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INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

# APPRAISAL OF THE SENN NUCLEAR POWER PLANT

# ITALY

September 4, 1959



Department of Technical Operations

## CURRENCY EQUIVALENTS

| | | |
|---|---|---|
| U.S. $1 | - | 625 Lire |
| 1 lira | - | 0.16 U.S. cents |
| 1 million lire | - | U.S.$ 1,600 |
| 1 billion lire | - | U.S.$ 1.6 million |

# APPRAISAL OF THE SENN NUCLEAR POWER PLANT - ITALY

## LIST OF CONTENTS

## LIST OF ANNEXES

# APPRAISAL OF THE SENN NUCLEAR POWER PLANT - ITALY

## Summary

The Italian Government has asked the Bank for a loan of $40 million equivalent. The loan would finance 60% of the estimated cost of a nuclear power plant to be constructed between Rome and Naples. The plant would have an installed capacity of 160 MW and a net output of 150 MW.

ii. The borrower, as in the case of previous Bank loans to Italy, would be Cassa per il Mezzogiorno, which would relend the proceeds of the proposed loan to Societa Elettronucleare Nazionale (SENN). This company, which would build, own and operate the plant, is largely owned by a group of public utility companies. In 1958, these companies accounted for 36% of total power generation in Italy.

iii. The project was developed as a result of a joint study, sponsored by the Government of Italy and the Bank, to establish the technical, economic and financial merits of a nuclear plant to be located in South Italy. As a part of this study, tenders were invited on an international basis in October 1957. In making the selection of the successful tender, SENN had available to it the advice of an International Panel set up by the Bank, reviews prepared by the United Kingdom Atomic Energy Authority and the United States Atomic Energy Commission of individual tenders and a detailed analysis of bids prepared by a working group consisting of personnel from SENN, from its shareholding companies, from other Italian utilities, from Comitato Nazionale per le Ricerche Nucleari and from SENN's two consultants. The successful tender was submitted by International General Electric Company of New York.

iv. SENN was established on March 22, 1957; its paid-in share capital as of July 31, 1959 amounted to Lit. 1.5 billion. The bulk of SENN's shares (84%) are held by eight operating public utility companies. The balance is held by five industrial companies and a public utility holding company. The organization and management of SENN is satisfactory.

v. Utility companies owning shares in SENN would buy the power to be generated by the SENN nuclear plant. Detailed studies of future energy requirements in the interconnected power system operated by these companies show that there is a reasonable prospect that the SENN plant can be operated at a high plant factor.

vi. The project consists of a nuclear power plant with a net output capacity of 150 MW, to be located on the Garigliano river between Rome and Naples, and 100 kilometers of transmission lines connecting the plant with existing substations. The plant is expected to be in operation by the summer of 1963. The cost of the project is estimated at $66.40 million equivalent of which $43.55 million equivalent would be required in foreign exchange.

vii. Enriched uranium fuel for the plant is expected to be obtained through EURATOM. In the event that this would not be possible, SENN would be able to obtain fuel under the terms of the bilateral agreement signed between the United States and Italy.

viii. The funds required by the construction of the SENN plant in addition to the proposed Bank loan, would be obtained from SENN's shareholders, partly in the form of share capital and partly in the form of shareholders' advances. Based on the reasonable assumptions made, the forecasts show that the future financial position of SENN would be sound.

ix. Three of SENN's shareholders, which are in a strong financial position, would, in the Project Agreement between the Bank and SENN, jointly and severally guarantee the performance by SENN of all its covenants in that agreement and in the subsidiary loan agreement between Cassa and SENN. The Project Agreement will also contain a more specific guarantee by these three shareholders that they will cause the project to be completed and operated efficiently, acting in place of SENN if necessary.

x. The economic comparison between the SENN nuclear plant and a conventional thermal plant of equal capacity shows that from the standpoint of SENN the two plants would produce power at about the same cost, assuming a plant factor of 80% and a long-run average oil price at current levels. From the standpoint of the national economy, eliminating taxes on oil, the annual costs of the nuclear plant would be about 15% higher than the costs of a conventional thermal plant. This gap would be narrowed if, (a) the price of oil would increase, (b) the price of uranium would decrease, (c) an expansion of the nuclear plant based on a substantial increase of the heat output of the nuclear reactor proved to be technically feasible, or (d) the project were credited with indirect benefits resulting from experience gained with construction and operation of a large-scale nuclear plant.

xi. The SENN nuclear plant is suitable as a basis for a Bank loan to Cassa of $40 million equivalent. A term of 20 years with a grace period of 4-1/2 years would be appropriate.

# APPRAISAL OF THE SENN NUCLEAR POWER PLANT - ITALY

## I. INTRODUCTION

1. The Italian Government has asked the Bank for a loan in connection with the construction of a 160 MW nuclear power plant to be located on the Garigliano River about midway between Rome and Naples. The proposed loan of $40 million equivalent would cover 60% of the total estimated cost of $66.4 million equivalent.

2. The borrower, as in the case of previous Bank loans to Italy, would be Cassa per il Mezzogiorno, which would relend the proceeds of the proposed loan to Societa Elettronucleare Nazionale (SENN). This company, which would build, own and operate the project, is largely owned by a group of public utility companies. In 1958 these companies accounted for about 36% of total electric energy requirements in Italy.

3. This report covers an appraisal of the SENN nuclear power project. It is based on the results of the joint study of the possibilities of a nuclear power plant in South Italy, sponsored by the Italian Government and the Bank and supplemented by information obtained by members of the Bank staff during visits to Italy during the second half of 1958 and the spring of 1959.

## II. BACKGROUND

4. The Bank issued in June 1956 a report in which the status of nuclear power development at that time was examined. The conclusion of the report, based on the information then available, was that there were good prospects that power could be produced by a nuclear plant at costs competitive, or close to competitive, with power produced by a conventional plant in the following circumstances:

a) The nuclear plant would have to be integrated with an extensive generation and distribution system, permitting a 100 MW or larger plant to be operated as a base load unit.

b) The nuclear plant would have to be located in a country with relatively high fossil fuel costs, with poor hydroelectric potential, and with sufficient availability of capital so that relatively low-cost money could be obtained.

c) The country would have to execute the necessary intergovernmental agreements assuring a continuing supply of fuel, reprocessing and, if necessary, the import of components, unless these materials and technical abilities were available.

d) Power rates in the system into which the plant would be connected should be flexible enough so that if the nuclear plant should cost more than expected or should not perform as anticipated, the excess cost could be absorbed without a significant adverse effect.

e) Until further operational experience had been obtained, it would not be prudent to establish the nuclear plant in a system where it would represent a considerable proportion of the total system generating capacity.

The Italian Study

5. Several locations, where a nuclear power plant might be considered, were examined by the Bank. The conditions in Southern Italy appeared to be favorable for the construction of a nuclear plant.

6. In July 1957, the Government of Italy and the Bank agreed to sponsor a joint study of the possibilities of a nuclear power station in Southern Italy. This study was to serve three purposes:

a) By obtaining tenders on an international competitive basis, it would provide firm data on the relative costs of competing types of nuclear plants.

b) It would ascertain the relative capital and operating costs of a nuclear power plant of a given output compared with a conventional power plant of the same capacity and output.

c) By providing these facts and the judgment on them of qualified nuclear specialists, the study would assist the Italians in selecting for construction the plant which seemed to have most merit taking all factors into consideration.

Project ENSI

7. The joint study, known as "ENSI" (Energia Nucleare Sud-Italia), included (i) the selection of a site for a nuclear plant; (ii) the preparation of invitations to qualified manufacturers, chosen on an international basis, to tender for a nuclear plant at the proposed location; (iii) a review of the tenders submitted and the preparation of a judgment on them, in particular with respect to technical feasibility, comparative costs and performances; and (iv) the simultaneous development of cost information for a conventional thermal power plant operating under the conditions and load envisaged for the proposed nuclear plant.

8. The executive responsibility for Italian participation in Project ENSI was given by the Italian Government to Comitato Nazionale per le Ricerche Nucleari (CNRN), the official institution responsible for nuclear research and development in Italy. The Secretary General of the Comitato and the Advisor on Atomic Energy to the Bank made up the Steering Committee of Project ENSI and had responsibility for its overall direction.

The International Panel

9. An International Panel was set up by the Bank to provide advice and guidance on the nuclear aspects of the Project ENSI study. The Panel consisted of seven experts in the field of nuclear energy selected by the

Bank from four countries on the advice of the official nuclear agencies of those countries. In addition to providing general guidance to the study, the Panel had the responsibility for making a review and evaluation of international tenders for the power station and for preparation of a report, particularly regarding cost and performance, which would be made available to the Italian utility company which would build and operate the nuclear station.

10. The Italian Government designated, as the company which would own and operate the nuclear plant, Societa Elettronucleare Nazionale (SENN), organized for that purpose in March 1957 and described more fully in Chapter IV of this report.

11. A Working Group was established in Rome, under the direction of the President of SENN, which included Italian personnel drawn from SENN, from its shareholding companies, from other Italian utilities and from the Comitato, together with personnel from SENN's two nuclear engineering consultant firms, Internuclear Company of Clayton, Missouri, USA, and Kennedy & Donkin of London, England.

International Tenders

12. The first phase of the work of the Project ENSI entailed the preparation of an "invitation to bid".

13. In preparing the form of invitation, two objectives were kept in mind: (i) to make it possible for manufacturers and bidders to propose whatever type of nuclear plant the particular manufacturer or bidder believed best and was willing to tender at a firm price with warranties of output and performance; and (ii) to provide for competitive international bidding, which, it was believed, would lead to lower costs.

14. The invitation was sent in October 1957, to seventeen firms which had indicated interest in tendering for the project. The firms included eight American, five British, two French, one Canadian and one Belgian-American. The invitation called for the submission of firm price bids for a nuclear power plant with a net output between 130 and 150 MW to be erected in Southern Italy and to be completed in approximately four years from the date of selection of the contractor. Fifteen firms confirmed in December 1957 their intention to submit bids.

15. Concurrently with the preparation of the invitation to bid, work proceeded on the selection of a site for the nuclear plant, to determine the geological, hydrological, seismological and meteorological conditions. The services of Italian and foreign consultants were retained to assist in this work. As a result of these investigations, SENN prepared a detailed report on site selection in January 1958, and forwarded it to the bidders.

16. By April, 1958, the final closing date, the following nine companies or groups of companies had submitted tenders to SENN:

AEI John Thompson Nuclear Energy Co.Ltd. London

Atomics International, Canoga Park, California, (Engineering Associates - Bechtel Corporation and Montecatini)

GEC Simon Carves Atomic Energy Group, Erith, Kent

H.K. Ferguson Co., New York (Reactor designed and to be built by Babcock & Wilcox Co., New York)

International General Electric Company, New York (Engineering Associates - Ebasco Services, Inc.)

Kaiser Engineers, Oakland, California (Reactor designed and to be built by Westinghouse Electric Co.)

Mitchell Engineering Ltd., London (in association with American Machine & Foundry Co., and General Nuclear Engineering Corp.)

Societe Générale de Constructions Electriques et Mecaniques, Alsthom, Paris.

The English Electric Company Ltd., Stafford.

17. The Working Group of Project ENSI examined all tenders, prepared an estimate of the civil works cost of each and made a technical tabulation of each proposal. Under agreements between the Bank and United Kingdom Atomic Energy Authority (UKAEA) and United States Atomic Energy Commission (USAEC) the technical aspects of the tenders for gas-cooled graphite-moderated natural uranium reactors were reviewed by the Industrial Group of UKAEA and, concurrently, the tenders for enriched uranium systems, i.e., pressurized water, boiling water and organic-moderated reactors, were reviewed by Argonne National Laboratory of USAEC.

18. The reports prepared by UKAEA and Argonne National Laboratory commented on compliance of each tender with the invitation to bid, and assessed the technical features of the proposed design including a detailed analysis of each tender and appraisal of the design in the light of present knowledge. The assessment encompassed, inter alia, safety (including control and instrumentation) and design, performance and handling of fuel elements.

Selection of the Tender

19. SENN was responsible for the selection of the successful tender. In making the selection, the management of SENN had available to it (i) the report of the International Panel, evaluating the tenders and commenting upon cost and performance; (ii) the reports of UKAEA on gas-cooled natural uranium reactors and the reports of Argonne National Laboratory on enriched reactors; (iii) the detailed analysis and tabulation of bids prepared by the Working Group; and (iv) a report by the SENN technical staff on the nine bids, including engineering comments and estimates of costs of power for each. Personnel of SENN's two consulting firms

participated in the analysis of each bid.

20. On the basis of all information available to it, SENN selected the tender of International General Electric Company, U.S.A., a division of the General Electric Company.[1]

## III. THE BORROWER - CASSA

21. The borrower would be Cassa per il Mezzogiorno, an agency of the Italian Government created by a law of August 10, 1950. The Bank has made six loans to Cassa, totalling $260 million, over a period of eight years. The origin of Cassa and the progress and results of its work have been described in a report submitted to the Executive Directors in February 1958.[2] Unless the present legislation is extended, Cassa would terminate its operations in 1965. The legislation provides that its liabilities and obligations would then be taken over by other appropriate government agencies.

22. The proceeds of the proposed loan would be relent by Cassa to SENN. The subsidiary loan agreement, between Cassa and SENN would be subject to Bank approval and would protect the interests and rights of the Cassa and provide for security and guarantees appropriate to the circumstances. Furthermore, SENN would undertake various obligations in regard to the construction and operation of the project in a project agreement with the Bank.

