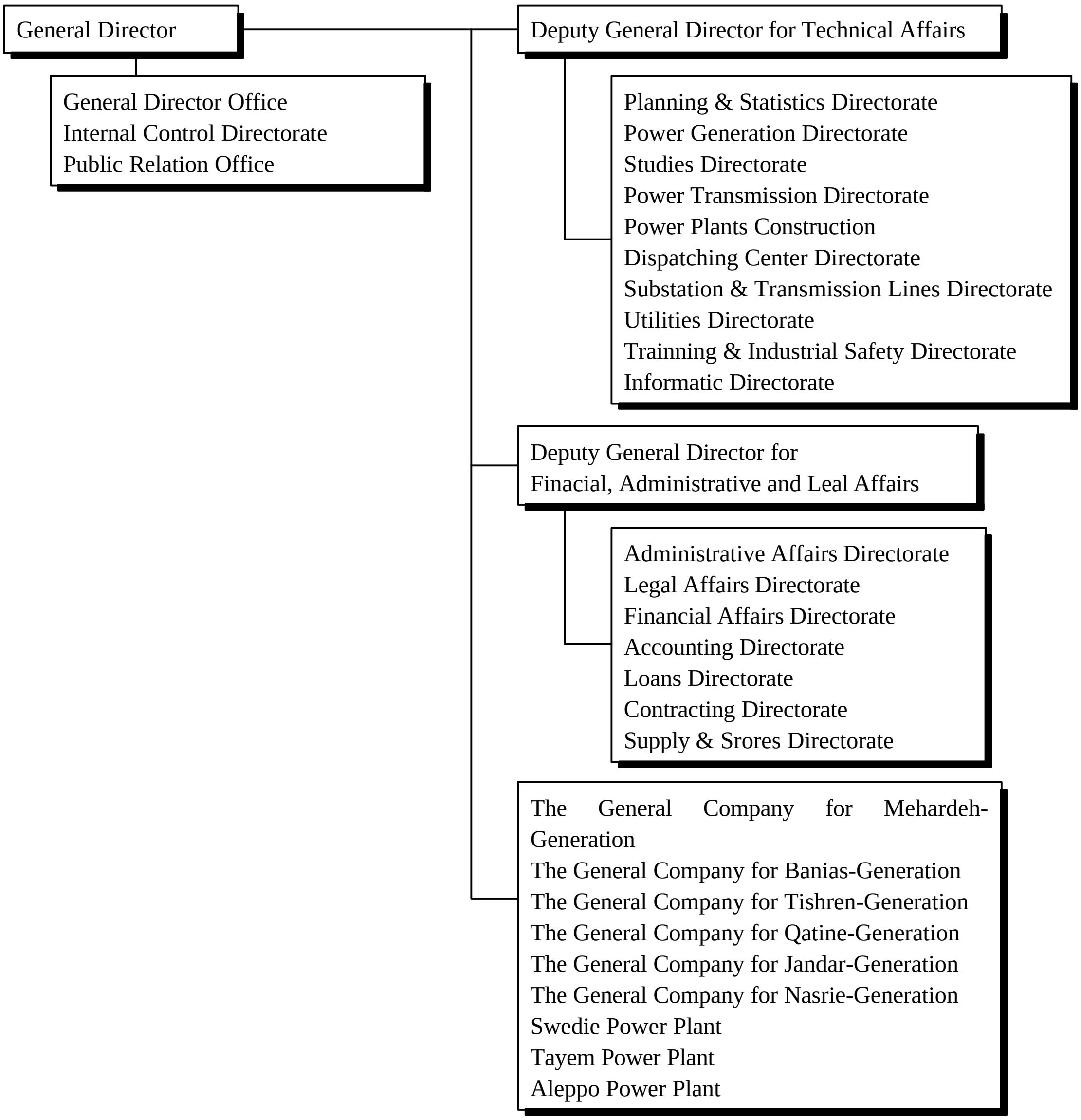
The PEDEEE, which has a paid-in capital of 8,300 million Syrian pounds, is also headquartered in Damascus, and oversees power distribution and efficient power utilization.
Concretely, its responsibilities include the following.

① Power distribution planning
② Construction of sub - stations and power distribution networks (66/20/0.4 kV)
③ Management, operation, and maintenance of power stations and power distribution networks (66/20/0.4 kV), secondary regulation centers, concrete plants in Derizooru and Homs, electrical repair sector, and small-scale generators for reserve purposes, including hydraulic generators
④ Maintenance of transforming stations (230/66/20 kV) at 22 kV



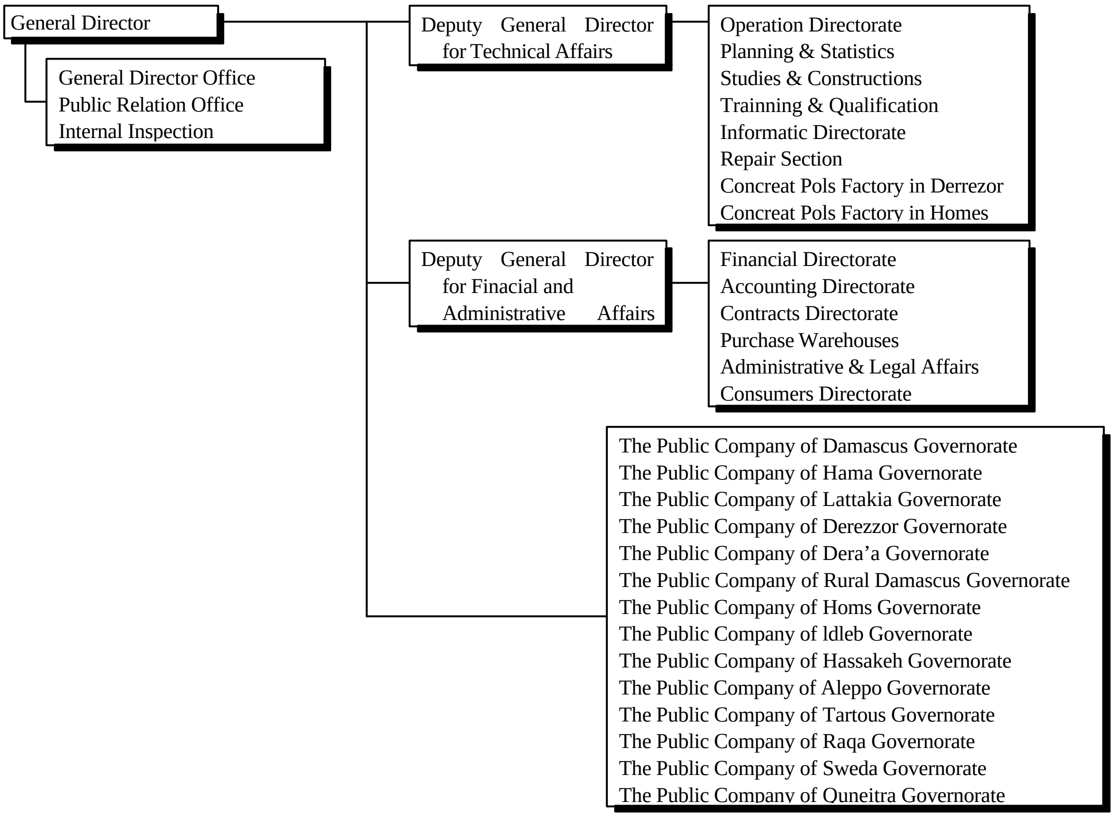
Source: "Annual Statistical Report Year 1996" MOE

