Chapter 3 Electric Power

3.1 Situation of Electric Power in Argentina

3.1.1 Formation of Current Electric Power Sector

The business structure of Argentina's power industry was liberalized in 1992. The regulatory agency "the Ente Nacional Regulador de la Electricidad - Argentina (ENRE)" and the electric wholesale market "the Mercado de Electrico Mayorista (MEM)", were founded. Also CAMMESA (Administrative Company of Electric Wholesale Market) was established as an executive company for administration and operation. CAMMESA is responsible for the national load dispatch in the wholesale electricity market and its functional share is shown in Table 3.1.1.

The three federal electric corporations, i.e. the Servicios Eléctricos del Gran Buenos Aires (Segba), the Agua y Energía Eléctrica Sociedad del Estado (AyEE) and the Hidroeléctrica Norpatagonica S.A. (Hidronor) were privatized. On the other hand the power transmission and distribution sectors were separated from the power generation sector, in process of the reorganization of the business structure. The power generation sector of the Segba was divided into 4 power generation companies, the AyEE into 12 thermal power generation companies and 4 hydraulic power companies, and the Hidronor into 5 hydraulic power companies.

This Study involves the 5 power generation companies in the model areas: Central Costanera S.A., Central Buenos Aires S.A., Centrales Termicas Mendoza S.A., Central Puerto S.A. and Central Termica San Nicolas S.A.

Table 3.1.1 Shares and Role of CAMMESA

Shares	Holding Ratio %	Organization	Role
Class A	20	National Government (Secretariat of Energy)	・Determine the technical and economical dispatch ways to the SADI*,by maximizing wholesale energy prices on the spot market while maintaining a maximum level both of system security and quality of supply. ・Plan power requirements and optimize the program established on a periodic basis by the Energy Secretary. ・Supervise periodically the operation of the market and administrate technically the dispatch of the contracts agreed in the market.
Class B	20	AGEERA (Argentine Association of Electric Power Generators)	
Class C	20	ADEERA(Argentine Association of Distributors of Electric Power)	
Class D	20	ATEERA(Argentine Association of Transporters of Electric Power)	
Class E	20	AGUEERA(Argentine Association of Major Electricity User)	

* SADI : Argentine National Grid System

3.1.2 Trends of Electric Power Demands

Table 3.1.2 and Figure 3.1.1 show the power consumption by use in Argentina. The largest consumption arises from industrial use. The residential and the commercial use follow in sequence. These top three account for about 86 - 88% of all power consumption.

The power consumption had increased 1.24 times in the four years from 1995 to 1999 and the mean annual growth rate in this period was 5.6%. Increments of the consumption are recorded as 1.55 times by commercial users, 1.24 times by residential users and 1.18 times by industrial users.

Table 3.1.2 Electric Power Consumption by Use in Argentina

(Unit : million kWh)

Year	Residen -tial	Commer- cial	Industri -al	Water supply	Street light	Transp- ortation	Irriga- tion	Govern- ment	Others	Agricult -ural	Total
1995	16,745	7,135	21,506	792	2,140	344	457	1,764	210	343	51,435
1996	17,102	7,566	22,276	1,054	2,268	420	469	1,969	629	527	54,280
1997	18,087	8,750	25,155	801	2,363	437	535	1,856	496	427	58,907
1998	18,664	9,638	26,029	902	2,579	475	586	2,485	1,050	512	62,918
1999	20,041	11,042	25,384	900	2,700	490	560	1,900	307	530	63,854

Source : #117

Figure 3.1.1 Electric Power Consumption by Use in Argentina

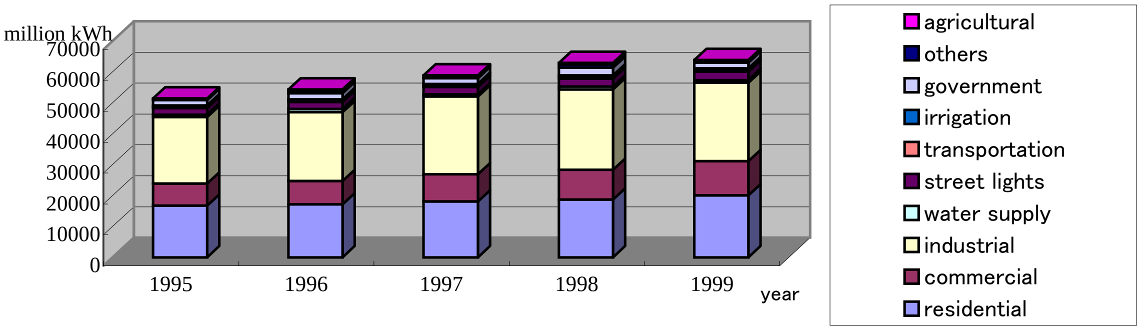

Table 3.1.3 and Figure 3.1.2 show the power generating capacity of the power stations connected to the domestic electricity grid. The power generating capacity had increased 1.22 times in the 4 years from 1995 to 1999 and the mean annual growth rate was 5.2% over this period. In terms of facility type, the combined cycles showed a substantial increase as much as 15.4 times over. In 1999, the thermal power generating capacity reached 10,389MW in total including the combined cycles and accounted for 50.7% of all power generating capacity. As for the breakdown, the steam turbines account for 22.3% of all power generation. The remaining generating capacity comes from gas turbines 14.8%, combined cycles 12.0% and diesels 1.6%. The power generating capacity of the

principal thermal stations of Argentina is summarized in S3-1.

Table 3.1.3 Power Generating Rated Capacities

(Unit : MW)

Year	Hydraulic power	Nuclear power	Thermal power				Wind power	Total
			Steam turbine	Gas turbine	Diesel	Combined cycle		
1995	7,587	1,018	5,018	2,867	103	160	--	16,753
1996	8,129	1,018	5,018	3,155	7	149	1	17,476
1997	8,543	1,018	4,716	3,336	-	710	--	18,324
1998	8,715	1,018	4,603	3,146	307	2,053	7	19,842
1999	9,093	1,018	4,570	3,029	329	2,461	--	20,501

Source : #117

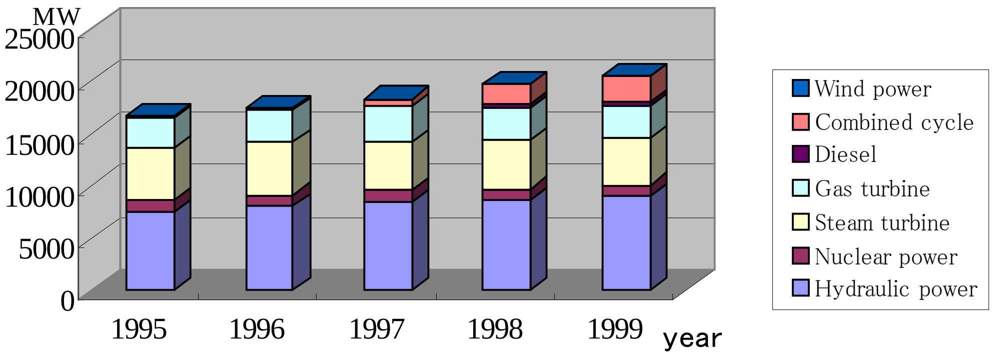

Figure 3.1.2 Power Generating Capacities

Table 3.1.4 and Figure 3.1.3 show the electricity generation of the power stations connected with the domestic electricity grid. Total electricity generation had increased 1.27 times in the 4 years from 1995 to 1999 and the mean annual growth rate was 6.1%. Total electricity generation in 1999 was 74,640GWh. Diminution of the hydraulic power generation is supplemented by thermal power generation. Of the total electricity generated, 69,286GWh are provided by domestic power generation and 5,354GWh are by imported power. The dependence on imported power mainly from Paraguay is about 7%.

Table 3.1.4 Electricity Generation

(Unit : GWh)

	Hydraulic	Nuclear	Thermal	Domestic total	Import	Total
1995	22,854	7,066	27,057	56,893	2,013	58,906
1996	19,614	7,459	32,738	59,812	3,204	63,016
1997	24,170	7,961	30,575	62,705	5,160	67,865
1998	23,204	7,453	32,476	63,133	8,000	71,133
1999	19,395	7,106	42,786	69,286	5,354	74,640

source : #117

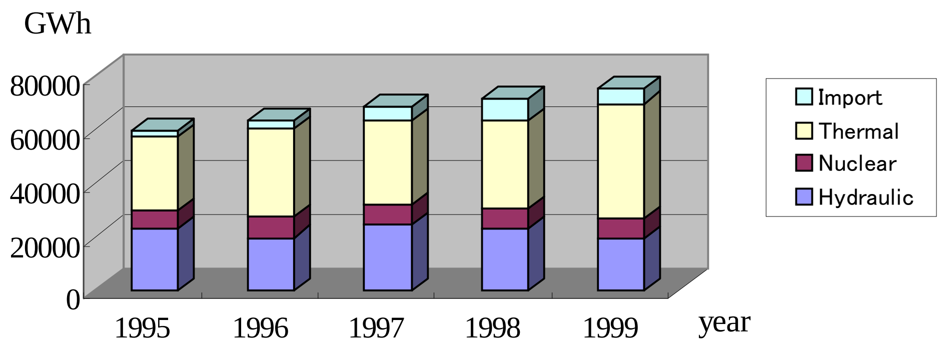

Figure 3.1.3 Electricity Generation

3.1.3 Prospect of Supply and Demand of Electric Power

Argentina's Secretariat of Energy is obligated to plan energy policy, to provide precise information regarding short, medium and a long-term supply-demand policy for energy, and to issue a guideline concerning an evaluation of available natural resources for energy use. The "PROSPECTIVA 1999" (#144) and "PROSPECTIVA 2000" (#255) have forecasted the prospect of supply and demand of electric power required for economic development in the future. The following summarizes its contents.