## IV. THE COMPANY - SENN

23. The company which would build, own and operate the project is Societa Elettronucleare Nazionale (SENN), a joint stock company; its legal seat is Naples, but its offices are located in Rome.

### Capital and Shareholders

24. SENN was established on March 22, 1957. Its original paid-in share capital has been increased in successive steps and amounted to Lit. 1.5 billion as of July 31, 1959. Further increases in capital will be required. The total amount of share capital contemplated in connection with the construction of the SENN nuclear plant is about Lit. 8 billion ($13 million). The payments will be made as required to meet construction expenditures.

25. The bulk of SENN's shares (90%) is held by twelve companies controlled indirectly by Istituto Riconstruzione Industriale (IRI), while the rest is held by two privately-controlled power utility companies. IRI is a government-owned entity which effectively controls a large segment of Italian enterprise, particularly in the fields of banking, power, iron and steel,

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1/ The contract with SENN will be entered into by International General Electric Operations S.A., a wholly owned Swiss subsidiary of the General Electric Company.

2/ FA-80a "Cassa per il Mezzogiorno and the Economic Development of Southern Italy", February 6, 1958.

machinery manufacturing, shipping, shipbuilding and telecommunications.

26. IRI exercises its control of a part of this complex group of enterprises through three holding companies, Societa Finanziaria Elettrica Nazionale - Finelettrica (electric power) Societa Finanziaria Siderurgica - Finsider (iron and steel) and Societa Finanziaria Meccanica - Finmeccanica (machinery manufacturing). Large shareholdings in many of the individual companies are, however, held by private interests. Several of the companies in the Finelettrica group are both operating and subholding companies. A list of the present fourteen shareholders of SENN is given in Annex 1.

27. The two largest shareholders of SENN, Societa Meridionale di Elettricita (SME) and Societa Idroelettrica Piemonte (SIP) as well as the holding company of Finelettrica, which is also a direct shareholder of SENN, would be parties to the Project Agreement between the Bank and SENN, guaranteeing its performance

28. Finelettrica was created in 1952 by the Italian Government to own and administer IRI's participations in electric utility companies. The share capital of Finelettrica amounted, as of June 30, 1958 to Lit. 45 billion. Total value of its investments made up largely by participations in utility companies, amounted to Lit. 43 billion.

29. Finelettrica operates as a holding company; it assists in the financing of the enterprises it controls, and is responsible for their general development policies and technical coordination. The financial results for the financial years ending June 30, 1957 and 1958 show net profits before distribution of dividends of Lit. 2.4 billion and Lit. 3.0 billion respectively. The company paid a dividend of 7.5% on its shares in both years.

30. SME was a beneficiary of the four previous loans made by the Bank to Cassa with a total amount of $58.5 million. The share capital of SME, as of December 31, 1958, amounted to Lit. 75 billion of which 36% was owned by IRI and Finelettrica and the balance by private interests. Net fixed assets amounted to Lit. 116 billion. The long-term debt was Lit. 33 billion, resulting in a debt/equity ratio of 24/76. SME's investments, mainly in subsidiary and associated utility companies, amounted to Lit. 24.6 billion. The company's earnings record is good. Net profit before distribution of dividends for the financial year ended March 31, 1958, was Lit. 5.6 billion. The net income represented a return of 7.5% on net fixed assets in operation. A dividend of 7.5% has been paid in recent years.

31. SIP had a share capital of Lit. 83 billion as of December 31, 1958. About 48% of its shares are owned by IRI and Finelettrica and the balance by private interests. Net fixed assets amounted to Lit. 134 billion. The total long-term debt was Lit. 43 billion, resulting in a debt/equity ratio of 26/74. SIP's investments in subsidiaries and associated companies amounted to Lit. 32.2 billion. The Company's earnings record is good. Net profit before distribution of dividends for 1958 was Lit. 5.9 billion. The net income represented a return of 5.9% on net fixed assets in operation. A dividend of 7% has been paid in recent years.

32. Summary balance sheets and profit and loss statements for the last two financial years for Finelettrica, SME and SIP are given in Annex 2.

Organization and Management

33. SENN is governed by a Board of 15 Directors. The President of the Board is the executive head of SENN. Most of the other Board members are presidents and managers of the shareholding companies or of IRI. SENN has also a Managing Director appointed by the Board. SENN currently has a staff of 68 persons, half of whom carry managerial and professional responsibilities. This includes 28 qualified engineers.

34. SENN plans to train its operating staff during the period of construction of the station. A total of 20 engineers will be sent to universities, laboratories and utilities operating nuclear plants in the United States and in Europe in the course of the next three years for 3 to 12 month courses. Further, the IGEOSA contract will provide for attendance of 20 SENN engineers at an eight week technical and practical training course to be held at Vallecitos, California. SENN plans to select its future operating personnel in sufficient time to permit them, after suitable training, to follow erection, start-up and tests of the nuclear plant.

35. SENN has a qualified and efficient management and organization, well prepared to be responsible for the execution of the project. For special problems, both nuclear and of a conventional nature, SENN has made arrangements to obtain advice from qualified consultants. The contemplated training program will assure that experienced personnel will be available for the operation of the plant.

Concessions and Licenses

36. SENN has applied for the necessary government authorization to construct a 160 MW power plant and for a concession to permit the diversion and use of water from the Garigliano river. Preliminary approvals have been obtained, permitting construction work to be started, and there is no reason to believe that the final concessions will not be granted in due course.

37. Although legislation covering production of nuclear energy and possession of nuclear fuel elements in Italy is at present under consideration, and appropriate laws may be enacted in due course, no specific authorization appears to be necessary at present in connection with the nuclear aspects of the project. (For a discussion of the necessity of governmental action in the area of insurance against nuclear risks see para 56).

## V. POWER MARKET

38. A large number of utility companies is responsible for the generation and sale of electricity in Italy. The power systems of these companies are all interconnected by an extensive network of transmission lines reaching all parts of the country with the exception of Sardinia and some smaller islands. This network is also connected with the power systems of France, Switzerland and Austria.

39. At the end of 1958 the total installed capacity of the interconnected Italian power system amounted to 13,500 MW, consisting of 10,400 MW hydro and 3,100 MW thermal capacity. Total generation amounted to about 45 billion kwh.

40. Utility companies, which are shareholders of SENN would purchase the power to be generated by the nuclear plant. The detailed arrangements including the proportion to be taken by each of these Companies have not yet been worked out. In considering the potential market for the SENN plant, the future demand of the interconnected system of all the utility shareholders of SENN has been studied. The area supplied by these companies and their affiliates is about 158,000 square kilometers or 50% of the total area of Italy. It covers the southern, central and north western parts of the country. (See map attached) The population in this area is 26.5 million, representing 55% of the country's total population.

41. The total generating capacity operated by SENN's shareholders at the end of 1958 was 4,140 MW, consisting of 3,355 MW hydro and 785 MW thermal. Total energy production in 1958 was 16.5 billion kwh.

42. The power demand has in recent years increased at an average annual rate of 7% in the north of Italy, 8% in the central and south and 15% in Sicily. The higher rate in the southern part of the country is a result of the activities of Cassa.

43. The shareholders of SENN have made detailed studies of the future power demands in their systems. By 1965, the second year of operation of SENN, it is estimated that the total energy requirements would amount to 24.7 billion kwh. This corresponds to an average annual rate of increase of 6.1%. The peak load in 1965 is estimated at 5,200 MW.

44. The construction program of these companies would, by 1965, increase the total generating capacity to 7,250 MW, consisting of:

| | | |
|---|---|---|
| Hydro Plants | | |
| Run-of-river | 1,275 MW | |
| Reservoir | 2,905 " | |
| Sub-total | | 4,180 MW |
| Thermal Plants | | |
| Geothermal | 270 " | |
| Conventional Steam | 2,440 " | |
| Nuclear | 360 " | |
| Sub-total | | 3,070 MW |
| Total | | 7,250 MW |

45. The firm capacity is of the order of 6,300 MW. The nuclear capacity includes, in addition to the SENN plant, a 200 MW plant to be located at Latina near Rome. An announcement on the construction of this plant has been made.

46. As will be discussed later in this report (Chapter VIII) it is of particular interest to establish the plant factor[1/] at which the nuclear plants can be expected to be operated to meet the energy requirements of the system.

47. Detailed studies for the year 1965 have been made by the staff of Finelettrica of the estimated load characteristics and plant loading programs in the interconnected power system operated by SENN's shareholders. Due account was taken of the need to utilize fully geothermal and hydro plants and the provision of adequate voltage regulation and security of supply at all times.

48. These studies indicate that, although there would be some restrictions in the use of the two nuclear plants now planned during the night in the summer months, particularly in years with an exceptionally large supply of water for the run-of-river hydro plants, the system should be able to accept their combined output at a high plant factor (75% - 80%). Typical daily load curves as estimated for 1965 are shown in Annexes 3 and 4.

49. In 1965, the output of the two nuclear plants (1 billion kwh for SENN and 1.5 billion kwh for Latina at 80% plant factor) would represent about 7% of total energy requirements in the system. Beyond 1965, this share would gradually be reduced. The full utilization of the nuclear plants is also expected to be improved by construction of pumped storage hydro plants in addition to the 380 MW of capacity expected to be in operation by 1965. Plants of this type show a good prospect of being economical in conjunction with nuclear generation because they can utilize surplus capacity for pumping during periods of low system load and provide peaking capacity during periods of high load. On the other hand, it is expected that future development of nuclear power will result in cheaper nuclear generation and that Italy will in due course construct more nuclear plants which would be operated at the highest practical plant factor. Taking all factors into consideration it is reasonable to assume that the power requirements in the system will permit the SENN plant to operate at a high plant factor also in later years.

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1/ The plant factor is the annual number of hours the generating capacity of a plant is in operation expressed as a percentage of the total number of hours in a year.

## VI. THE PROJECT

### Description

50. The project would consist of (i) a nuclear power plant located on the southern bank of the Garigliano River, about 7 kilometers inland from the point of its outflow into the Gulf of Gaeta (see map attached); (ii) a primary step-up substation; and (iii) two single circuit 220 kv transmission lines; one 44 kilometers long, extending northward, connecting the plant with the Ceprano substation of the Societa Romana di Elettricita system and the other 56 kilometers long, extending southward, connecting the plant with the Fratta Maggiore substation of the SME system.

51. The site of the plant, between Rome and Naples, was selected because of its favorable characteristics for the safe release of waste gases and for disposal of solid radioactive wastes, good supply of cooling water, its satisfactory geological and meteorological conditions and the low population density.

52. The proposed generating station would incorporate a dual-cycle forced circulation boiling water nuclear reactor supplying steam to a dual admission, tandem compound turbine, directly connected to a single generator. The net guaranteed capacity of the station, at the main transformer terminal, would be 150 MW.

53. The design margins adopted by GE are conservative and it is likely that the nuclear reactor may be capable of producing considerably more than the guaranteed 509 MW output of heat. The GE tender includes a statement that an increase in heat production of 50% above the guaranteed level is considered possible. To take advantage of this increased output it would be necessary at some future date to install an additional turbo-generator unit, condenser and auxiliary pumps and piping. 1/

54. The core of the reactor would be contained in a cylindrical pressure vessel and the reactor would be enclosed in a containment sphere, 160 feet in diameter. The fuel would be in the form of uranium oxide pellets, enriched to about 2% U-235 by weight, contained in zircalloy tubes. The total weight of the uranium charge would be 41.4 metric tons. The overall plant heat rate would be 11.553 BTU/kwh, corresponding to a net plant efficiency of 29.6%. The fuel cycle contemplated would require the replacement of one-fifth of the fuel elements about every nine months of operation. A detailed technical description of the project is given in Annex 5.

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1/ For SENN to be able to take advantage of additional heat output at minimum additional investment, it would be necessary for SENN to invest during the initial construction stage about $400,000 for oversizing the steam drum and associated piping. This could also be accomplished at higher cost after the plant is in operation. The present indications are that SENN will choose to postpone its decision until a later date.

Engineering and Construction

55. IGEOSA with Ebasco Services would construct the plant on essentially a "turn-key" basis. Their work would include the detailed design, supply of equipment, erection and operation of the plant during an initial test period. On February 4, 1959, SENN signed a Letter of Intent with GE and work began under this arrangement on March 9, 1959. Negotiations of the final contract between SENN and GE are proceeding at present and the signing is expected to take place shortly. By mutual agreement, GE is proceeding with the detailed engineering of the plant.

56. It is understood that the problem of the possible liability of GE and SENN to others in connection with nuclear accident has been a principal item of discussion between GE and SENN. This third party liability problem is being studied by European governments, and a draft convention has been prepared by a committee of the OEEC under which the total third party liability for a nuclear incident would be limited to $15 million. The present arrangements between GE and SENN would prohibit the fueling of the plant if a third party liability limitation, similar to that proposed in the OEEC draft convention, is not in effect in Italy. There is, therefore, some possibility that the operation of the plant could be delayed. However, it seems almost certain that an adequate liability limitation will be in effect in Italy before the SENN plant is ready for fueling.

57. The design and engineering of civil works for the conventional parts of the plant, the substation and the transmission lines would be carried out by the staff of SENN. Italian consultants have been retained to advise on special problems in connection with these works.

Supervision of Construction

58. SENN would have the responsibility for supervising the execution of the project. For the nuclear part, SENN would continue to use the services of its consultant, having particular expertise in enriched reactor systems, the Internuclear Co.

Schedule of Construction

59. The construction of the project is estimated to be completed and the plant to be ready for commercial operation by the summer of 1963.