【Figure 11 Organization Chart of Ministry of Electricity (1995) 】



Source: MOE "Annual Statistical Report Year 1996"

【Figure 12 Organization Chart of PEEGT (1995) 】



Source: MOE "Annual Statistical Report Year 1996"

【Figure 13 Organization Chart of PEDEEE (1995) 】

(2) Consultants

Consultants were hired in this project, and the TOR was as follows

① Check and approval of engineering drawings submitted by contractors

② Factory inspection of manufacturing equipment and supervision of shipping schedule.

③ Installation of equipment on site and supervision of civil engineering work and trial operation

④ Supervision of training programs designed by contractors

⑤ Technical guidance during guaranty period

⑥ Supervision of entire project

The selection of consultants was performed on a short list basis, with six competing firms. As a result, French company, which provided consulting services for civil engineering during the construction of the No. 1 and No. 2 generators, was selected. The consultant completed 200 M/M of work in 42 months.

According to the PEE (executing agency)'s report, this performance is "average", and the same evaluation judged that no particular problems were caused by consultants.

As mentioned previously, due to the Syrian government's policy of hiring consultants from countries other than those supplying equipment, Japanese consultants were barred from participating in the bidding process. For this reason, consulting fees were excluded from the application scope of the ODA loan this time.

(3) Contractors

As the result of the international bidding process for this project, a consortium headed by Japanese companies was chosen as the contractors for this project.

According to the PEE's report, the performance of the contractors was "good".

2.2 Evaluation of Operations and Maintenance

2.2.1 Operation Scheme and Performance

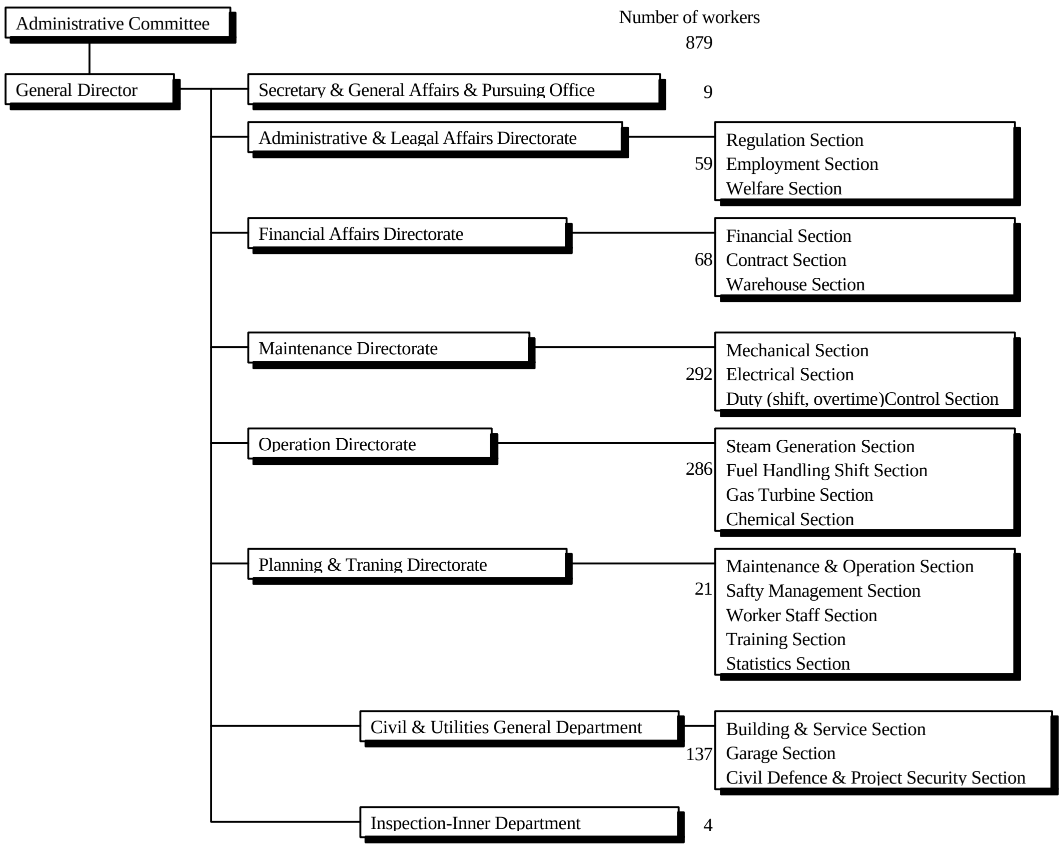
(1) Organization of power stations

As previously mentioned, upon completion of this project, the PEE was split into the PEEGT and PEDEEE, so that the Banias Power Station is now a part of the PEEGT organization.