1) Conditions

The following four aspects are considered in order to estimate the future trends of supply and demand of electric power (energy) from 2000 to 2010.

- Trends of GDP (Gross Domestic Product)
- Trends of electric power demand
- Trends of export of electric power
- Trends of electric power supply

The growth rate of the GDP is assumed to change over the years as follows based on the national economic accounting system introduced in 1993.

1999/2000	2000/2001	2001/2002	2002/2003	2003/2005	2006/2010
0%	2.5%	4.0%	5.0%	5.0%	4.0%

According to the changing GDP, three representative cases (hypotheses) of power demand in the future, i.e. Case A, B and C, can be considered, which cover the cases of large, medium and small power demand, respectively. These hypotheses are based on the trend of past power demand from 1993 to 2000 and take into account such factors as the predicted power demand in response to the change of the GDP, the fact that the power demand does not always correlate well with the GDP trend in a recession period and that the power demands of residential, commercial and industrial use are assumed to increase without reference to the economic situation.

As for the export of electric power, the estimation of power demand is carried out considering the possible demand arisen from mutual import-export agreements with neighboring countries (i.e. Brazil, Uruguay and Chile) during the said period including currently valid contracts as well as future projects in progress of application and/or under examination.

As for the change of power supply, the entry projects, which have clear information of the going of work, the accessibility to transmission system, the supply contract of fuel and the financing program, etc., are considered in the estimation of power supply projects that are known at this time. The estimation of power supply also includes some surplus power involved with export, which are expected as a result of the international transaction of electricity.

2) Prospect of electric power demand

The prospect of electric power demand estimated by the above-mentioned conditions is shown in Table 3.1.5, Table 3.1.6 and Table 3.1.7.

Table 3.1.5 Electric Power Demand - Mercado de Energía Mayorista (MEM)

	Electric power demand（GWh）			Annual increasing rate（%）		
	A	B	C	A	B	C
1999	68,733	68,733	68,733	-	-	-
2000	71,934	71,934	71,934	4.7	4.7	4.7
2001	76,250	75,407	74,092	6.0	4.8	3.0
2002	80,825	78,505	76,314	6.0	4.1	3.0
2003	86,638	82,989	79,568	7.2	5.7	4.3
2004	93,092	88,111	83,240	7.5	6.2	4.6
2005	99,768	93,329	86,895	7.2	5.9	4.4
2006	105,062	97,295	89,397	5.3	4.2	2.9
2007	110,648	101,440	91,973	5.3	4.3	2.9
2008	116,541	105,766	94,627	5.3	4.3	2.9
2009	122,758	110,282	97,361	5.3	4.3	2.9
2010	129,317	115,001	100,177	5.3	4.3	2.9

The actual values are indicated in 1999 and 2000.

Table 3.1.6 Prospect of Electric Power Demand (MEM and Nation)

Case A

	Whole country		MEMSP		Patagonia Sur		Other		MEM	
	GWh	Growth rate%	GWh	Growth rate%	GWh	Growth rate%	GWh	Growth rate%	GWh	Growth rate%
1998	71,156	4.9	3,443	-10.8	345	7.7	1,636	15.3	65,732	5.6
1999	73,896	3.9	2,913	-15.4	395	14.7	1,855	13.4	68,733	4.6
2000	77,932	5.5	3,655	25.5	405	2.5	1,938	4.5	71,934	4.7
2003	93,822	6.4	4,485	7.1	436	2.5	2,263	5.3	86,638	6.4
2005	107,530	7.1	4,804	3.5	458	2.5	2,500	5.1	99,768	7.3
2010	138,732	5.2	5,706	3.5	519	2.5	3,191	5.0	129,317	5.3

Case B

	Whole country		MEMSP		Patagonia Sur		Other		MEM	
	GWh	Growth rate%	GWh	Growth rate%	GWh	Growth rate%	GWh	Growth rate%	GWh	Growth rate%
1998	71,156	4.9	3,443	-10.8	345	7.7	1,636	15.3	65,732	5.6
1999	73,896	3.9	2,913	-15.4	395	14.7	1,855	13.4	68,733	4.6
2000	77,932	5.5	3,655	25.5	405	2.5	1,938	4.5	71,934	4.7
2003	89,984	4.9	4,388	6.3	430	2.0	2,178	4.0	82,989	4.9
2005	100,728	5.8	4,610	2.5	447	2.0	2,343	3.7	93,329	6.0
2010	123,425	4.1	5,215	2.5	494	2.0	2,716	3.0	115,001	4.3

MEMSP: Mercado Eléctrico Mayorista Sistema Patagónico

Case C

	Whole country		MEMSP		Patagonia Sur		Other		MEM	
	GWh	Growth rate%	GWh	Growth rate%	GWh	Growth rate%	GWh	Growth rate%	GWh	Growth rate%
1998	71,156	4.9	3,443	-10.8	345	7.7	1,636	15.3	65,732	5.6
1999	73,896	3.9	2,913	-15.4	395	14.7	1,855	13.4	68,733	4.6
2000	77,932	5.5	3,655	25.5	405	2.5	1,938	4.5	71,934	4.7
2003	86,137	3.4	4,027	3.3	422	1.4	2,120	3.0	79,568	3.4
2005	93,666	4.3	4,116	1.1	432	1.1	2,223	2.4	86,895	4.5
2010	107,435	2.8	4,347	1.1	456	1.1	2,455	2.0	100,177	2.9

Table 3.1.7 Prospect of Electric Power Demand (Users)

Case A（Scenario of high demand of electric power） (Unit : GWh)

Year	1999	2000	2003	2005	2010
Housing	20,871	21,069	25,523	29,472	39,441
Commerce	17,213	18,054	21,884	25,263	33,648
Industries	25,354	27,240	32,942	37,674	49,753
Agriculture and cattle breeding	534	558	672	779	1,028
Transportation	517	541	651	751	988
Total	64,489	67,463	81,671	93,939	124,859

Case B（Scenario of medium demand of electric power）

Year	1999	2000	2003	2005	2010
Housing	20,871	21,069	24,502	27,537	34,811
Commerce	17,213	18,054	21,019	23,591	29,824
Industries	25,354	27,240	31,534	35,434	44,624
Agriculture and cattle breeding	534	558	646	722	918
Transportation	517	541	629	710	906
Total	64,489	67,463	78,330	87,997	111,083

Case C（Scenario of low demand of electric power）

Year	1999	2000	2003	2005	2010
Housing	20,871	21,069	23,496	25,696	30,269
Commerce	17,213	18,054	20,110	21,966	25,900
Industries	25,354	27,240	30,158	32,825	38,948
Agriculture and cattle breeding	534	558	619	682	802
Transportation	517	541	599	659	772
Total	64,489	67,463	74,981	81,827	96,691

The electric power demand of MEM by region in the Case B (assuming a medium demand) with social economy in mind is shown in Table 3.1.8 and Figure 3.1.4, and the mean annual growth rate is shown in Table 3.1.9 and Figure 3.1.5, respectively.

Table 3.1.8 Net Demand of National Electric Power System

(Unit : %)

Year	Great B. Aires	Litoral	Comahue	Buenos Aires	Centro	Cuyo	North -east	North -west	MEM Total	
									%	GWh
1999	43.7	12.8	4.2	12.6	8.6	6.3	4.7	7.1	100.0	68,733
2000	43.9	12.9	4.0	13.0	8.5	6.1	4.7	6.9	100.0	71,934
2003	44.2	13.1	3.9	12.4	8.6	6.0	4.5	7.2	100.0	82,989
2005	43.0	14.0	3.8	11.5	8.1	6.6	4.7	8.3	100.0	93,329
2010	43.0	14.0	3.8	11.5	8.1	6.6	4.7	8.3	100.0	115,001

In 2000, the demand of GBA was 31,547GWh, which accounts for 43.9% of all MEM demand. The growth rate in GBA from 1999 to 2010 was 4.6%. As for the Province of Buenos Aires, the demand was 9,335GWh, which accounts for 13.0% of all MEM demand, and the growth rate was about 3.9%. As for Cuyo, the demand was 4,399GWh, accounting for 6.1% of all MEM demand, and the growth rate was 6.6%.

