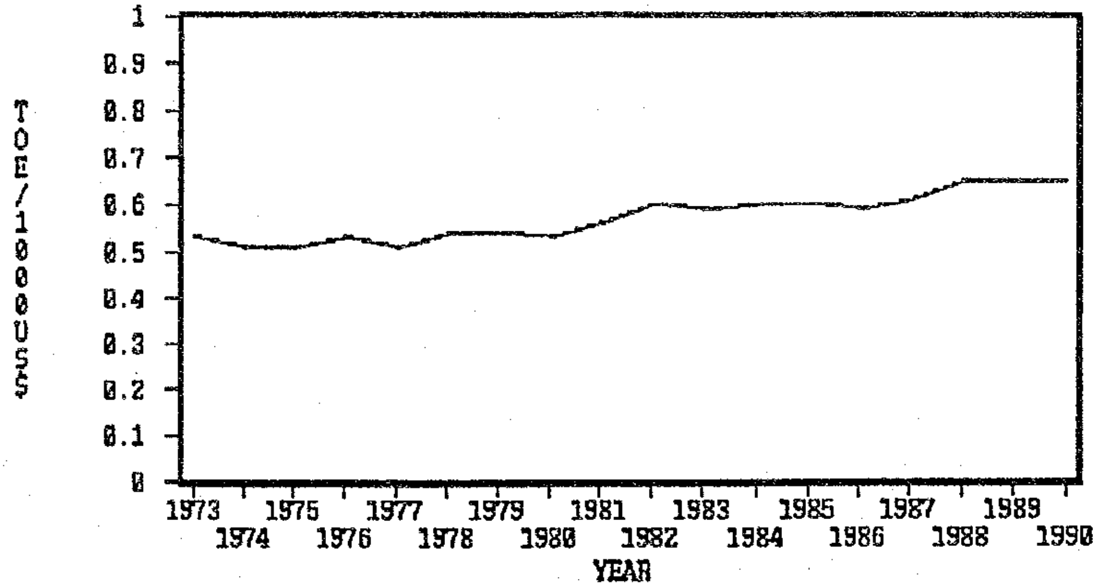
(T.O.E.)/G.D.P. 1000US4



G.D.P. REAL VALUE (1970 CONST.PRICE)

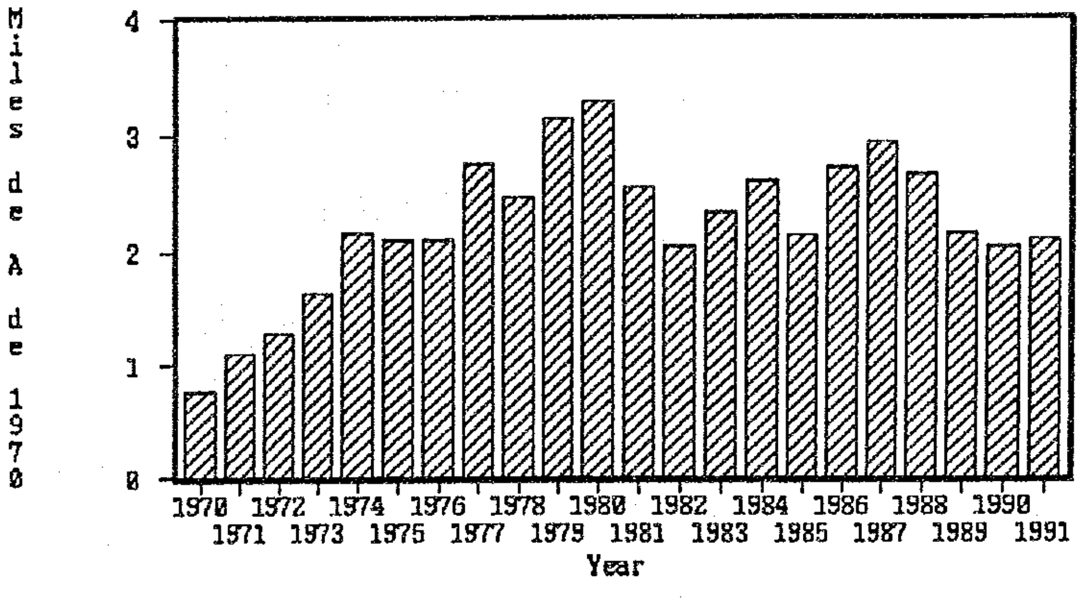
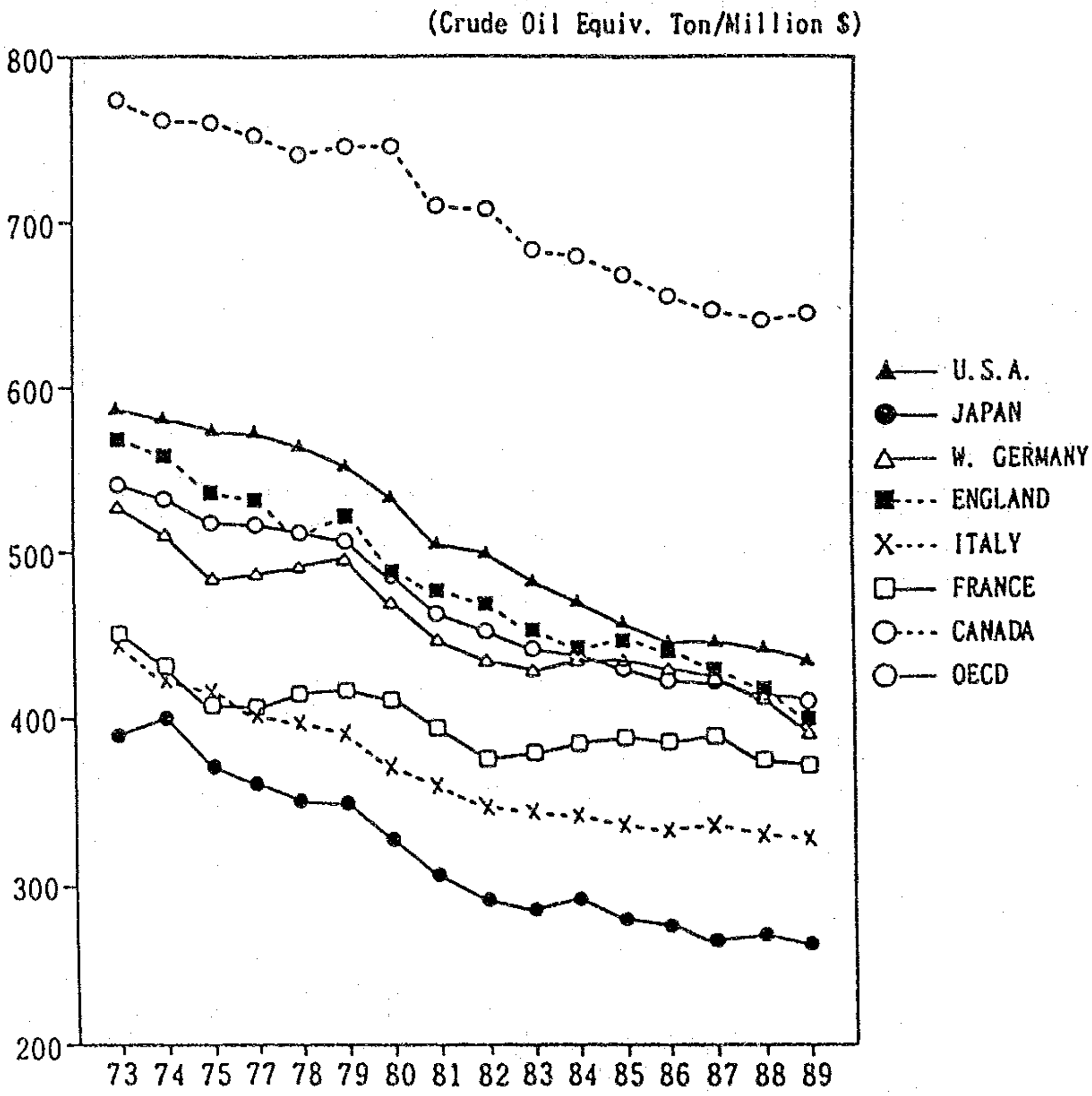


Figure A8-1 ARGENTINE ENERGY REQUIREMENT



Source : OECD Energy Balance (1980-89)

Figure A8-2 ENERGY CONSUMPTION V.S. G.D.P.