The 876 workers at the Banias Power Station are distributed according to the organization shown in Figure 14. Work is organized into four teams operating on 8-hour shifts (morning, noon, evening, and standby).

The working hours of the administrative division are from 8:00 AM to 2:00 PM, or six hours daily (no lunch break). Although the working hours of the administrative division are short, the pay level at state-owned enterprises is said to be half that of the private sector (monthly wages of just US$150 for engineers). This reduced schedule is employed due to the fact that thermal power plant wages are too low to pay for living expenses.

Compared to when the Banias Power Station had only two generators, at which time it employed in excess of 1,000 workers, the current work force of 876 is an indication of the rationalization that has been achieved; however, considering that power stations of similar scale in Japan employ about 400 people, the Banias Power Station's workforce is still bloated. This situation is linked to the Syrian government's policy of prioritizing employment security. Furthermore, thermal power plants are also used as schools of technology transfer to Syrian citizen such as university and industrial technical school students. In this context, it is probably impossible to meaningfully advocate the Japanese model of efficiency for power stations in Syria.



Source: Banias Power Station

【Figure 14 Organization Chart of Banias Power Station (1996) 】

(2) Training

There are two types of training, training performed internally by the Banias Power Station, and training performed by the Ministry of Electricity and the PEEGT.

① Training system of Banias Power Station

The Banias Power Station has 16 full-time instructors who are in charge of training the staff. The following training courses are offered.

New employee education — Basic training for operators
English courses — OJT (for operations and maintenance personnel)

Two full-time instructors are in charge of operations training, and when employees complete their basic education, OJT is performed. Although the training methods resemble those used in Japan, the biggest portion of the training currently relies on practical training on the job. OJT is performed by shift chiefs (4 for the No. 1 and No. 2 generators, and 4 for the No. 3 and No. 4 generators, thus a total of 8 persons) during their watch.

Clerical training is done by 4 instructors for business duties and 2 instructors for English.

② Ministry of Electricity and PEEGT training

The Ministry of Electricity and the PEEGT have established electrical and mechanical engineering schools directly under them for administering intensive training for each power station. Schools exist at Adras, Aleppo, and Lattakia. The training course lasts for two years, and the level of education is equivalent to that of a 2-year college. Graduates can become assistant engineers, and 1,443 were graduated in the six-year period from 1990 to 1995.

Moreover, more advanced education is performed at the three major thermal power plants of Adras, Aleppo, and Jandar. Adras and Aleppo perform education about power distribution, while Jandar is planning to provide training in the operation of thermal power plants at a school that is schedule to close in 1999. The three schools will be able to train 1,000 students at a time.

Moreover, the Jandar Power Station trains operators using a simulator of the No. 3 and No. 4 generators of the Banias Power Station built on the plant's premises. 50 students divided into five groups undergo two years of training there. The training contents include normal startup and stop operations, as well as fuel increase/decrease operation, switch operation for accidents, recovery of boil control operation errors, etc., using more than 100 failure simulations. Measurement, warning, and control equipment simulating real-life conditions make operators feel they are handling real equipment in training.

Currently, this equipment is used only for operation training, but it also suitable for use in training for major accidents that actually occur during operations.

(3) Number of qualified workers at Banias Power Station

The number of qualified workers at the Banias Power Station consists of 25 firemen, 25 car drivers, 4 dangerous materials specialists, 16 licensed turbine engineers, 16 licensed generator engineers, and 2 crane operators. This qualification system[1] is nearly the same as that of Britain.

2.2.2 Maintenance System and Status

The following maintenance-related problems were identified during the mission’s visit at the Banias Power Station.

(1) Underground pipeline leaks

The heavy oil used at the Banias Power Station is supplied through a buried pipeline from the Banias Refinery located 8 km away (this pipeline was not financed by the ODA loan). This pipeline was buried upon request by the military, but underground water has bored holes in the pipes, and oil leaks from these holes frequently occur. When the pipes get covered with underground water, an electrolytic effect is produced in places, which speeds up localized corrosion, causing cracks in the pipes.

This pipeline has already been in use for 15 years, and leak incidents occur several times every year. According to OECF report (1995), incidents of pipeline up to 1995 is as shown in Table 18.

[1] However, the system of licensed engineers differs from British licensed engineers. 8 licensed engineers are assigned to the No. 1 and No. 2 generators, and 8 others to the No. 3 and No. 4 generators, thus a total of 16 licensed engineers. But these are positions of responsible persons, and different from qualification system.

【Table 18　Pipeline History up to 1995】

Year	Description	Year	Description
1980	Completion of construction work	1988-1990	About 1 incident per year
1981	Start of operation	1991-1994	About 7 incidents per year (in winter)
1981-1985	No incidents involving damage	1995/2	6 incidents
1986	Buckling incident	1995/4	5 incidents
1987	Multiple leak incident		

Recently, the frequency of these heavy oil leaks has increased, and they are even occurring in residential areas, making them a major problem. Even fixing does not remedy the problem since leaks soon appear in different locations.

According to the OECF report (1998), the incidence of subsequent leaks fell on the following dates.

【Table 19　Incidence of Leaks from 1996】

1996/4/6	1996/11/6	1997/4/18
1996/9/12	1996/12/22	1997/4/29
1996/9/21	1997/4/10	1997/5/29
1996/10/9	1997/4/16	1997/6/24

To prevent corrosion and thermal expansion from the aspect of simplifying maintenance and inspections, a surface pipeline would be desirable, but the implementation of this solution is unlikely due to the special circumstances of Syria. For this reason, studies are being conducted on retiring this pipeline and laying a new gas pipeline instead (switching from oil to gas as the employed fuel).

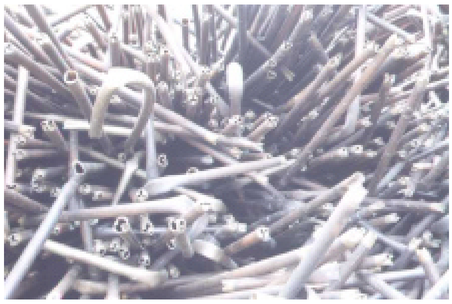
(2) Seawater leaks from condenser tubes

The Banias Power Station's condenser tubes have been afflicted by seawater leaks to the point that the plant's stock of spare tubes had been exhausted in 1995. The No. 3 generators, where this problem was most severe, had to stop operations for 50 days from November 1997 to January 1998.

