Status of Nuclear Energy Program in Indonesia

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Abstract. The demand for energy, especially in the form of electricity, continues increasing in developing countries like Indonesia. Electricity is indeed the main fuel for industrialization and socio-economic development in any country. The increase of population, especially in the rural areas where adequate access to the electric grid has not been available yet, is consequently leading to an expected high-growth rate of electricity demand. In recognition of the need to develop a viable nuclear regulatory infrastructure, the government of Indonesia has issued the new basic nuclear energy act on April 1997 (Act No. 10 of 1997). In this new act, the responsibility to promote the application of nuclear energy is vested to the “Promotional Body” (National Nuclear Energy Agency or BATAN) and the responsibility to regulate and control is vested to the “Regulatory Body” (Nuclear Energy Control Board or BAPETEN). Regarding the International engagement, the Preamble of the Indonesian Constitution stipulates among others, that Indonesia will take part in maintaining the world order based on freedom, eternal peace and social justice. Therefore when the Treaty on Non Proliferation (NPT) entered into force in 1970 the Government of Indonesia immediately acceded to the Treaty on the same year, the Treaty was then ratified in 1978. At the present time, there are no power reactors in the country. The first idea to have a nuclear power plant in Indonesia however has started in 1956, and then until 1996 many activities on the preparation of NPP introduction including the feasibility study have been done without any conclusive result. The recent study of long energy and electricity planning namely “Comprehensive Assessment of Different Energy Sources for Electricity Generation in Indonesia” prepared by Indonesian Team and supported by IAEA has already finished in 2001. The result of this study shows that the introduction of NPP on Java-Bali electricity grid to suffice the optimum energy mix will be in 2016 for 2 GWe and it will reach more than 6 GWe in 2024. However, the general prospect for nuclear power is relied on two main driving forces, such as public and political acceptance and economic and financing scheme.

1. Introduction

The demand for energy, especially in the form of electricity, continues increasing in developing countries like Indonesia. Electricity is indeed the main fuel for industrialization and socio-economic development in any country.

From another perspective, the existence of energy demand can be considered as the most important driving force for installing or introducing a new power generating plant. Another driving force that can be mentioned here is the existence of national energy policy and plan in the country. This policy will provide guidance to experts, industrialists, entrepreneurs, business people, and even laymen on how they can contribute their creativity to achieve the vision and road map of energy supply in the country.

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Indonesia is an archipelago. It consists of more than 17,700 islands. Its population is around 210 million people. Energy consumption per capita per year is very low, or about one third (1/3) of the average consumption of ASEAN people. Indonesia still has reasonable abundance of natural resources as an asset to contribute to a rapid socio-economic development in the 21st century.

At the present time, we live in the 21st century, an era of unprecedented change due to globalization, an era of uncertainty and challenge but also of great opportunities. These phenomena have great impacts on every nation and community, including our nuclear community. Globalization has enhanced people’s awareness of safety and global environmental pollution due to green house gases especially CO2, the main cause of global warming. Fossil fired plants are the source of CO2 emission. By contrast, the present use of nuclear power has been able to avoid 8% of global CO2 emission. It is therefore our task to convince people and national decision makers to objectively consider nuclear power plant for energy supply in the country if it is competitive.

2. National Energy Policy

Indonesia has considerable reserves of primary energy resources, even though not abundant. At present the Indonesian energy consumption per capita is relatively low even as compared to other ASEAN countries. The increase of population, especially in the rural areas where an adequate access to the electric grid has not been available yet, is consequently leading to an expected high-growth rate of electricity demand. Most energy resources are located outside of the Java Island, while Java has large population and industries, constitutes the major area of energy demand. The government has adopted a policy of promoting development of these energy resources in a way that will maximizes economic efficiency and provides regional development and employment opportunities.

Briefly, the National Energy Policy has a vision to secure the energy supply for national interest. This vision should be realized by implementing five missions, as follow:

1. To secure the continuity of domestic energy supply
2. To enhance the added value of energy sources
3. To manage the energy use ethically and sustainable in considering the preservation of environment.
4. To make available the attainable energy for poor people and less develop region.
5. To enhance the national capability for energy development.