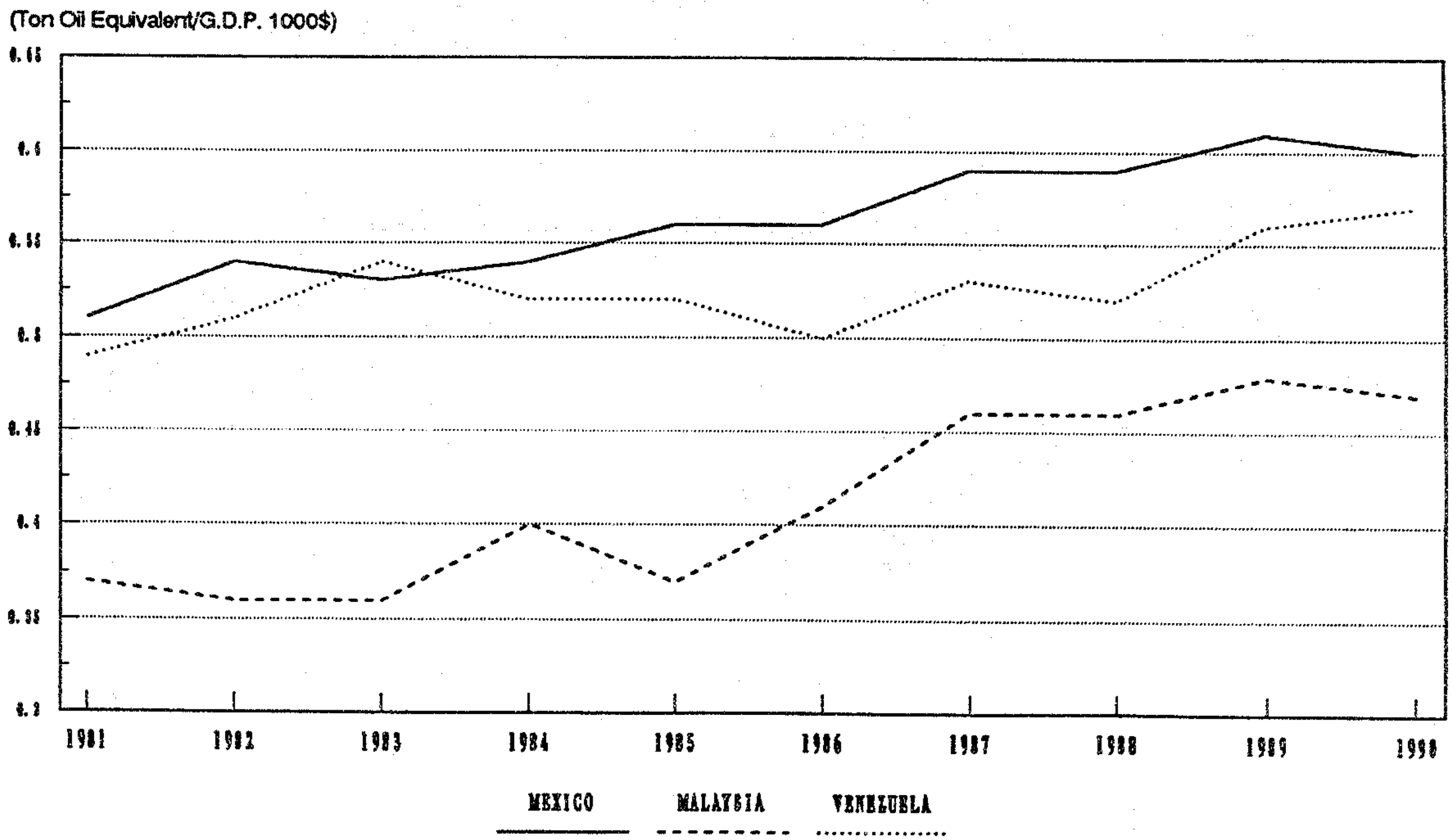


Figure A8-3 T.O.E./G.D.P. 1,000 US4 OF MIDDLE INCOME COUNTRY
G.D.P. AND ENERGY CONSUMPTION OF MIDDLE-INCOME COUNTRIES

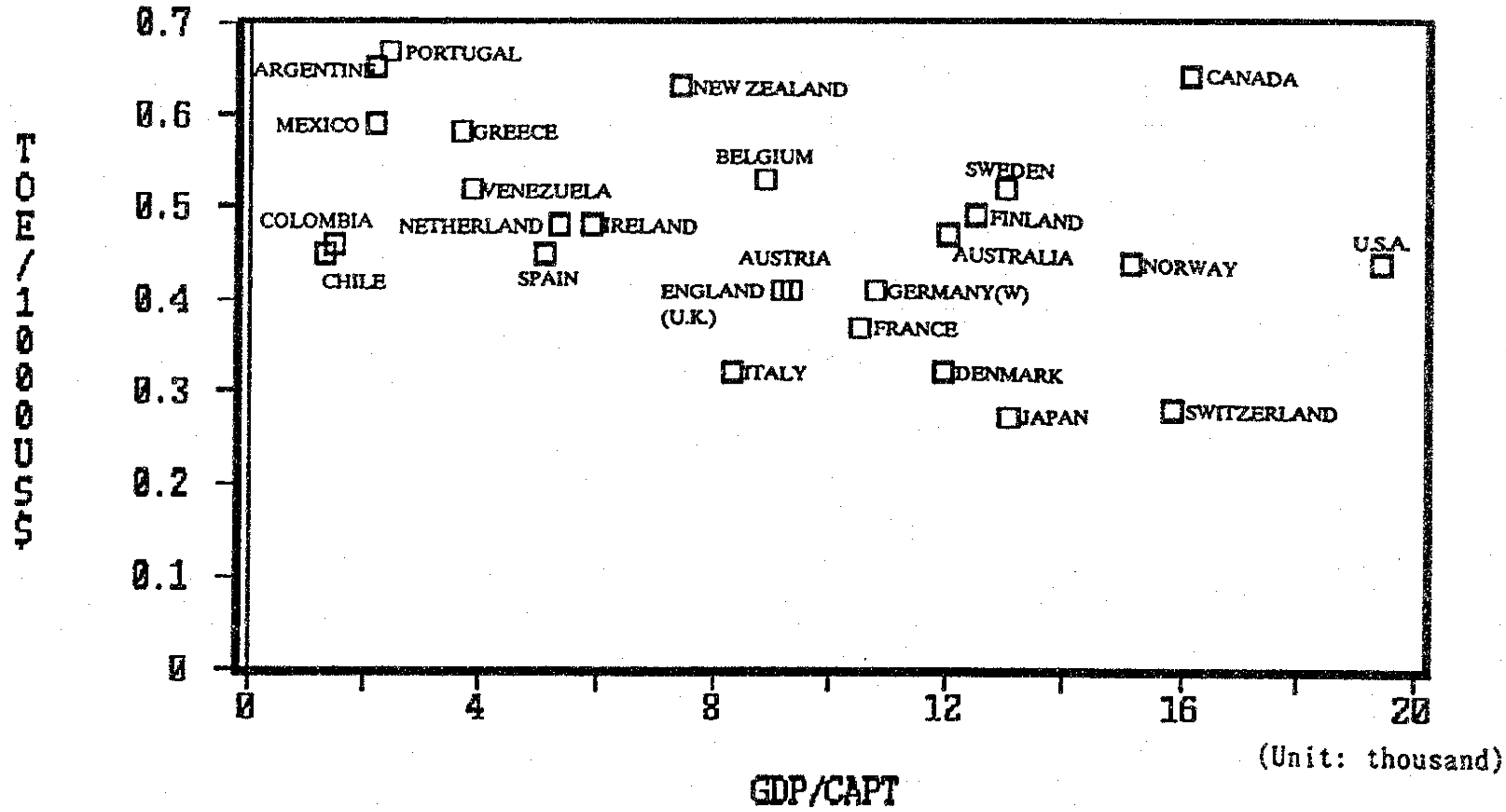
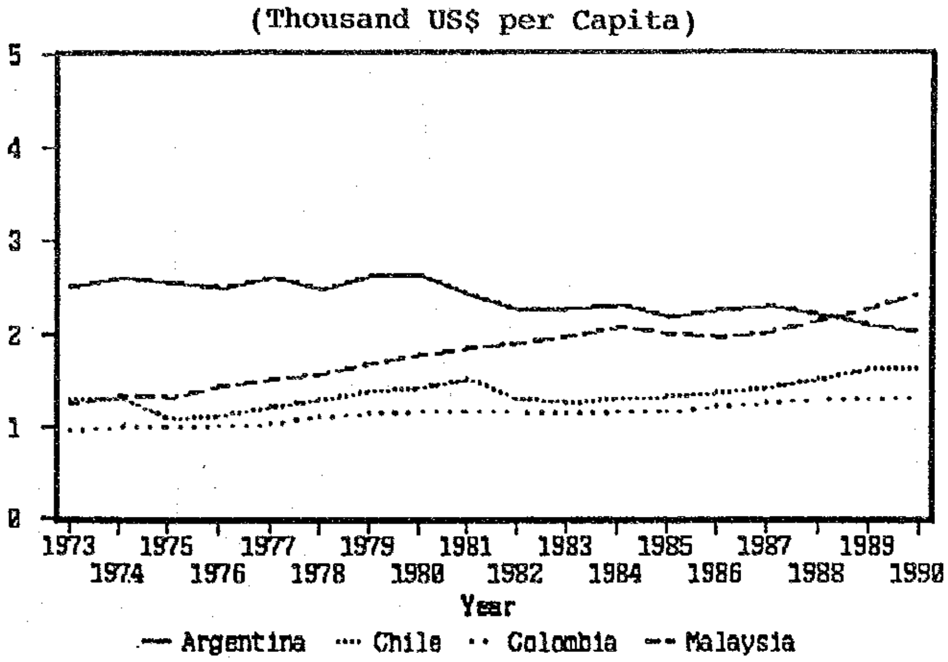