Estimated Cost

60. The cost of the project is estimated as follows:

| | Foreign Exchange Costs | Local Costs | Total Costs |
|---|---|---|---|
| | (in million US$ equiv.) | | |
| Nuclear reactor with auxiliaries | 27.90 | | 27.90 |
| Turbogenerator with auxiliaries | | 7.50 | 7.50 |
| Spare parts | 0.55 | 0.40 | 0.95 |
| Civil works | | 7.72 | 7.72 |
| Substation and transmission lines | | 2.47 | 2.47 |
| Fabrication and freight charges for uranium core, including 20% spares 1/ | 7.09 | | 7.09 |
| Engineering and administration | 0.50 | 1.50 | 2.00 |
| Contingencies and escalation | 2.74 | 2.91 | 5.65 |
| | 38.78 | 22.50 | 61.28 |
| Interest and other charges during construction | 4.77 | 0.35 | 5.12 |
| Totals | 43.55 | 22.85 | 66.40 |

61. The above estimate is based on the GE tender and prices of materials and wages as of January 1, 1958. The firm price bids in the IGEOSA contract will be subject to escalation from the date on which it becomes effective; the contingency allowances shown above are, however, adequate to cover possible escalation. The overall estimate is realistic.

Fuel Arrangements

62. SENN contemplates obtaining fuel from the United States through EURATOM. An exchange of letters has taken place between the Government of Italy (as a member of EURATOM) and SENN, recording this plan. Under the present U.S.-EURATOM program the initial supply of enriched uranium would be made available on a deferred payment basis at prices equivalent to those established for the U.S. domestic nuclear energy program. The value of the fuel inventory required for the SENN plant would be about $11 million. The terms under which fuel is expected to be supplied provide that during the first ten years of operation the annual interest charge would amount to 4% of this amount. Beginning at the eleventh year, the inventory cost would be amortized in about ten equal annual installments, and annual interest would be charged at 4% on the unamortized value. There are no apparent reasons why SENN should not obtain fuel through EURATOM.

63. If this should not be possible, SENN would still be able to obtain fuel under the terms of the bilateral agreement between the U.S. and Italy, signed on July 3, 1957. An exchange of letters has taken place between the CNRN on behalf of the Government of Italy and the USAEC on behalf of the U.S. assuring this possibility if the need arises.

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1/ This does not include the value of the uranium. See Para. 62.

64. The fabrication cost of the first fuel charge is included in the capital cost of the project. Fuel replacements, shipping, subsequent fabrication and reprocessing would be treated as an operational expense. Funds received for depleted uranium and for recovered reprocessed plutonium would be treated as credit to operational expenses. The financial projections discussed in the following Chapter have been prepared on these bases.

## VII. FINANCIAL ASPECTS

### Proposed Financing

65. The estimated cost of the project, $66.40 million equivalent is proposed to be financed by a $40 million loan from the Bank (via the Cassa) and by $26.40 million equivalent from fourteen shareholders. The Bank's loan would represent 60% of the total. The shareholders' participation, in accordance with normal Italian practice, would be one-half in the form of share capital and one-half in the form of shareholders' advances, both amounting to $13.20 million equivalent.

66. The sharecapital and advances would be paid to SENN on a schedule consistent with construction requirements. If the construction costs should prove to be higher than estimated, the additional funds required would be covered by increased payments by the shareholders. SENN would agree not to repay any portion of the advances, nor to amend its Charter and thereby retire any or all of its share capital, so long as any debt is outstanding to Cassa.

67. The Bank loan is assumed to be for a period of 20 years of which about 4 years is the estimated period of construction, leaving 16 years for amortization. An interest rate of 6% and level debt service payments have been assumed for the Bank loan to Cassa and it has been assumed that Cassa would relend the proceeds of the proposed Bank loan on the same terms to SENN, except for an additional charge of 1/4% making the cost of the money to the latter 6-1/4%.

68. It is also assumed that no dividends or interest would be paid, either on the shares or on shareholders' advances, during the construction period. Thereafter, dividends and interest on the advances have been assumed at 7% per annum.

### Estimated Expenses and Revenues

69. Annex 6 shows the projection of estimated annual expenses and the corresponding necessary revenues for the first 16 years of operation, the repayment period of the proposed Bank loan. These estimates have been made on the assumption that an average annual plant factor of 75% would be achieved over the period considered. (A discussion of the plant factor is given in Chapter VIII).

70. Fuel payments vary considerably from year to year as a result of the technical assumptions made. Details of these are given in Annex 7. All items of fuel payments prior to start-up were capitalized with exception of interest on fuel inventory during the nine months before start of operations. This was included in the fuel payments during the first year of operation.

71. Other operating expenses and taxes on an annual basis, exclusive of fuel payments and income taxes, were assumed for purposes of calculation, to remain constant throughout the period as follows:

| | |
|---|---|
| Operation and Maintenance | $970,000 |
| Insurance | 300,000 |
| Administration and General | 300,000 |
| Tax on share capital - 3/4% | 100,000 |
| Local taxes (may be abated in part or in whole) | 117,000 |
| Total | 1,787,000 |

72. Since the SENN nuclear plant will be the first of its type in Italy there is no firm information on insurance costs. The amount allowed ($300,000 per annum) is in line with the amounts allowed for comparable U.S. nuclear plants, taking into account the probable difference in the limit on third party liability. This limit would probably be lower in Europe than in the U.S.

73. SENN would be exempted from payment of income taxes during the initial ten years of operation because it would operate in Southern Italy. Thereafter, income taxes were computed at the current rate of 27% of net income before deduction of income tax. Depreciation was taken on a straight line basis at 5% per annum. As previously mentioned, 6-1/4% interest on the proposed loan was assumed; dividends on the share capital and interest on the shareholders' advances were taken at the rate of 7%.

74. The following table, based on the estimated results for the individual years, shows the average annual amounts which the purchasers of power would have to pay in the 16 years considered:

| | (in thousands US$ equiv.) |
|---|---|
| Fuel payments | 2,575 |
| Other Operating Expenses | 1,570 |
| Depreciation | 3,320 |
| Taxes other than income tax | 217 |
| Income Tax | 158 |
| Sub-total | 7,840 |
| Interest on Bank loan | 1,483 |
| Interest and dividends on shareholders' equity | 1,848 |
| Legal Reserve | 71 |
| Total | 11,242 |

75. The payments shown above, except for fuel, would not vary much with energy production. Fuel payments are computed on the basis of an annual generation of 985.5 million kwh, equivalent to a 75% plant factor. The shareholders to be supplied with power would therefore pay an estimated average of 11.4 mills per kwh.

76. The projections of estimated expenses and revenues do not include two government subsidies which at present are available to power companies in Italy including SENN. These subsidies are paid by two equalization funds (Cassa Conguaglio) established by the Government to partly compensate the Italian power companies for (i) the higher capital costs of new plants as compared with plants already in operation and (ii) the higher operating costs of thermal plants as compared with hydro plants. These two subsidies at present rates, would reduce the net annual payments by the purchasers of energy by about 20%.

Estimated Cash Flow

77. An examination of the projected cash flow statement given in Annex 8 shows a substantial generation of cash over the 16 years, amounting to a total of about $14.5 million; the rate of generation of cash is higher in the first 10 years due to the fact that deferred payments for the original fuel do not become due until the 11th year of operation. The cash generation arises out of the fact that depreciation is taken on a straight-line basis and on the total investment, while the proposed loan, representing 60% of the investment, would be serviced by level payments of principal and interest.

78. On the assumptions made, the rate of cash accumulation would enable SENN to pay for all or a substantial portion of the costs of the expansion noted in paragraph 53, from its own resources if such expansion should be found technically and economically justified. On the other hand, cash accumulated in the course of operation of the SENN plant would be available to SFNN for other investment in nuclear power or related power activities, or could be used, at SENN's option, to prepay all or a part of the Cassa loan. In the latter case, Cassa has agreed to prepay an equivalent amount of the Bank loan.

Projected Balance Sheets and Debt Coverage

79. Projected balance sheets of the company at the beginning and end of the first year of operations, and at the end of the tenth and sixteenth years, are shown in Annex 9. They do not reflect any additional plant investment, nor the possible earlier repayment of the proposed loan. It should be noted that, without accelerated amortization of the loan, the debt equity ratio is reduced to 42/58 by the end of the 10th year of operation.

80. Interest on the proposed loan would be covered 1.78 times the first year of operation; the coverage would gradually increase to 2.43 times in the tenth year. At the end of this year the loan would have been reduced to $19.53 million. Debt service on the loan would be

covered 1.92 times before depreciation the first year and decline slowly to 1.65 times in the tenth year, and to 1.35 times in the sixteenth year, the year of final amortization of the proposed loan. These are adequate coverage ratios.

Security

81. As has been noted in Paragraph 27, three of the shareholders of SENN (Finelettrica, SEM and SIP) would in the Project Agreement jointly and severally guarantee the performance by SENN of all its covenants in that agreement and in the subsidiary loan agreement between Cassa and SENN. The Project Agreement would also contain a more specific guarantee by these three shareholders that they will cause the project to be completed and operated efficiently, acting in place of SENN if necessary. These guarantees are adequate to protect the Bank.

82. Finelettrica, SME and SIP would also join in the subsidiary loan agreement as sureties, granting joint and several suretyship for the performance of the obligations of SENN thereunder. In addition to this suretyship, the Cassa's loan to SENN would be secured by a first mortgage and a privileged lien on the real estate, plants and equipment connected with the project.

## VIII. ECONOMIC COMPARISON OF NUCLEAR GENERATION COSTS WITH THOSE OF A CONVENTIONAL ALTERNATIVE

The Conventional Alternative

83. The site of the SENN nuclear plant is well located to supply energy to meet part of the base load requirements in the power systems of the main shareholders of SENN and it would be equally logical to site the alternative conventional plant in the same area. Bearing in mind its fueling requirements, it would probably be located at Gaeta, a few miles north, where there is a good harbor and where the construction of an oil refinery is planned.

84. Following established Italian practice, the conventional plant would be equipped for burning either oil or coal, although oil would be the normal fuel. The existing harbor at Gaeta would be available for the discharge of coal, which would then be moved to the plant by barge. Oil would be piped directly from the refinery to the plant.

85. The plant would be of a design similar to the Bank-financed Napoli Levante plant now under construction in Naples harbor. The capital cost estimates given in Annex 10 are based on the Napoli Levante plant, but adjustments have been made to allow for the fact that this plant will share certain facilities with the existing Vigliena plant (coal handling, laboratory, offices), and to allow for the more extensive circulating water intake works which would be necessary at Gaeta. If a conventional plant were to be built it would have an ultimate capacity of at least 300 MW (286 MW net). Its cost is estimated at $42.56 million equivalent,

corresponding to $149 per installed kw net. The proportional cost of a conventional alternative plant with a net capacity of 150 MW would amount to $22.3 million equivalent.

86. The connections to the main transmission system would be virtually the same for both plants and the estimated cost of this item amounting to $1.1 million has been added both for the nuclear plant and the conventional alternative. Total cost of the alternative conventional plant would therefore amount to $23.4 million equivalent, corresponding to $156 per installed kw net. The cost of the nuclear plant on the same basis, excluding initial fuel and fabrication costs, would amount to $59.3 million equivalent, corresponding to $395 per installed kw net.

87. The conventional plant would operate under advanced steam conditions and could be expected to achieve an average net annual thermal efficiency of 35% (equivalent to 9750 BTU per net kwh).

Concepts of Cost Comparison

88. The alternative cost comparisons are made on two bases, i.e., one including and the other excluding the government tax on fuel. With respect to SENN, the appropriate cost comparison necessarily includes this tax. From the standpoint of the Italian economy, however, the tax represents merely a transfer of income and not a cost of production. Consequently, in a cost comparison of alternative forms of power supply for the Italian economy, the fuel tax is excluded.

89. The bases for the comparisons are the estimated financial costs discussed in Chapter VII. Certain adjustments, described in Annex 11, have been made for fuel costs, depreciation and taxes.

Alternative Costs to SENN

90. Estimates of costs (expressed in mills per kwh) for both the nuclear plant and the conventional alternative are shown plotted against annual plant factor in Annex 12 and further details are given in Annex 13. The estimates are based on the following assumptions:

a) The cost of oil to Italian utilities would remain at a level corresponding to the average for the last seven years, i.e., 67 cents per million BTU including tax. This would amount to about 55 cents excluding tax. This estimate is based on a study of future oil costs (Bank memorandum dated August 12, 1958) which concluded, with reservations concerning short-term changes, that the average real price (ex tax) of oil in Europe during the next decade is unlikely to differ substantially from 55 cents per million BTU, the average during the 1951-57 period. The spread between high and low Italian oil prices in the 1951-57 period has exceeded 20 cents per million BTU, not unlike spreads prevailing in other important oil marketing areas in the same period; it should, therefore, be expected that fuel costs for conventional plants may vary substantially from year to year.

b) The estimated operating costs for the conventional plant, excluding fuel costs, have been based on actual costs incurred in existing plants in Italy. Those for the nuclear plant are the same as those given in Chapter VII.

c) The return on the investment in both cases has been assumed at 6-1/2%.

d) Allowances for depreciation for both types of plants have been assessed on a sinking fund basis with interest accruing at 6%. For the conventional plant a 30-year life is assumed. For the nuclear plant 20 years has been assumed for the reactor and associated equipment, and 30 years for the conventional sections of the plant.

e) All taxes and reserves based on profits have been excluded.

f) The special insurance allowance of $300,000 per year has been included for the nuclear plant.