In order to provide successful support to the national missions, an integrated and solid energy policy has been set up. Principally, there are three main energy policy measures:

1. **Intensification**: to increase the available energy sources in accordance with the increasing of economic and population growth;
2. **Diversification**: to reduce the dependence on certain fuel types and to develop optimally and economically other available fuels;
3. **Conservation**: to enhance the efficiency of energy in developing the efficient technology used in the energy production and utilization.

These main policies should be followed by several supporting policies, such as:

1. Development of energy infrastructure to increase energy availability in order to open the
1. Energy access for consumers.
2. Establishment of market mechanism in the energy production and utilization.
3. Protection of poor people to ensure energy accessibility, especially for poor urban, villages and remote areas.
4. Preservation of environment to minimize the environmental impact related to all of energy activities.
5. Establishment of partnership between government and private sector to perform the energy sector development especially for the big scales.
6. Reinforcement the people to develop energy availability by themselves, especially for villages and remote areas.
7. Strengthening the research and development as well as training and education for preparing the technology and man-power in the energy sector.

Nuclear energy is mentioned in the national energy policy as a possible energy to be developed in Indonesia because of more economic, proliferation resistance, environmentally friendly. Nuclear energy is taken account to support the diversification policy to electricity development in the future.

3. Status of Nuclear Research Reactor

Presently, National Nuclear Energy Agency of Indonesia has operated 3 (three) research reactors. The first reactor was commissioned in 1964. It was TRIGA MARK type with capacity of 250 KWt located in Bandung Nuclear Facility Area -West Java. To fulfill the demand on utilizing of that reactor, then, the capacity was upgraded to be 1 MWt. This reactor was mainly used for radioisotope production and used as training facility. In the year of 2000, this reactor was upgraded again to the power of 2 MWt while to change the critical components. The second research reactor was also TRIGA MARK type that commissioned in 1979 located in Yogyakarta Nuclear Facility Area. The power capacity of this reactor is 100 KWt. This research reactor was utilized for training and conducting experiment on reactor physics and experiment related to sub-critical assembly. This research reactor is planned to be up-rated to the power of 250 KWt. The first and the second research reactor have limited in function due to low neutron flux and limited space for irradiation facilities.

As the BATAN organization growth and the BATAN program developed, on introducing the Nuclear Power Plant in Indonesia. Therefore BATAN needs an adequate nuclear facility to support that program. For that reason, BATAN established nuclear facility area near Jakarta called Serpong Nuclear Facility Area on which the third research reactor was also established. By the way it can be said that the establishment of this nuclear facility was connected to the program of the first NPP introduction in Indonesia. For supporting this program, some laboratories were established i.e. research reactor in MTR type and as the third research reactor in Indonesia, radioactive waste treatment laboratory, fuel fabrication plant, engineering and safety laboratory, radio-metallurgy laboratory, radioisotope production laboratory, nuclear mechanic-electric laboratory, etc.

The third research reactor due to its function was called the Multi-purpose reactor that can be utilized for fuel and material testing, radioisotope production, to conduct experiment utilizing
neutron beam for neutron radiography and for basic research. The power of this Multi-purpose reactor is 30 MWt that suitable for material testing facility.

By the presence of those laboratories, research and development (R & D) activities related to the nuclear power plant technology were carried out. For examples, by utilizing the research reactor, R & D on fuel and material related to NPP can be carried out, by utilizing Engineering and Safety laboratory, R&D related to safety technology can be carried out including safety analysis and accident analysis.

The multipurpose research reactor was commissioned and getting the first criticality in 1987. The purpose to establish nuclear facility besides to support technologically to the introducing of NPP , it was also to prepare and provide the adequate man power development related to number and capability or skill for facing the project on the establishment of NPP in Indonesia.

By conducting experiments using laboratories the experiences, knowledge and capability of the personnel would be developed. The man power development was also carried out by sending the personnel to abroad in the form of study, training and design participation. Study and training were conducted by government to government cooperation in the field of nuclear technology. Design participation was conducted by joining of Indonesian staffs to the vendor of nuclear power plant, for examples to Westinghouse on the design of AP600, to General Electric on the design of SBWR, etc.

4. Status of Nuclear Power Plants

At the present time, there are no power reactors in the country. In the seventies the National Atomic Energy Agency (BATAN) initiated a program for introducing nuclear power in the country. The activities on site selection were then conducted in several places in Java Island and a site at Muria peninsula has been recommended.

