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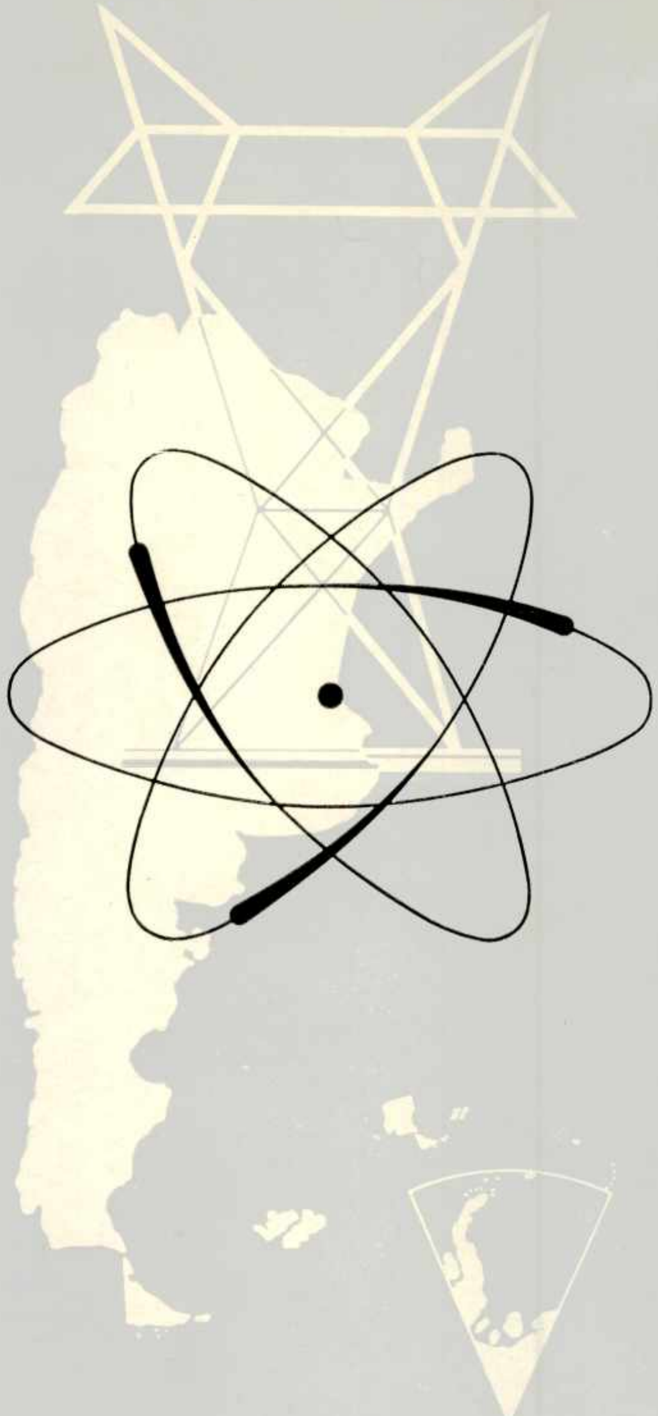

FEASIBILITY STUDY

NUCLEAR POWER PLANT FOR THE GREATER BUENOS AIRES - LITTORAL AREA

SUMMARY

In compliance with Presidential Decree No. 485/65, of January 22nd., 1965, the Argentine Atomic Energy Commission (CNEA) organized a special study group to determine the Feasibility of a Nuclear Power Plant for the Greater Buenos Aires-Littoral Area. The present Summary is the first of eight chapters which constitute the technical, economical and financial report prepared by this group with the cooperation of several branches of the CNEA as well as that of national, foreign and international agencies, companies and experts.

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FEASIBILITY STUDY
NUCLEAR POWER PLANT FOR THE
GREATER BUENOS AIRES-LITTORAL AREA

SUMMARY

I - MAIN CONCLUSIONS

This report contains a detailed study on the feasibility of supplying the Greater Buenos Aires-Littoral (GBA-L) area with electric power by means of a nuclear power plant (Central Nuclear Buenos Aires; CNBA), under economically competitive conditions.

According to estimates of the "Secretaría de Energía y Combustibles" and the National Development Council (CONADE), confirmed by the present study, the growth of electricity demand in the GBA-L - Argentina's highest consumption area - will require the installation of at least 1,300 MW between 1966 and 1972.

According to present previsions, hydroelectric supply to this region will not be available until 1972-73. It, therefore, becomes necessary to meet the requirements until that date exclusively with thermal power plants.