Figure A8-4 ENERGY ELASTICITY AND G.D.P. PER CAPT IN THE OECD AND CENTRAL AND SOUTH AMERICAN COUNTRIES



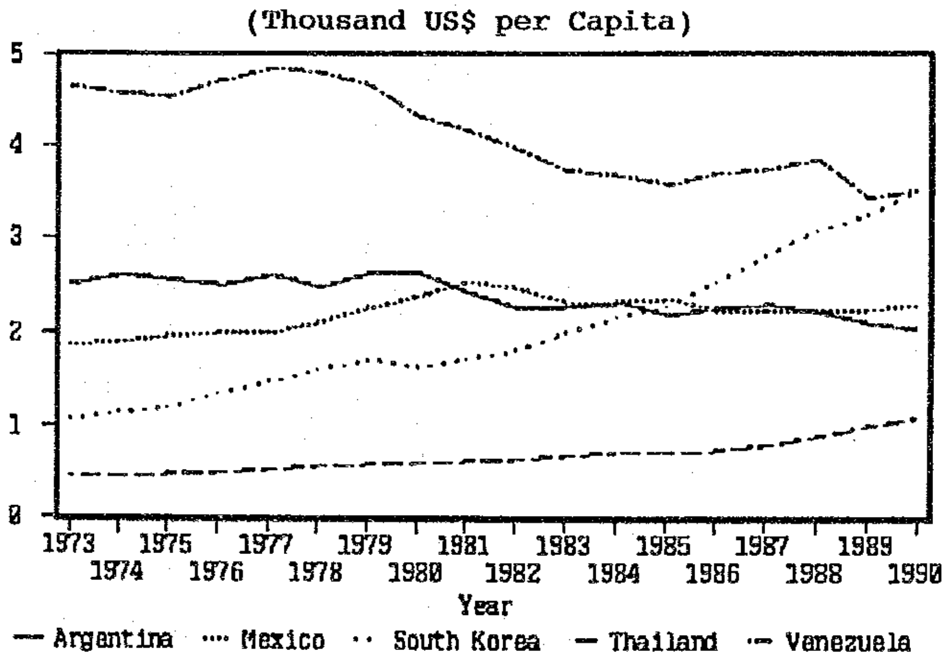


Figure A8-5 G.D.P./POPULATION

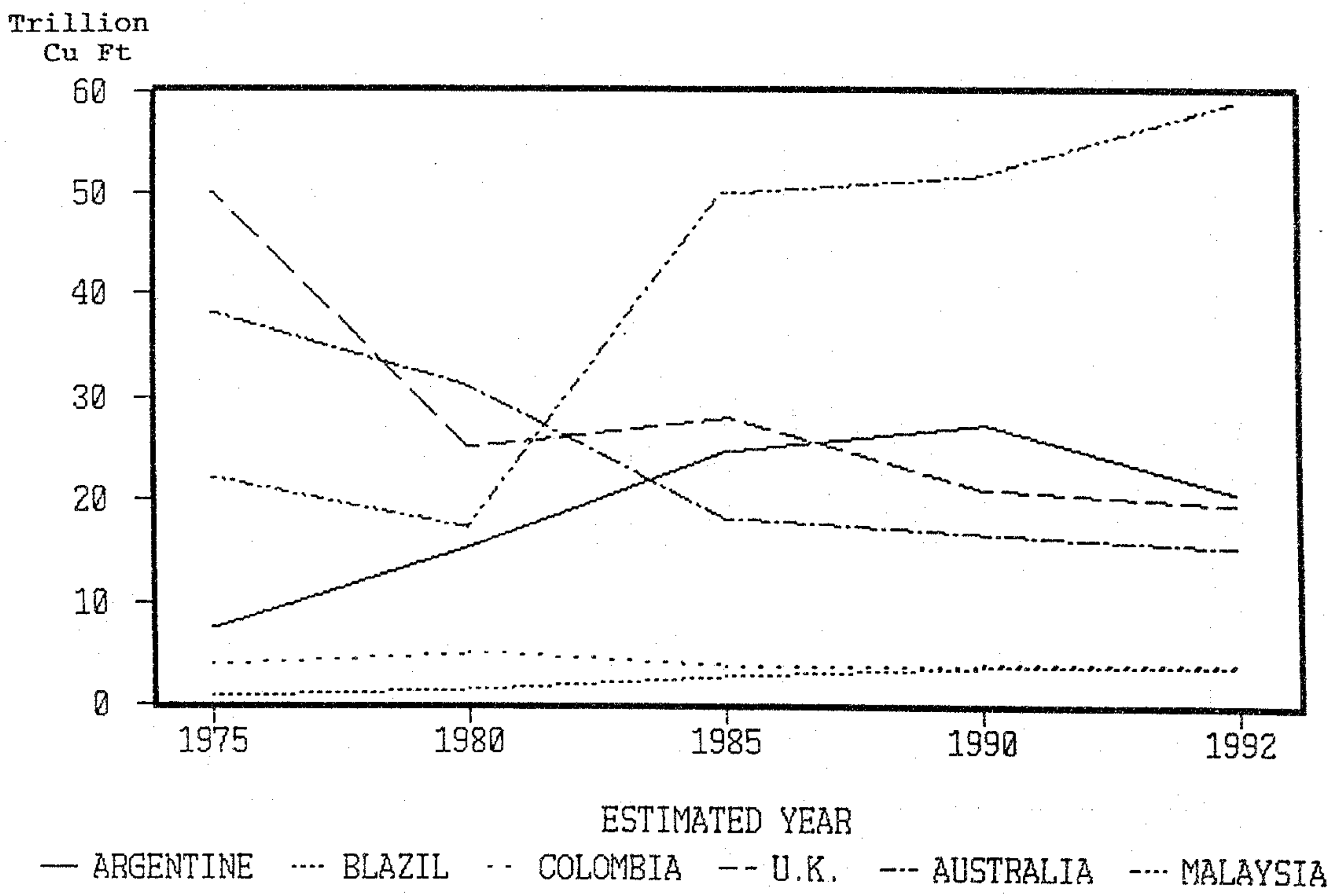


Figure A8-6 NATURAL GAS RESERVES OF ARGENTINE AND SIMILLAR COUNTRIES

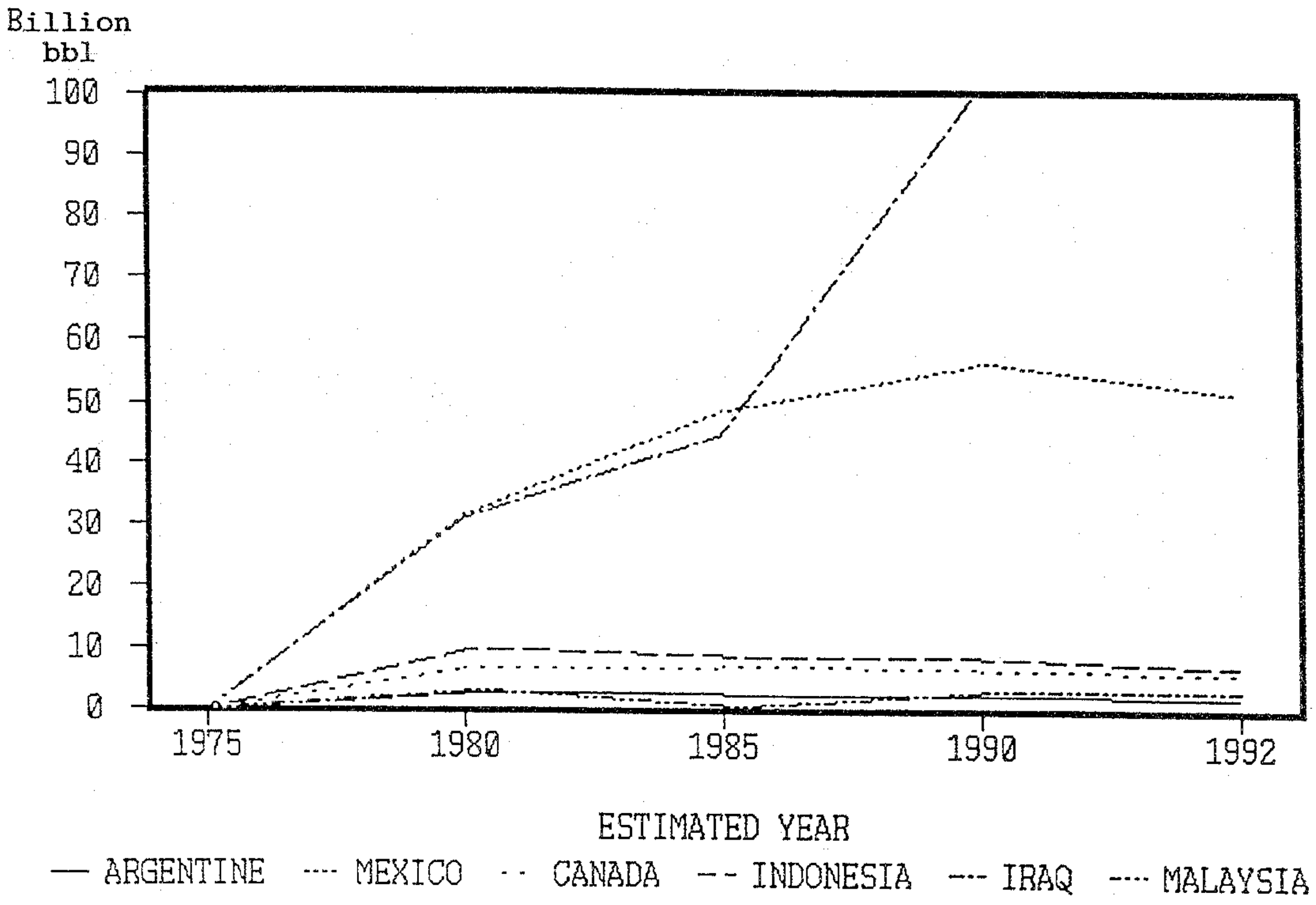