91. Annex 12 shows that as a result of the higher capital investment and lower unit fuel costs for the nuclear plant, the unit generating cost of this plant will fall more rapidly than the unit generating cost of the conventional plant with higher annual plant factors. At a value of 80%, the costs for both plants would be equal. At lower plant factors, the conventional plant would produce more cheaply and at higher plant factors the nuclear plant would produce more cheaply.

92. One aspect of the annual plant factor is the ability of the power system, to which the plant is connected, to absorb the full output of the plant. As concluded in Chapter V it is reasonable to assume that the SENN plant could be operated at a high annual plant factor.

93. Another aspect governing the plant factor is the time required to have the plant shut down for refueling, repairs and maintenance, reducing the availability of the plant. The experience obtained in various European countries and in the USA of annual availability of conventional plants has been studied by the Bank. No experience is at present available to indicate the annual availability which could be expected from a commercial boiling water nuclear plant, but, bearing in mind the comparatively low steam conditions under which it will operate, it would be reasonable to assume that the availability of the SENN nuclear plant would equal that of a conventional plant. The report of the International Panel had this to say on this point:

" At the present stage of development of nuclear power the cost of electricity cannot be evaluated in advance with any pretence of certainty. Even a firm price bid coupled with a guaranteed power output leaves uncertain what proportion of a given period the plant will be available for use. In all cases (of the 9 SENN bids) the prospect of a high proportion of availability is good but there is always the risk that the failure of a single fuel element or other reactor component could set off a chain of events that would necessitate the

station being out of commission for several months. In the developing state of technology, lack of experience makes it impossible to set a valid 'assurance premium' for such events. "

94. It is clearly impossible to appraise the probability of the events referred to by the Panel; however, having regard to the studies referred to above and the general considerations mentioned, it is concluded that there would be a reasonable prospect of realizing an average annual plant factor of 80% over the life of the plant. At this plant factor, the nuclear energy costs would be almost exactly equal to those of the conventional alternative. The return on the additional investment ($35.9 million) required for the nuclear plant would be 6.6%. (See Annex 14) If the more conservative assumption is made of a plant factor of 75%, nuclear generation costs would be 3% ($293,000) greater per year, corresponding to a return of 5.7% on the additional investment required for the nuclear plant.

Comparison of Costs to the Italian Economy of Nuclear and Conventional Generation.

95. The costs for the nuclear plant and its conventional alternative have also been estimated excluding the taxes on oil. These costs are also plotted against average annual plant factor in Annex 12.

96. On this basis the costs would be equal at approximately 100% plant factor. At an 80% plant factor the nuclear costs would exceed those of the conventional alternative by 15% and the additional annual cost to the national economy would be $1,221,000. The return on the additional investment ($35.9 million) in the nuclear plant would be about 3.1%. At a 75% plant factor, the nuclear costs would be 18% higher (equal to $1,456,000 per year) and the return on additional investment would be 2.4%.

Increased Plant Output.

97. As described in paragraph 53, the design margins adopted by GE for the SENN plant may permit the plant to be operated at a considerably higher power level than guaranteed. To take advantage of this possibility, if it should prove to be feasible, SENN would have to make an additional investment in generating facilities. A reliable estimate of the size of this investment is not available at present.

98. Calculations have been made on the assumption that the output of the SENN plant could be increased to 230 MW net. If the cost would amount to $7.6 million ($95/kw for the additional net capacity), the unit production cost of the SENN plant would amount to 7.94 mills/kwh at a 75% plant factor. This cost would be equal to the unit production cost (excluding tax on oil) of a conventional plant with a net output capacity of 230 MW.

99. If the tax on oil is taken into consideration, the expanded nuclear plant would produce power at a cost 13% less than the cost of a conventional alternative plant.

Other Economic Aspects

100. One significant assumption is continued fuel availability at 55 cents per million BTU, equivalent to $22.50 per long ton of oil. A change of 10% in oil prices in either direction would involve a change in energy costs for the initial conventional plant of over $500,000 per year or about 1.5% on the added investment in nuclear power. Putting it another way, a 10% drop in oil prices from 55 cents per million BTU to 50 cents per million BTU would decrease fueling costs in the conventional plant by about 0.5 mills/kwh. On the other hand, a possible decrease in the cost of uranium has not been taken into account in the present calculations. At $8/lb. for uranium oxide ($U_3O_8$), a price at which many companies are prepared to sell large quantities of uranium, it has been calculated that savings in nuclear fuel costs of about 0.4 mills/kwh would be achieved.

101. To summarize the economic comparison, the energy cost estimates for the nuclear and conventional thermal plants show, from the standpoint of SENN, virtual cost equality, assuming an average plant factor of 80% and a long-run average oil price at current levels (67 cents per million BTU including taxes). At a 75% plant factor nuclear energy costs would be 3% greater than those for conventional thermal plant.

102. From the standpoint of the national economy, i.e., eliminating the tax on oil which has amounted to 12 cents per million BTU, nuclear plant operation at 80% plant factor would involve higher annual costs of about $1,200,000 or 15%. At a 75% plant factor the higher annual costs would amount to about $1,450,000 or 18%.

103. This gap would be narrowed or even overcome if (a) a higher level (higher than 55 cents per million BTU) of world oil prices prevailed, (b) the prices for uranium are reduced as seems likely, or (c) the possible expansion of the nuclear plant proved feasible.

104. Many developed countries engage in scientific and industrial research which cannot be demonstrated as profitable by customary economic calculations. Indirect benefits which flow from such efforts, when even partially successful are generally recognized as substantial though hard to measure in money terms. In Italy, new generating capacity of 500 MW or more[1/] is put in operation annually, and an interconnected system exists, which is capable of absorbing the output of nuclear plants of the size now contemplated operating on base-load at a high plant factor. Experience with construction, installation and operation of large-scale nuclear power plants is more likely to be translated quickly into substantial benefits to the Italian national economy than in less industrialized countries. In evaluating the project it is important therefore not to overlook such intangible but nevertheless real indirect benefits.

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1/ In the 5-year period 1952-1957, capacity was increased by 2,715 MW.

## IX. CONCLUSIONS

105. The project is technically sound. Satisfactory arrangements have been made for the detailed design and construction of the project. The cost estimate is realistic and the proposed financing plan is sound. The estimated demand for power in the area to be served by the plant would permit it to be operated at a high plant factor.

106. The organization and management of SENN are satisfactory. On the assumptions made in this report, the financial forecasts show that the future financial position of SENN would be sound.

107. A comparison of nuclear and conventional thermal generation costs shows that the energy costs to SENN would be about the same with either alternative if an average annual plant factor of 80% was achieved. Excluding taxes on oil from the comparison, the cost to the Italian economy of nuclear generation would be about 15% higher than the cost of conventional thermal generation at this plant factor.

108. There are reasonable prospects of achieving an 80% plant factor, but even if only 75% were realized, in which case the costs to the Italian economy of nuclear generation would exceed those of conventional generation by about 18%, or $1,450,000 per annum, it would still seem advisable that the SENN nuclear project should be carried out. In arriving at this conclusion it is taken into account that future increases in base load requirements in Italy's power system will have to be met by new thermal plants. In due course, as nuclear generation becomes cheaper Italy will no doubt have to embark on a substantial nuclear power program and in the meantime needs to obtain the necessary experience in the construction and operation of nuclear power plants.

109. The figures quoted above do not take account of the possibility that the output of the nuclear reactor may be increased. If this possibility were realized the costs to the Italian economy of nuclear generation and of conventional thermal generation may be about the same at 75% plant factor.

110. The project is suitable for a Bank loan of $40 million equivalent. A term of 20 years, including a grace period of 4-1/2 years would be appropriate.

ANNEX 1

## SOCIETA ELETTRONUCLEARE NAZIONALE (SENN)

### List of Shareholders

| | Percent of Total Shares |
|---|---|
| **Finelettrica Group** | |
| Societa Meridionale di Elettricita (SME) | 25.0 |
| Unione Esercizi Elettrici (UNES) | 10.0 |
| Societa Idroelettrica, Piemonte (SIP) | 20.0 |
| Terni - Societa' per l'Industria e l'Elettricita | 10.0 |
| Societa Finanziaria Elettrica Nazionale (Finelettrica) | 0.625 |
| Societa Trentina di Elettricita (STE) | 4.375 |
| Societa Lombarda per Distribuzione di Energia Elettrica (Vizzola) | 5.0 |
| | 75.0 |
| **Finmeccanica Group** | |
| Ansaldo S.p.A. | 3.0 |
| Ansaldo San Giorgia S.p.A. | 2.0 |
| | 5.0 |
| **Finsider Group** | |
| Dalmine S.p.A. | 4.0 |
| Ilva Alti Forni e Acciaierie d'Italia | 4.0 |
| Societa Italiana Acciaierie di Cornigliano | 2.0 |
| | 10.0 |
| **Independent** | |
| Societa Romana di Elettricita (SRE) | 7.5 |
| Societa Generale Elettrica della Sicilia (SGES) | 2.5 |
| | 10.0 |
| Total | 100.0 |

FINELETTRICA
SOCIETA FINANZIARIA ELETTRICA NAZIONALE

Summary of Balance Sheets
(in millions of L.)

| Years ended June: | 1957 | 1958 | | 1957 | 1958 |
|---|---|---|---|---|---|
| ASSETS | | | LIABILITIES | | |
| Share participations 1/ | 40,094 | 43,503 | Share capital | 30,000 | 45,000 |
| Loans to group | 14,458 | 14,723 | Reserves | 1,651 | 1,803 |
| | 54,552 | 58,226 | Due group companies | 606 | 54 |
| | | | Loans | 16,107 | 14,381 |
| Government bonds | 95 | 95 | Accounts payable | 5,050 | 3,888 |
| Due from shareholders | - | 6,259 | Dividends payable | 2,249 | 2,906 |
| Cash and banks | 529 | 3,595 | Other liabilities | 93 | 138 |
| Other current assets | 653 | 63 | Surplus forward | 73 | 68 |
| Total | 55,829 | 68,238 | Total | 55,829 | 68,238 |

1/ A list of the participations is given in Annex 2, Page 2.

PROFIT AND LOSS ACCOUNT

| | 1957 | 1958 |
|---|---|---|
| Dividends from participations | 2,650 | 2,520 |
| Interest from Government bonds | 5 | 5 |
| Income from financial activity | 1,602 | 2,215 |
| Total income | 4,257 | 4,740 |
| Overhead | 145 | 133 |
| Depreciation | 5 | 7 |
| Taxes | 226 | 227 |
| Total cost | 376 | 367 |
| Net income | 3,881 | 4,373 |
| Less: interest | 1,514 | 1,320 |
| Net profit | 2,367 | 3,053 |
| Balance from previous year | 73 | 73 |
| | 2,440 | 3,126 |
| Ordinary reserve - 5% | 118 | 153 |
| Dividends | 2,249 | 2,905 |
| Balance forward | 73 | 68 |

FINELETTRICA

SOCIETA FINANZIARIA ELETTRICA NAZIONALE

Participations as of June 30, 1958

| | Number of shares (number) | Nominal value by unit (Lire) | Cost by unit (Lire) | Total value on balance sheet as of June 30, 1958 (Lire) | Percentage of shares & capital % |
|---|---|---|---|---|---|
| SIP - Societa Idroelettrica Piemonte | 21.730.875 | 1.200 | 962,36 | 20.912.974.714 | 31,52 |
| SME - Societa Meridionale di Elettricita | 15.820.201 | 1.000 | 851,26 | 13.467.204.193 | 21,10 |
| TERNI - Societa per l'Industria e l'Elettricita | 27.241.910 | 250 | 209,18 | 5.698.656.032 | 20,48 |
| STE - Societa Trentina di Elettricita | 1.309.985 | 1.000 | 945,68 | 1.238.831.365 | 13,10 |
| SIMEA - Societa Italiana Meridionale Energia Atomica | 50.000 | 1.000 | 1.000,-- | 50.000.000 | 10,00 |
| SENN - Societa Elettronucleare Nazionale | 1.250 | 10.000 | 10.000,-- | 12.500.000 | 2,50 |
| SAMET - Societa Meridionale Metano | 184.800 | 500 | 500,007 | 92.401.288 | 33,33 |
| POMET - Societa Pontina Metano | 50.000 | 500 | 500,-- | 25.000.000 | 50,00 |
| GEMINA - Societa Geomineraria Nazionale | 20.000 | 1.000 | 1.000,-- | 20.000.000 | 33,33 |
| SEAF - Societa Esercizi Attivita Finanziarie | 198.500 | 10.000 | 10.000,-- | 1.985.000.000 | 99,25 |
| | | | | 43.502.567.592 | |

Annex 2, Page 2

## SOCIETA MERIDIONALE DI ELECTTRICITA (S.M.E.)

### Summary of Balance Sheets
(in millions of L.)

| Years ended March: | 1957 | | 1958 | |
|---|---|---|---|---|
| **ASSETS** | | | | |
| Fixed assets | 164,575 | | 170,054 | |
| Less: depreciation reserve | 48,703 | | 53,703 | |
| Net fixed assets | | 115,872 | | 116,351 |
| Work in progress | | 3,295 | | 4,464 |
| Inventories | | 2,525 | | 3,087 |
| Share participations | 23,655 | | 24,582 | |
| Loans to group | 11,217 | 34,872 | 12,674 | 37,256 |
| Government bonds | | 1,120 | | 1,110 |
| Due from shareholders | | 3,759 | | 3,759 |
| Other current assets | | 6,754 | | 7,407 |
| Cash and Bank | | 2,926 | | 2,700 |
| Total Assets | | 171,123 | | 176,134 |

| | 1957 | | 1958 | |
|---|---|---|---|---|
| **LIABILITIES** | | | | |
| Share capital | 74,982 | | 74,982 | |
| Revaluation account | 29,867 | | 29,867 | |
| Reserves | 2,441 | | 2,723 | |
| Total Equity | | 107,290 | | 107,572 |
| Long and medium term debt | 33,988 | | 33,599 | |
| Due group companies | 1,695 | | 1,619 | |
| Floating debt | 4,909 | | 10,290 | |
| Total Debt | | 40,592 | | 44,508 |
| Accounts payable | | 2,218 | | 1,601 |
| Dividends and bonus payable | | 4,903 | | 5,358 |
| Other liabilities | | 16,038 | | 16,013 |
| Surplus forward | | 82 | | 82 |
| Total Liabilities | | 171,123 | | 176,134 |

### INCOME STATEMENT

| Years ended March: | 1957 | 1958 |
|---|---|---|
| Revenues from sales of electricity | 22,404 | 22,936 |
| Subsidies and payments by equalization fund | 2,568 | 2,015 |
| Other income (net) | 3,829 | 4,265 |
| Total Revenues | 28,801 | 29,216 |
| Operating cost | 13,894 | 13,791 |
| Depreciation | 4,850 | 5,000 |
| Taxes | 1,486 | 1,591 |
| Net Income | 8,571 | 8,834 |
| Interest (other than capitalized) | 3,409 | 3,193 |
| Net Profit | 5,162 | 5,641 |
| Balance from previous year | 82 | 82 |
| | 5,244 | 5,723 |
| Ordinary reserve - 5% | 259 | 283 |
| Dividends | 4,888 | 5,342 |
| Bonus to management | 15 | 16 |
| Balance brought forward | 82 | 82 |
| Net income as percentage of net fixed assets in operation | 7.3% | 7.5% |
| Long-term debt/equity ratio | 24/76 | 24/76 |

SOCIETA IDROELECTTRICA PIEMONTE (S.I.P.)

