

PROSPECT AND POTENTIAL OF NUCLEAR POWER PLANTS IN INDONESIA

I.R. SUBKI, ADIWARDJO, M.S. KASIM,
A. ISKANDAR, MULYANTO
BATAN, Jakarta,
Indonesia



XA9743461

Abstract

In line with the national energy policy of Indonesia in promoting the intensification, diversification and conservation of energy, some important steps need to be taken in order to establish alternative energy strategies which will be decisive in the formulation and development of the national energy plan in the future. At present, Indonesia does not have any nuclear power plants. The introduction of nuclear power in Indonesia is not only to reach an optimum energy mix based on costs and the environment, but also to relieve the pressure arising from increasing domestic demand for oil and gas.

This paper addresses the present feasibility study being performed on the introduction of nuclear power plants in Indonesia. It is anticipated that nuclear power will contribute about 10% of Indonesia's electrical supply as of the year 2019. This represents approximately 12,600 MWe in capability. The paper describes the results, to date, of the Feasibility Study on nuclear power including the national energy market analysis, the electricity expansion plan and the associated role of nuclear power, the economics and financial plan, site studies on volcanology, seismology and the environment.

I. INTRODUCTION

The main objective of the Indonesian Long Term Development Programme is to give stress to development of the national economy, through developing a more active and advanced national industry, supported by a strong agriculture, which in turn will create a strong basis for a self-sustaining growth and development in the efforts toward social justice and welfare of the people based on our Five Principles (Pancasila) ideology.

Accordingly, the development of the national industries will need the supply of an abundant amount of energy. It must be noted, however, that the growth of this development should be maintained equally and widely spread, and to assure a self-sustaining development in accordance with the principle of social justice.

This principle is an important guideline in establishing the national energy policy for the future in supporting our second long term 25 year development programme, whereas the main objective would be the creation of a high quality people, a better standard of living, a healthier environment, and a prosperous and peaceful nation.

In line with the national energy policy in promoting intensification, diversification and conservation of energy, some important steps need to be taken in order to establish alternative energy strategies which will be decisive in the formulation and development of the national energy plan in the future. At present Indonesia does not have any nuclear power plants. The introduction of Nuclear Power Plants in Indonesia is not only to reach an *optimum energy mix* based on costs and environment, but also to relieve the pressure arising from increasing domestic demand for oil and gas. Therefore, oil and gas could be used for other strategies, such as for export and feedstocks to support the take-off era towards the 2nd

Long Term Development Programme. This strategy is an integral part of the overall energy strategy.

Even though Indonesia has some oil and gas resources, it has to be realized that these resources are not abundant and not unlimited. The role of Nuclear Power Plants is clearly to stabilize the supply of electricity, conserve strategic oil and gas resources and protect the environment from deleterious pollutants.

II. NATIONAL ENERGY POLICY

Indonesia has been implementing a National Development plan, whose goal is to create a just and prosperous nation. The first 25 years of the National Development plan was called the first long term national development programme. This programme was started in 1969 and consisted of Five-Year Development Programmes. One of the main objectives of the first long term national development programme is to broaden the basis of our economic structure, that is to strengthen and to promote national industrialization. The national programme on industrialization has given rise to substantial increase in the demand for energy. The energy sector is of particular importance in the development of the Indonesian economy, as Indonesia's current per capita energy consumption is relatively low compared to other ASEAN countries. The increase of population, especially in the rural areas do not yet have adequate access to electric power, an indication of an expected high growth rate of electricity generation. Most energy resources are located outside the Island of Java, yet Java, with its large population and industry constitutes the major area of energy demand. In a way which maximizes economic efficiency and provides employment and regional development opportunities, the Government has adopted a policy of promoting development of the energy resources with a view toward more diversification.