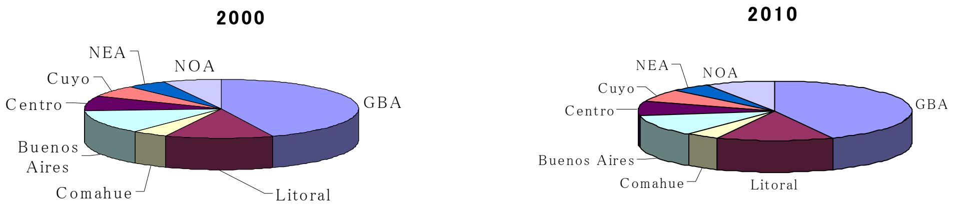

Figure 3.1.4 Net Demand by Region

Table 3.1.9 Growth Rate of Net Demand of National Electric Power System (Case B)

(Unit : %)

Year	Great B. Aires	Litoral	Comahue	Buenos Aires	Centro	Cuyo	North-east	North -west	MEM Total
1999-2000	5.1	5.6	-0.9	7.7	4.0	1.1	5.2	1.9	4.7
2000-2005	4.9	5.8	4.3	3.6	4.6	8.3	4.4	9.7	5.3
2005-2010	4.3	5.6	4.0	3.5	4.0	3.1	5.0	4.0	4.3
1999-2010	4.6	5.7	3.7	3.9	4.3	5.2	4.7	6.4	4.8

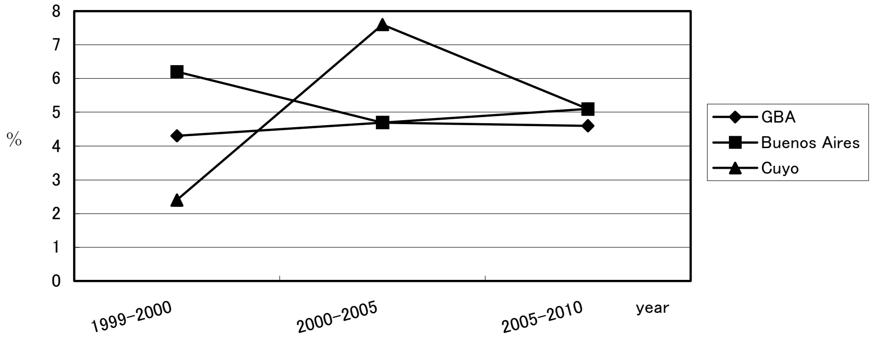

Figure 3.1.5 The Mean Annual Growth Rate

3) Prospect of electric power supply

The electric power supply scenarios assume Case B (the moderate growth rate of domestic demand) and the supposed external demand by mutual import-export with neighboring countries as follows.

(Unit:GWh)

Year	Brazil	Uruguay	Chile
2001	1,000	365	300
2002	2,000		
2003			300
2004	3,200		
2005			

The electric power supply scenarios have included the supply from the Yacyreta hydraulic power plant, from the planned Atucha II atomic power plant, from published projects of new and extensions to existing plants, and also from wind and photovoltaic power generation.

The published projects of new facilities and the extension of existing facilities, are summarized in Table 3.1.10. The total supply plan of all thermal projects is expected to be 6,048 MW, which is composed of 3,568MW from new sources, 2,483MW from the extension of existing enterprises, and 1,066MW from the nuclear and hydraulic power plants under construction.

In addition to the published projects, new thermal and hydraulic plants and the Yacyreta hydraulic plant are also included in the supply scenarios.

Table 3.1.10 Published Power Plant Projects of New and Extension

Increment from new sources

Power plant	Province	Plant Type	Rated Output (MW)	Year in operation
Absolute entry				
AES PARANA	Buenos Aires	Combined cycle	845	2001
C.T.PLUSPETROLNORTE	Tucuman	Gas turbine	123	2002
NUEVA CENTRAL INDEPENCIA	Tucuman	Combined cycle	242	2003
ELECTROPATAGONIA	Chubut	Combined cycle	68	2001
ENARGEN	Neuquen	Combined cycle	480	
TERMOANDES	Salta	Combined cycle	270	
Uncertain entry				
CEBAN	Buenos Aires	Combined cycle	775	2001/2005
ENTERGY	Buenos Aires	Combined cycle	762	2003
Subtotal			3,565	

Extension of existing enterprises

Power plant	Province	Plant Type	Rated Output (MW)	Year in operation
Absolute entry(in processing)				
S.M.DE TUCUMAN (remodeling)	Tucuman	Combined cycle	273	
LAS PLAYAS	Cordoba	Combined cycle	250	
SAN PEDRO	Jujuy	Combined cycle	60	2002/2006
TERMOROCA	Neuquen	Combined cycle	60	2003/2004
Others				
LOMA DE LALATA (remodeling)		Combined cycle	190	
PIEDRABUENA	Neuquen	Combined cycle	800	
GENELBA2	Buenos Aires	Combined cycle	850	2003
Subtotal			2,483	
Total			6,048	

Power plants under construction

Power plant	Province	Plant Type	Rated Output (MW)	Year in operation
ATUCHA II	Buenos Aires	Nuclear	745	2007
CUESTA DEL VIENT		Hydraulic	9	2001
POTRERILLOS		Hydraulic	129	2002
LOS CARACOLES		Hydraulic	123.4	2005
PUNTA NEGRA		Hydraulic	60	2006
Total			1,066.4	

The Yacyreta hydraulic power plant has 3,100MW (155MW×20 units) of the total power output. However the actual power output of each unit is about 85 to 95MW because the plant is currently operated with a low water elevation dam 76m in height. The water elevation of the dam is supposed to be increased up to 83m in 2006 and an increment of power output about 1,200MW is expected by this project.

In 2005, the integration project of three power plants, the Cambari power plant of 102MW in the border area upstream of the Tarija river, the Las Pavas power plant of 88MW in the upriver area of the Bermejo river and the Arrazayal power plant, is planned and expected to bring the total power output to 283MW. In Neuquen, offers by retail investors are being discussed for the construction of the Chihuido II power plant of 228MW.

With regard to the existing power generation facilities, it was supposed that they would continue to be used in future as backup facilities for the domestic market and for export contracts in the scenario. No extensive demolition was assumed.

On the above-mentioned assumption, “PROSPECTIVA 2000” (#255) shows the prospect of projects of new and the expansion of existing plants by 2010 as shown in the Table 3.1.11.

Table 3.1.11 Power Supply Entry to MEM and MEMSP

Supply power plant	Type	Year	MDO	Pampeana	Nor-oeste	Litral, Noreste	Comahue	Centro	Cuya-na	Patagonico
Dock Sud	CC	2001	780							
San Nicolas	CC	2001				845				
Termoandes	CC	2001			630					
Los Perales	CC	2001								78
Electropatagonia	CC	2001								68
Conversion San M.De Tucuman	CC	2002			270					
CTPPN	TG	2002			123					
Independencia	CC	2003			242					
Other hydraulic power plants	HID	2003						320		
Bermejo	HID	2005			283					
Yacyreta（water elevation : 83m）	HID	2006				1,20				
Brazo Ana Cua	HID	2006				0				
Atucha	NUC	2007	745			250				
Proposed Combined Cycle	CC	2003		800				240	400	78
Proposed Combined Cycle	CC	2004	800		400		480			
Proposed Combined Cycle	CC	2005			460		650			
Proposed Combined Cycle	CC	2006	800							
Proposed Combined Cycle	CC	2007			400					
Proposed Combined Cycle	CC	2008					400			
Proposed Combined Cycle	CC	2010	800				400			
Total by region			3925	800	2808	2295	1930	560	400	224

CC: combined cycle, TG: gas turbine, HID: hydraulic, NUC: nuclear, MDO: Mercado or Greater BA,

Only such published projects of power generation facilities, as the Puerto Nuevo power plant (already in service) and a new combined cycle unit of the San Nicolas power plant (that has commenced commercial operation in September of 2001) are concerned with this survey. In the prospect of electric power supply by 2010, most thermal power generation plans are based on the combined cycle unit, except for the projects of hydraulic and nuclear power generation.

4) Environmental concerns of thermal power plants

Considering the thermal power plant from the environmental point of view, the Secretariat of Energy stated that emissions of gas pollutants would cause a problem (#144). Several pollution control measures are presented, including use of natural gas for fuel, adoption of the new high-efficient power generation facility (combined cycle), and making the installation of low-NOx combustors mandatory. It is considered that these measures are effective in controlling soot and dust, SO_2 and NOx that cause regional contamination. Consequently these measures would be of help to decrease the environmental impact of power plants.

3.2 Summary of Target Power Plants

3.2.1 Facilities

In the Study areas, there are four electric power companies and five power plants in total. The Nuevo Puerto power plant and the Puerto Nuevo power plant belong to the Central Puerto S.A., the Central Costanera power plant to the Central Costanera S.A., Central Buenos Aires Power Plant to the Central Buenos Aires S.A., the San Nicolas power plant to the Central San Nicolas S.A., and the Lujan de Cuyo power plant to the Centrales Termicas Mendoza S.A. Summary of the facilities of these power plants is tabulated in Table 3.2.1 (1)～(4).