Summary of Balance Sheets
(millions of L.)

| Years ended December: | 1957 | | 1958 | |
|---|---|---|---|---|
| **ASSETS** | | | | |
| Fixed assets | 192,168 | | 201,268 | |
| Less: depreciation | 60,925 | | 67,082 | |
| Net fixed assets | | 131,243 | | 134,186 |
| Work in progress | | 6,138 | | 6,550 |
| Financial charges | | 2,635 | | 2,441 |
| Share participations | 26,426 | | 32,179 | |
| Loans to group | 16,682 | 43,108 | 12,743 | 44,922 |
| Government bonds | | 1,667 | | 1,663 |
| Due from shareholders | | 3,560 | | - |
| Other current assets | | 7,452 | | 7,294 |
| Cash and Bank | | 91 | | 61 |
| Total Assets | | 195,894 | | 197,117 |
| **LIABILITIES** | | | | |
| Share capital | 82,738 | | 82,738 | |
| Revaluation account | 32,258 | | 31,983 | |
| Reserves | 4,006 | | 4,300 | |
| Total Equity | | 118,002 | | 119,021 |
| Long-term debt | 44,230 | | 42,571 | |
| Due group companies | 226 | | 5,313 | |
| Floating debt | 8,466 | | 6,480 | |
| Total Debt | | 52,922 | | 54,364 |
| Accounts payable | | 3,702 | | 2,387 |
| Dividends and bonus payable | | 5,561 | | 5,582 |
| Other liabilities | | 14,665 | | 15,721 |
| Surplus forward | | 42 | | 42 |
| Total Liabilities | | 195,894 | | 197,117 |

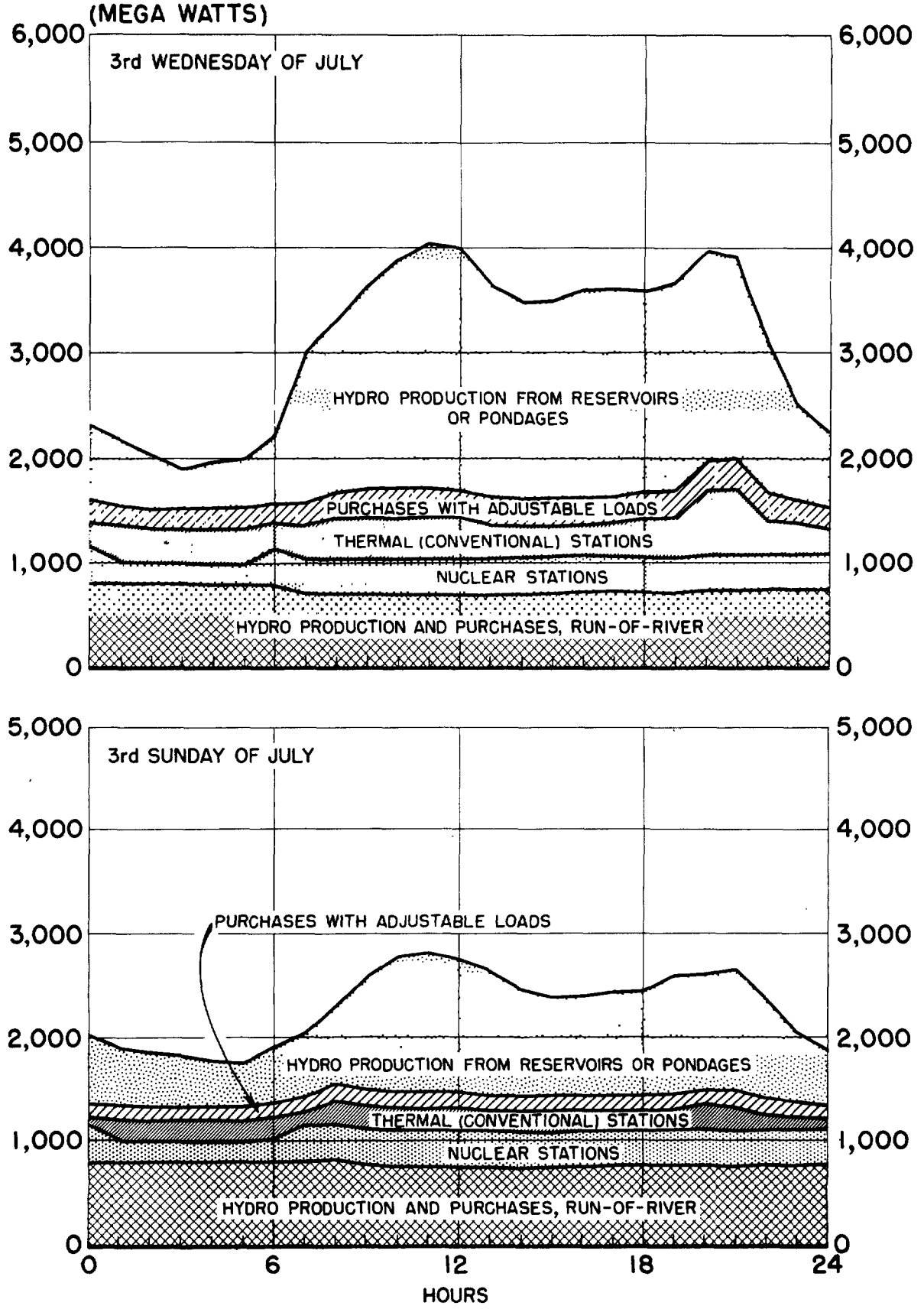
INCOME STATEMENT

| Years ended December: | 1957 | 1958 |
|---|---|---|
| Energy sales | 25,786 | 27,565 |
| Investment income | 3,229 | 3,349 |
| Others | 614 | 801 |
| Total Revenues | 29,629 | 31,715 |
| Total cost of operations (including fuel and general overhead) | 15,517 | 16,327 |
| Depreciation | 5,250 | 6,250 |
| Taxes | 1,011 | 1,150 |
| Others | 265 | 114 |
| Total Cost | 22,043 | 23,841 |
| Net income of operations | 7,586 | 7,874 |
| Less: interest charged to operations | 1,732 | 1,998 |
| Net Profit | 5,854 | 5,876 |
| Balance from previous year | 41 | 42 |
| | 5,895 | 5,918 |
| Ordinary reserve - 5% | 292 | 294 |
| Dividends | 5,544 | 5,565 |
| Bonus to management | 17 | 17 |
| Balance brought forward | 42 | 42 |
| Net income as a percentage of net fixed assets in operations | 5.8% | 5.9% |
| Long-term debt/equity ratio | 27/73 | 26/74 |

# ITALY: UTILITY SHAREHOLDERS OF SENN NUCLEAR POWER PLANT

ESTIMATED DAILY LOAD CURVES, SUMMER 1965

(MEGA WATTS)



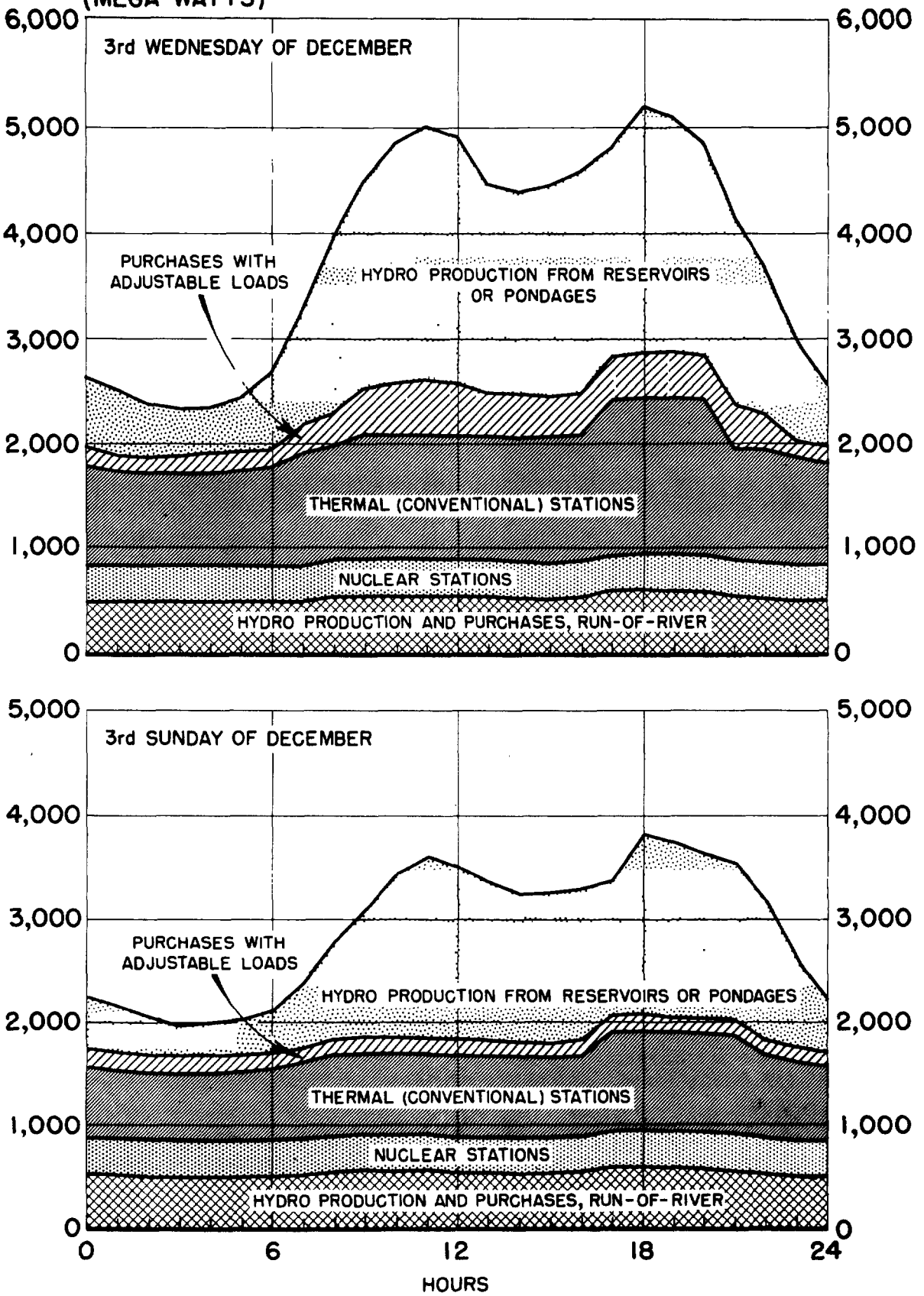

IBRD - Economic Staff

(R) 1533

# ITALY: UTILITY SHAREHOLDERS OF SENN NUCLEAR POWER PLANT

ESTIMATED DAILY LOAD CURVES, WINTER 1965

(MEGA WATTS)

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(R) 1534

# SENN NUCLEAR PLANT

## TECHNICAL DESCRIPTION OF THE PROJECT

### The Nuclear Power Station

The reactor system included in the project is the forced circulation dual cycle light water cooled and moderated type. In the dual cycle reactor, energy is removed from the reactor core directly by steam which flows to the primary turbine control valves and indirectly by extracting heat through a steam generator from the recirculating reactor water to produce steam at a lower pressure, which flows to the turbine through the secondary control valves. The pressure in the reactor is held constant by the primary turbine control valves. The fraction of the total energy removed through the secondary or low pressure system controls the temperature of the water returning to the reactor, which in turn determines the reactor output. The primary and secondary steam passes through a conventional turbine cycle with a condenser, feed pumps, and extraction feedwater heaters. The feedwater is returned to the steam drum and to the secondary steam generators.