Up to few years ago, these could not have been but those presently known as conventional thermal plants, burning either oil, or coal, or natural gas. But nowadays, there exists a competing alternative, nuclear power plants, which generate electricity from the energy released by nuclear fission of uranium. During the 23 years that have elapsed since Enrico Fermi achieved the first controlled nuclear chain reaction with the first nuclear reactor in history, billions of kilowatt hours of electricity have been generated by nuclear fission. Over the same period, the development of this new technology proceeded from the purely conceptual level to the demonstrated operation of a substantial number of nuclear power plants in several countries.

Already 50 nuclear power plants, with a total capacity of 7,225 MW are operating in Great Britain, the USA, the USRR, Italy, France, Japan, the German Federal Republic, Canada, Belgium and Sweden. The same countries - excepting Italy, Japan, and Belgium - have another 27 such plants under construction, totalling 8,322 MW, while India, Czechoslovakia, Spain, the Netherlands, and Switzerland have started construction of 6 plants with a total capacity of 924 MW.

On the basis of their operating experience, nuclear power plants have been found safe, economically convenient and efficient. Safe, as proved by the fact that no accident of importance was ever observed in any of them. Economically convenient, since wherever installed for commercial purposes, they are expected to produce electricity at competitive costs. Efficient, because they have always performed strictly according to their designers' most severe specifications.

The purpose of this report is to establish what can be the contribution of a nuclear power plant towards covering the required 1,300 MW to be installed in the GBA-L area between 1966 and 1972.

Work towards that aim included the study of the technical, economical, financial, political, legal , social, and sanitary aspects inherent to the installation and the operation of the CNBA. Its effects on the conservation of natural resources, the country's self-sufficiency of energy supply, the development of Argentine industry, as well as on a future Latin American nuclear energy market and on the country's social and cultural status, have also been considered.

These studies were conducted for plant capacities ranging from 300 to 500 MW and considering four different reactor types, two of which use natural uranium - which can be produced in Argentina - while the other two utilize enriched uranium, which has to be processed necessarily abroad.

The four reactor types considered, are :

a) Graphite moderated, gas cooled, natural uranium fuelled reactor (GCR).

b) Heavy water moderated and cooled, natural uranium fuelled, pressure tube reactor (HWR).

c) Pressurized water moderated and cooled, enriched uranium fuelled reactor (PWR).

d) Boiling water moderated and cooled, enriched uranium fuelled reactor (BWR).

The main technical conclusions of the study, equally applicable to the four reactor types mentioned above, and for power capacities of 300 to 500 MW, are the following :

1) By 1971, the GBA-L electric power system would technically accept the CNBA.

2) It is possible to have the CNBA in operation by 1971, considering that the average time necessary to achieve full power is approximately four years after the contracts are signed.

3) During its 25 years of estimated life the CNBA could operate with as much efficiency and safety as any conventional station.

4) Argentine industry could participate in an estimated 40 to 50% in the erection and operation of the CNBA.

5) From the point of view of the health and safety of its personnel and surrounding population, the CNBA is equivalent to other industrial plants, such as conventional thermal stations, oil and chemical industrial concerns, etc.

6) The availability and load - following characteristics of the CNBA are similar to those of conventional power plants included in the system.

7) The most convenient site for installing the CNBA is identified in this report by the name ATUCHA. It lies on the right shore of the Paranā de las Palmas river, approximately 100 km to the northwest from Buenos Aires.

A comparative study of economic and financial data was performed in order to estimate the economic competitiveness of the CNBA as against a modern thermal station of the same capacity (500 MW), fuelled by oil and operating under similar conditions. The conclusions are :

1) With any of the four reactor types considered, electricity would be produced by the CNBA at a lower cost than by the equivalent conventional plant.

2) It is economically more convenient to install the CNBA than an equivalent conventional thermal power plant.

3) The project is financially sound under the assumed conditions.

Item (Present worth value) (at 8%)	Units	PWR	BWR	GCR	HWR	Conv.
Generating Cost	mills/kWh	5.74	5.73	6.64	5.91	6.99
Initial investment	millions of U$S	96.7	98.5	135.6	138.6	82.1
Total cost during estimated life	millions of U$S	203.8	203.6	235.9	210.2	258.9
Benefit-cost ratio (comparative)	-	1.22	1.22	1.06	1.18	1.00

Other important consequences of the installation of the CNBA are also analyzed in this report :

1) With regard to the conservation of natural resources, it would mean the addition of Argentine uranium reserves to the country's exploited energy resources and consequently a greater diversification of the sources of energy.

2) With regard to the country's scientific and technical development, the establishment of nuclear technology - one of the most advanced in the world today - would strongly stimulate all scientific and technological activities, would create an increased need for training highly specialized personnel, etc.