The Unit 7 (Parana) of 830MW of the San Nicolas power plant was in operation in September 2001. There is no other project of new construction or extension of power plant planned in the model areas by 2010, according to the “PROSPECTIVA 1999”（#144） and “PROSPECTIVA 2000”（#255）.

1) Nuevo Puerto and Puerto Nuevo Power Plants

The building of the Nuevo Puerto power plant is beautifully designed out of regard for the landscape, which is illuminated every Friday and Saturday night, and is now becoming one of most notable sights in Buenos Aires.

Unit 4 of 60MW is progressively in a state of deterioration. The actual power output is now about 30MW. Recently the Unit works as a backup facility. Unit 4 is now composed of 4 boilers (No.1 to 4) and a steam turbine.

Mixed fuel combustion of natural gas and fuel oil（heavy oil）can be applied for Units 4, 5 and 6 of the Nuevo Puerto power plant and Units 7, 8 and 9 of the Puerto Nuevo power plant. The combined cycle power generation facilities（TG11・TG12）, also use dual fuel of natural gas and gas oil. Conventionally in these power plants, the natural gas was used for fuel in summer and the fuel oil in winter, although the tendency is now waning. The fuel switch depends on the natural gas supplier, which gives notice of the amount supplied.

2) Central Costanera Power Plant

Unit 5 is called Buenos Aires Central Termica, and is the first large scale combined cycle power generation in Argentina. It has 320MW of the total power output, being composed of a new gas turbine of 220MW and an existing steam turbine No.5 of 100MW (designed power: 120MW). Units 8 and 9 employ water injection systems at air intake ducts to improve the power efficiency of turbines by giving humidity and temperature drop to the air.

Mixed fuel of natural gas and fuel oil can be used in the steam turbines of Units 1, 2, 3, 4, 6 and 7, and also natural gas and gas oil or their mixture can be fueled in the combined cycles.

3) San Nicolas Power Plant

Unit 7 of 830MW (called Parana) was constructed and put into operation in September 2001, at the vacant lot of the Unit 6 that was pulled down after 10 years suspension.

With regard to the fuel used in the power generation facility, Units 1, 2 and 5 use coal, natural gas and fuel oil (heavy oil), while Units 3 and 4 use natural gas and fuel oil. Mixed fuel combustion can be applied. The present situation of fuel in use is that Units 1 and 2 generally use natural gas only, while Units 3 and 4 use dual fuel of natural gas and fuel oil, and Unit 5 uses mainly coal (95%) and the rest natural gas.

Table3.2.1(1) Specifications of Existing Units in Buenos Aires

(Existing)

Power Plant	Unit No.	Rated Output (MW)		Plant type	Fuel Type	Fuel Burnt (m^3/h)	Assumed Stack Gas (m^3N/h)	Stack Gas Temp. (℃)	Stack Gas Velocity (m/s)	Stack Height (m)	Stack Diameter (m)	Environmental Measures for Existing Facilities	Manufactures	Start Up Year
Buenos Aires	4	60		TV	G+FO	16,000	200,000	120	16.3	47	2.5		B&W－BB	1952
	5	110		TV	G+FO	32,000	393,000	120	22.2	47	3.0		CE－BB	1965
Nuevo Puerto	6	250		TV	G+FO	67,000	821,000	120	19.2	52	4.67		B&W－BB	1969
	TV	282	CC	TV								Low NOx Combustor Water Injection	GE	2000
	TG11	252		TG	G	55.9ton/h	1,914,000	100	22.6	40	6.4			
					GO		1,841,000	140	24.1					
	TG12	252		TG	G	55.9ton/h	1,914,000	100	22.6	40	6.4			
					GO		1,841,000	140	24.1					
Total		**1206**												
Puerto Nuevo	7	145		TV	G+FO	38,000	470,000	120	19.3	80	5.66	Low NOx Burners	CE－WH	1961
	8	194		TV	G+FO	49,000	600,000	120		stack for	Common use		CE－GE	1963
	9	250		TV	G+FO	65,000	800,000	120	22.4	59	4.3		B&W－BB	1970
Total		**589**												

TV: Steam Turbine, TG: Gas Turbine, CC: Combined Cycle, G: Natural Gas, FO: Fuel Oil, GO: Gas Oil

Note:1.Unit 1 and 4 are back up facilities.

2.Flue gas at only natural gas combustion

Table3.2.1(2)　　Specifications of Existing Units in Central Costanera

(Existing)

Power Plant	Unit No.	Rated Output (MW)		Plant type	Fuel Type	Fuel Burnt (m^3/h)	Assumed Stack Gas (m^3N/h)	Stack Gas Temp. (℃)	Stack Gas Velocity (m/s)	Stack Height (m)	Stack Diameter (m)	Environmental Measures for Existing Facilities	Manufactures	Start Up Year
Central Costanera	1	120		TV	FO＋G	33,000	400,000	125	9.9	86.7	6.42		IC-BTH	1962
	2	120		TV	FO＋G	33,000	400,000	125					IC-BTH	1963
	3	120		TV	FO＋G	33,000	400,000	125	9.9	86.7	6.42		IC-BTH	1963
	4	120		TV	FO＋G	33,000	400,000	125					IC-BTH	1963
Central Buenos Aires	5	220	CC	TG	G＋GO	56,000	1,570,000	115.6	14.4	50	7.4	Low NOx Combustor	Siemens	1995
		120*		TV									BTH	1962
Central Costanera	6	350		TV	FO＋G	82,000	1,000,000	120	22.1	97.5	4.8		DBO－Hitachi	1976
	7	310		TV	FO＋G	78,000	960,000	120	16.8	154.4	5.4		DBO－LMZ	1984
	8	264.3	CC	TG	G＋GO	65,000	1,836,000	87.7	15.7	50	7.4	Low NOx Combustor	Mitsubishi	1998
	9	264.3		TG		65,000	1,836,000	87.7	15.7	50	7.4	Low NOx Combustor		
	10	322.6		TV										
Total		**2211.2**												

TV: Steam Turbine, TG: Gas Turbine, CC: Combined Cycle,　　C: Coal, G: Natural Gas, FO: Fuel Oil, GO:Gas Oil

Note:1.Flue gas at only natural gas combustion.

2.＊The output as the combined cycle is 100MW

Table3.2.1(3) Specifications of Existing Units in San Nicolas

(Existing)

Power Plant		Unit No.	Rated Output (MW)		Plant type	Fuel Type	Fuel Burnt (m^3/h)	Assumed Stack Gas (m^3N/h)	Stack Gas Temp. (℃)	Stack Gas Velocity (m/s)	Stack Height (m)	Stack Diameter (m)	Environmental Measures for Existing Facilities	Manufactures	Start Up Year
San Nicolas		1	75		TV	C+G＋FO	20,000	250,000	140	6.7	90	6.3	EP	Stein－SSW	1956
		2	75		TV	C+G＋FO	20,000	250,000	140		Common	stack	EP	Stein－SSW	1956
		3	75		TV	G＋FO	20,000	250,000	130	6.6	90	6.3		Stein－AEG	1956
		4	75		TV	G＋FO	20,000	250,000	130		Common	stack		Stein－AEG	1956
		5	350		TV	C+G+FO	152ton/h	1,350,000	115	10.3	123.7	8.1	EP	Tosi-Ansaldo-BB	1983
AES Parana		7	830		TV										
				CC	TG	G＋GO	62,000	1,725,600	95	17.8	65	6.8	Low Nox Combustor	Mitsubishi	9.2001
					TG		62,000	1,725,600	95	17.8	65	6.8			
	Total		1480												

TV: Steam Turbine, TG: Gas Turbine, CC: Combined Cycle, C: Coal, G: Natural Gas, F: Fuel Oil

Note:1.The amount of flue gas is estimated at only natural gas combustion in Unit 1 and 4 only coal combustion in Unit 5

Table3.2.1(4) Specifications of Existing Units in Mendoza

(Existing)

Power Plant	Unit No.	Rated Output (MW)	Plant type		Fuel Type	Fuel Burnt (m^3/h)	Assumed Stack Gas (m^3N/h)	Stack Gas Temp. (℃)	Stack Gas Velocity (m/s)	Stack Height (m)	Stack Diameter (m)	Environmental Measures for Existing Facilities	Manufactures	Start Up Year
Lujan de	11	60		TV	G＋FO	20,000	245,000	90	13.7	50	4.1		Marelli	1971
Cuyo	12	60		TV	G＋FO	20,000	245,000	90		stack for	Common use		Marelli	1971
	15	94		TV									SKODA	1983
	25	200	CC	TG	G	65,000	1,950,000	120	20.3	50	7.0	Low NOx Combustor	Siemens	1998
	14	30		TV										
	21	20	CC	TG	G＋GO	13,000	360,000	195	7.8	19.8	5.3		BB	1980
	22	20		TG		13,000	360,000	195	7.8	19.8	5.3			
	23	22	cogene	TG	G＋GO	12,500	345,000	153	21.2	40	3.0		Alsthom	1989
	24	22		TG		12,500	345,000	148	20.9	40	3.0			
Total		**528**												

TV: Steam Turbine, TG: Gas Turbine, CC: Combined Cycle, G: Natural Gas, FO: Fuel Oil, GO: Gas Oil

Note:1.Flue Gas at only gas combnstion

4) Lujan de Cuyo Power Plant

Units 11 and 12 are steam power generation facilities and can apply mixed fuel combustion of natural gas and fuel oil.