During this period, the Banias Power Station self-financed the replacement of all condenser tubes (11,780) with 10% cupro nickel tubes (tubes made with a material combining aluminum and nickel that is harder and has excellent heat conductivity).

Condenser

Stack of 11,780 replaced tubes, on plant premises



Terminal treatment of cooling water tubes

The condenser tubes of the No. 4 generator had a relatively few seawater leaks, but the number of plugged tubes rapidly rose during the 8-year period from November 1989, reaching a cumulative total of 1,260 plugged tubes by the end of September 1997 (11% of total of 11,780 tubes). For this reason, plans are to stop production for 50 days from March 1998 to replace all tubes with 10% cupro nickel tubes.

As a result, seawater leak incidents in condenser tubes are expected to drop. The number of plugged cooling water tube replacements from the middle of 1995 is described in Table 20.

【Table 20　Plugged Cooling Water Tube Replacements】

	No.3 Generator		No.4 Generator	
	No. of replaced tubes	Cumulative	No. of replaced tubes	Cumulative
Until Jul.’95 (at the time of SAPS survey)		892		493
August’95～August’96	284	1,176	3	496
September’96～January’97	58	1,234	0	496
February’97～April’97	242	1,476	264	760
May’97～January‘98	270	1,746	1,740	2,500

(3) Gas turbine failures

A gas turbine generator (34.5 MW, 28 MW max. in summer) for peak load support was down from April 1993 due to failures, but repairs were recently completed, and the generator became operational again from December 12, 1997. A manufacturer's startup engineer came to the site and discovered defective electronic parts (sequence cards), gas and oil valves, and check valves, as well as operational defects, and procured and replaced parts, restoring operability. As a result, the gas turbine can now be used whenever needed. Until these repairs were completed, repairs had been attempted several times by manufacturer without success. This indicated the fact that the repair of gas turbines by machine specialists was difficult, and that the tasks required a specialist with a broad scope of knowledge to discover defective sequence cards (IC card containing mechanical operational sequence) and who must understand digital computer control procedures.

Gas turbine

(4) Spare parts shortages

Until now, the No. 3 and No. 4 generators were subject to gas leaks in the air heater section, soot and smoke production during operation, gas duct fires, corrosion of supporters for air heater section, expansion of gas ducts, defective joints, etc. Recently, five burner guns for the No. 3 and No. 4 generators (total of 10 burner guns) have been purchased from a contractor. Since they are to be replaced during intermediate inspections and burner chips cleaned, improvements in combustion efficiency are expected. Moreover, condenser tubes have also been replaced.

As repeatedly pointed in this post-evaluation, since the Banias Power Station does not generate profits on its own (no surplus funds), the procurement of spare parts depends on funding from the state (via the PEEGT). While the Ministry of Electricity and the Ministry of Finance are showing increasing understanding regarding the necessity and importance of repairs, based on the observation of the current situation, that is still insufficient. To ensure sufficient maintenance of the power station, the Syrian government must either approve power rate hikes to a suitable level, or if this is not possible, supply sufficient funds for maintenance to power stations.

(5) Unit trip

Unit trip refers to the separation of a given unit from the overall system by throwing a circuit breaker in order to avoid further mechanical damage when a problem develops during operation. In other words, this is a handling in urgent circumstances when a problem arises that call for immediately stopping a unit regardless of electric power demand at that time.

Fortunately, the Banias Power Station has not experienced any accidents involving physical injury or death, and there has been only one accident involving burning caused by steam, treated in the power station's infirmary, with the worker in question could return to work the following day. Details of unit trips are shown in Table 21.

【Table 21　List of Unit Trips at Banias Power Station in 1996/1997】

Generator	Cause of Trip	Date	Duration	Countermeasure
No.3 generator	Overheating of exit pipe	95/01	2 days	Repair
	Seawater leak	95/08	2 hours	Plug
	Condenser vacuum down	95/09	2 hours	Replacement
	General black out	95/09	1.5 hours	System recovery
	Frequency down	96/02	2 hours	
	Steam leak around boiler combustion chamber inspection glass	96/02	23 hours	Repair
	Main steam temperature	96/02	11.5 hours	Repair
	Broken drum water gauge drain pipe	96/04	17 hours	Repair
	High condenser conductivity	97/10	5 days	Plug
	Abnormality in cooling water pump bearing	97/12	2 days	Repair
	Lightning Damage	97/01	3 days	Unknown cause
	Condenser Seawater leak	97/03	6 days	Plug
	Condenser Seawater leak	97/08	4 days	Plug
	Replacement of condenser cooling pipe	97/11	51 days	Replacement of pipe
No.4 generator	General black out	95/09	3 hours	System recovery
	Burner fire loss	96/03	1 hours	Malfunction
	Cable burn due to lightning	97/01	10 days	Repair
	Control panel abnormality	97/01	1.5 days	Unknown cause
	Frequency down	97/02	30 hours	Power system variatior
	Drum level too high	97/02	3 hours	Repair

Source:　Banias Power Station

2.2.3　Management System and Performance

Although the Banias Power Station has several minor problems, its operating condition is overall positive, and the equipment has been operated safely. However, recently, there has been a reverse flow of water which bent the shaft in the turbine of the No. 1 generator. Although the common sense approach to this occurrence would have been to infer an abnormality that led to this accident, and to take a suitable measure (the simplest one is to stop operation upon suspecting an anomaly), the fact that these two measures were not taken suggest that the accident is by an operation error.