Figure A8-7(a) CRUDE OIL RESERVES OF ARGENTINE AND SIMILLAR COUNTRIES

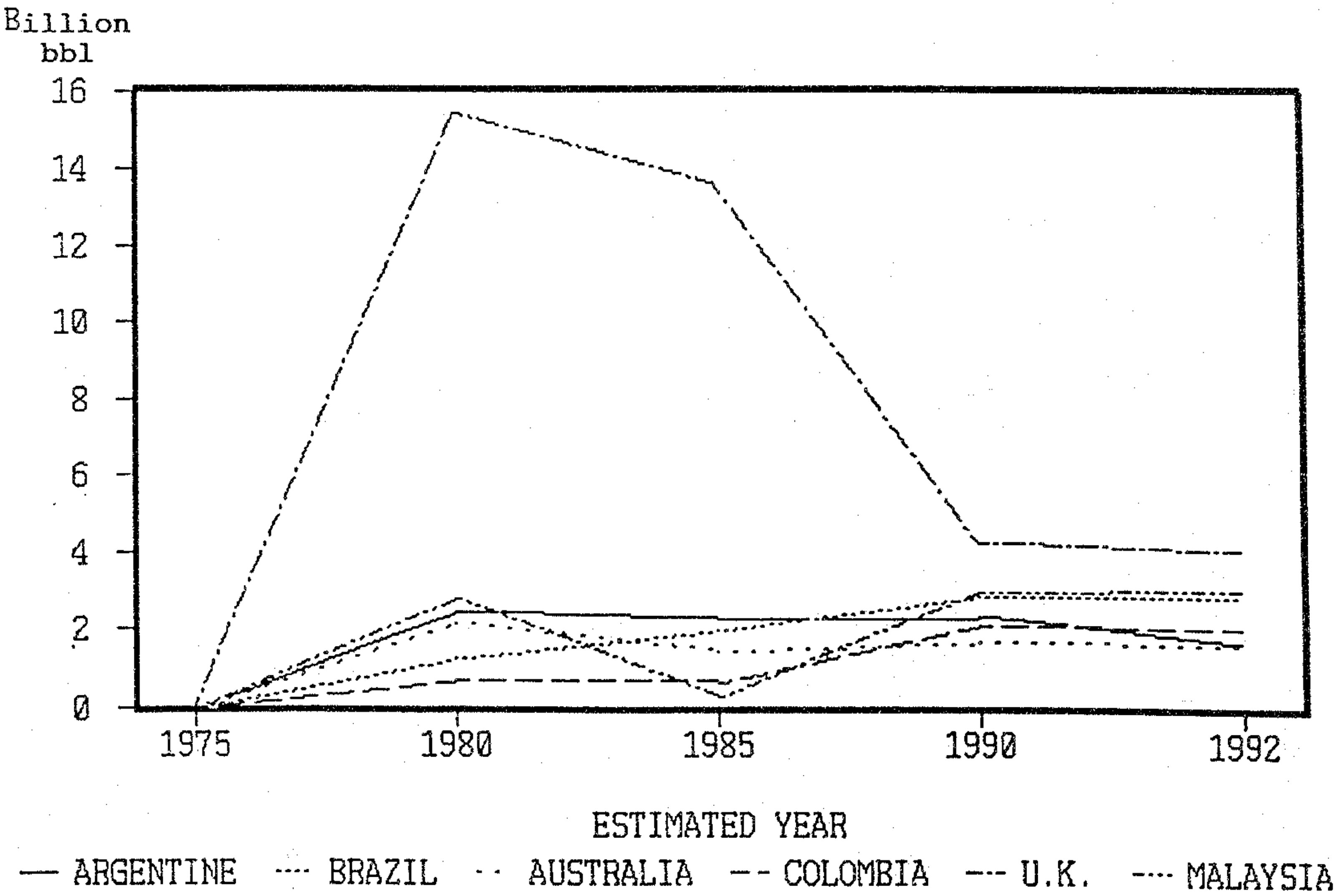


Figure A8-7(b) CRUDE OIL RESERVES OF ARGENTINE AND SIMILLAR COUNTRIES

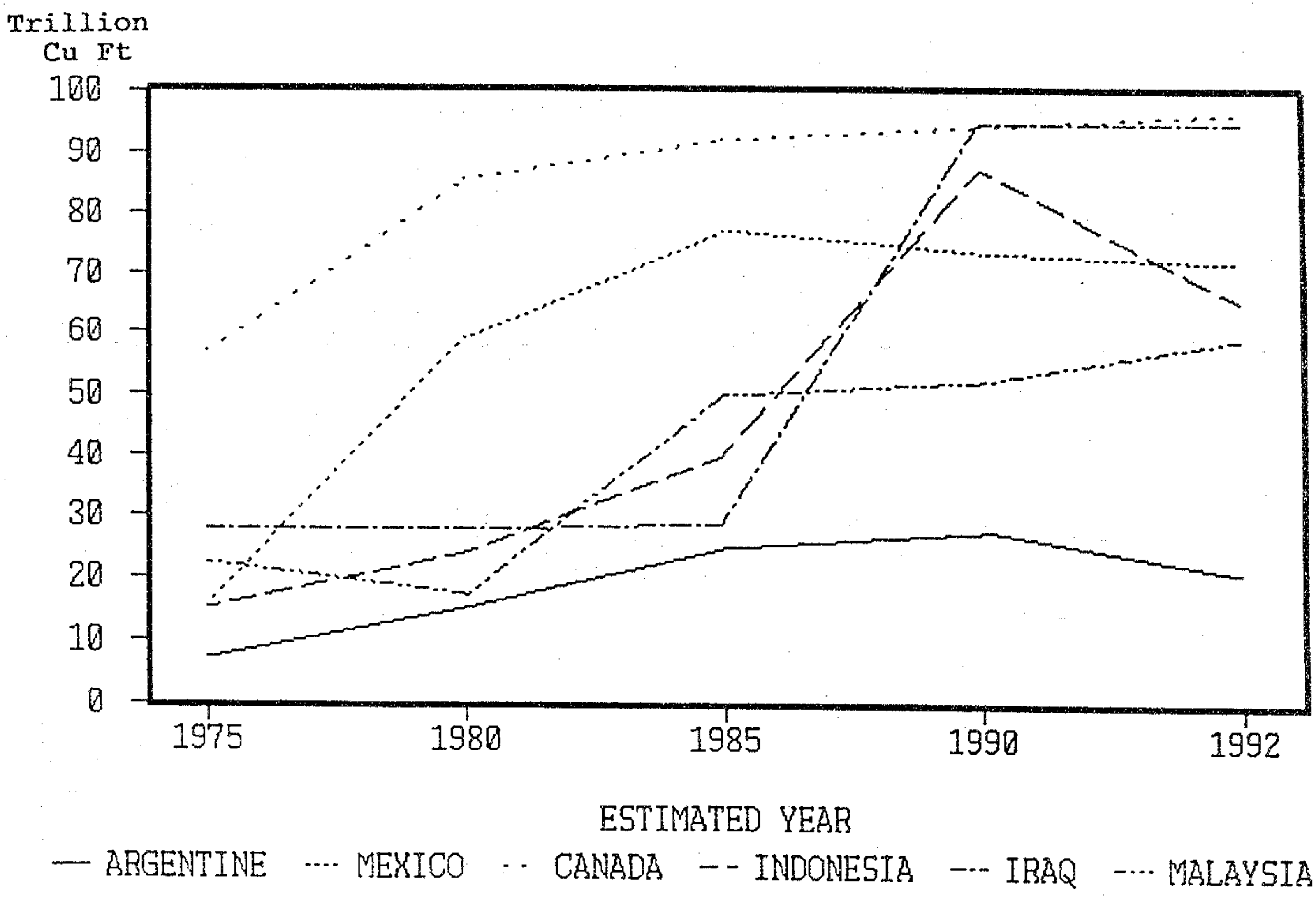


Figure A8-8(a) **NATURAL GAS RESERVES OF ARGENTINE AND SIMILLAR COUNTRIES**

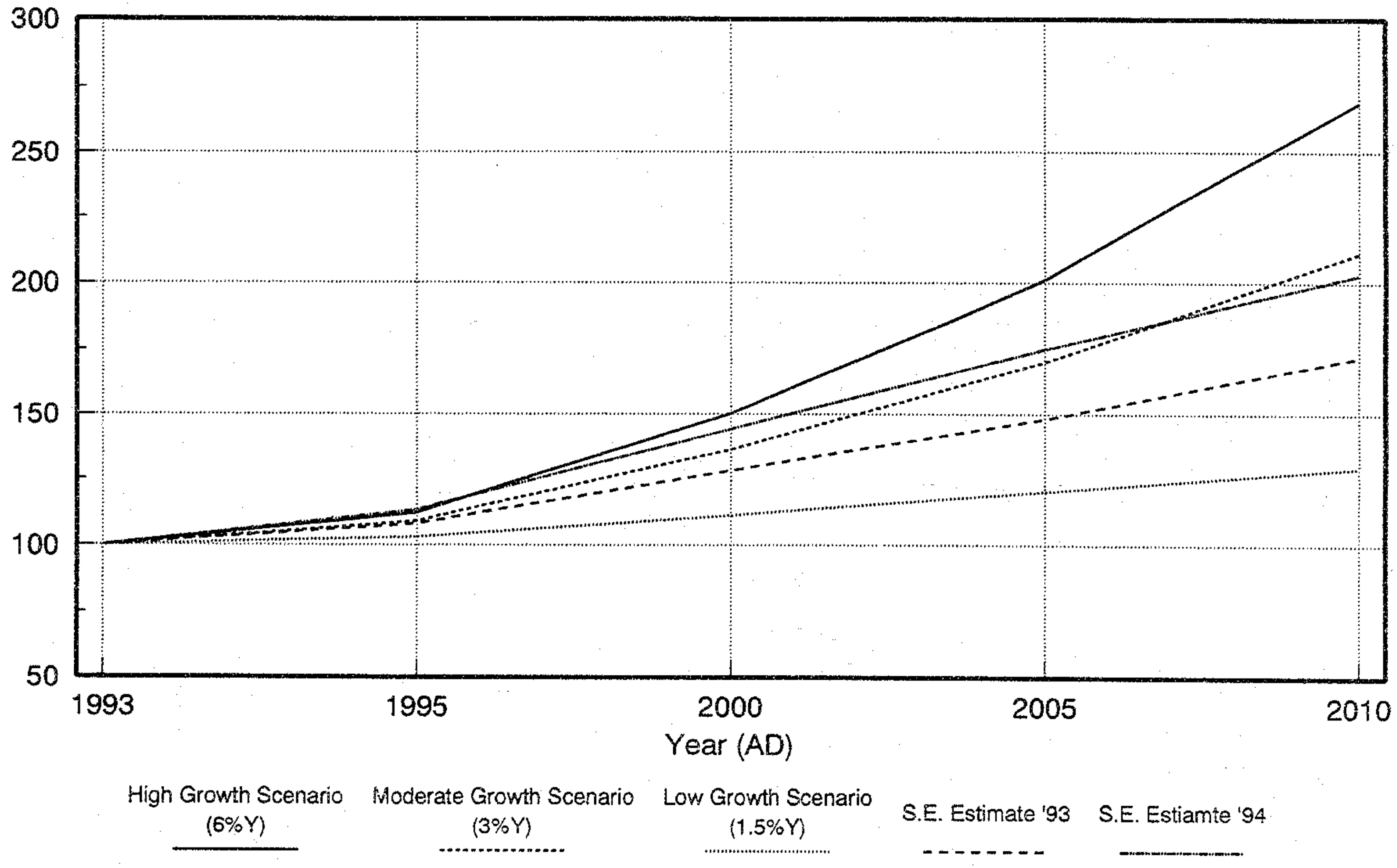


Figure A8-8(b) G.D.P. GROWTH FORECAST (INDEX)