Historically, Indonesia's energy policy and petroleum policy were synonymous. Oil had the dual role of being the nation's prime source of commercial energy and of providing both foreign exchange and Government revenue to finance economic development. By the late 1970's however, domestic consumption grew at an annual rate of up to 15 %. Domestic consumption began to divert oil from the export market. In the late 1970's, the Government embarked on an ambitious programme to move domestic energy consumption away from crude oil in order to maximize the amount of oil production available for export. The indirect result of this diversification effort was the construction of electrical generation facilities which utilize non-oil energy resources such as coal. Cement plants were converted from burning oil to using coal. Diversification also led to increasing use of liquefied petroleum gas (from gas reserves) by households. There were also plans for increasing utilization of natural gas in domestic industry and for electricity generation.

Briefly, our National Energy Policy has four main objectives. These objectives include :

1. To secure the continuity of supply of energy for domestic use at prices affordable to the public,
2. To enhance the quality of life of the people,
3. To stimulate economic growth, and
4. To reserve an adequate supply of oil and gas for export, in order to provide an important source of foreign exchange to fund national development programs.

There are three policy measures adopted by the government to meet these objectives :

1. Intensification, i.e. to increase and expand exploration of energy sources available in the country.
2. Diversification, i.e. to reduce dependence on only a few sources of energy (i.e. gas and petroleum), and later to replace it with other available sources.
3. Conservation, i.e. to economize on the energy use and to increase the efficiency of energy production.

Implementation of the energy policy covers several aspects such as issuance of regulations, standards, energy pricing incentives and disincentives, and the application of appropriate technologies. The technologies that would be considered are identified as follows :

- a. Technology to produce substitutes for oil, as oil is non-renewable, Gasi-fication and liquefaction of coal could well meet the fuel needs of the future.
- b. Technologies to support a more sustainable energy supply, through the harnessing of available and renewable energy sources.
- c. Clean and efficient energy technologies to support environmental concerns.

III. The Present Feasibility Study for The First NPP In Indonesia

In September 1989 the Indonesian Government through the National Energy Co-ordination Board (BAKOREN) decided to perform anew the NPP feasibility study including a comprehensive investigation of the Muria site. The study itself should be carried out by the National Atomic Energy Agency (BATAN), under the directives of the Energy Technical Committee (PTE) of the Department of Mines and Energy, and in cooperation with other institutions.

On August 23, 1991, an agreement was signed in Jakarta between the Indonesian Ministry of Finance and BATAN on behalf of Indonesia, and the consultancy company NEWJEC Inc. This agreement contracts NEWJEC for a four and a half year period to perform a site selection and evaluation, as well as a comprehensive nuclear power plant feasibility study. The principal part of the contract value will be spent on studies related to the site, which is to be sought in the northern coast of the Muria Peninsula in Central Java.

The scope of the feasibility study includes two main components

1. The non-site studies, covering energy economics and financing, technical and safety aspects, the fuel cycle and waste management, and general management aspects, among other things.
2. Site and environmental studies, covering field investigations and assessment of site selection, site qualification/evaluation, and environmental, socio-economic and socio-cultural impacts.

On December 30, 1993, two years after the starting date (22 November 1991), NEWJEC submitted the feasibility study report (FSR) and preliminary site data report (PSDR) to BATAN. At the end of the four and half year contract, a final report will be provided, including a site and environmental report, and a preliminary safety analysis report. These documents will provide the information necessary for site permit application, for the

design engineering basis and other industrial infrastructure preparations. The attached Figure-I shows the overall schedule of the feasibility study.

In this chapter a more general description concerning the results of the Feasibility Studies including National Energy Market Analysis, Electric Expansion Plan and the role of NPP, Economics and Financial Study, as well as Site Studies on Earthquake, Volcanology and Environmental Impacts shall be presented.

III.1 National Energy Market Analysis

The objectives of the National Energy Market Analysis are to conduct a study of the national energy development to support the long term energy demand, and to conduct analysis of the energy system, specifically the electrical energy sector by the use of the ENPEP (Energy aNd Power Evaluation Program).