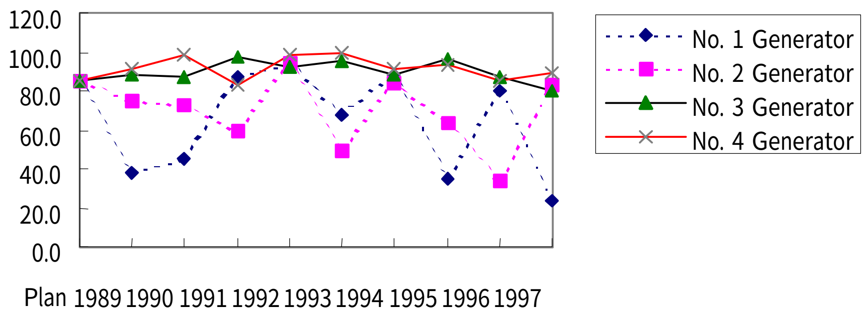
In order to make sure that such accidents do not occur again, attention should be given to the following points.

(1) Establish adequate rate of operation

The performance record of the No. 3 and No. 4 generators, which frequently exceeds the planned level, is higher than 90%, which is a source of concern for the security of the power generation equipment. Therefore, measures need to be taken to ensure the maintenance of an adequate rate of operation.

【Table 22　Changes in Rate of Operation of Generators】

	Generator#	Plan	1989	1990	1991	1992	1993	1994	1995	1996	1997
Generating volume	1	1,139	931	395	795	848	556	943	299	576	175
(GWh)	2	1,139	816	804	644	660	454	839	585	233	582
	3	1,139	747	1,095	1,260	1,251	1,245	1,002	821	544	509
	4	1,139	361	1,231	1,065	1,321	1,299	976	777	493	546
	Sub-total	4,556	2,855	3,525	3,764	4,080	3,554	3,760	2,482	1,846	1,812
Electricity sales volume	1	1,139	874	370	738	786	518	886	279	534	162
(GWh)	2	1,139	767	768	602	611	427	790	545	213	537
	3	1,139	697	1,048	1,197	1,191	1,187	950	722	504	470
	4	1,139	346	1,179	1,011	1,156	1,235	922	728	455	504
	Sub-total	4,556	2,684	3,365	3,548	3,744	3,367	3,548	2,274	1,706	1,673
Peak load	1	170	145	152	153	149	148	168	150	154	150
(MW)	2	170	160	160	160	94	158	165	152	145	136
	3	170	170	170	170	170	170	170	170	170	156
	4	170	170	170	170	170	170	170	170	170	170
Operation hours	1	6,701	7,725	3,973	7,657	8,315	5,969	7,753	3,056	6,981	2,029
	2	6,701	6,590	6,373	5,280	8,167	4,314	7,384	5,616	2,983	7,244
	3	6,701	5,201	7,618	8,530	8,088	8,349	7,769	3,488	7,664	7,049
	4	6,701	2,818	8,558	7,313	8,643	8,709	8,006	8,211	7,421	7,847
Rate of operation	1	85.0	38.0	45.0	87.0	94.0	68.0	88.0	34.9	79.7	23.2
	2	85.0	75.0	73.0	60.0	94.0	49.0	84.0	64.1	34.1	82.7
	3	85.0	88.0	87.0	97.0	92.0	95.0	88.0	96.8	87.5	80.5
	4	85.0	91.0	98.0	83.0	98.0	99.0	91.0	93.7	84.7	89.6
Plant factor	1	76.5	62.0	26.0	53.0	57.0	37.0	63.0	20.0	39.0	12.0
	2	76.5	55.0	54.0	43.0	44.0	30.0	56.0	39.0	16.0	39.0
	3	76.5	50.0	73.0	85.0	84.0	84.0	67.0	55.0	36.0	34.0
	4	76.5	24.0	83.0	71.0	89.0	87.0	65.0	52.0	33.0	37.0



Note:　The rate of operation was calculated as Utilizable time/8,760 hours (24 hours x 365 days).
Source:　PEEGT

【Figure 15　Changes in Rate of Operation of Generators】

(2) Problems related to general maintenance

The each equipment units of the Banias Power Station have a specific lifetime, and in particular the parts subject to friction need to be replaced regularly. By performing periodic repairs, power stations can have a useful economic life of 20 to 30 years. In order to prevent failures, thermal power stations should be stopped periodically every year and deteriorated parts be fixed or replaced. Moreover, every 15 years or 10,000 hours of operation, they should undergo comprehensive inspections and repairs, to ensure a longer service life.

Generally, the ways to perform inspections and repairs include the following.

① Stop operations for 2 weeks every 6 months to perform checks and repairs. Being implemented, in principle, at Banias Power Station

② Stop operations for 1 month every year to perform checks and repairs. Being implemented, in principle, at Banias Power Station

③ General maintenance (Stop operations for 4 months every 30,000 to 40,000 hours of operation for overhaul inspection and repairs). Not implemented at Banias Power Station

Until now, due to shortages of funds, electric power, and reserve funds, at the Banias Power Station, while check and repairs items ① and ② above are being implemented, there is a tendency to handle problems after they occur rather than preventing them beforehand. Moreover, due to the difficulty of procuring spare parts in the required quantities, operational reliability is declining, as is output. However, since some power stations including the Jandar Power Station has been achieved on the supply side, the role of the Banias Power Station is gradually being changed from a base load power station to a peak load power station. In other words, progressively, it is becoming possible to stop operation in order to perform the maintenance required to maintain a basic supply capacity.

General maintenance is already being implemented for the No. 1 and No. 2 generators, and, in 1999, should be implemented for one of the No. 3 and No. 4 generators, and the following year for the other remaining one. At any rate, the danger of allowing time to pass without knowing the condition of the equipment is considerable. Preventive maintenance is important for generators and other power-related equipment, because of the great danger of serious problems occurring due to wear arising from overworking over long periods of time without sufficient maintenance. The No. 3 and No. 4 generators at the Banias Power Station are already well past the time periodic general maintenance should be performed for them (every four years), and such maintenance is urgently required.

(3) Status of data-related resources

Currently, the Banias Power Station is using nine sophisticated computers (32-bit, Windows 3.1 or Windows 95 as OS), and is thus well set in terms of hardware. On the other hand, it seems that operational data, accounting data, and other data required for efficient operations and management are not managed with sufficient efficiency and accuracy. In other words, while there are no problems on the hardware side, software resources required to make full use of these computers are thought to be insufficient.

(4) Other measures and points of caution

When the management of the Banias Power Station was asked about their views regarding improvements, it mentioned the following items. Their views are summarized here.