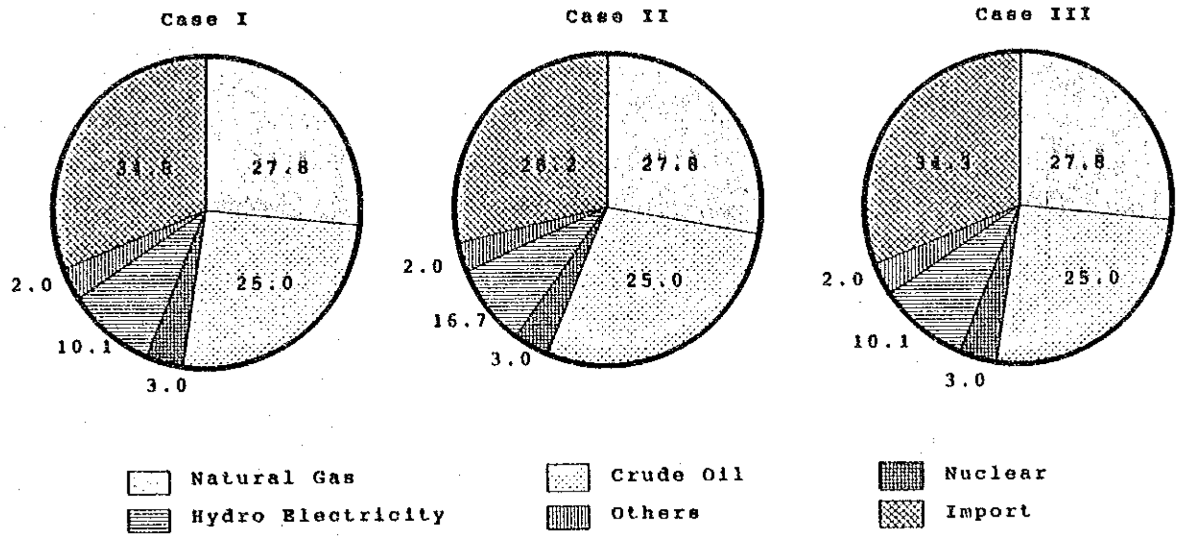


Figure A8-9 PRIMARY ENERGY SUPPLY AD2010

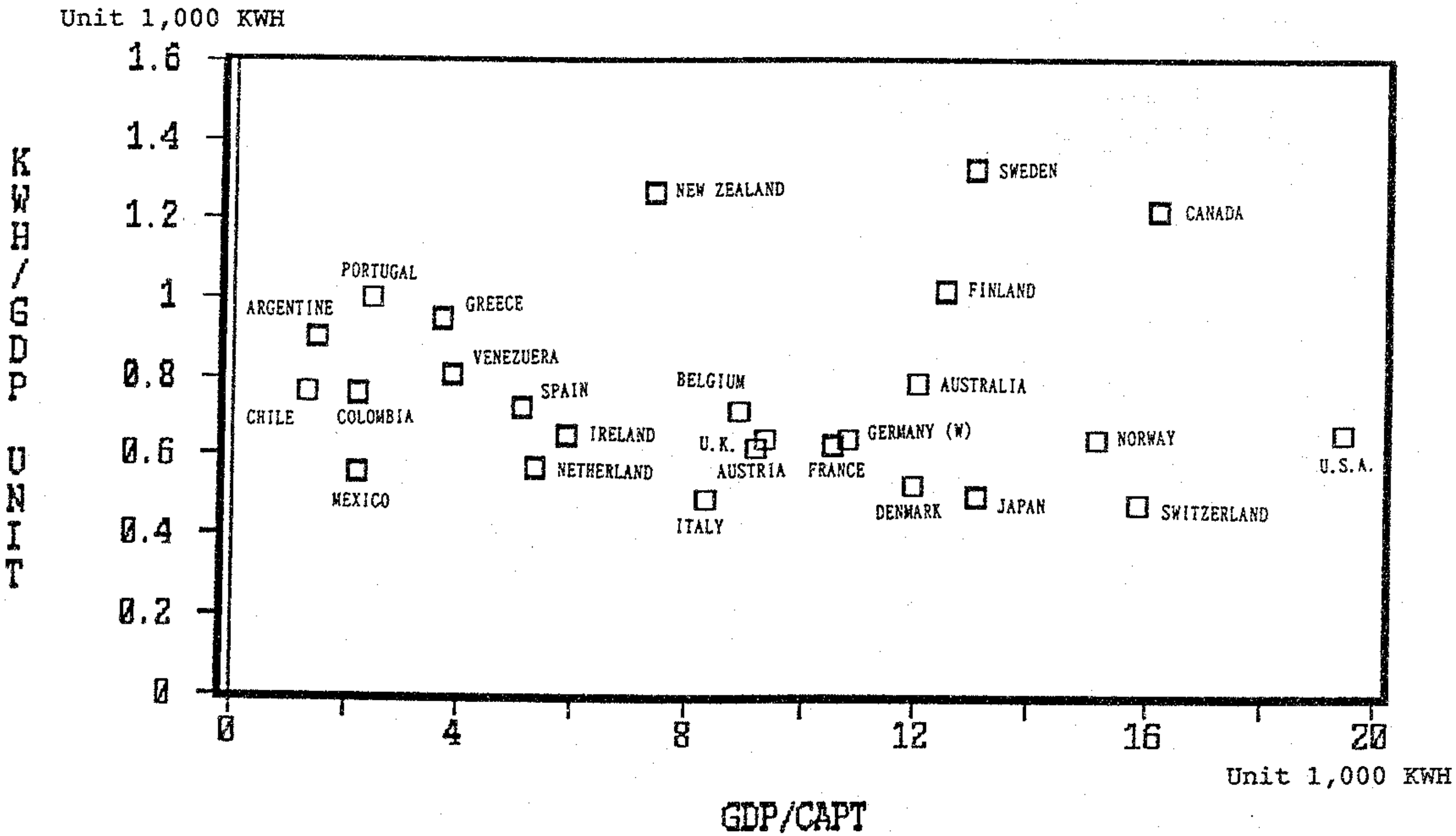
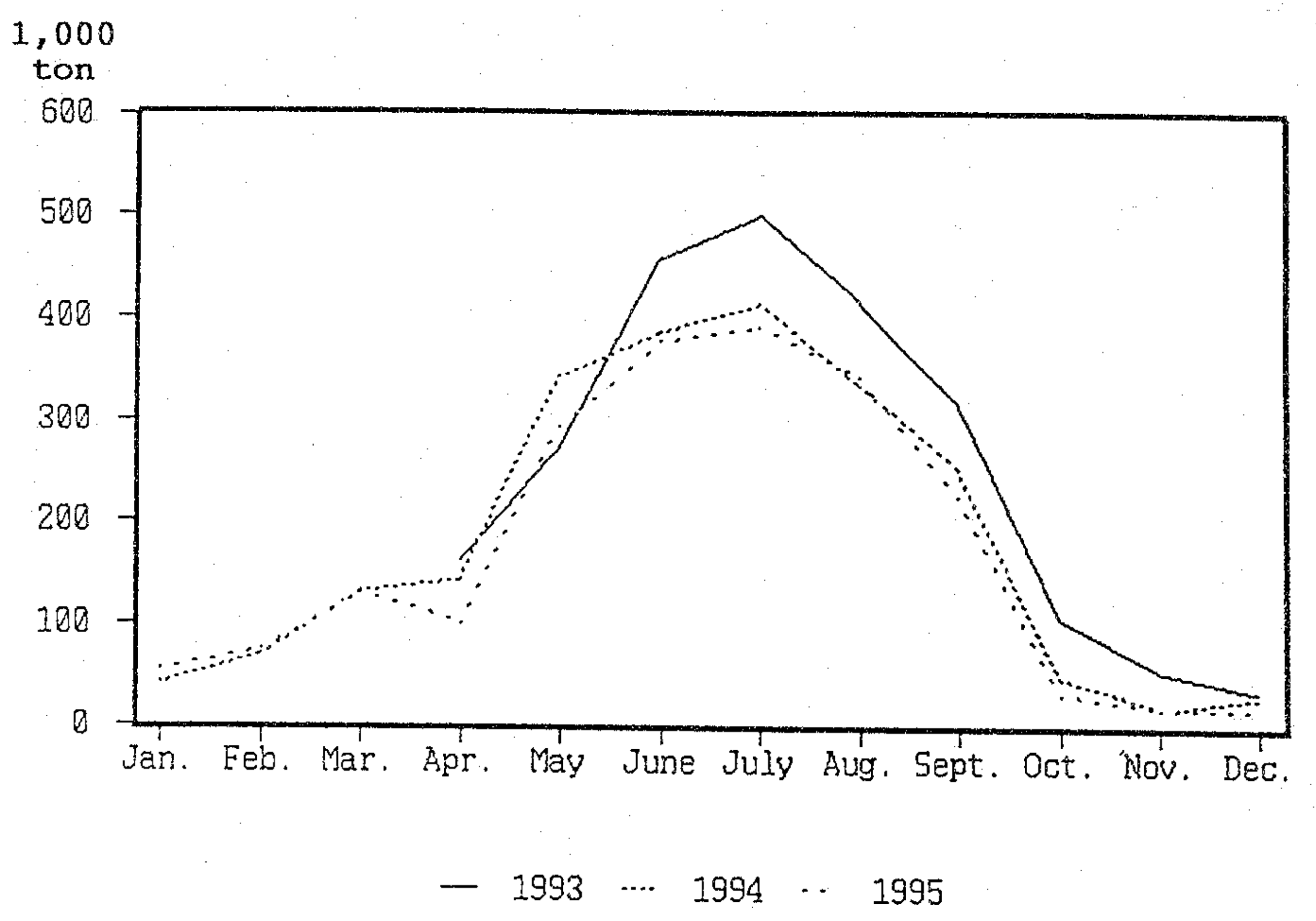
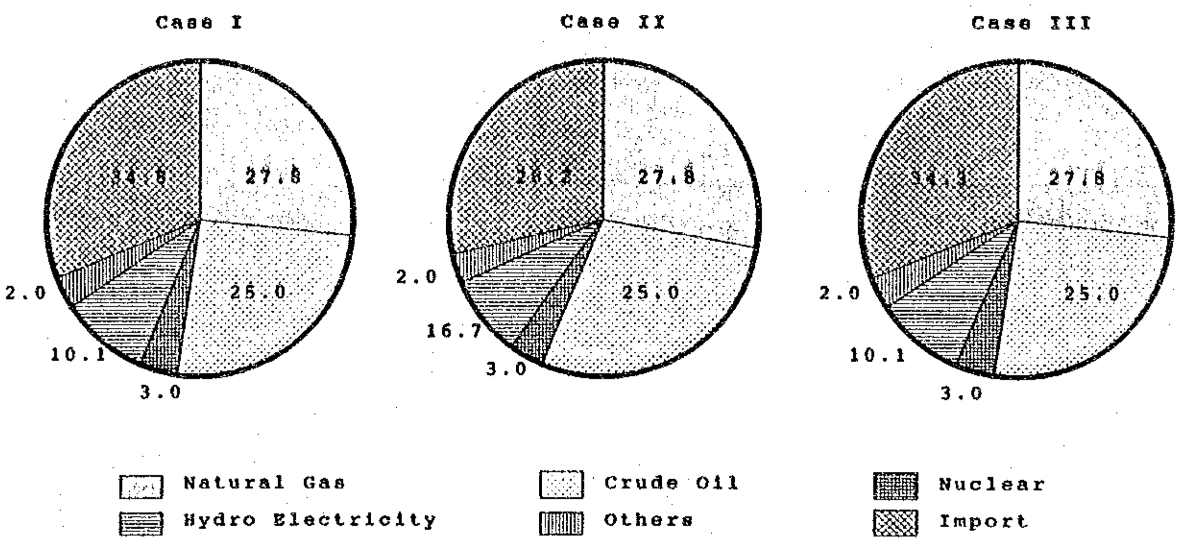


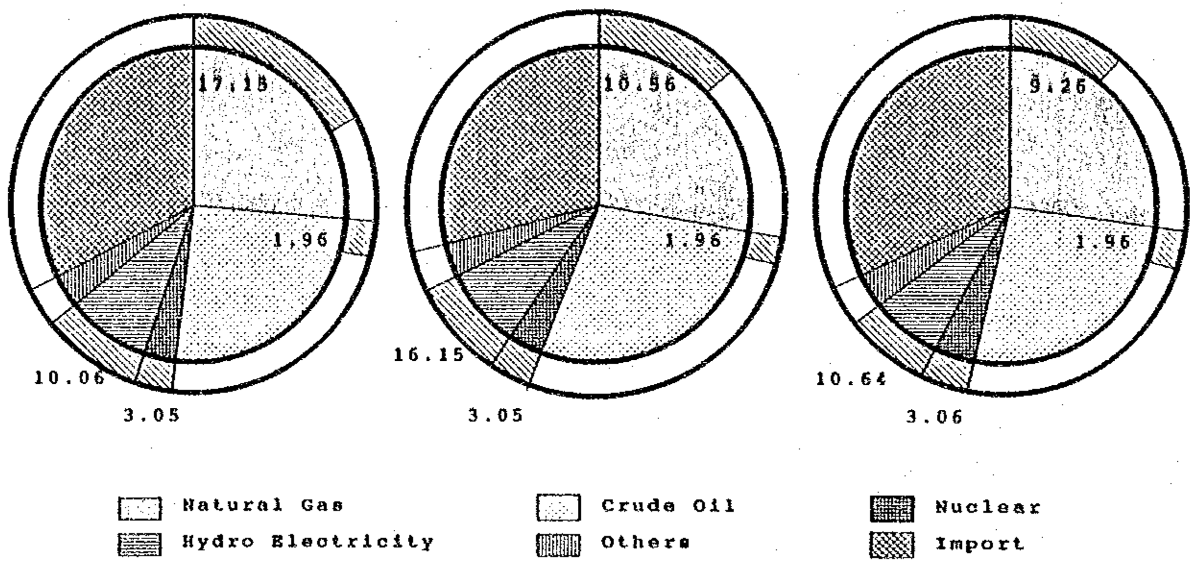
Figure A8-10 RELATION BETWEEN ELECTRICITY CONSUMPTION AND G.D.P. PER CAPUT



MONTHLY FUEL OIL CONSUMPTION (CAMMESA ESTIMATE)
ARGENTINE THERMAL POWER PLANT (NATURAL GAS SUPPLY PRESENT LEVEL)

Figure A8-11 THERMAL POWER PLANT





* Hatched portion in the outer circle indicates the allocated to electricity generation energy.

Figure A8-12 PRIMARY ENERGY SUPPLY IN ARGENTINE (T.O.E.10^6)

APPENDIX 9 Studies of Air Pollution Control by Fuel (Energy) Conversion

Appendix 9 Studies of Air Pollution Control by Fuel (Energy) Conversion

Foreword

It is, now, expected that the Argentine economy grow at relatively at fast pace in the future, major industrial development may occur in the area around Buenos Aires, including Santa Fe and Cordoba. In this case, deterioration of air quality will become a problem and flue gas treatment facilities will be needed at coal- or oil-fired plants.

At the same time, however, demand of fuel oil and coal can be absorbed by strengthening clean energy supply including hydropower and natural gas, and also desulfurization and denitrogenation of fuel oil, instead of flue gas treatment. In any case, the most appropriate alternative scheme for atmospheric environmental control should be selected in consideration of its economy and future national benefits.

From this viewpoint, possible energy supply alternatives in the Buenos Aires area, particularly in winter when fuel oil and coal demand concentrates, will be studied in the following;

A9.1 The standard cost for abatement of atmospheric pollution of the thermal power plant.

It is estimated that the investment cost and operating cost of gas base combined cycle power plant and its cost for reduction of NOx by application of continuous catalytic reduction and cost of de SOx, de NOx and de Particulate Matter for fuel oil base steam turbine plant as follows: (Ref:chapter 5)

	500 MW Combine Cycle Gas Power Plant	Denox	Fuel Oil Power Plant	Steam Turbine DeNox, SOx, PM
Investment (million U.S.$)	312.00	13.75	495.65	86.80
Direct Operating Cost U.S.¢/KWH	0.38	0.02	0.66	0.09
Capital Cost U.S.¢/KWH	1.07	0.05	1.89	0.33
Fuel Cost (2.0U.S.$/MMBTU) U.S.¢/KWH	1.76	-	1.76	-
Variable Cost U.S.¢/KWH	-	0.08	-	0.34
Total U.S.¢/KWH	3.09	0.15	4.19	0.76

Note(1) these calculation based on 365 x 24 x 0.75 hr operation. (New High Efficiency plant will be used maximum days in year)

Note(2) In case when the fuel oil is used only four months in a year, the capital cost of pollution control facility per KWH will be three times of above. (Gas Combine 0.15 ¢KWH F.O. Steam 0.99 ¢KWH)

This means the replacement of high sulphur fuel by clean fuel such as L.P.G. or Low sulphur fuel, which will not require abatement facility, will be possible even the additional fuel cost is (9,800 x 10^3 ÷ 2,200 x 1.42$/ton) 63.3$/ton equiv. F.O. as far as abatement facility is used only four months in a year.