After a furnace explosion while burning natural gas 12 years ago which rendered the boiler unusable, the Unit 13 was converted to a combined cycle facility and rebuilt as the new Units 15 and 25. The surviving steam turbine was coupled with the new gas turbine and the new heat recovery steam generator.

Units 21 and 22 are also combined cycle facilities, while Units 23 and 24 are co-generation facilities. Units 23 and 24 generate electric power by gas turbine equipped with the heat recovery steam generator, which provides steam (150t/h, 440℃) co-generated to the adjoining YPF Refinery. The fuel used in both combined cycle and co-generation facilities is mainly natural gas. However Units 21, 22, 23 and 24 can also use gas oil for fuel. This is a so-called mine-mouth plant, as both natural gas and oil used for fuel are produced in the vicinity.

3.2.2 Present Situation of Environmental Measures

1) Nuevo Puerto and Puerto Nuevo Power Plants

A dry low-NOx combustor is employed in the combined cycle facility as air pollution control measures for the power plant. In the combined cycle, water injection (water/fuel = 1/1) is used to reduce the NOx amount in flue gas, when gas oil is used for fuel.

Unit 7 of the Puerto Nuevo power plant was equipped with the low-NOx burners as measures for NOx reduction, at the start of privatization. Other facilities have no equipment for air pollution control measures. A conversion to low NOx burners is planned for Unit 8.

At Units 5, 6, 7, 8 and 9, NOx, SO_2, Opacity, O_2 in flue gas are continuously measured. At the combined cycles, NOx, Opacity, and O_2 are also measured in the same way, although no law regulates the measurement. The pollutant data of both power plants is summed up in the neighboring control room of Unit 9, and is reported to the ENRE quarterly.

2) Central Costanera Power Plant and Central Buenos Aires Power Plant

A dry low-NOx combustor is employed for the combined cycle facility as an environmental measures fore plant. Other facilities have no equipment for environmental measures.

NOx, SO_2, Opacity, and O_2 in flue gas of Units 1, 2, 3, 4, 6 and 7, and NOx and O_2 of Unit 5 (combined cycle facility) are continuously measured. At Units 8 and 9 of combined cycle facilities, NOx and O_2 in flue gas are continuously recorded for operation control.

3) San Nicolas Power Plant

Electrostatic Precipitators (EP) are installed for each of Units 1, 2 and 5 as environmental measures. Although Units 3 and 4 were equipped with EPs at the commencement of the commercial operation, now both EPs are not operative. Regarding Unit 5, in order to reduce soot emission, 4～20ppm of SO_3 (Max. 25ppm) is injected into the flue gas at coal combustion. The SO_3 injector, manufactured by an American company Chemington was installed in 1996 to improve the collection efficiency. The collection efficiency of Unit 5 is 98.7%.

At all Units, NOx, SO_2, Opacity, and O_2 (only for Unit 5) in flue gas are continuously measured. Moreover the CNEA implements the annual measurement of pollutants under the guidance of the ENRE. The power company has the intention to use coal ash generated in plant for cement and as a waterproofing agent in the roof and bricks. The coal ash is now repossessed for free by a local company, an affiliate of Minetti that occupies 40% of the total cement production in Argentina.

4) Lujan de Cuyo Power Plant

The steam power generation facilities of Units 11 and 12 have no equipment for environmental measures. The combined cycles of Units 21 and 22 and the co-generation facilities of Units 23 and 24 have no equipment for environmental measures, either. The combined cycle of Unit 25 with large enough output is only equipped with a dry low-NOx combustor.

At Units 11 and 12, NOx, SO_2, Opacity and O_2 in flue gas are continuously measured. At Unit 25, although no law regulates the measurement of pollutants because it is a combined cycle for only natural gas combustion, NOx and O_2 in flue gas are continuously measured. Units 21, 22, 23 and 24, which are dedicated only for natural gas combustion, are not equipped with continuous measuring instruments for the monitoring of pollutant in flue gas. Flue gases from Units 21, 22, 23 and 24 are measured monthly by manual analyses.

3.2.3 Fuel used in Power Plants

1) Property of Fuel

The fuels used in the target power plants are natural gas, fuel oil（heavy oil） gas oil and coal. The properties of the fuels are summarized in Table 3.2.2 and Table3.2.3. The JICA Team assumes the data regarding fuel oil and gas oil shown in Table 3.2.3 because the data are not presented by the power plants.

2) Transportation and Storage of Fuel in Power Plants

The Nuevo Puerto and Puerto Nuevo power plants receive natural gas via pipeline. Gas oil is shipped to the wharf of the Central Puerto Nuevo by oil barges and used at both plants via the interconnected pipeline. For emergency use, gas oil can be supplied by tank lorries.

Table 3.2.2 Examples of Natural Gas Properties

Components		(#147)		(#156)	
		Vol. %	Wt. %	Vol. %	Wt. %
N_2		0.98	1.57	1.894	3.092
CO_2		1.81	4.97	0.137	0.352
CH_4		93.45	85.61	93.862	87.910
C_2H_6		2.58	4.43	3.152	5.569
C_3H_8		0.79	1.99	0.649	1.697
i-C_4H_{10}		0.10	0.33	0.073	0.255
n-C_4H_{10}		0.17	0.56	0.108	0.380
i-C_5H_{12}		0.04	0.17	0.025	0.110
n-C_5H_{12}		0.04	0.17	0.023	0.105
C_6H_{14}		0.04	0.20	0.025	0.136
C_7H_{16}		0.00	0.00	0.022	0.146
C_8H_{18}+		0.00	0.00	0.030	0.247
H_2S		0.00	0.00	0.000	0.000
Property					
Weight Mol.	kg/kmol	17.437		17.121	
Density	kg/m^3	0.7391		0.7257	
High calorific value	kcal/m^3	9,148		9,237	
	kcal/kg	12,375		12,720	
Low calorific value	kcal/m^3	8,247		8,330	

Table 3.2.3 Properties of Fuel Oil, Gas Oil and Coal

(unit : Wt%)

Type of Fuel		Fuel Oil	Gas Oil	Coal (#230)		
				Mixed firing※1)	South Africa	Rio Turbio
Component	C	86.1	85.6	63.80	68.59	59.02
	H	11.9	14.2	3.97	3.30	4.64
	O	0.5	-	7.36	6.24	8.48
	S	0.5	0.2	0.50	0.3	0.69
	Cl	-	-	-	-	-
	N	0.4	-	1.24	1.51	0.96
	Water content	0.6	-	10.44	7.76	13.12
	Ash content	0.1	-	12.69	12.30	13.09
	Density g/ml	0.9931	0.8549	-	-	-
Low calorific value (kcal/kg)		9,840	10,280	6,123	6,388	5,857

Note) ※1 The weight mixing ratio between the South African coal and the Rio Turbio coal is 1:1.

As for the Central Costanera power plant, natural gas is provided through pipelines, fuel oil by tankers, and gas oil by tankers or tank lorries from an adjoining refinery.

Coal is also used for fuel in the San Nicolas power plant, along with natural gas and fuel oil. San Nicolas receives natural gas by pipeline and fuel oil by tankers. As for coal, the local Rio Turbio coal and the South African coal are mainly used in a ratio of 1:1, supplementing the Indonesian and the Colombian. Coal is transported by ship passing along the La Plata and the Parana rivers, and stocked at the local coal yard.

In Lujan de Cuyo power plant, natural gas is piped from the Province of Neuquen and fuel oil from the YPF Refinery in the same industrial park.

3.2.4 Operations of Power Generation Facilities

The daily power generating capacity of Argentina has the general pattern that decreases in a period encompassed between late night hours and early morning (22:00pm to 6:00am) and increases in the daytime (with one a decline from 12:00 to 14:00). Seasonally, winter needs more generation. The operation of power generation facilities including the decision to commence or stop operation, and power adjustment is conducted following the dispatch direction of CAMMESA (Administrative Company of Electric Wholesale Market) issued to each power plant.

The JICA Team has evaluated that the power generation facilities have been maintained the original performance by daily inspections, repair and independent periodical inspections, even the facilities that have been in operation for 30 to 40 years. By the observation at the control rooms, the JICA Team also found that the operators were well trained and had high level of technical skills. However, they seemed to be working without making conscious effort to improve the thermal efficiency. This is a probable consequence of the abundant supply of energy in Argentina.