① Fuel switch
Switch from heavy oil to gas at each unit

② Raising efficiency
Raise the efficiency of the No. 1 and No. 2 generators, currently 28%, and that of the No. 3 and No. 4 generators, currently 33-34%, to the average high efficiency of turbines, which is 36-37%.

③ Study of ways to efficiently use repair funds
Prioritize repairs of leaking pipes of heavy oil sent from refinery. Repairs should be considered from the viewpoint of cost and effect, and the most effective measures should be taken as much as possible.

④ Environmental conservation by switching to gas combustion
Lower the level of NOx, SOx, and dust emissions from the current level.

⑤ Rehabilitation of control equipment
Aging control equipment for the No. 1 and No. 2 generators does not indicate accurate readings and thus should be replaced. Measurement equipment and control equipment for the No. 3 and No 4 generators are separated, which has no problems. For all of equipments, aged deterioration should be handled with greater use of computers.

⑥ Reduction of internal load
The water supply pumps for the No. 1 and No. 2 generators have poor operation characteristics, and are prone to high losses. They should be replaced with modern boiler water supply pumps.

⑦ Use of computerized unit control
Introduce computer control system to create intelligent plant

Control room

2.2.4 Environmental Problems

Recently, the gravity of environmental problems has been recognized in Syria also. This is due to the fact that waste water from power stations pollute the Mediterranean Sea, and the fact that complaints have arisen regarding atmospheric pollution in the vicinity of power stations and oil refineries.

(1) Air pollution

1) Current status of air pollution

Because, at the time of this project, Syria and the PEE did not have environmental regulations, pollution control equipment was not installed. However, based on the WHO guidelines, Syria has enforced atmospheric pollution guidelines since 1994, so that the PEEGT is aiming to implement measures such as the following.

① Install electrostatic dust collectors, and if necessary, SOx and NOx filters

② Switch from heavy oil to gas as the employed fuel

In 1989, the Syrian government conducted a survey of gas emissions by the Banias Power Station. The results of this survey are shown in Table 23. In the view of the Banias Power Station, the pollution that residents complain about comes from refineries, and they assert that the Banias Power Station is not responsible.

【Table 23　Emission Gas Measurement Results by Each Generator】

	Unit 1	Unit 2	Unit 3	Unit 4	Total
Emission gas　O_2 (% Dry)	6	7.3	4.9	4.5	
Emission gas　temperature (℃)	167.9	131.5	155	155	
SO_2　emission (t/day)	11.3	8.6	21.5	21.4	62.8
CO_2　emission (t/day)	481	366.4	916.1	911.9	2,675.4

Source: OECF Report

2) Measurement results

The quality of the air in four locations around the Banias Power Station was measured as part of a OECF survey conducted in 1995 as mentioned above. The results of these measurements are shown in Table 24.

A point........9 km south-southwest
The wind blows seldom in this direction and few car traffic in this area, so that the air quality at this point is considered to be clean.

B point........5.5 km east-southeast
The wind sometimes blows in this direction.

C point........9 km east-northeast
This point, located on top of a hill, is the location that is considered to have the most severe air pollution. Black soot and dust fallout called acid smut rains in this location.

D point........2.5 km northeast.
This busy urban location in Banias has heavy car traffic.

【Table 24　Air Pollution at Four Locations】

Note:　The values above were measured over one hour during 60% load at the Banias Power Station

	Nox (ppm)		Sox (ppm)		Dust (mg/m^3)		Measurement time (Hr)
	Average	Max	Average	Max	Average	Max	
A	0.002	0.010	0.001	0.005	0.024	0.062	42
B	0.002	0.012	0.001	0.001	0.030	0.049	24
C	0.010	0.025	0.011	0.078	0.020	0.055	117
D	0.008	0.020	0.009	0.049	0.025	0.071	24
Syrian standards	0.130		0.210		0.254		
Japanese standards	0.100		0.040		0.100		

The figures in Table 24 show that the highest recorded pollution values were 0.078 ppm for SOx, 0.025 ppm for NOx, and 0.055 ppm for dust. They were measured when the Banias Power Station operated at 60% load. The emission value over one hour for SOx during 100% load operation would be converted to 0.13 ppm (by simply using the fact that 1/0.6 = 1.67 times).

The average value is 0.02 ppm, which is not considered to be a problem, but the one-hour value equals the maximum allowed value.The average level of sulfur emission over one day at the Banias Power Station has been calculated to be one hundred ten tons at the maxium, as follows.

(Assumption)

The maximum power level was in 1992 when 4,080 GWh were produced (this output figure was less half in 1997)

Heavy oil consumption: 4,080/3.57(GWh / thousand tons) = 1,150 (thousand tons)

Sulfur content: 3.5%

(Calculated value)

Average sulfur emission amount: (1,150,000 (tons)/365 (days)) × (3.5/100) = 110 (ton/day)

Based on the above, the daily SO_2 emission amount was calculated to be double the amount of sulfur emissions, or 220 tons/day. While this emission level satisfies the former standard of the World Bank (500 tons/day or less), it exceeds the new standard of 680 MW x 0.2 = 136 (tons/day) and the emission concentration of 2000 mg/Nm^3 (= approx. 700 ppm). Although the new standard does not apply to existing power stations, caution is required.

In relation to the above, the white spots that cover grape leaves in their early stage (1 to 2 spots per leaf) are believed to be due to acid smut, which is a problem. Whether the cause of this damage is the power station or refineries cannot be determined because the area where the grapes grow is downwind from both the power plant and the refineries, but is matter also requires caution. To solve the problems, dust collector and ash-incinerator, which can reduce the weigh of ash to one tenth and make easy to convey it, are installed. To collect heavy metals, it is recommendable to make a plant which covers not only Syria but other neighboring countries.

NOx is not particularly a problem, with emission levels normal.

Soot and dust is related to acid smut, and it cannot be ruled out that it is a problem.