Plant performance:

| | |
|---|---|
| Gross generator output | 160,000 KWe |
| Net electric output | 150,000 KWe |
| Reactor power | 507,800 KWth |
| Net plant heat rate | 11,553 BTU/kwh |
| Reactor pressure | 1,015 psia |
| Secondary steam generator pressure | 500 psia |

The dual cycle has inherent self-control over a considerable range by only the regulation of the secondary steam control valves on the turbine. The admission of more secondary steam to the turbine causes increased subcooling of the water passing through the steam generators to the reactor. This increased subcooling causes increased reactor power and primary steam generation. The reverse occurs when the secondary steam flow is reduced.

The light water moderated and cooled reactor core is contained within a single reactor vessel. The fuel consists of slightly enriched uranium oxide pellets encased in zircalloy tubing. The individual fuel rods are grouped into fuel assemblies, each consisting of 36 fuel rods. These assemblies are surrounded with a zircalloy-2 channel. This grouping of the fuel rods into assemblies provides for easier handling and, as the entrance to each assembly is provided with an orifice, gives a means of adjusting the pattern of flow and steam generation within the core. The assemblies are grouped vertically, resting on a core support plate at the bottom and are held in alignment by a guide grid at the top. There are no other structural elements within the core.

Control rods enter the bottom of the reactor core and are operated by a hydraulic system located below the reactor vessel. The rods are cross-shaped, passing vertically between the fuel assemblies. The control-rods are used to start-up and shut down the reactor, set the range of automatic dual cycle control, and shape the neutron flux pattern.

The turbine is a 160,000 KW, 1500 RPM tandem compound, double flow, three casing machine with special moisture removal features for handling saturated steam. It is connected to a 200,000 KVA generator with conventional hydrogen cooling. The turbine is designed for 965 psia saturated primary steam and 475 psia saturated secondary steam admission, and is designed to heat the feedwater with extraction steam to 375°F in four stages. The turbine control includes bypass valves to direct primary steam around the turbine to the condenser in the event of transients which may cause higher primary steam pressure than is used by the turbine.

High purity of the water in the reactor system is provided by a condensate demineralizer through which all feedwater flows, a continuous clean-up demineralizer as a part of the reactor system, and a make-up demineralizer to purify make-up water to the system. Maintaining high purity of the water prevents accumulation of any radio-active corrosion products in the system and permits normal or nearly normal maintenance procedures.

The plant design includes reliable safeguards to prevent hazardous incidents, and, in the remote event of an incident, to minimize hazard to plant personnel and to the surrounding area. Specific safety features include:

(1) A nuclear reactor of such design that it tends to shut itself down upon a potentially dangerous increase in power; that is, a temperature increase or excessive steam formation tend to shut down the reactor.

(2) Two separated and independent safety systems to shut down the reactor. These consist of the control rods mentioned above and a liquid poison injection system.

(3) Two separate and independent systems for cooling the reactor. These consist of the main condenser and an emergency condenser.

(4) Design of safety devices in such a way that their malfunction tends to shut the reactor down.

(5) To confine any radioactive material that might be liberated in an accident, the reactor and its auxiliaries are enclosed in a 160 foot diameter steel sphere designed to remain leak proof following any possible reactor incident.

Civil Works

The civil works required in connection with the nuclear power station and which are to be built according to specifications supplied by the International General Electric Company are the following:

(1) The reactor enclosure containing the reactor, its auxiliaries, all steam generating equipment, and fuel handling and storage facilities.

(2) The turbine building housing the turbine-generator, the condenser, the feedwater system, and various plant auxiliaries. The control room and the access control area are in a wing of the turbine building.

(3) The radioactive waste disposal building containing the radioactive waste treatment and disposal equipment.

(4) The intake structure housing the condenser circulating water pumping and screening equipment.

(5) Other conventional structures including the administration building, shop and warehouse, and the switchyard.

The detailed estimate of costs for civil works, exclusive of contingency allowance, is contained in the following table:

Estimated Cost of Civil Works

| | | Amount in $ |
|---|---|---|
| 1. | Reactors: shielding concrete | 704,000 |
| | Foundation | 1,278,000 |
| | Cooling pond | 64,000 |
| 2. | Turbine house | 896,000 |
| | Foundation | 280,000 |
| | Auxiliaries | 480,000 |
| | Turbine base | 192,000 |
| 3. | Hydraulic works | 960,000 |
| 4. | Earth fills, grading, fencing, sewage | 240,000 |
| 5. | Cable canals and tunnels | 240,000 |
| 6. | Access road | 80,000 |
| 7. | Service buildings | 288,000 |
| 8. | Lodgings | 320,000 |
| 9. | Accessory works | 480,000 |
| | Total | 6,502,000 |

Sub-Station and Transmission Line

The characteristics of the main sub-station and the transmission line are as follows:

Substation:

| | |
|---|---|
| Main transformers, number and type | 4, single phase |
| Capacity each . . . . . | 64 MWA |
| Voltage ratio . . . . . | 13.8/220 KV |
| Estimated cost (including switchgear) | $1.34 million |

The transmission lines comprise 100 kilometers of 220 KV lines at estimated cost of $1.13 million, exclusive of contingencies.

Engineering and Supervision

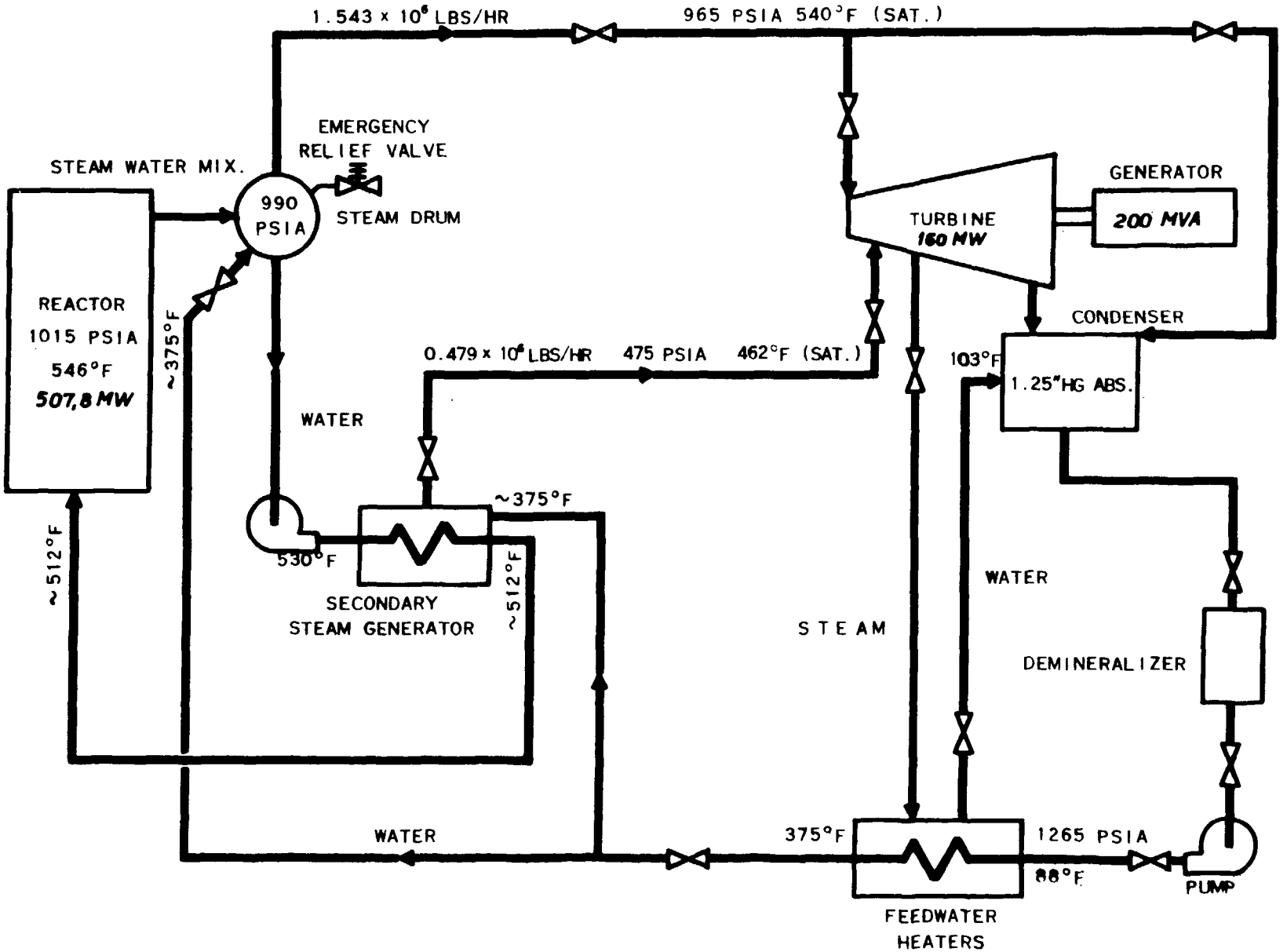
An estimate of SENN's expenses from January 1, 1959 to the estimated date of commissioning the plant (52 months) for engineering and supervision of the project are as follows:

Estimate of SENN's Requirements for Overhead Expenses from January 1, 1959 to the Plant Commission Date after about 52 Months

| | |
|---|---|
| Foreign Consultants | $ 500,000 |
| Civil Works Consultants | 296,000 |
| SENN Personnel | 800,000 |
| Rents and Miscellaneous Expenditures | 404,000 |
| | $2,000,000 |

# SENN NUCLEAR PLANT

## STEAM FLOW DIAGRAM



SOCIETA' ELETTRONUCLEARE NAZIONALE (S.E.N.N.)

Estimates of Annual Expenses and Necessary Revenues
(expressed in thousands U.S. dollars)

| | 1st Year | 2nd Year | 3rd Year | 4th Year | 5th Year | 6th Year | 7th Year | 8th Year | 9th Year | 10th Year | 11th Year | 12th Year | 13th Year | 14th Year | 15th Year | 16th Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Fuel Costs** | | | | | | | | | | | | | | | | |
| Rent of Original fuel | 765 | 437 | 437 | 437 | 437 | 437 | 437 | 437 | 437 | 437 | 437 | 394 | 350 | 306 | 262 | 219 |
| Transportation and stripping insurance | - | - | 122 | 137 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 107 | 122 | 122 |
| Fabrication | - | 900 | 900 | 900 | 900 | 900 | 800 | 800 | 800 | 800 | 800 | 700 | 700 | 700 | 700 | - |
| Purchase of additional fuel | - | - | 3,640 | 1,820 | 1,820 | 1,820 | 1,820 | 1,820 | 1,820 | 1,820 | 1,820 | 1,820 | 1,820 | 1,820 | - | 1,820 |
| Purchase of original fuel | - | - | - | - | - | - | - | - | - | - | 1,093 | 1,093 | 1,093 | 1,093 | 1,093 | 1,093 |
| Credit for plutonium and uranium (net) | - | - | - | (1,706) | (853) | (853) | (853) | (750) | (750) | (750) | (750) | (750) | (624) | (624) | (624) | (624) |
| Total fuel costs | 765 | 1,337 | 5,099 | 1,588 | 2,426 | 2,426 | 2,326 | 2,429 | 2,429 | 2,429 | 3,522 | 3,379 | 3,461 | 3,402 | 1,553 | 2,630 |
| **Other Operating Expenses** | | | | | | | | | | | | | | | | |
| Operation and Maintenance | 970 | 970 | 970 | 970 | 970 | 970 | 970 | 970 | 970 | 970 | 970 | 970 | 970 | 970 | 970 | 970 |
| Administration and General | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| Insurance | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| Sub-total | 1,570 | 1,570 | 1,570 | 1,570 | 1,570 | 1,570 | 1,570 | 1,570 | 1,570 | 1,570 | 1,570 | 1,570 | 1,570 | 1,570 | 1,570 | 1,570 |
| Depreciation | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 |
| Capital Share Tax | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Local Taxes | 117 | 117 | 117 | 117 | 117 | 117 | 117 | 117 | 117 | 117 | 117 | 117 | 117 | 117 | 117 | 117 |
| Corporate Income Tax | - | - | - | - | - | - | - | - | - | - | 422 | 422 | 422 | 422 | 422 | 422 |
| Total Operating Expenses | 5,872 | 6,444 | 10,206 | 6,695 | 7,533 | 7,533 | 7,433 | 7,536 | 7,536 | 7,536 | 9,051 | 8,908 | 8,990 | 8,931 | 7,082 | 8,159 |
| Interest on IBRD-Cassa Loan[a/] | 2,476 | 2,378 | 2,274 | 2,163 | 2,046 | 1,922 | 1,790 | 1,650 | 1,502 | 1,345 | 1,178 | 1,000 | 812 | 613 | 401 | 177 |
| Interest on Stockholders' Advances | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 |
| Total Interest | 3,400 | 3,302 | 3,198 | 3,087 | 2,970 | 2,846 | 2,714 | 2,574 | 2,426 | 2,269 | 2,102 | 1,924 | 1,736 | 1,537 | 1,325 | 1,101 |
| Dividends | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 |
| Legal Reserve | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 |
| Total Necessary Revenues | 10,267 | 10,741 | 14,399 | 10,777 | 11,498 | 11,374 | 11,142 | 11,105 | 10,957 | 10,800 | 12,148 | 11,827 | 11,721 | 11,463 | 9,402 | 10,255 |

a/ Consisting of 6% to IBRD and 1/4% to Cassa

ANNEX 9

## SENN NUCLEAR PLANT

## TECHNICAL ASSUMPTIONS USED IN ESTIMATING FUEL COSTS

1. Plant factor . . . . . 75%

2. Plant net power . . . . . 150,000 KW

3. Plant heat power. . . . . 508,000 KW

4. Spare fuel elements corresponding to 20% of the original core have been allowed. These elements were assumed to be utilized in the last core.