A9.2 Alternative A

A9.2.1 Increase natural gas supply during winter (Introduction of peak shaving scheme for peak demand of natural gas in the winter in Grand Buenos Aires region)

According to the results of actual measurement of SOx level in Buenos Aires, Rosario and Mendoza this time, there is no immediate requirement of reduction of SOx emission from the power plants in these area.

However, the replacement of fuel oil being used in winter by the power plants in Buenos Aires region is desirable to eliminate the possibility of damage of historical monument and general buildings in the area from acidic mist and rain generated by SOx and other acidic emission to air.

At present, the bottleneck in natural gas production and supply capacity necessitates the use of fuel oil in winter to the most of power plants, and therefore economic feasibility of natural gas supply for the winter peak shaving is to be assessed.

Thermal power plants are consuming about 1.5 million tons of fuel oil (equivalent) annually in the country, which are expected to increase in future. According to the CAMESA's estimates:
The fuel oil consumption in the power plant has seasonal change;

Maximum month in a year (July)	413 x 10^3 ton
May, June, August	330 - 380 x 10^3 ton
February, March	70 - 130 x 10^3 ton
Other month	50 x 10^3 ton

(Figure A8-5-3)

From the above data, even the time natural gas supply is sufficient, around 50,000 tons monthly of fuel oil will be used throughout the year due to facility restraint and price consideration. Thus, natural gas requirements for replacement of fuel oil during the peak period are assumed to be 360,000 tons/month (July) of fuel oil equivalent for the time being.
Daily amount is 360,000 tons/31 days = 11,600 tons on average, and 120% of the average 14,000 tons/day are assumed to be the required supply capacity at the peak.
14,000 tons/day of fuel oil (equivalent natural gas to ton of fuel oil is 1180 cubic meter) is equivalent to natural gas of 16.5 x 10^6 cubic meter/day (582 MMCFD).

Natural gas production and supply facilities currently in operation are designed to meet the average demand throughout the year. As a result, if consumption for commercial and household uses increases, the supply shortage occurs for thermal power

plants and industries which are thus forced to use fuel oil and gas oil.
Assuming that thermal power plants in and around Buenos Aires are required to use clean fuel gas for air pollution control, the capacity expansion cost to supply natural gas for the peak demand is estimated below.
Assumptions: From CAMMESA's data, fuel oil requirements during the peak period are assumed to be 14,000 tons/day, which are equivalent to 120% of the monthly average consumption of 11,600 tons. (582MMCFD in case of natural gas)
Production wells will be drilled in the northern part (1,200km from the capital) or the central west part (1,700km) of Argentina, and a new pipeline to Buenos Aires will be constructed. (The pipeline construction cost is assumed to be 0.5 - 1.0 million/mile on the basis of U.S. cases.

Investment requirement:
Number of gas well required 582 MMCFD/20mmCFD = 30 wells
One well cost 5 million U.S.$
Pipeline cost 30 inches 0.5-1.0 million U.S. Doller (U.S.data)/mile
1,200 KM (750 mile)
Total investment of US$525 - 900 million

On the other hand, investment required for air pollution control facilities of thermal power plants amounts to US$400 million, as calculated on the basis of the 2,300MW output (11,600 tons/fuel oil equivalent) and US$174/KW. This indicates that the pipe line construction cost is determinal to the economy of this alternative. Particularly, when there is a pipeline construction plan under way, the pipeline construction cost for the peak shaving project will decrease considerably when these two project integrated, and this way of replacing fuel oil by gas will further improve economy of the original pipe line project. Therefore the plan for new natural gas transmission pipeline construction should be reviewed in connection with the requirement with the peak shaving in winter.

A9.2.2 Replacement of high sulphur fuel oil by low sulphur fuel

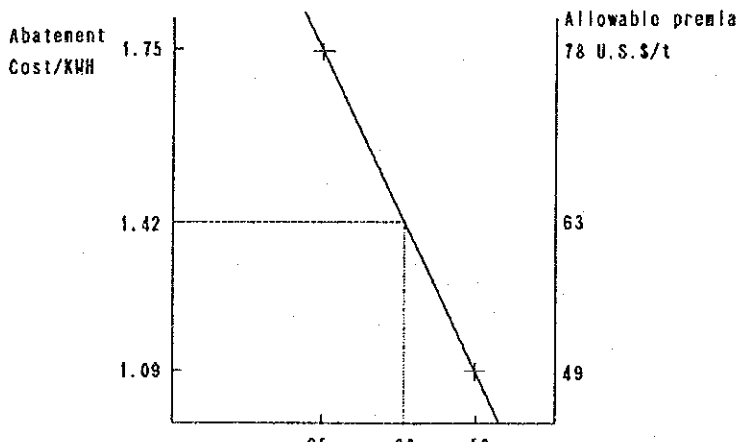
In future, the total energy consumption will increase very much and the import of low cost fuel will be necessary, and the supply of low sulphur fuel oil from domestic supply will become difficult.

When new industrial projects are kept locating present industrial area in future,the power plants which use fuel oil and/or coal will require to install some air pollution abatement facilities.

As it is mentioned in the preceding paragraph, the cost of flue gas treatment of power plant will be 0.15¢/KWH for De NOx and 0.76 ¢/KWH for De SOx, NOx, PM.

Particularly, the case when the use of fuel oil or coal is limited time in normal year, the installation of standard abatement facilities will not be justified in its economy.

The price difference between 1.0% sulphur F.O. and 3.0% F.O. at Rotterdiam Netherlands during 1992 - 1993 is reported maximum 35 - 36 U.S.$/ton normally 10 - 25 U.S./ton. This means even 0.8% or lower sulphur fuel oil can be obtained as far as the additional price 50 U.S.$/ton is considered. When we assume to use low sulphur fuel oil instead of installation of the pollution abatement facility, the break even of fuel price increase and on stream parcent of the abatement facility will be as follow:-



This means that when the on stream days of DeSOx, NOx, P.M. facility is not more than 183 days in a year, securing of low sulphur fuel during winter season seems more economical than installation of abatement facility. However, the DeNOx facilities is still to be installed the allowable additional fuel price should be 7.2 U.S./ton less than above figure

A9.2.3 Economy of Application of L.P.G. for SOx reduction

The international price of L.P.G. (propane, butane) is comparably higher than that of fuel oil, but the sulphur content is almost nil. This means that when the reduction of SOx emission from the thermal power plant to zero level is required, the use of L.P.G. can be one of alternative of the installation of typical DeSOx facility provided the operating time of the DeSOx facilities are only winter season.

When L.P.G. price is converted to fuel oil equivalent on the caloric value basis, the price range will be around 150 - 160 U.S.$/ton as CIF to Argentine. The price difference between fuel oil and L.P.G. seems around 30 - 40 $/ton. Even if we consider the cost for DeNOx and storage cost, the use of L.P.G. as the alternative of other SOx reduction measure is possible as far as the operation of DeSOx facility is required at limited time in a year.

LPG price (Typical)

(July)	1990	1991	1992	1993
FOB Saudi Arabia U.S.$/ton				
Propane	99.02	121.5	136.00	128.50
Butane	97.01	119.86	134.00	135.50
CIF Japan Yen L.P.G.	19,988	27,677	23,520	22,517
U.S.$/ton	133.25	197.69	180.82	195.80
U.S.$/Ton Equiv. F.O.	111.0	164.74	150.76	163.17

A9.2.4 Application of LNG (liquefied natural gas)

As one of country's natural gas development program, a liquefied natural gas project in the southern part (Tierra de Fuego) is expected to be realized for export purposes. The project may include the scheme to supply liquefied natural gas to the Buenos Aires area in order to supplement the shortage of natural gas in the area in winter, thereby to prevent air pollution due to the burning of fuel oil and coal.
A major prerequisite to the project is that LNG from the project can be exported to countries in the Northern hemisphere during the off-peak season of Argentine.

Generally, the plant to liquefy 500MMCFD of natural gas is estimated to cost 750 million U.S.$, and the storage facility will be at US$160 million. If the project bears one half the cost, or US$450 million, the use of LNG will be worth considering as a feasible means of air pollution control, partly because the investment cost is more or less the same for the cost of pollution control facilities for a 2,200MW plant capacity, and partly because domestic LNG prices will be set at a price level equivalent in calorific value to fuel oil prices.

The cost of L.N.G. delivered to the consuming area normally equivalent to the low sulphur fuel oil in Caloric value. This means as present international price 150 US$/ton of low sulphur fuel oil, equivalent to about 3.82 US$/MMBTU, is considered standard price on CIF basis.
Generally speaking, the cost of liquefaction at natural gas producing area (more than one million tons/Y) is considered about 2.2 - 2.5 U.S.$/MMBTU, and transportation cost to consuming area is considered about 0.6 - 1.2 U.S.$/MMBTU, and the cost of storage and gasification at consuming area may require additional 0.5 - 1.0 U.S.$/MMBTU.
In case, when the natural gas available in the location isolated from national transmission net work at the price of 1.0 US$/MMBTU, the price of gas at re-gasification facility in consuming area could be 4.3 - 5.7 US$/MMBTU including regasification cost.

If the gas is available near the country, low side price will be possible. This means, when a new LNG project is implemented, sulphur free fuel will be available to the power plant and other users at the cost of 169 U.S.$/ton equivalent to one ton fuel oil. Therefore, as we assessed already, the introduction of LNG to replace high sulphur fuel, which is used only limited period of time in a year, should be considered as the alternative of installation of DeSOx facility to the thermal power plant.

A9.2.5 Alternative D: New Fuel (Methanol)

The use of the alcohol fuel, particularly methanol produced from low cost natural gas, at thermal power plants around urban areas has been experimented in various pilot projects in Japan. As a result, its feasibility has been verified in all aspects except for cost competitiveness.
While the above LNG project is considered as one of economic uses of natural gas produced in the southern part of Argentine, the use of fuel methanol to replace fuel oil consumption at thermal power plants in winter seems to be highly feasible for pollution control. In particular, methanol shows an advantage over LNG, if there is no market for LNG during the off-peak season, because of international chemicals market. Furthermore, if crude oil prices rise in the near future, the country's energy strategy may be directed to replace the petroleum base power plants in the areas where construction of a natural gas pipeline and a power transmission line from remote hydro power plant is not economically feasible. If this happens, methanol will be a feasible fuel to replace petroleum products for these isolated power plant, thus improving the project's economy further.

Assuming that a raw material for methanol - natural gas - is available at US$1.0/MM BTU, the cost of methanol production is estimated as US$120/ton. Compared to the fuel (fuel oil 120$/ton) cost plus the flue gas treatment cost at US60/ton of fuel oil (operating rate of 30%), the methanol cost is to be equivalent to US$180US$/ton of fuel oil. Since methanol's calorific value is approximately one half that of fuel oil the price should be about 90 U.S.$/ton. Methanol production at this price level is only possible the gas being flare is avairable at 0.3 - 0.5US$/MMBTU and the finance for the project is available at the cost of 5 - 6% annualy. At present, international crude oil prices as well as fuel oil prices are hovering low to prohibit methanol production for replacement of fuel oil on a commercial basis. However when crude oil prices rise again, methanol will receive spot light as an economical and polluting free fuel in Argentine. In addition, there is a new technology to use methanol for power generation at very high energy efficiency, such as reformed methanol gas turbine system, which is being developed in Japan, the use of methanol as clean fuel should be kept in the future plan as the source of clean fuel.