This report includes an analysis of the evolution of the energy market, evaluation of energy resources, forecast of energy demand, analysis of energy demand management options, and the formulation of an energy supply planning.

Following are some tables showing results of the Macro Economic, Energy Demand and Energy Supply projections.

a. Macro Economic Projection

	GDP GROWTH TOTAL (%/year)	POPULATION GROWTH (%/year)
1990 - 2000	6.50	1.87
2000 - 2010	6.00	1.35
2010 - 2019	5.00	0.85

b. Energy Demand

The energy demand will increased by 6 - 7% per year during the study period of 30 years (1990 - 2019).

	GROWTH OF TOTAL ENERGY DEMAND (%/year)	ELECTRICITY DEMAND GROWTH (%/year)
1990 - 2000	6.27	10.30
2000 - 2010	7.20	9.64
2010 - 2019	7.09	8.27
AVERAGE GROWTH	7.18	9.41

c. **Energy Supply**

- **Share of Primary Energy Supply during the Study Period**

PRIMARY ENERGY	1990	2000	2010	2019
OIL	60.21	60.79	51.14	34.34
GAS	32.52	18.60	7.01	3.41
COAL	5.72	18.21	35.55	54.29
NUCLEAR	0.00	0.00	3.92	6.18
OTHERS (hydro, geothermal)	1.55	2.40	2.38	1.79

d. **Crude Oil Projection (%)**

- **Crude Oil Projection during the Study Period**

PRIMARY ENERGY	1990	2000	2010	2019
OIL	60.20	60.80	51.10	34.3
(DOMESTIC PROD.)	(92.1)	(48.0)	(21.4)	(12.8)
(IMPORT)	(7.9)	(52.0)	(78.6)	(87.2)
(EXPORT)	(51.1)	(32.5)	(17.0)	(11.4)

III.2 Electric Expansion Plan and The Role of NPP

The Electric expansion studies include studies on the Electric System Analysis and Choice of Unit Size.

a. **Electric System Analysis**

The objective of the Electric System Analysis, is to determine an optimum configuration for the Java-Bali electric generation system with the introduction of Nuclear Power Plants including the size and its main features.

The results obtained through the optimization study in the development of the Java-Bali electric generation system with the use of the ELECTRIC module (WASP III) of the ENPEP program, shows that the introduction of nuclear power plants in the early 2000s to the Java-Bali electric system represents an optimal solution.

b. Choice of Unit Size

The objective of Choice of Unit Size study, is to determine the nuclear power plant unit size, taking into consideration the capability and reliability of the electric network system in relation to the load flow, short circuit capacity and the stability of the network.

The results show that commencing in the early 2000s and supported by development of the electrical network, the introduction of the 600 to 900 class nuclear power plants into the Java-Bali electric system is absolutely possible, furthermore based on economic aspects, the introduction of the 900 unit size class is a better option. Meanwhile, to anticipate the increasing demand of electricity in the future, it is very necessary to conduct updating studies of the electric network system.

Based on the above studies, the following may be concluded :

Coal fired plants will dominate the electricity generation system. Nuclear power plants will be feasible to be in operation in the early 2000s (based on current projection studies). Nuclear power plants will increase in accordance with the demand. The result of the analysis of this scope of work is used as reference for optimization studies in the development of the Java-Bali electric system.

In the year 2019 the role of nuclear power plants will give a contribution of 10% to the electricity supply, an amount equal to about 12600 MW.

III.3 Economics and Financial Study

a. Nuclear Cost Estimate

This study covers an analysis of capital cost (based on vendor's overnight cost, in April 1992 US dollars) for each type of nuclear power plant, as offered by various vendors: Mitsubishi Heavy Industries (Japan), Atomic Energy of Canada Limited, Nuclear Power International (German - French Consortium), Westinghouse Electric Company (USA), General Electric Company (USA). Comparisons of maintenance and decommissioning costs of the various designs, based on NEWJEC's method and experience are given.