5. Plant life 20 years with a uniform output over this time.

6. 4% for the use charge of the uranium fuel with purchase of the fuel over the second 10 years.

7. Core fabrication cost:

| | |
|---|---|
| First core | $5,200,000 |
| Second core | 4,500,000 |
| Third core | 4,000,000 |
| All other cores | 3,500,000 |

8. Chemical Processing:

   The U.S. Atomic Energy Commission's published prices were used of $15,300 per day plus an 8-day turn-around time for one-fifth of a core. A 1% loss of plutonium and uranium was included.

9. Chemical Conversion:

   The U.S. Atomic Energy Commission's published price of $5.60 per kg. of uranium was used for this conversion.

10. Uranium Value:

    Values were taken from the U.S. Atomic Energy Commission's published prices for various U-235 concentration.

11. Plutonium Value:

    A net plutonium value of $10.50 per gm. for the first core
    9.00 per gm. for the second core
    8.00 per gm. for the subsequent cores

12. Shipping and insurance on fuel charges:

| | |
|---|---|
| First core | $400 per metric ton of materials |
| Insurance | $0.004 per $1 value |
| Weight ratio of shipped material to uranium 2.5 to 1 | |

| | |
|---|---|
| Subsequent cores | |
| New elements | $200 per metric ton of material |
| (Material to uranium 2.5 to 1) | |
| Old elements | $200 per metric ton of material |
| (1/5 of core shipped in four 60-ton casks) | |
| Empty casks | $50 per metric ton of material |

| | |
|---|---|
| Insurance fresh fuel | $0.004 per $1 |
| Insurance spent fuel | $0.008 per $1 |
| plus | $10,000 per cask |

13. Amount of uranium in core equals 41.4 metric tons

14. Clean-up charge at end of operation - $500,000

15. Time schedule:

| | | |
|---|---|---|
| First core: | Fabrication payment | 15 months before |
| | Rent starts | 9 " " |
| | Shipping payment | 8 " " |
| | On Hand | 6 " " |
| | ("before" means "before power operation") | |

| | | |
|---|---|---|
| Subsequent 1/5 of core: | | |
| | Fabrication payment | 6 months before |
| | Rent | 3 " " |
| | Shipping | 2 " " |
| | On hand | 1 " " |
| | ("before" means "before charge to reactor") | |

| | | |
|---|---|---|
| Discharge: | | |
| | Cooling period | 4 months |
| | Transportation payment | 4 months after |
| | Return of casks | 6 " " |
| | Credit of payment | 8 " " |
| | ("after" means "after discharge from reactor") | |

16. Burn-up of material:

| | |
|---|---|
| First core | 13,200 MW days per metric ton |
| Second core | 15,000 " " " " " |
| Third core | 18,000 " " " " " |
| Thereafter | 20,000 " " " " " |

Under the assumptions of burn-up above, fuel elements representing 4.6 cores would be used in the 20 years of operation. To reflect the actual practice a smoothing method was used on the transition between these various burn-ups.

SOCIETA' ELETTRONUCLEARE NAZIONALE (S.E.N.N.)

Estimates of Income and Cash Flow Statements
(expressed in thousands of U.S.dollars)

| | 1st Year | 2nd Year | 3rd Year | 4th Year | 5th Year | 6th Year | 7th Year | 8th Year | 9th Year | 10th Year | 11th Year | 12th Year | 13th Year | 14th Year | 15th Year | 16th Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ome Statements** | | | | | | | | | | | | | | | | |
| evenues | 10,267 | 10,741 | 14,399 | 10,777 | 11,498 | 11,374 | 11,142 | 11,105 | 10,957 | 10,800 | 12,148 | 11,827 | 11,721 | 11,463 | 9,402 | 10,255 |
| perating expenses, including taxes | 2,522 | 3,124 | 6,886 | 3,375 | 4,213 | 4,213 | 4,113 | 4,216 | 4,216 | 4,216 | 5,731 | 5,588 | 5,670 | 5,611 | 3,762 | 4,839 |
| epreciation | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 |
| **Gross Income** | 4,395 | 4,297 | 4,193 | 4,082 | 3,965 | 3,841 | 3,709 | 3,569 | 3,421 | 3,264 | 3,097 | 2,919 | 2,731 | 2,532 | 2,320 | 2,096 |
| nterest on IBRD-Cassa loan | 2,476 | 2,378 | 2,274 | 2,163 | 2,046 | 1,922 | 1,790 | 1,650 | 1,502 | 1,345 | 1,178 | 1,000 | 812 | 613 | 401 | 177 |
| nterest on stockholders' advances | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 |
| **Net Income** | 995 | 995 | 995 | 995 | 995 | 995 | 995 | 995 | 995 | 995 | 995 | 995 | 995 | 995 | 995 | 995 |
| ividends | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 |
| gal reserves | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 71 |
| **Flow Statements** | | | | | | | | | | | | | | | | |
| **ources of Funds** | | | | | | | | | | | | | | | | |
| Gross Income | 4,395 | 4,297 | 4,193 | 4,082 | 3,965 | 3,841 | 3,709 | 3,569 | 3,421 | 3,264 | 3,097 | 2,919 | 2,731 | 2,532 | 2,320 | 2,096 |
| Depreciation | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 | 3,320 |
| **Receipts from Operations** | 7,715 | 7,617 | 7,513 | 7,402 | 7,285 | 7,161 | 7,029 | 6,889 | 6,741 | 6,584 | 6,417 | 6,239 | 6,051 | 5,852 | 5,640 | 5,416 |
| **plication of Funds** | | | | | | | | | | | | | | | | |
| Interest on IBRD-Cassa Loan | 2,476 | 2,378 | 2,274 | 2,163 | 2,046 | 1,922 | 1,790 | 1,650 | 1,502 | 1,345 | 1,178 | 1,000 | 812 | 613 | 401 | 177 |
| mortisation of IBRD-Cassa Loan | 1,547 | 1,641 | 1,741 | 1,847 | 1,959 | 2,078 | 2,205 | 2,339 | 2,482 | 2,633 | 2,793 | 2,964 | 3,144 | 3,335 | 3,538 | 3,754 |
| **Debt Service on IBRD-Cassa Loan** | 4,023 | 4,019 | 4,015 | 4,010 | 4,005 | 4,000 | 3,995 | 3,989 | 3,984 | 3,978 | 3,971 | 3,964 | 3,956 | 3,948 | 3,939 | 3,931 |
| nterest on stockholders' advances | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 |
| ividends | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 | 924 |
| **Total application of funds** | 5,871 | 5,867 | 5,863 | 5,858 | 5,853 | 5,848 | 5,843 | 5,837 | 5,832 | 5,826 | 5,819 | 5,812 | 5,804 | 5,796 | 5,787 | 5,779 |
| ash accrual for year | 1,844 | 1,750 | 1,650 | 1,544 | 1,432 | 1,313 | 1,186 | 1,052 | 909 | 758 | 598 | 427 | 247 | 56 | (147) | (363) |
| ash balance at beginning of year | - | 1,844 | 3,594 | 5,244 | 6,788 | 8,220 | 9,533 | 10,719 | 11,771 | 12,680 | 13,438 | 14,036 | 14,463 | 14,710 | 14,766 | 14,619 |
| ash balance at end of year | 1,844 | 3,594 | 5,244 | 6,788 | 8,220 | 9,533 | 10,719 | 11,771 | 12,680 | 13,438 | 14,036 | 14,463 | 14,710 | 14,766 | 14,619 | 14,256 |
| | | | | | | | | | | | | | | | | |
| o interest on IBRD-Cassa loan covered gross income | 1.78 | 1.81 | 1.84 | 1.89 | 1.94 | 2.00 | 2.07 | 2.16 | 2.28 | 2.43 | 2.63 | 2.92 | 3.4 | 4.1 | 5.8 | 11.8 |
| o debt service on IBRD-Cassa loan vered by receipts from operations | 1.92 | 1.90 | 1.87 | 1.85 | 1.82 | 1.79 | 1.76 | 1.73 | 1.69 | 1.65 | 1.62 | 1.57 | 1.53 | 1.48 | 1.43 | 1.38 |

ANNEX 20

Annex 9

SOCIETA ELETTRONUCLEARE NAZIONALE

PROJECTED BALANCE SHEETS
(in millions of US dollars equivalent)

| | At beginning of 1st yr.of operations | At end of 1st Year | At end of 10th Year | At end of 16th Year |
|---|---|---|---|---|
| **Assets** | | | | |
| Fixed assets, at cost | 66.40 | 66.40 | 66.40 | 66.40 |
| Depreciation reserve | - | 3.32 | 33.20 | 53.12 |
| Net fixed assets | 66.40 | 63.08 | 33.20 | 13.28 |
| Net current assets | - | 1.84 | 13.44 | 14.26 |
| Total | 66.40 | 64.92 | 46.64 | 27.54 |
| **Liabilities and Capital** | | | | |
| Proposed Bank Loan | 40.00 | 38.45 | 19.53 | - |
| Stockholders' advances | 13.20 | 13.20 | 13.20 | 13.20 |
| Total Debt | 53.20 | 51.65 | 32.73 | 13.20 |
| Legal reserve | - | .07 | .71 | 1.14 |
| Share capital | 13.20 | 13.20 | 13.20 | 13.20 |
| Total Capital and Reserves | 13.20 | 13.27 | 13.91 | 14.34 |
| Total | 66.40 | 64.92 | 46.64 | 27.54 |
| Debt/Equity Ratio 1/ | 60/40 | 59/41 | 42/58 | - |

1/ Taking shareholders' advances as equity.

Annex 10

## SENN NUCLEAR PLANT

### Cost Estimate of 300 MW Conventional Thermal Plant

| | | Million Lire |
|---|---|---|
| 1. | Design and Engineering | 600 |
| 2. | Land | 300 |
| 3. | Fuel Discharge Facilities | 2,200 |
| 4. | Civil Works | 2,200 |
| 5. | Coal Storage and Conveyors | 1,150 |
| 6. | Cooling Plant | 1,350 |
| 7. | Boilers, Turbogenerators and auxiliaries | 12,800 |
| 8. | Transformers, Electrical Equipment | 1,750 |
| 9. | Miscellaneous Installations | 200 |
| 10. | Oil Storage and Transport Equipment | 350 |
| 11. | Housing | 400 |
| 12. | Workshop, Stores, Laboratory | 200 |
| 13. | Miscellaneous works, Overhead and Interest during Construction | 3,100 |
| | Total | 26,600 |

Equivalent to $42.56 million

## SENN NUCLEAR PLANT

### Adjustments to Financial Costs for Purposes of Comparing Nuclear and Conventional Thermal Power Costs

In Chapter VII, the annual costs to SENN over the 16-year operating period were estimated to average $11,242,000 or 11.41 mills per kwh sold, assuming a plant factor of 75%. At an 80% plant factor, these costs would be $11,414,000 or 10.86 mills per kwh sold. The difference is entirely attributable to increased fuel use, necessitated by increased generation.

The breakdown of these costs is shown below:

| | Plant Factor | |
|---|---|---|
| | 75% ($'000) | 80% ($'000) |
| Payments to fuel | 2,575 | 2,747 |
| Other Operating Expenses | 1,570 | 1,570 |
| Depreciation | 3,320 | 3,320 |
| Interest on Loan | 1,483 | 1,483 |
| Interest on Advances and Dividends | 1,848 | 1,848 |
| Share Capital Tax | 100 | 100 |
| Income Taxes | 158 | 158 |
| Other Taxes | 117 | 117 |
| Legal Reserve | 71 | 71 |
| Total | $11,242 | $11,414 |

These estimates for SENN's operation of the proposed nuclear plant are based on the proposed contractual and legal arrangements. They represent total costs incurred within a given period.

In comparing costs of operation of a nuclear plant and of a conventional thermal plant, an appropriate comparison implies an assessment of the costs to the enterprise. Reserves based on profits or taxes on profits are in this connection not true costs, since they are incurred by the enterprise only if revenues exceed costs. Furthermore, taxes on oil fuel for the conventional plant do not represent a cost to the economy as a whole, but only a cost to the enterprise. Therefore, estimates have been made showing both the comparative costs of the alternatives to the economy as a whole, and the costs of the alternatives to the enterprise.

#### Fuel

In the financial estimates, fuel costs included the rental costs of original fuel, transport and shipping insurance, fabrication, purchase of additional fuel, annual payments starting in the eleventh year of operation to cover the cost of original fuel. The costs were credited with receipts from return of plutonium and uranium. These estimated costs for

fuel reflect essentially cash payments made by SENN, and take no account of the value of the residual fuel remaining in the reactor after 20 years operation. Estimated value of such residual fuel is $4,160,000, based on the present U.S. prices for nuclear fuels.

For financial purposes, the cost of fabrication and transport of the initial core were capitalized and depreciated over 20 years, which has the effect of treating this cost as a capital investment with a life similar to that assumed for the nuclear plant as a whole. For purposes of cost comparisons between a nuclear and conventional thermal plant, it is more logical to amortize this cost separately over its own expected life (45 months) and to include it in the fuel cost. This item is estimated to cost $8,758,000, including $1,638,000 of interest. Taking account of the value of residual fuel remaining after 20 years and the cost of fabrication and transport of the initial core the adjusted net cost to the enterprise for fuel would amount to $58,918,000 for the 20-year operating period, corresponding to an annual average of $2,946,000.