The operations of the power generation facilities in 2000 are summarized in Table 3.2.4, where the values of total heat input were calculated from the low calorific values in Table 3.2.2 and Table 3.2.3 because of lack of data.

1) Combustion Control

The mean oxygen concentration in flue gas measured by the continuous measuring instrument in 2000 was 11.1% at the stack of Unit 5 and 8.7% at the stack of Unit 6 in the Nuevo Puerto plant. At the Puerto Nuevo plant, it was 9.4% at the common stack of Unit 7 and 8 and 9.0% at the stack of Unit 9, while at the Central Costanera it was 10.6% at the common stack of Unit 1 and 2, 11.9% at the common stack of Unit 3 and 4, 7.3% at the Unit 6, 11.9% at Unit 7, respectively. The mean oxygen concentration in flue gas measured in the period of the Summer Air Quality Monitoring in February 2000 was 9.3% at the stack of Unit 5 in the San Nicolas. These values are significantly high and are reportedly related to leaks through the seals of the regenerative air heaters.

Generally, it is possible to control the oxygen concentration in flue gas of the boiler burning in a range of 3 to 6% at the outlet of the air heater. The oxygen and pollutant concentrations in flue gas have been measured at all power generation facilities by continuous measurement or manual analysis. Therefore, the operators should understand the burning condition of the boiler by observing the measured values and implementing a careful combustion control in order to improve thermal efficiency.

2) Thermal Efficiency

The thermal efficiency of Unit 6 of the Nuevo Puerto plant, Unit 9 of the Puerto Nuevo plant and Units 6 and 7 of the Central Costanera plant are 37.5%, 39.2%, 36.8% and 37.9%, respectively. However Unit 5 of the Nuevo Puerto, Units 7 and 8 of the Puerto Nuevo and Units 1, 2, 3 and 4 of the Central Costanera have such low thermal efficiency as 33 to 34%. This arises from inadequate combustion control. Also it is considered that the low annual utilization factor, less operational periods under the high efficient rated load and longer low efficiency operation by lower load requirement may contribute to the deterioration of efficiency.

Units 1, 2, 3 and 4 of the San Nicolas plant and Units 11 and 12 of the Lujan de Cuyo plant also have very low thermal efficiency of 26%. Even at Unit 5 of the San Nicolas, whose annual utilization factor is relatively high, the thermal efficiency is low at 33%.

Regarding the combined cycles, the thermal efficiencies of all of Unit 5 of the Central Buenos Aires plant, Units 8, 9 and 10 of the Central Costanera and Units 15 and 25 of the Lujan de Cuyo exceed 50%, although the value may not be accurate because the value of total heat input was estimated.

3) Utilization Factor

Overall, the utilization factor of the targeted power generation facilities, is low for the steam turbines and high for the combined cycles. Above all, the utilization factor is extremely low at 30% at the highest, for all facilities of Unit 1, 2, 3, 4, 6 and 7 in the Central Costanera, Units 1, 2, 3 and 4 of the San Nicolas plant and a steam turbine of Unit 12 in the Lujan de Cuyo.

The utilization factors of Unit 5 and 6 of the Nuevo Puerto plant, Unit 7 and 8 of the Puerto Nuevo plant, Unit 5 of the San Nicolas plant and Unit 12 of the Lujan de Cuyo plant are in a range of 33 - 60%. Regarding steam turbines, the utilization factor of Unit 9 of the Puerto Nuevo is 67.9% and is notably high compared with the others.

Combined cycles have high utilization factor, which exceeds 50% in all cases because of its good thermal efficiency, except for the 36.7% of Unit 14, 21 and 22 of the Lujan de Cuyo plant. Especially in the Lujan de Cuyo plant, the utilization factors of Unit 15 and 25 as well as co-generation facility of Unit 24 exceed 80%.

4) Auxiliary Power Ratio

Regarding steam turbines, the auxiliary power ratio of Units 5 and 6 of the Nuevo Puerto plant and Unit 9 of the Puerto Nuevo plant is in a range of 5.3～5.7%, while those of Units 7 and 8 of the Nuevo Puerto plant are high and 7.3% and 9.8%, respectively.

The auxiliary power ratio is distinctly high in the Central Costanera with in a range of 6.2～11.5%. The low utilization factor and standby power consumption of auxiliary machinery and equipment have caused these high percentages.

The auxiliary power ratio of combined cycle and co-generation facilities are generally low when compared with steam turbines and are in a range of 2.4～2.9%. In the Lujan de Cuyo, the auxiliary power ratios of Unit 15 and 25, and that of 14, 21 and 22 are very low at 1.0% and 1.8% respectively

Table 3.2.4 Operational Summaries of Power Generation Facilities (2000)*)

Power Plants	Units	Rated Output	Type	Fuel Burnt				Generation（MWh）		Total Heat Input	Thermal Efficiency	Heat Input per kWh	Auxiliary P. Ratio	Utilization Factor
				Natural Gas	Fuel Oil	Gas Oil	Coal							
		MW		1,000 m^3	ton	ton	ton	Net	Gross	$\times 10^6$kcal	%	kcal/kWh	%	%
Nuevo Puerto	4	60	TV	430	0	-	-	-	-	-	-	-	-	-
	5	110	TV	75,381	39,502	-	-	377,537	399,145	1,005,075	34.2	2,518	5.4	41.4
	6	250	TV	217,912	117,189	-	-	1,205,189	1,278,400	2,934,410	37.5	2,295	5.7	58.4
	TG11,12	786	CC	-	-	-	-	-	-	-	-	-	-	0.0
Puerto Nuevo	7	145	TV	95,200	32,150	-	-	389,920	420,748	1,095,075	33.0	2,603	7.3	33.1
	8	194	TV	176,542	66,369	-	-	715,038	792,490	2,093,243	32.6	2,641	9.8	46.6
	9	250	TV	236,670	134,730	-	-	1,407,533	1,486,679	3,258,799	39.2	2,192	5.3	67.9
Central Costanera	1	120	TV	12,011	9,093	-	-	68,819	74,824	189,527	34.0	2,533	8.0	7.1
	2	120	TV	23,901	15,758	-	-	124,012	135,039	354,154	32.8	2,623	8.2	12.8
	3	120	TV	47,528	19,412	-	-	214,055	230,667	586,922	33.8	2,544	7.2	21.9
	4	120	TV	54,239	11,590	-	-	210,459	224,450	565,856	34.1	2,521	6.2	21.4
Central Buenos Aires	5	340	CC	314,555	-	864	-	1,515,594	1,561,569	2,629,042	51.1	1,684	2.9	52.4
Central Costanera	6	350	TV	151,727	35,039	-	-	643,102	688,973	1,608,670	36.8	2,335	6.7	22.5
	7	310	TV	55,458	7,275	-	-	208,229	235,286	533,551	37.9	2,268	11.5	8.7
	8,9,10	850	CC	941,914	-	6,579	-	4,852,573	4,994,284	7,913,776	54.3	1,585	2.8	67.1
San Nicolas	1	75	TV	15,620	1,690	-	2,070	-	45,259	159,419	24.4	3,522	-	6.9
	2	75	TV	66,767	3,841	-	11,077	-	198,250	661,789	25.8	3,338	-	30.2
	3	75	TV	8,870	2,306	-	-	-	19,798	96,578	17.6	4,878	-	3.0
	4	75	TV	5,252	2,557	-	-	-	18,991	68,910	23.7	3,629	-	2.9
	5	350	TV	119,226	0	-	459,331	-	1,462,888	3,805,636	33.1	2,601	-	47.7
AES Parana	7	830	CC	-	-	-	-	-	-	-	-	-	-	0.0
Lujan de Cuyo	11	60	TV	21,786	27,730	-	-	172,948	176,166	454,341	33.3	2,579	1.8	33.5
	12	60	TV	8,224	8,785	-	-	60,770	60,876	154,950	33.8	2,545	0.2	11.6
	15,25	294	CC	414,683	-	-	-	2,083,278	2,105,276	3,454,309	52.4	1,641	1.0	81.7
	14,21,22	70	CC	59,768	-	248	-	220,904	224,933	500,417	38.7	2,225	1.8	36.7
	23	22	Co-Ge	36,929	-	0	-	110,482	113,466	307,619	31.7	1,146	2.6	58.9
	24	22	Co-Ge					151,305	155,048				2.4	80.5

*) 1999 value is used for Nuevo Puerto, Puerto Nuevo, and Lujan de Cuyo.

3.3 Pollutant Emissions from Target Power Plants

3.3.1 Collection of the emission data

Hourly pollutant emission data (NOx, SO_2, Opacity) of flue gases emitted from the targeted power generation facilities, measured by the continuous measuring instrument in 2000 were provided in principle. The concentration of PM was calculated by the Opacity-PM conversion formula.