The results of the analysis and information acquired are as follows :

1. The capital costs (vendors budgetary estimate) of various types and capacities of conventional NPP (600 - 1000 MW) is around 1530 - 2200 US\$/kWe and 1530 - 2020 US\$/kWe for advanced designs.

2. The operation and maintenance cost of various types and power of NPP averages about US\$ 70/kWa.
3. The estimated decommissioning cost is around 10% of the capital cost.
4. The data and information from points 1, 2 dan 3 have been used as a basis for Generation Cost calculation of nuclear power plants.

b. Financial Study

The objective of the Financial Review Study, is to obtain various options and sources of viable financing for the construction of Nuclear Power Plants in Indonesia. The scope of the study consists of : 1) Conventional Financing, and 2) BOO/BOT Financing Scheme. Following are the results of the study :

1. Conventional Financing

Implementing conventional financing for the construction of 600 or 900 MW units can be done like any other construction of power plants. Feasible or viable sources of financing can be conducted for example : US component 50%-Japanese component 50%, US component 100%, French component 50%-German component 50%, and Canadian component 100%.

The results show that the energy price of the 600 and 900 MW class Nuclear Power Plant units are competitive to the energy price of similiar capacity of Coal Fired Plants using deSOx and deNOx equipment.

2. BOO/BOT Financing Scheme

The study is still very preliminary in nature.

The implementation of the BOO/BOT financing scheme for 600 and 900 MW unit nuclear power projects in Indonesia should be supported by the Government through the following instruments :

- The need of a bilateral agreement between the Government of Indonesia and the related country concerning the use of nuclear energy for peaceful uses.
- Activities related to the decommissioning and back end of the fuel cycle.
- Guarantee of fuel supply.
- Third Party Liability insurance from nuclear hazards.

Furthermore a power purchase agreement is necessary between PLN with the company, covering the following guarantees and requirements :

- a. The obligation of PLN to remit payments according to the requirements, using the agreed determined exchange rates.
- b. A guarantee by the Government to return loans, dividends, and other financial arrangements in the determined exchange rate and currency.

III.4 Site and Environmental Studies

Site and Environment Study (SES) for the NPP in the Muria Peninsula has been going on since end of 1991. The study consisting of general site survey, site evaluation, and site confirmation currently has reached its third or final stage. The completion of the study is scheduled for May 1996, with the submission of complete report of Site Data Report (SDR), Preliminary Safety Analysis (PSAR), Environmental Impact Analysis Report (EIAR), and the Final Report of Site and Environmental Study (FR-SES).

By far, preliminary conclusions drawn from data and information of the study show that the candidate site, Ujung Lemahabang (ULA), an area of approximately 500 hectares at the Northern part of Peninsula, is the best choice for the siting of NPP from both technical and economical point of views. There is no immediate hazard that could affect the NPP integrity and its operation.

The Site Studies concern many aspects, however, only the results of the volcanology, seismology and environmental studies will be briefly described here, as follows :

a. Volcanology and Seismology

These two aspects of SES receive special attention during the study. Networks of Microearthquake Telemetry System (MTS) consists of 5 and 3 seismometers are installed in the area. This system records every single earthquake with the magnitude of < 3 Richter. To record earthquake having $M > 3-5$, A Strong Motion Accelerometer (SMA) system is installed at the Ujung Lemahabang site. By far, no single earthquake that could trigger this SMA system is ever recorded.

There are two volcano systems in the area, they are, the Genuk and Muria volcanos. Mount Genuk (719 m) had activities in the age between 3.29 to 1.65 ma, and had lasted till about 0.49 ma. Mounth Muria (1602 m) that is situated in the center of Peninsula had

activities between 2.1 to 0.8 ma. The last volcanic eruption is judged to have occurred about 0.32 ma ago. The candidate Site, Ujung Lemahabang, has never been affected by lava or pyroclastic flows from either volcano. Careful assessment of the phreatic and gas emission phenomena at flank of Muria is still underway.

b. Environmental Studies

As mentioned before, most of environment studies in the candidate site Ujung Lemahabang are still underway. However, preliminary results in some aspects of studies further confirm the acceptability of Ujung Lemahabang.