Other Operating Expenses

These comprise: a) operation and maintenance, b) administration and general, and c) insurance. The earlier estimates need no adjustment.

Depreciation

The financial cost estimates are based on 20-year straight line depreciation of the total investment. As indicated earlier, the cost of fabricating and shipping the initial core is shifted to fuel costs for purposes of nuclear-thermal cost comparisons.

The remaining investment may be divided into two categories:

(a) equipment equally usable for nuclear and conventional thermal plants;

(b) equipment peculiar to a nuclear plant.

The useful life of conventional thermal equipment may be estimated at 30 years. The useful life of a reactor cannot be accurately estimated, because of limited experience. There is no inherent reason to believe that it need be less long-lived than the conventional alternative after initial difficulties are surmounted, but it is reasonable to make some allowance for such difficulties. For this reason a useful life of 20 years for the reactor has been assumed. Since the cost of the reactor represents about 40% of the investment, a conservative average life of 25 years has been used for the plant as a whole.

Total investment is estimated at $66.39 million. Deducting $7.12 million for the cost of fabricating and shipping the initial core, including spares, and 10% for contingencies, leaves a net adjusted investment of $59.27 million in the nuclear plant, subject to depreciation. Of this total, about $35.3 million is for the conventional part of the plant and $24 million for the nuclear part.

Depreciation for cost comparison purposes is taken on a sinking fund basis over 25 years, assuming 6% per annum interest on the accumulated fund.

Return on Investment

The financial costs include (a) interest payable on the proposed loan according to the contemplated provisions for repayment and (b) 7% on share capital and shareholder's advances.

Interest payments decline as repayments are made. As the cash flow forecast indicates, substantial cash balances are expected to accrue after the first few years and these could be used to expand the plant or retire debt faster than contemplated under the terms of the proposed loan. Whether used for new plant, debt retirement, investment in short-term securities or invested in other power utility securities, revenues would be increased or financial charges reduced.

When depreciation is computed on the sinking fund basis and a return on the accumulated fund is assumed, calculation of the return on investment is simplified. In the calculation of rates of return it was found appropriate to consider the total investment as a unit. This would also simplify the cost comparison, since it makes it unnecessary to estimate the proportions of capital structure attributable to debt, share capital and shareholder's advances for the conventional thermal alternative.

In the estimates, it has been assumed that the overall cost of capital to the enterprise is 6-1/2% per annum. For the nuclear plant this amounts to $3,853,000 on the adjusted net investment of $59.27 million.

Treatment of Certain Taxes and Reserves

The national income tax and local taxes based on net income have been excluded from the nuclear-thermal comparison, as indicated earlier, because they are incurred only if revenues exceed costs. Further, from the standpoint of the national economy, they constitute a transfer of income rather than a real cost to the economy.

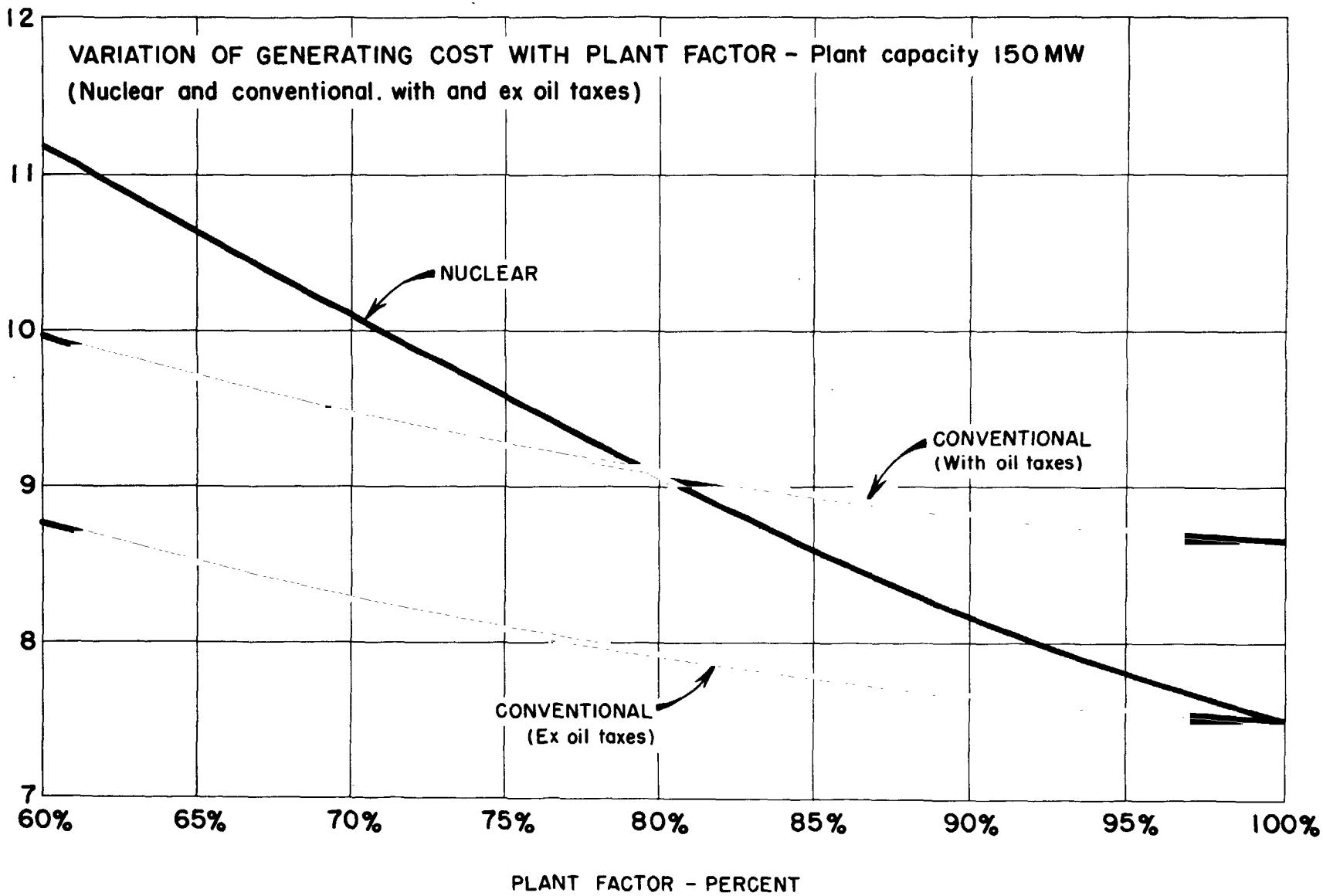
The tax on share-capital is included in costs because it is a fixed sum like a license fee or franchise tax, clearly a cost of doing business, irrespective of profits.

The legal reserve is required by Italian law; since provision need only be made in the event of profits, it is excluded for reasons cited earlier.

In summary, for purposes of nuclear-thermal comparison, costs are defined as excluding certain taxes and reserves included in financial costs. Fuel costs are increased reflecting the inclusion of the expenditures for fabrication and shipping of the initial core. Investment in the nuclear plant, subject to depreciation, is reduced by the cost of this item. Depreciation on the adjusted investment is calculated on a sinking fund basis, using

an average life of 25 years. Finally, costs include an allowance for a return on total investment rather than separate costs of the different forms of capital.

# ITALY: SENN NUCLEAR PLANT

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ANNEX 12

Annex 13

## SENN NUCLEAR PLANT

### Comparison of Annual Production Costs of 150 MW Plants (Nuclear and Conventional) at Varying Plant Factors

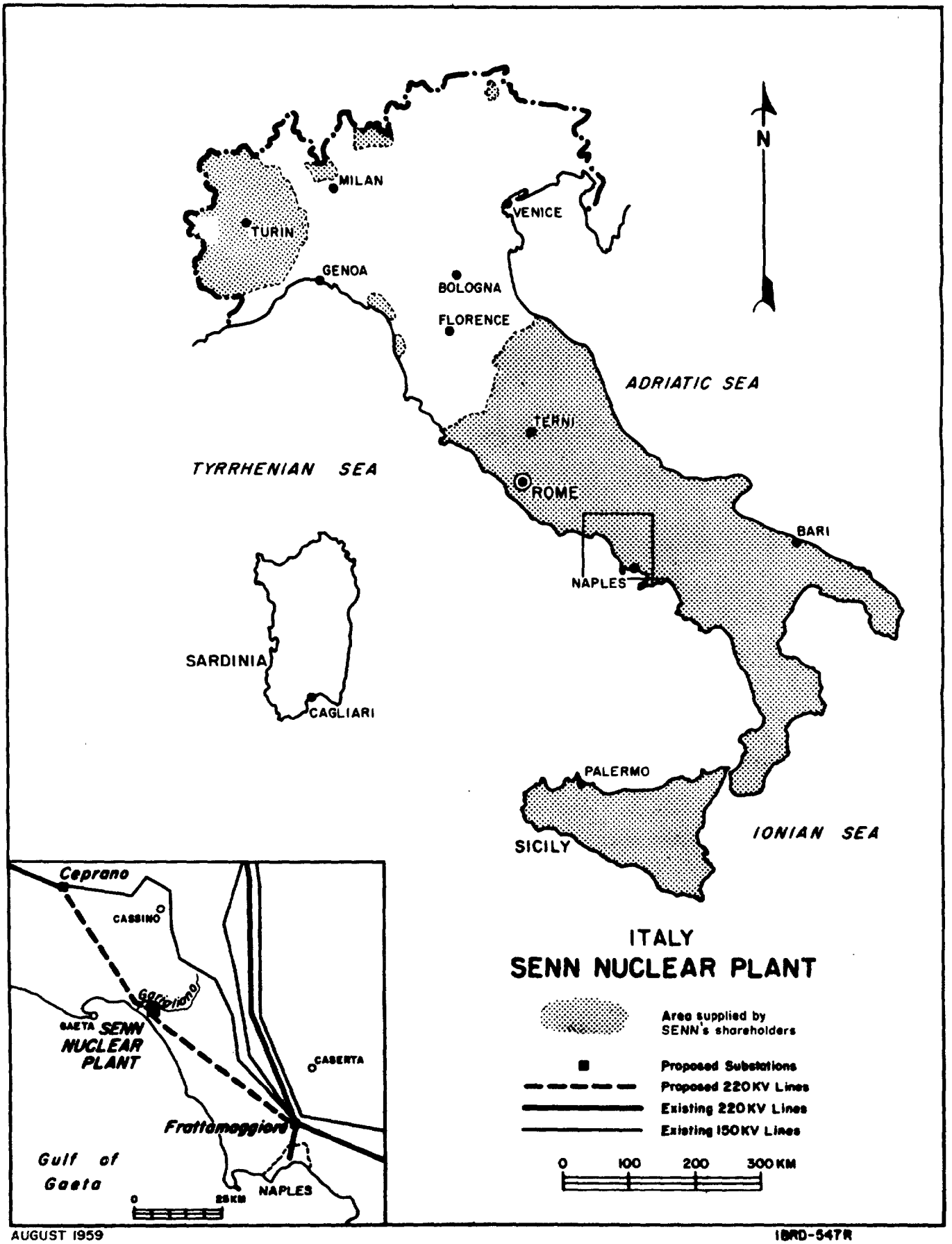
| | Nuclear | | Conventional | | | |
|---|---|---|---|---|---|---|
| | | | ex Tax | | With Tax | |
| Plant Factor | 75 | 80 | 75 | 80 | 75 | 80 |
| Fuel ($000) | 2,829 | 2,946 | 5,286 | 5,638 | 5,286 | 5,638 |
| Fuel Tax ($000) | - | - | - | - | 1,163 | 1,240 |
| Operation & Maintenance and Insurance ($000) | 1,570 | 1,570 | 841 | 841 | 841 | 841 |
| Taxes (except those based on profits) ($000) | 100 | 100 | 35 | 35 | 35 | 35 |
| Depreciation-Sinking Fund Basis ($000) | 1,080 | 1,080 | 296 | 296 | 296 | 296 |
| 6-1/2% return on Investment ($000) | 3,853 | 3,853 | 1,518 | 1,518 | 1,518 | 1,518 |
| Total Cost ($000) | 9,432 | 9,549 | 7,976 | 8,328 | 9,139 | 9,568 |
| Net Generation (kwh (000,000)) | 985.5 | 1,051.2 | 985.5 | 1,051.2 | 985.5 | 1,051.2 |
| Cost per kwh (mills) | 9.57 | 9.08 | 8.09 | 7.92 | 9.27 | 9.10 |
| % Cost Difference of nuclear over conventional at same plant factor | | | +18% | +15% | +3% | |

Annex 14

## SENN NUCLEAR PLANT

## Rate of Return Comparisons
(150 MW)

| | Economy | | Enterprise | |
|---|---|---|---|---|
| Plant Factor | 75 | 80 | 75 | 80 |
| Costs (excluding 6-1/2% return on capital | | | | |
| Nuclear ($000) | 5,579 | 5,696 | 5,579 | 5,696 |
| Conventional ($000) | 6,458 | 6,810 | 7,621 | 8,050 |
| Excess Costs for Conventional ($000) | 879 | 1,114 | 2,042 | 2,354 |
| Excess Investment for Nuclear ($000) | 35,910 | 35,910 | 35,910 | 35,910 |
| Cost Saving as % on Excess Investment | 2.4% | 3.1% | 5.7% | 6.6% |

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