The emission data, obtained at the operation room during the Field Work stages, were used for Units TG11 and TG12 of the Puerto Nuevo plant, Unit 5 of the Central Buenos Aires plant, Units 8 and 9 of the Central Costanera. The monthly actual measurement data is used for the Units 21, 22, 23 and 24 of the Lujan de Cuyo plant.

3.3.2 Amounts of Flue Gas per Unit Fuel

The generated amounts of flue gas, when each unit amount of fuels given in Table 3.2.2 and 3.2.3 is burnt, are listed in Table 3.3.1.

Table 3.3.1 Calculated Amounts of Flue Gas by Fuel

Plant Type	Type of Fuel	Amount of Flue Gas		remarks
		wet	dry	
Steam power	Natural gas	12.23	10.23	air ratio：1.16
	Fuel oil	13.4	12.1	air ratio：1.18
	Coal	8.86	8.28	air ratio：1.3
Combined cycle	Natural gas	28.0	26.3	fuel-air ratio：27
	Gas oil	28.0	26.3	

（unit：m^3N/1kg of liquid and solid fuel, m^3N/ $1m^3N$ of Natural gas）

Note）The amounts of flue gas by coal combustion were calculated based on a 1:1 of the mixing ratio between the South African and the Rio Turbio coal.

The concentration of pollutants in the flue gas is generally indicated for dry base at the state of 0℃ 1 atmospheric pressure. However, it is necessary to convert the data into dry basis because the data obtained also includes wet base data besides dry base. Table 3.3.1 can serve as a mutual conversion of dry base and wet base flue gas, and also is useful for approximate calculation of the flue gas when the amount of fuel used is known.

3.3.3 Conforming Status to the Emission Standards

To assess the conforming status to the emission standards regarding the pollutant concentrations, it is necessary to compare not the mean value but the maximum value of concentration with the emission standards. The pollutant data (hourly value) presented by each power plant to ENRE had contained apparent abnormal values. Therefore, the JICA Team screened the data based on the following conditions.

- The fuel oil and coal containing more than 0.7% of sulfur content (the equivalent of 2,000mg/m^{3}N, converting to the SO_2 concentration in flue gas) are not used for fuel.
- The recorded pollutant data should be rejected when the data lacks the amount of fuel used and/or the value of heat input.

1) Conformance to the SO_2 emission standard

All power generation facilities are conforming to the SO_2 emission standard, except for Unit 5 of the San Nicolas plant where 2,017mg/m^{3}N of SO_2 concentration was recorded in December of 2000, exceeding the emission standard of 1,700 mg/m^{3}N. An environmental engineer of the power plant commented that the instrument might be mal-functioning accidentally as the data were under 1,700mg/m^{3}N while the same kind of fuel was used continuously without change before and after the incident.

2) Conformance to the NOx emission standard

The power generation facilities installed before January 15th of 1992 are ruled out for application of the NOx emission standard.

The facilities governed by the NOx emission standard are Units TG11 and TG12 of the Nuevo Puerto plant, Units 8 and 9 of the Central Costanera plant, Unit 5 of the Central Buenos Aires plant, AES Parana (Unit 7) of the San Nicolas plant and Unit 25 of the Lujan de Cuyo plant, which are all combined cycles. The highest value of the NOx concentration measured at these facilities was 132mg/m^{3}N at the Lujan de Cuyo plant and this fully conforms to the emission standard of 200mg/m^{3}N.

3) Conformance to the PM emission standard

The combined cycle facilities are considered to conform to the emission standard because natural gas is mainly used as the principal fuel for their operation.

At other power generation facilities, the Opacity is continuously measured instead of direct measurement of PM. The Opacity was less than 5% at Unit 5 of the Nuevo Puerto plant, Unit 7 of the Central Costanera plant and Units 11 and 12 of the Lujan de Cuyo plant, which conforms to the emission standard. The Opacity value of Units 1, 2, 3, 4, 5, 6, 7, 8 and 9 of the Central Costanera plant was 15% at the highest and clears the 20% of the emission standard.

Higher levels (less than 40%) of opacity are currently considered to be acceptable in the resolution (#36) during boiler blowing, start-up and change of fuel type. However, at the San

Nicolas plants, a few data of Units 1 to 4 did not conform to the emission standards. Also Unit 5 gave data over the standards. One maximum value of Opacity at each unit was 58% at Units 1 and 2 in August 2000, 46% at Units 3 and 4 in July 2000, and 48% at Unit 5in May 2000.

3.3.4 Amounts of Pollutant Emission

The mean concentration of pollutants in the flue gas of each power plant is shown in Table 3.3.2. Basically, the data shown is the average of continuous measurement (hourly value) in 2000 or the average of monthly data, where available. As for the cases without actual measurement data, the operational data on the control panels observed in the First Field Work stage is listed.

The concentration of pollutants in flue gas of steam turbines varies very widely, where the NOx concentration is found as 11.1mg/m^3N～301.2mg/m^3N and the SO_2 concentration is 30.2mg/m^3N～579.5mg/m^3N and the PM is 1.7mg/m^3N～65.7mg/m^3N.
The maximum concentrations of each pollutant emitted from steam turbines have arisen from Unit 5 of the San Nicolas plant, which uses coal as its principal fuel.

Regarding the combined cycles, the NOx concentration is 22.5mg/m^3N～75.5mg/m^3N in the Nuevo Puerto, Central Costanera and Central Buenos Aires power plants, while it shows such higher concentration of 107.4mg/m^3N～269.6mg/m^3N (269.4mg/m^3N corresponds to the combined cycle installed before the privatization.) in the Lujan de Cuyo power plant.

The amounts of pollutant emission of each power plant estimated by both the annual mean amount of flue gas and the annual mean concentration of pollutants, are shown in Table 3.3.3.

Table 3.3.2 Mean Concentration of Pollutants in Flue Gases

(Unit: mg/m^3N)

Power Plant	Unit No.	Fuel	Mean Concentration of Pollutants			Remarks
			NOx	SO_2	PM	
Nuevo Puerto	4	Natural gas Heavy oil				The facility was not operated practically in 2000.
	5	Natural gas Heavy oil	11.1	94.8	2.1	Continuous measurement data of 2000
	6	Natural gas Heavy oil	119.3	523.4	3.5	
	TG 11	Natural gas Gas oil	22.5	-	-	Operational data of 2000
	TG 12	Natural gas Gas oil	22.5	-	-	
Puerto Nuevo	7 + 8	Natural gas Heavy oil	127.3	50.1	5.5	Continuous measurement data of 2000
	9	Natural gas Heavy oil	276.2	400.3	1.7	
Central Costanera	1 + 2	Natural gas Heavy oil	48.6	158.6	5.6	Continuous measurement data of 2000
	3 + 4	Natural gas Heavy oil	85.3	225.6	8.8	
Central B.A.	5	Natural gas Gas oil	45.6	-	-	Operational data of 2000
Central Costanera	6	Natural gas Heavy oil	76.6	30.2	6.1	Continuous measurement data of 2000
	7	Natural gas Heavy oil	31.4	117.7	3.9	
	8	Natural gas Gas oil	75.5	-	-	Operational data of 2000
	9	Natural gas Gas oil	75.5	-	-	
San Nicolas	1 + 2	Natural gas Heavy oil	125.2	39.3	32.1	Continuous measurement data of 2000
	3 + 4	Natural gas Heavy oil	158.2	40.2	12.4	
	5	Coal Natural gas Heavy oil	301.2	579.5	65.7	
AES Parana	Parana TG1	Natural gas Gas oil				No data obtained. Commenced from September 2001.
	Parana TG2	Natural gas Gas oil				
Lujan de Cuyo	11 + 12	Natural gas Heavy oil	193.7	31.6	1.7	Continuous measurement data of 2000
	25	Natural gas	※107.4	-	-	
	21	Natural gas Gas oil	※269.6	※2.8	-	Actual measurement data of 2000.
	22		※249.5	※2.8		
	23		※198.2	※7.0		
	24		※197.1	※7.7		

Note: 1. Basically, the data shown is the average of continuous measurement (hourly value) in 2000 or the average of monthly data.

Note: 2. ※ marked shows the average of monthly measured values.