3) Air pollution countermeasures

① Installation of industrial TV for monitoring stack emissions

Combustion control at the Banias Power Station is not satisfactory. Considering the facts that the air flow is not augmented when black smoke spills out, and there is no colored glass on the flame monitoring window to permit observation of the flames, it appears that defects exist such as the O_2 meter of the central control room being defective, or there being drifts within the boiler gas flow (in the majority of cases, the gas flow is not uniform), making O_2 meter readings inaccurate(measurement point is not typical point). Furthermore, observing flames without colored glass is like trying to look at the sun without dark glasses, and only the most glaring combustion defects can be detected. It appears that there is no custom of watching burner flames through colored glass at present.

Based on the above-described conditions, full control of the air flow through monitoring of black smoke with industrial TV monitors is the simplest prescription for combustion control.

② Washing of inside of stacks

The boilers were operated continuously until 1995, and there was relatively little need for washing them. However, as peak load operation will rise, opportunities to stop the units will increase, at which time the temperature in the boiler heat transfer section will inevitably drop.

On the other hand, as long as the thickness of the ashes adhering to the inside of the stacks is on the order of 0.1 mm, no flaking occurs, but when the thickness is on the order of 0.2 mm, the temperatures of the stack and the ashes cause different expansion coefficients that lead to flaking when the unit operation is stopped, and as a result scattering can occur when the unit is started up again. To prevent such scattering, it is useful to water to remove thick ash layers. Thus, during intermediate inspections, during a unit operation is stopped for a long time, or during general maintenance, washing should be done.

(2) Water contamination

Raw water supplied from wells, and is used as drinking water at the power plant is not a problem, but because household sewage water from employee housing and general non-industrial sewage water are discharged untreated in the Mediterranean, the BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), and SS (Suspended Solids) values all rose, causing a problem.

Recently, this situation has been improved by processing sewage water before releasing it into the sea.

① Household sewage water

The OECF survey suggested measuring BOD following treatment of household sewage water, which had been suspected as a problem, and BOD values started being recorded from the OECF Monitoring Report. Regardless of the level of the measurement values, what is most significant is that, through follow-up by the OECF, the Banias Power Station itself has officially announced that it will take measures to enable BOD measurements, and moreover release BOD measurement values. Currently, the BOD value exceed 100 ppm, and while this level cannot be declared to be bad, ideally the plant, as a community model, should lower this value to about 30 ppm.

【Table 25　Results of BOD Monitoring for Household Sewage Water】

	BOD (mg/l)		COD (mg/l)		SS (mg/l)		PH	
	First	Second	First	Second	First	Second	First	Second
Oct. ' 97	—	—	4	3.5	—	—	7.6	7.5
Nov. ' 97	—	—	3	5	—	—	7.4	7.6
Dec. ' 97	120	—	4	3	—	—	7.3	7.4
Jan. ' 98	110	100	3.5	3	—	—	7.5	7.6

Source:　OECF report, submitted in March 1998

Household sewage water treatment tanks

② General sewage water

While such sewage water is called general sewage water, it has a high BOD and pH value, so that there is the possibility that it is mixed with sewage water from the neutralizing tanks of the demineralizers of the power plant. Devising suitable measures based on surveys is necessary.

【Table 26　General Sewage Water Monitoring Results】

	BOD (mg/l)		COD (mg/l)		SS (mg/l)		PH	
	First	Second	First	Second	First	Second	First	Second
Oct. ' 97	—	—	3.5	3	—	—	9.4	9.3
Nov. ' 97	—	—	4	3.5	—	—	9.2	9.1
Dec. ' 97	100	80	3.3	4	—	—	9.0	9.1
Jan. ' 98	40	50	3.8	2.5	—	—	9.1	8.1

Source:　OECF report, submitted in March 1998

(3) Noise pollution

The area around the power station site is vacant, and since city residents' housing is distant, noise does not represent a problem and staff apartments and management housing are located next to the power plant (the power plant and housing sites are connected, separated by a concrete wall), and the noise level at the boundary line is 47 to 59 DB, which is also an acceptable level.

2.3 Project Effects and Impacts

2.3.1 Qualitative Effects and Impacts

(1) Resolution of chronic power shortages and industrial development impact

From the beginning of the 1980's, Syria has experienced chronic shortages of electric power. The capital city of Damascus itself suffered from daily power outages lasting 2 to 3 hours in 1992, and in 1993 the situation grew even worse with power outages lasting 5 to 6 hours. This irregular power outages have naturally been a major source of inconvenience for the people, as well as a source of uncertainty for the operation of plants, and chronic power shortages have been a very great impediment to the development of the manufacturing industry. In response, in 1993, the Syrian government moved to implement a plan to strengthen the nation's power output capacity, and currently this problem has almost been solved. As a result, many new plants have been constructed; according to Ministry of Industry survey, there were 3,816 business establishments around Damascus in 1997, and industrial outfits accounted for one fifth of this figure (the rest are mostly individual businesses).

The output capacity of the Banias Power Station, as shown in Table 27, accounted for over 30% of Syria's total output in 1989, when the No. 3 and No. 4 generators started producing electricity. Thereafter, thermal power plants have been constructed one after the other, including the Jandar Power Station, the Aleppo Thermal Power Plant, and the Al-Zala Thermal Power Plant. As a result, the relative contribution of the Banias Power Station compared to Syria's total output has steadily declined, and by the year 2000 it is estimated that it will contribute less than 10% of the nation's total electric power output. However, as the forerunner of other power stations that were built later, its importance remains high.

【Table 27　Percentage of Output Capacity of Banias Power Station】

	a: Total in Syria (MW)	b: Banias (MW)	b/a (%)
1983	1,200	300	25.0
1989	1,980	600	30.3
1993	2,575	600	23.3
1995	3,875	600	15.5
1997	5,175	600	11.6
2000	6,375	600	9.4

Source: PEEGT

(2) Employment impact

Of the 850 persons working at the Banias Power Station, approximately 50% are from Banias and its suburbs, 10% are from Lattakia (approx. 40 km to the north of Banias), and 40% are from Tartus (approx. 20 km south of Banias), so that the great majority of workers are from the Mediterranean coast area. (However, some 10 persons in management are university graduates who have been assigned by government orders to Banias from all parts of the country.) In this way, the Banias Power Station has a very strong impact on regional employment.