3) With regard to Argentine industrial development, the CNBA would be the starting point for a nuclear industry in Argentina, and it would also lead to a general upgrading of the production and quality standards of traditional industry.

Summing up : It is technically feasible, economically convenient, and financially sound to install a 500 MW nuclear power plant, to supply electricity starting from 1971 to the Greater Buenos Aires-Littoral area.

II - FUNDAMENTAL ASPECTS OF THE STUDY

The subjects covered by this study can be divided into four main groups :

a) The GBA-L energy requirements and the way to meet them (Chapter 3; Annex 3A).

b) The country's human,energy, technological and industrial resources, as related to the project (Chapters 2 and 5; Annexes 1A, 3A, 5B, 5C, 5D, 5E and 7A).

c) The project's specific characteristics, in particular the power capacity and siting of the CNBA (Chapter 4; Annexes 4A, 4B and 4C); the project technical description (Chapter 5; Annexes 5A, 5B and 5F); its legal aspects (Chapter 6), and its economic and financial aspects (Chapter 7; Annexes 7A, 7B, 7C and 7D).

d) The project evaluation for each type of reactor considered, as economically compared against an equivalent conventional thermal station, and including its intangible benefits (Chapter 8; Annex 7A).

The estimates of the evolution of electric energy demand in the GBA-L area during the next 15 years are based on the analysis of past demand, including public utility and autogeneration, as well as deficit.. These studies show that the public utility installed capacity and generated power were not adequate to meet the requirements. The resulting deficit was somewhat lessened by a vigorous development of industrial autogeneration.

The region is interconnected by a high voltage network which ties power stations totalling about 2,200 MW. There is a certain exchange of energy among the involved utilities (SEGBA; A y E; CIAE; DEBA), but no coordinated power distribution system has yet been applied.

It was estimated that energy demand from the GBA-L area will grow at a cumulative rate of 9% per year, and that the now excessive participation of autogeneration will gradually decrease to more reasonable levels. It was estimated, that in order to meet the growing power demand in the area, it will be necessary to install an approximate 5,000 MW between 1966 and 1980, not including equipment renewals. This 15-year interval was divided into three periods.

The power capacity to be installed during the first period - 1,400 to 1,600 MW - will have to be necessarily thermal, conventional and/or nuclear. During the second period, that would begin in 1972-73 with the first hydroelectric supply to the area, the additional power requirements would be totally covered by hydroelectric stations (Chocón-Cerros Colorados; Salto Grande). Finally, during the third period, the addition of new thermal power plants - either conventional or nuclear - will become necessary once again, until the completion of a new hydroelectric project, possibly "Apipé", by 1980.

In order to meet its energy requirements, Argentina has both conventional (hydraulic and fossil fuels) and nuclear resources (uranium).

Economically exploitable hydroelectric resources amount to 11,000 MW, but only a small percentage of these are presently utilized.

The established fossil fuel reserves amount to an approximate 800 millions of cubic meters of oil and equivalent natural gas, and to about 450 million tons of coal. Present total energy consumption in Argentina is in the order of 23 million e.t.o. (equivalent tons of oil), 16 millions of which are covered by oil and its by-products. Analysis of these data leads to the conclusion that additional reserves will have to be exploited in a near future.

The country's established and potential uranium reserves represent a very important contribution to its energy resources. The corresponding figures are listed below, according to their production costs and the degree of certainty with which they were established.

Uranium resources (tons of U_3O_8)	Cost of production of yellow-cake		
	5 to 10 U$S/lb	10 to 15 U$S/lb	15 to 30 U$S/lb
Reasonably assured	4,000	4,500	4,000
Possible immediate development	4,000	5,000	10,000
Additional Potential	19,000	29,500	66,000

These reserves, which amount to almost 150,000 tons, are considered adequate to start and to develop a nuclear power program.

The country would undoubtedly benefit from a better exploitation of its hydroelectric potential, as well as from the utilization of its uranium resources. Fossil fuels, would be thus preserved for better purposes.

As to human resources, the GBA-L area - residence of almost half the country's population - can furnish technically qualified personnel to carry out the project, except for the design of the CNBA and the construction of some special components. In particular, the CNEA has a staff of about 600 professionals, specialized in different aspects of nuclear technology.

Due to the country's present technical, industrial and scientific development, Argentine industry can have a significant participation (40 to 50%) in the project.