Table 3.3.3 Amounts of Pollutant Emissions

(Unit : kg/h)

Power Plant	Unit No.	Fuel	Amount of dry flue gas ($10^3m^3N/h$)	Amount of Pollutant Emission NOx	SO2	PM	Remarks
Nuevo Puerto	4	Natural gas Heavy oil					
	5	Natural gas Heavy oil	252	2.8	23.9	0.53	
	6	Natural gas Heavy oil	319	38.1	167.0	1.1	
	TG 11	Natural gas	1,817(wet)		-	-	In gas oil combustion with water injection
		Gas oil	1,862(wet)				
	TG 12	Natural gas	1,817(wet)		-	-	
		Gas oil	1,862(wet)				
Puerto Nuevo	7 + 8	Natural gas Heavy oil	243	30.9	12.2	1.3	
	9	Natural gas Heavy oil	322	88.9	128.9	0.55	
Central Costanera	1 + 2	Natural gas Heavy oil	242	11.8	38.4	1.4	
	3 + 4	Natural gas Heavy oil	236	20.1	53.2	2.1	
Central B.A.	5	Natural gas Gas oil	1,326	60.5	-	-	
Central Costanera	6	Natural gas Heavy oil	481	36.8	14.5	2.9	
	7	Natural gas Heavy oil	403	12.6	47.4	1.6	
	8	Natural gas Gas oil	1,489	112.4	-	-	
	9	Natural gas Gas oil	1,489	112.4	-	-	
San Nicolas	1 + 2	Natural gas Heavy oil Coal	104	13.0	4.1	3.3	
	3 + 4	Natural gas Heavy oil	112	17.7	4.5	1.4	
	5	Coal Natural gas Heavy oil	720	216.9	417.2	47.3	
AES Parana	Parana TG1	Natural gas Gas oil					No data obtained. Commenced from 2001.
	Parana TG2	Natural gas Gas oil					
Lujan de Cuyo	11 + 12	Natural gas Heavy oil	181	35.1	5.7	0.31	
	25	Natural gas	345	37.1	-	-	Without water injection
	21	Natural gas Gas oil	109	29.4	0.3	-	Without water injection
	22		109	21.6	0.3	-	
	23		213	42.2	1.5	-	
	24		213	42.0	1.6	-	

3.4 Outline of Control Measures to Prevent Air Pollution at Thermal Plants

The air pollutants in flue gas emitted from thermal power plants, which could cause problem, are SOx, NOx and particulate. Generally, air pollution control measures to reduce these emissions taken at thermal power plants can be roughly classified into three categories; i.e. selection of fuel, installation of preventive equipment and improvement of operation and management. These three measures are integrated to work effectively for pollutant control.

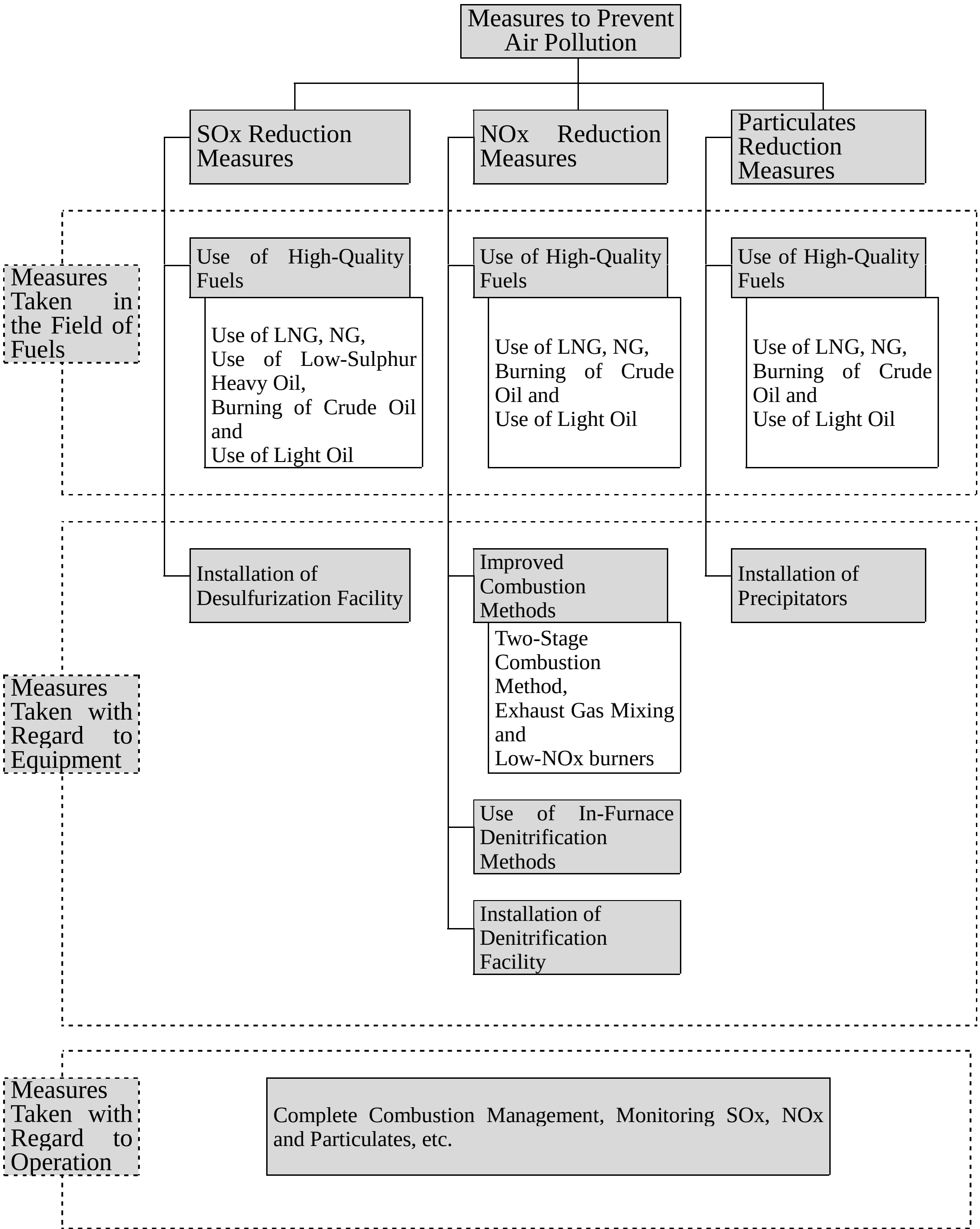

Figure 3.4.1 Outline of Measures to Prevent Air Pollution for Thermal Plant

In practice, the best way should be adopted comprehensively taking into consideration various factors including own resources, national policy, technical level, states of society at the location of the power plant, limit of investment for preventive measures and the cost-efficiency, etc.

The outline of control measures to prevent air pollution at the thermal plant is shown in Figure 3.4.1. Also taller stacks, concentrated stacks and narrowed stack outlet areas, all of which are effective for pollutant diffusion in air, are also employed as facility measures in order to reduce the impact on the surrounding environment.

To design air pollution control measures at thermal power plants, it is essential to consider not only the emission standard for the impact on surrounding environment but also costs, available spaces for the equipment in case of remodeling, operating period, degree of deterioration and difficulty of remodeling, and work schedule.

In regard to the need of concrete measures to prevent air pollution at targeted thermal power plants, the JICA team conferred with their counterparts taking into account through comprehensive examination of various conditions such as the situation of conformance to the emission standards, the conformance of air environmental concentration to the environmental quality standard, status of fuel use, presence of any reinforcing project for the existing facility, and the type of power generation. Accordingly the JICA Team decided not to take any new facility measures for the existing facility (i.e. installation of desulfurization and denitrification facilities, etc.) in order to reduce the emission of pollutants, based on the following reasons.

- According to the result of air environmental measurement and model simulation, it is assessed that the environmental impact of the air pollutants emitted from each targeted power plant on the surrounding environment is extremely small.
- In recent years, natural gas has been used for principal fuel at the existing facility, and it is expected that the use of natural gas will continue to increase in the future. At this facility, full measures have already been taken to reduce the emission of pollutants by means of the fuel measures.
- The fuel oil is now used for steam power generation facilities to make up for the shortage of natural gas, when the supply of natural gas cannot overtake the demand. There is a rare case that a facility applies only fuel oil combustion.
- At the San Nicolas plant, as contractual circumstances oblige them to use the local coal as fuel, the concentration of pollutants in flue gas is high when compared with the other plants and in

some cases exceeds the emission standard. However the utilization factors of the facilities except Unit 5 are distinctly low. Regarding the PM emission, it is possible to improve the collection efficiency by means of remedies and maintenance of EP.

- It is very wasteful to take some new facility measures (i.e. installation of desulfurization and denitrification facilities, etc.) for the existing steam power generation facilities, which have already been used for over 20 years and now are operated with low utilization factor.
- No reinforcing project of new construction and the extension of existing facilities is planned for the targeted power plants.
- Most of the newly planned facilities are combined cycles and are obligated to install a low-NOx burner. The NOx emission standard was reviewed and changed from 200mg/m^3N to 100mg/m^3N in February of 2001.
- Under the present situation where no emission standard for other stationary emission sources has been provided, it is not reasonable to reinforce the pollutants reduction measures for thermal power plants, especially in existing facilities and it is also difficult from an economic point of view.

Units 1, 2 and 5 of the San Nicolas plant did not conform to the PM emission standard even though having electrostatic precipitators (EPs) installed in each facility. Especially for Unit 5 that is highly utilized, it is required to carry out immediate remedies and adequate maintenance of EP in order to retain the performance and strive for conformance to the emission standard.

In the medium and long term, there are possibilities of deterioration of air environmental concentration, change of the fuel situation and proposals of large-scale reinforcing projects of power plants. Consequently desulfurization and denitrification facilities are discussed in S3-A2 of Support Volume for reference.