Some 200 employees in this work force live in employee housing adjacent to the power station site, some 200 more inside the city of Banias, and the remaining 400 employees commute to work from neighboring villages using 15 company buses.

The city of Banias also has other large plants including the Banias Refinery (2,500 workers), the crude oil terminal (850 workers). As the result of this concentration, Banias, which used to be a lonely village of a few fishermen, has grown into the flagship industrial city of Syria with a population of close to 200,000 persons (other industrial cities include Homs, Aleppo and Mehaldeh).

(3) Technology transfer

Banias Power Station has been instructing about 50 trainees for one month in summer every year. These trainees are students from universities (Syrian universities follow a system almost identical to the Japanese system, except that engineering study programs last five years; Syria has four universities in Damascus, Aleppo, Lattakia, and Homs), technical colleges (equivalent to Japan's 2-year junior colleges; Syria has ten 2-year technical colleges), and the PEEGT's Electricity Department. During the summer of 1997, five students from Aleppo University and Lattakia University, 25 students from technical colleges, and 5 students from the PEEGT were thus trained free of charge for one month.

In this way, the Banias Power Station functions as an important point for technology transfer. The plant also requests material testing and experiments from universities, and conducts joint experiments with universities, thus having an large impact on technology transfers in the region.

The Syrian school system resembles that of Japan, with six years of elementary school (compulsory education), three years of junior high school (preparatory, attended by some 80% of students), and three years of senior high school (secondary, attended by some 75% of students). Additionally, higher education is provided through 2-year technical colleges, and 4-year (as a rule) universities (except 6 years for medicine and 5 years for engineering).

Some 25 to 50% of high school graduates go on to study at technical colleges or universities. Education is completely free. However, in many cases university graduates are assigned posts by the government, and duty stations do not necessarily match the preference of the graduate.

【Table 28　Education Level of Banias Power Station Employees】

Ph.D.	1
Engineers (university graduates)	118
Assistant engineers (technical college = junior college graduates)	416
Technicians (high school graduates)	122
Junior high school graduates	42
Elementary school graduates	131
Skilled workers	46
Total	867

Source:　Banias Power Station

(4) Public relations impact

This project was Syria's first to be financed with an ODA loan, and it has an extremely high significance for the Syrian economy by improving Syria's power supply conditions. The success of this project has led to the second and third large-scale ODA loans to Syria, for the Jandar Power Station and the Al-Zala Thermal Power Plant. Furthermore, while financed with Saudi Arabian loan, the construction of the Aleppo Thermal Power Plant was done by Japanese companies, so that some 70% to 80% of Syria's electric power output capacity is provided by power stations built by Japanese companies. As a result, the Syrian people is kindly disposed toward Japan, and has strong feelings of interest. Such points deserve to be actively disseminated to Japanese people.

2.3.2　Quantitative Effects and Impacts

The net sales and cost figures collected in this survey show that the Banias Power Station has never been profitable on an independent basis since the start of operations.

Along with this fact, Syria's PEE is in charge of the entire cycle from power generation to selling power, but since the terminal sale price (power rates billed to end users) are kept low by policy, the PEE is constantly in the red, and has been receiving subsidy from the government. While power rates are revised once every few years, such subsidy are always kept within a range that is not burdensome to end users, and do not contribute to bringing the PEE in the black.

Then, as previously mentioned, the PEE was split into the PEEGT and the PEDEEE in 1994 in order to raise the efficiency of the power sector. However, the policy of keeping power rates low was maintained, and expecting more efficient management just through this split makes improving the management efficiency of the PEEGT and PEDEEE a very difficult proposition. Therefore, while each power station including the Banias Power Station under the umbrella of the PEEGT is gradually been required to make more efforts in the area of management, but as long as the Syrian government does not abandon its policy of keeping power rates low, it will be virtually impossible for power stations to become profitable on an individual basis. (Currently, the Jandar Power Station, which employs combined cycle power generation facilities with superb thermal efficiency, is barely breaking even.)

Accordingly, PEEGT should continue this financial subsidiary system to keep the plant’s maintenance in good condition, otherwise PEEGT has to raise the tariff of power to make the plant profitable.

The Banias Power Station having thus been in the red every year, we have decided to postpone recalculation of the FIRR.

Another basic problem that we would like to point out is the difficulty of obtaining related accounting and financial data. For instance, with regard to the business condition of the Banias Power Station on an independent basis, we were able to obtain the data shown in Table 29, these data were not obtained from the annual report of the power plant, but instead requested by the OECF mission and compiled separately.

Furthermore, the contents of the "Others" cost entry in the table are unclear, and the fact that questions of the OECF mission members were not given clear answers seems to indicate that standard accounting procedures are not employed. This problem, which has existed since before the management efforts at each power station, must first be clearly understood, and in order to do this, it is strongly hoped that each power station will introduce and establish an accounting system and follow standards accounting practices.

【Table 29　Profit/Loss Statement of Banias Power Station】

(Units: 1,000 S￡)

	Capital Cost	Turnover a	Operations/ maintenance b	Operation Cost c	Wages d	Others c	Total cost f=b+c+d+e	Profit g=a-f	Profit ratio h=g/a*100
1987	80,152						0	−80,152	
1988	227,418						0	−227,418	
1989	336,886	276,125	1,187	321,897	7,574	15,763	346,114	−69,989	−9.8
1990	176,380	594,899	1,117	704,565	14,847	100,954	821,483	−226,584	−25.1
1991	1,696	903,686	2,221	855,386	19,372	149,422	1,026,402	−122,716	−8.4
1992	5,212	1,007,677	2,586	1,045,836	24,931	300,340	1,373,393	−365,715	−22.9
1993	7,899	970,338	1,440	964,012	28,526	368,124	1,362,102	−391,764	−28.9
1994		889,311	5,323	871,601	31,703	160,606	1,069,234	−179,922	−10.6
1995		839,895	9,114	695,359	41,175	666,501	1,412,148	−572,253	−43.9
1996									
1997									

Note: Listed costs consist of total costs divided proportionally according to the power output capacity ratio of the No. 3 and No. 4 generators, and therefore they can be considered to be on the high side.

Gas Turbine

Boiler