Both the characteristics of the GBA-L electric system, and the technical and economical aspects of nuclear power plants, were analyzed in order to determine the power capacity of the CNBA. These studies show that the electric system would require and admit the installation of a 500 MW unit by 1971. It was also concluded, that there are no technical limitations for the installation and operation of a nuclear station of that size, its economical characteristics being favorable. By 1971, these 500 MW would represent about 15% of the GBA-L installed generating capacity.

Installation of the CNBA would have similar effects on the electrical system as any other base load station of the same capacity: existing stations of lower efficiency and higher fuel costs would have to operate with lower load factors, so as to minimize the average generating cost in the system.

The CNBA is expected to operate as a base load station. However, in a conservative way, it was estimated that its initial utilization factor would be around 0.6, and that it would then gradually increase to reach its highest value of 0.85 in five years.

Due to their economic competitiveness, nuclear power stations with ca-- pacities of 300 MW were also analyzed.

The site for the CNBA was selected by considering technical and economic requirements, most of which are similar to those applicable to the siting of a con ventional power plant. The main requirements analyzed were : the integration of the CNBA into the existing electric system; the availability of cooling-water; favorable topography; adequate conditions for the foundations; access and transportation facilities; meteorological and edaphological characteristics; and the sanitary implications of the project.

In a first selection, five possible areas were located - four of them northwest from Buenos Aires, on the Paraná and Paraná de las Palmas rivers, and the fifth on the Río de la Plata, southwest from Buenos Aires - totalling about 200 km of coast. The site denominated "Atucha" was finally selected as the most convenient, keeping "Magdalena" as a second choice.

The method adopted to select the four different types of reactor already mentioned, was to consider, first, the "proven" types (GCR, PWR, BWR), having an adequate operating experience, and secondly, those still under development. Among the latter, the HWR was selected due to its present characteristics and future possibilities.

The study led to the conclusion that the installation and operation of the CNBA with any of the four reactor types is technically feasible. The possible contribution of Argentine industry, as well as the different aspects of the nuclear fuel-cycle, deserved particular consideration because of their far-reaching implications.

The prospects for immediate development corresponding to each of the four reactor types considered, were found to be promissing in all cases. According to available nuclear reactor experience, it is reasonable to expect power levels to exceed guaranteed outputs. The operating staff requirements are reasonable, and training of such personnel presents no serious problems.

In case of hypothetical accidents, the study shows that the nuclear hazards to the operating personnel as well as the surrounding population, are equivalent to those of daily life and to labor hazards in other activities such as the oil, the chem ical or the steel industries.

The main legal aspects of the project deal with civil liability for nuclear damage. The CNEA advised the Federal Governement to sign and to ratify the Vienna Convention, which establishes the following basic points : the absolute and exclusive liability of the operator of a nuclear installation; the mandatory requirement of maintaning insurance or other financial security covering liability; the limitation of the operator's liability to not less than U$S 5 million and the possible subsidiary liability of the Installation State; the limitation of the operator's right of recourse against suppliers of nuclear materials. Regulations on prescription or extinction of an action, and on the corresponding jurisdiction are also included.

The legal problems caused by nuclear activities should be included, when possible, within the existing legislation. Law No. 15,336 establishes tha national jurisdiction over the generation of power by nuclear means, while Decree-Law No. 22,498/56 gives the CNEA cognizance, with national jurisdiction, over all nuclear energy matters.

The studies related to the economic and financial aspects of nuclear power plants considered the four selected reactor types for both power ranges (300 and 500 MW). It should be pointed out that a conservative point of view was adopted all over the study, to the detriment of the economic possibilities of nuclear energy. The results obtained should, therefore, be regarded as being an upper limit. This assertion was confirmed by recent information (March 1966).

Plant installation costs include all the necessary expenditures until the station is put into operation, except for the first fuel charge. The cost-estimates are based on the installation costs of nuclear power plants already installed or under construction in different countries, on information supplied by several companies, as well as on the analysis of local conditions and of the possibilities of Argentine industry participation.

The results of this study, corresponding to prices as of July 1965, and expressed in terms of U$S are the following :

Type of reactor	Cost per unit of installed capacity U$S/kW	
	300 MW	500 MW
PWR	223	196
BWR	237	199
GCR	349	281
HWR	337	290

Annual operating and maintenance costs include expenditures in personnel, spare parts, maintenance materiales (excluding fuel), insurance, and other non specified. As expressed in terms of U$S per kW installed, they are expected to be :

Type of reactor	Annual operating and maintenance cost per unit of installed capacity U$S/kW year	
	300 MW	500 MW
PWR	6.17	5.05
BWR	6.41	5.15
GCR	8.14	6.13
HWR	8.08	6.55