A9.3 Conclusion of this chapter

It is recommended that the future energy demand supply assessment of the country with due consideration on the environmental protection and new circumstance of energy structure of the country,which will be brought in near future by expected rapid demand increase by economic growth, should be conducted immediately. That study should include not only conventional technology but also the newly developed technology to be available in near future.

APPENDIX 10 Indicative Analysis Instruction Figures for Measured Value for Pollutants in Flue Gas

Appendix 10 Indicative Analysis Instruction Figures for Measured Value for Pollutants in Flue Gas

All results of measurement of concentration of pollutants from flue gas were attached in the form of figure in this Appendix 10.

This should be a start point for the analysis of measured value of concentration of pollutants from flue gas by means of miscellaneous analysers.

Further study on verification of the measured value shall be referred to Clause 3.2.3 in Chapter 3.

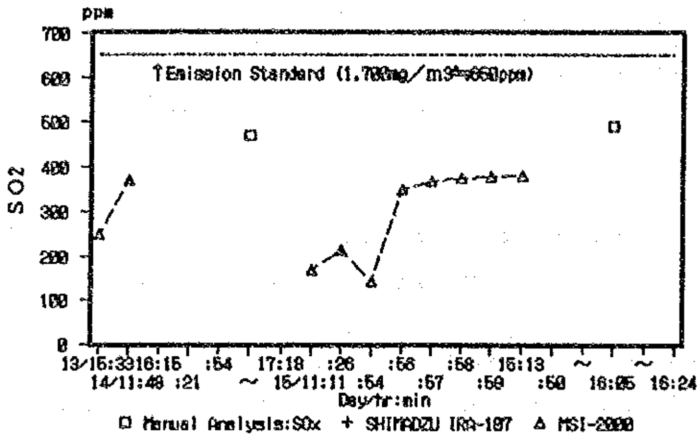


Figure A10-1 DETERMINATION OF POLLUTANTS IN FLUE GAS (SO2)
(Nuevo Puerto Power Plant No.13)

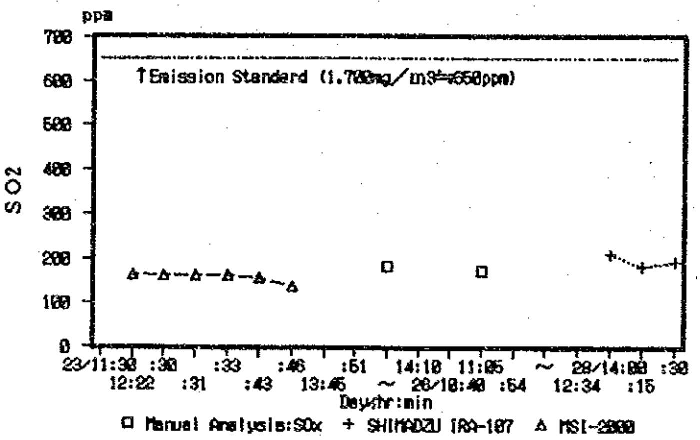


Figure A10-2 DETERMINATION OF POLLUTANTS IN FLUE GAS (SO2)
(Lujan de Cuyo Power Plant No.12)

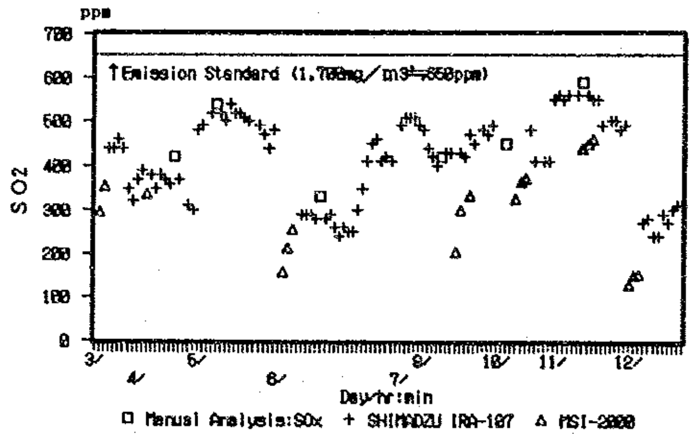


Figure A10-3 DETERMINATION OF POLLUTANTS IN FLUE GAS (SO2)
(San Nicolas Power Plant No.5)

Note: Figure A10-1 to Figure A10-3
All measurement value of SOx in effluent gas were plotted by analysers and chemical titration method.

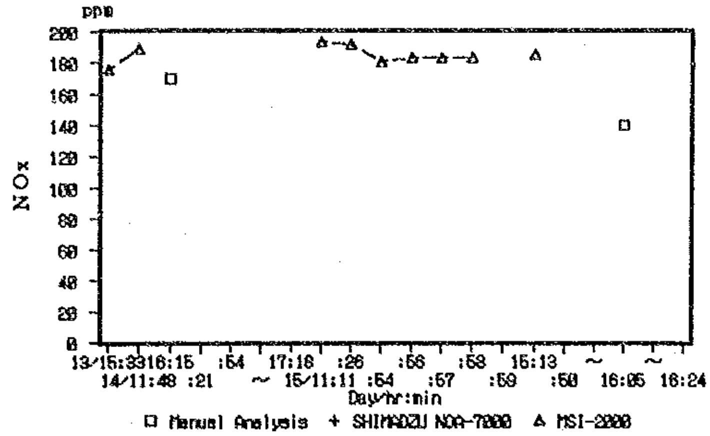


Figure A10-4 DETERMINATION OF POLLUTANTS IN FLUE GAS (NOx)
(Nuevo Puerto Power Plant No.13)

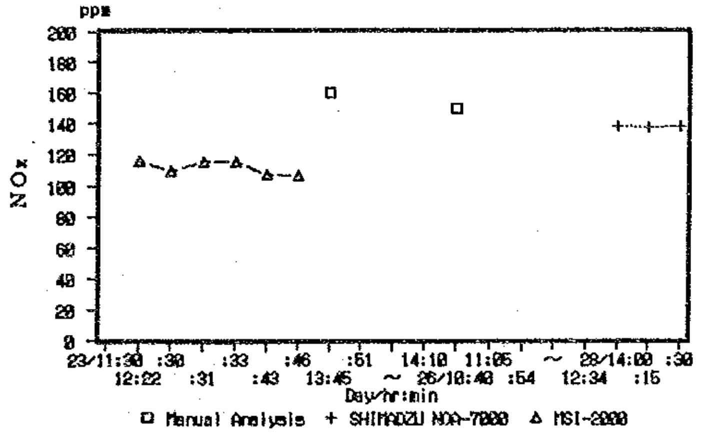


Figure A10-5 DETERMINATION OF POLLUTANTS IN FLUE GAS (NOx)
(Lujan de Cuyo Power Plant No.12)

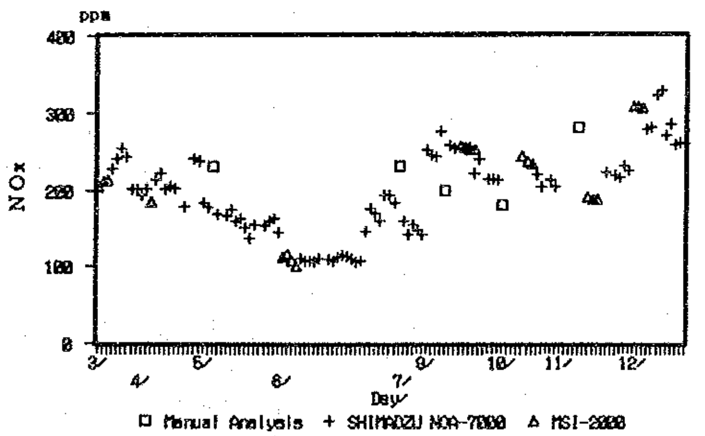


Figure A10-6 DETERMINATION OF POLLUTANTS IN FLUE GAS (NOx)
(San Nicolas Power Plant No.5)

Note: Figure A10-4 to Figure A10-6
All measurement value of NOx in effluent gas were plotted by analysers and chemical titration method. These shall be studied in comparasin of Figure 3-2-8 to Figure 3-2-10 and Figure 3-2-14 to Figure 3-2-16, respectivelly.

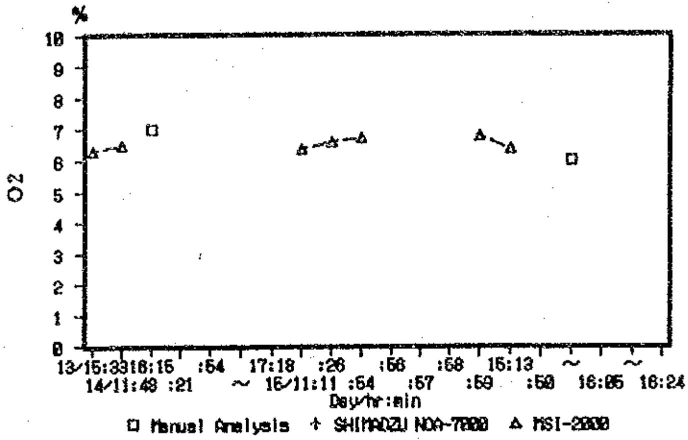


Figure A10-7 DETERMINATION OF POLLUTANTS IN FLUE GAS (O2) (Nuevo Puerto Power Plant No.13)

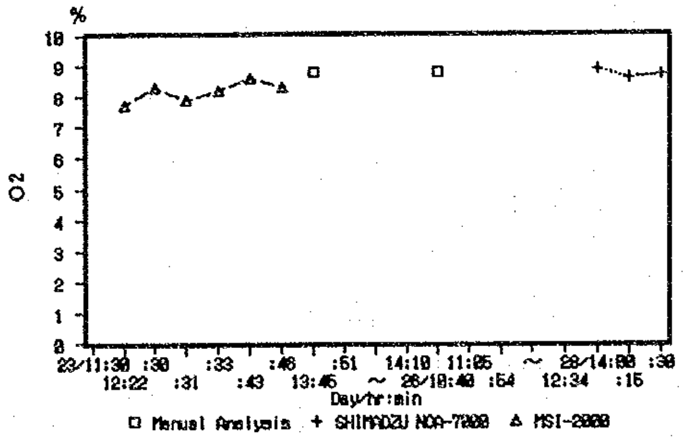


Figure A10-8 DETERMINATION OF POLLUTANTS IN FLUE GAS (O2) (Lujan de Cuyo Power Plant No.12)

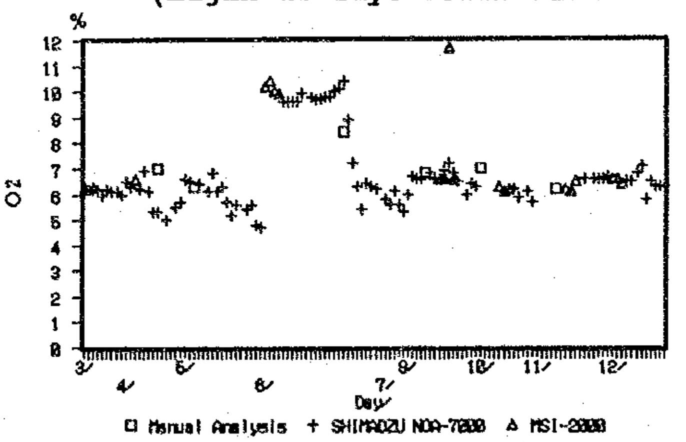


Figure A10-9 DETERMINATION OF POLLUTANTS IN FLUE GAS (O2) (San Nicolas Power Plant No.5)

Note: Figure A10-7 to Figure A10-9
All measurement value of O_2 in effluent flue gas were plotted for analysers and manual measurement.