The following parts is the highlight of preliminary results in the environment studies:

1. Evaluation based on the screening distance value (SDV) shows that none of sources of Man-Induced Event identified in near the site may affect the safety of the site.
2. No extreme meteorological phenomena such as tropical cyclone that may threaten the site is foreseen.
3. No sensitive ecological systems and communities are found within the 5 km radius from the site.

III.5 The Prospect and Public Concern of NPP in Indonesia

The prospect of Nuclear Power in Indonesia is very good both in the medium and long term future. Indonesian geography, resource distribution and population distribution have a great influence on the nuclear prospect besides environmental consideration. From the political point of view, we have got a new and stronger momentum from President Soeharto, who stated on 5 May 1995 that Indonesia should carefully plan for the nuclear power plant construction with due attention to its safety. We are now working on two main issues in nuclear power introduction, namely :

1. Public acceptance, where few important figures are still influenced by the negative information from anti-nuclear group.
2. Financing scheme, where we should choose the right scheme to make the NPP's really viable economically.

a. Public Acceptance

There have been growing concerns coming from the Indonesian public on the use of nuclear energy, especially concerning issues of NPP. Non Governmental organization and environmentalist have come up, making the public acceptance programme more challenging.

To enhance the public on the peaceful uses of nuclear technology including the aspects of nuclear power plants, an interdepartmental organization has been established since the year 1990. This interdepartmental organization, coordinated by National Atomic Energy Agency, has made efforts in promoting, giving information, and discussing openly to the public on the peaceful uses of nuclear energy and especially to the immediate environment where the feasibility site studies are being conducted. Efforts such as these will be a continuing program, as also practiced by many other countries.

This endeavor may not be enough. However, experiences from industrial countries that already have a history of NPP, may contribute positively to our endeavor, and cooperation among countries in this respect may also add to global concern on the need of NPP.

b. Financing of Nuclear Power Plants

As financing of nuclear power plants require large amounts of funding, it is necessary that funding of NPP must be considered as sound investments and being economically beneficial, not only to the NPP itself, but to expand the industrial capability and participation. Domestic industrial participation in the NPP construction assessed so far would represent around 25 % for the first units, and can increase progressively to 35 % for the third units. This means that large business opportunities will emerge in parallel with the required capabilities in the domestic industries themselves.

In case of expected substantial share of domestic participation, related domestic investments should be made available sufficiently and timely to support the required increased capabilities. These investments include also the development of human resources.

However, it will become more difficult to acquire funding in the future, which will be a challenge in the endeavor to build high scale projects having long investments periods. In order to prevent financial matters in becoming a hindrance, it is very important to anticipate this matter as early as possible by efforts to increase cooperation among nuclear concerned countries so that financial institutions will support and be in favour of building of nuclear power plants.

Type of Study	Year				
	1	2	3	4	5
A. SITE AND ENVIRONMENTAL STUDY					
1. Data acquisition and identification of two (2) alternative sites	[Bar]				
2. Selection of a preferred site		PSDR			
3. Evaluation of the preferred site			[Bar]		PSAR EIAR FR-SES
B. NON-SITE STUDIES			FSR		FFSR

- PSDR - Preliminary Site Data Report
- FSR - Feasibility Study Report
- SDR - Site Data Report
- PSAR - Preliminary Safety Analysis Report (Site Part)
- EIAR - Environmental Impact Analysis Report
- FR-SES - Final Report of Site and Environmental Study
- FFSR - Final Feasibility Study Report

Figure-1. Time Schedule of the Feasibility Study for a Nuclear Power Plant in the Muria Peninsula Region

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