Fuel costs, including all expenditures involved in the "fuel cycles", were estimated on the basis of a price of 25 U$S per kg for natural uranium produced in Argentina, and of 30 U$S per kg unit of separative work, according to present toll enrichment charges in the USA. Fuel fabrication costs considered are those corresponding to domestic fabrication. Reprocessing of irradiated fuel (at U$S 40 per kgU) and the corresponding transportation costs (at U$S 17 per kgU), were considered only for enriched uranium fuelled reactors. The probability of a future decrease in fuel cycle costs during the plant's estimated life was disregarded. The present-worth values, at an annual rate of 8%, as expressed in terms of mills per kWh would be :

Type of reactor	Fuel cost-mills/kWh	
	300 MW	500 MW
PWR	2.44	2.26
BWR	2.33	2.18
GCR	2.28	1.91
HWR	1.13	1.01

The present-worth costs of energy produced, including capital charges, operation, maintenance, and fuel expenses, considering annual rates of 6%, 8% and 10% and 25 years of estimated life, with an average utilization factor of 0.75 are as follows :

Type of reactor	Cost of production of electric energy mills/kWh					
	300 MW			500 MW		
	6%	8%	10%	6%	8%	10%
PWR	5.58	6.22	6.97	5.10	5.74	6.46
BWR	5.63	6.31	7.11	5.05	5.73	6.48
GCR	7.17	8.15	9.37	5.80	6.64	7.58
HWR	5.91	6.79	7.91	5.12	5.91	6.81

A marked cost reduction appears when going from 300 MW to 500 MW plants.

Financial schemes were prepared, the results of which are shown in the "Forecast of Earnings and Expenditures", "Use of Funds and Cash Flow", and "Assets" sheets. It was assumed that the investments would be covered by 30% in own capital, 10% in local currency loans, and 60% in foreign currency loans. The amortization time for local currency loans would be of 10 years at 10% annual rate of interest, while loans in foreign currency would be amortized in 10 or 20 years, at 7% annual rate of interest.

The electricity generated would be sold at a price of 10 mills/kWh. Some of the results for the shortest financing period assumed (10 years) are the following:

Type of reactor	Accumulated net benefit (millions of U$S)		Average profitability on the net investment (%)		Internal rate of return on the initial own capital (%)	
	300 MW	500 MW	300 MW	500 MW	300 MW	500 MW
PWR	264.4	474.5	26.3	31.4	25.5	30.1
BWR	266.4	484.2	24.6	30.9	23.4	29.7
GCR	202.4	427.9	16.1	23.8	13.1	20.3
HWR	257.1	475.1	27.7	35.8	20.5	25.7

The expenditures in foreign currency would be :

Type of reactor	Installation expenses (millions of U$S)		Accumulated expenses over 25 years (millions of U$S)	
	300 MW	500 MW	300 MW	500 MW
PWR	27.6	41.4	119.8	177.3
BWR	23.3	40.5	115.8	167.7
GCR	48.0	63.9	119.1	160.7
HWR	51.3	74.7	105.7	151.2

The four selected types of reactor were evaluated by comparing them against each other from different points of view. These included energy policy factors (fuel supply, nuclear development, and conservation of natural resources); technical factors (available experience, guarantees and warranties, and operating characteristics); economic factors (cost of electric energy produced, initial investment, financing, and expenses in foreign currency); and industrial policy factors (participation of Argentine industry in the erection and operation of the CNBA and of future stations of the same type).

There are some fundamental differences between natural uranium and enriched uranium reactors. Natural uranium reactors can be fuelled with Argentine uranium. They produce plutonium (the fuel for future reactors) more efficiently than enriched uranium reactors, so they are better qualified for a long-term nuclear development program. They can be refuelled during operation, thus offering the advantage of higher availability factors. On the other hand, enriched uranium reactors offer certain economical advantages.

The project was evaluated from an economic point of view by comparing the CNBA with an equivalent conventional thermal station. The main conclusions were already given in the first part of this Summary.

It was shown that the CNBA would continue to be competitive, even under conditions more unfavorable than those adopted in this study.

To complete the evaluation, other implications of the project were also considered, which go beyond its specific and immediate objectives. These implications would result in significant long-term advantages which, although difficult to estimate quantitatively, would definitely contribute to strengthen national development.

These intangible benefits include aspects such as the conservation of natural resources, the supply of the country's energy requirements and a general upgrading of the industrial level.

ZONA GRAN BUENOS AIRES-LITORAL
GREATER BUENOS AIRES – LITTORAL AREA
REGION DU GRAND BUENOS AIRES – LITTORAL

0 20 40 60 80 100km

FIGURA 1 – 1