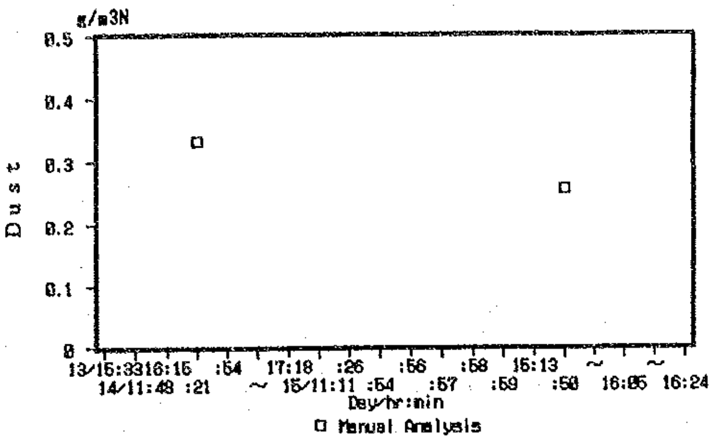


Figure A10-10 DETERMINATION OF POLLUTANTS IN FLUE GAS (DUST)
(Nuevo Puerto Power Plant No.13)

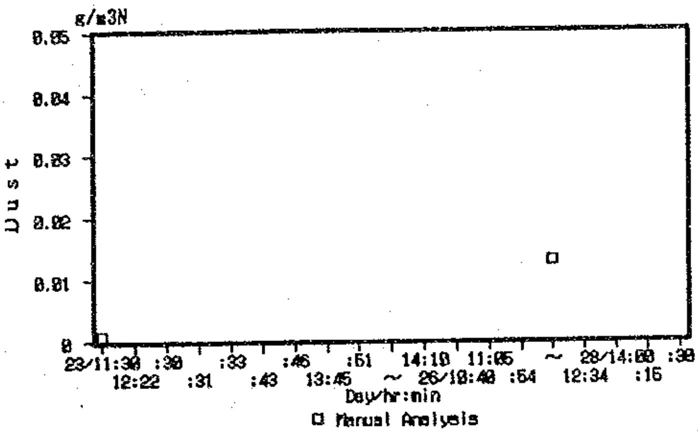


Figure A10-11 DETERMINATION OF POLLUTANTS IN FLUE GAS (DUST)
(Lujan de Cuyo Power Plant No.12)

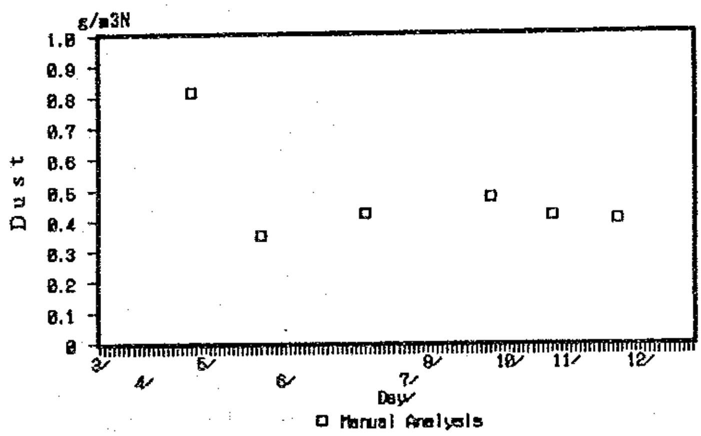


Figure A10-12 DETERMINATION OF POLLUTANTS IN FLUE GAS (DUST)
(San Nicolas Power Plant No.5)

Note: Figure A10-10 to Figure A10-12
All measurement value of DUST in effluent flue gas were plotted.

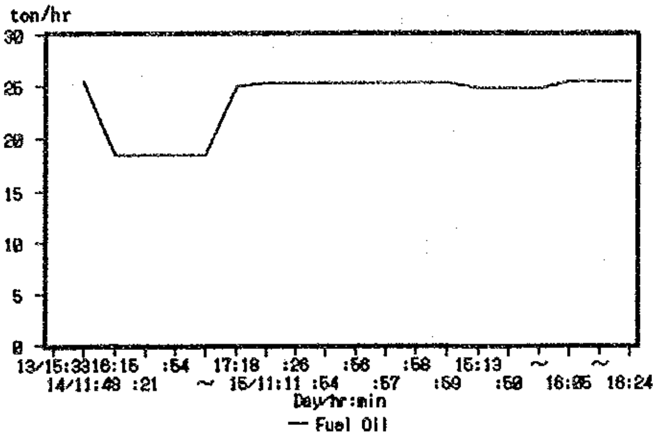


Figure A10-13 CONSUMPTION VOLUME OF FUEL (Nuevo Puerto Power Plant No.13)

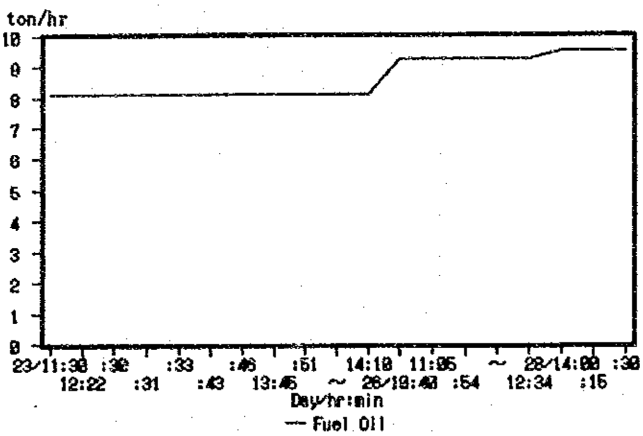


Figure A10-14 CONSUMPTION VOLUME OF FUEL (Lujan de Cuyo Power Plant No.12)

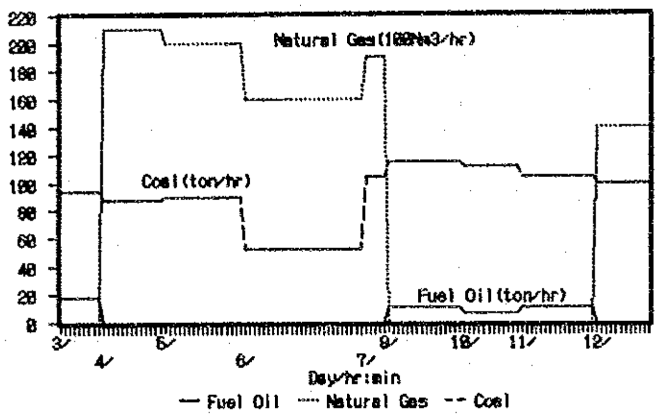


Figure A10-15 CONSUMPTION VOLUME OF FUEL (San Nicolas Power Plant No.5)

Note: Figure A10-13 to Figure A10-15
Record of feed rate of fuel, each measurement value should be analysed using this value together with other operating conditions of boiler.

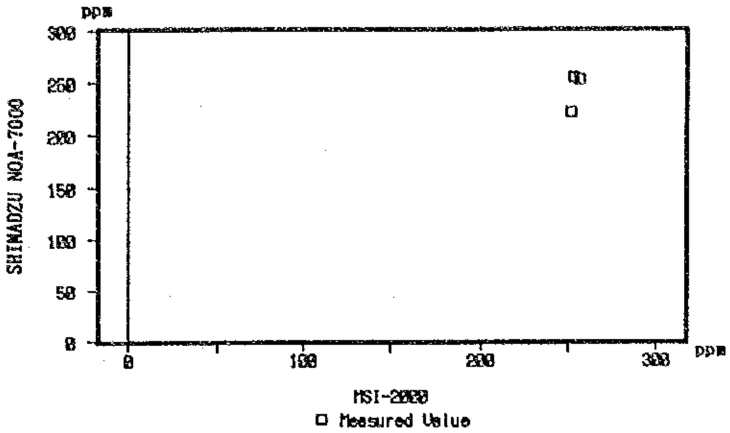


Figure A10-16 DETERMINATION OF POLLUTANTS IN FLUE GAS (NOx<ppm>)
(Nuevo Puerto Power Plant No.13)

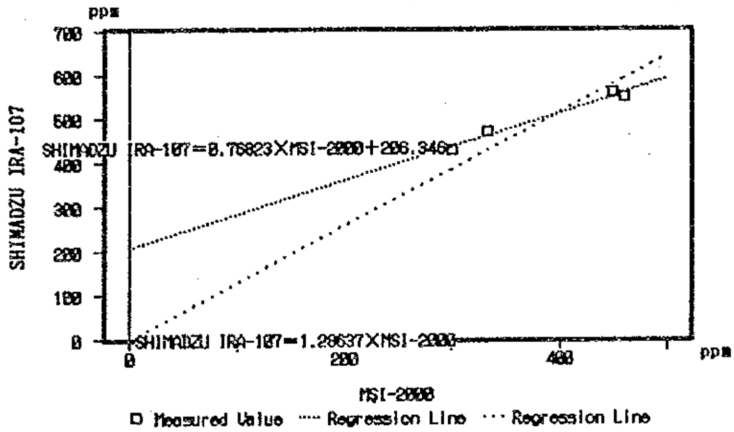


Figure A10-17 DETERMINATION OF POLLUTANTS IN FLUE GAS (SO2<ppm>)
(Lujan de Cuyo Power Plant No.12)

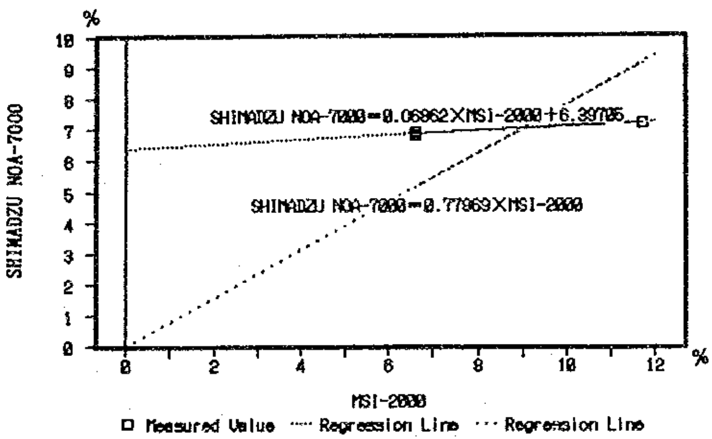


Figure A10-18 DETERMINATION OF POLLUTANTS IN FLUE GAS (O2<%>)
(San Nicolas Power Plant No.5)

Note: Figure A10-16 to Figure A10-18
Relationship of measured value between instrument analyser adopted were tried.