The first idea to have a nuclear power plant in Indonesia however has started in 1956 emerging from the university circle in Bandung and Yogyakarta in the form of seminars. The real task was started in 1972 when the Commission for Construction Preparation of NPP (KP2PLTN) was created by National Atomic Energy Agency (BATAN) and Civil Work Department (PUTL Dept.).

The Karangkates Seminar in 1975 organized by BATAN and PUTL Department has obtained the result about the decision of nuclear power development in Indonesia. It was proposed 14 possibilities of NPP location in Java Island, among them 5 locations were lately declared to become the potential site, and then the Muria site in Central of Java was chosen as the best site.

The first feasibility study for the introduction of a nuclear power plant was conducted in 1978 with the assistance of the government of Italy. However, following this study the Indonesian government deferred the decision until the nuclear research facilities in Serpong became fully operational.
In 1985 work began on updating the studies with the assistance of the International Atomic Energy Agency (IAEA), US government through the Bechtel International, the French government through SOFRATOME and the Italian government through CESEN. These updated reports, and the analytical capabilities developed by the Indonesian partners during the process of this cooperation, have become the foundation for the present planning activities.

In September 1989, the Indonesian government through the National Energy Co-ordination Board (BAKOREN) decided to perform a new NPP feasibility study including comprehensive investigations of the Muria Peninsula as a candidate site for NPPs. The study itself was 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, including other institutions as well.

In August 1991, an agreement was signed in Jakarta between the Indonesian Ministry of Finance and BATAN on behalf of Indonesia, and the consultant’s company NEWJEC Inc. This agreement contract NEWJEC for a four and a half years period to perform a site selection and evaluation, as well as a comprehensive nuclear power plant feasibility study for a nuclear power plant (7000 MWe). The principal part of the contract’s 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 first two phases (Steps 1-2) were performed during years 1992 and 1993 and three candidate sites were compared and ranked. As conclusion of these studies, the "preferred candidate site" was obtained (i.e., Ujung Lemahabang site). The last phase of the investigations (Step 3) is the evaluation of indicated preferred site in order to confirm its acceptability and it was finished by the end of 1995.

In May 1996, the feasibility study for the first NPP in Indonesia was completed. The result of the feasibility study, especially on the electrical system analysis using the 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.

In addition after the feasibility study, another studies have been done, such as the preparation of bid invitation specification, development of financing study (BOO and Barter), re-evaluation of nuclear energy for electricity planning and study development of Muria site. Considering the impact of the economic crisis in 1998, a re-evaluation study on electricity planning has been done. The study was still going on, while BATAN performed research and development activities including reactor safety, radiation protection, fuel, and radioactive waste treatment.

The recent study of long energy and electricity planning namely “Comprehensive Assessment of Different Energy Sources for Electricity Generation in Indonesia” prepared by Indonesian Team and supported by IAEA has already finished in 2002. The result of this study shows that the Indonesia energy demand is projected to increase in the future.

The final energy demand will grow on an average rate of 3.4% annually reaching the figure of about 8146 Peta Joules (PJ) in the year 2025. It will grow more then 2 times as compared to the beginning of study. The biggest growth of energy demand about 4.5 times will be in the form of electricity. Its share in total primary energy demand will grow about 1.5 times.
Installed electricity net generating capacity in Indonesia reaches 100 GW at the end of the planning study horizon. Almost 75% of this capacity is required in Java. For all cases, the Gas Base-load Plant is the top ranked technology for electricity generation in Java; gas is used up to the maximum volume exogenously set in the supply study, corresponding to a share of 40% in total installed capacity in Java. From a mere economic point of standing, the Coal Base-load Plant is the second ranked of the three principal generation options.

The introduction of NPP on Java-Bali electricity grid will be possible in 2016 for 2 GWe and it will reach more than 6 GWe in 2024, using proven reactor PWR1000 (1000 MWe) with 85% capacity factor and investment cost of $2000/kWe. The study continued on the environmental aspect and externalities studies for year 2002, and the environmental constraints lead apparently to an earlier introduction of nuclear power plant.

5. National Nuclear Organization

In recognition of the need to develop a viable nuclear regulatory infrastructure in order to proceed with the development of nuclear power, the government of Indonesia has issued the new basic nuclear energy act on April 1997 (Act No. 10 of 1997) to replace the Act No. 31 of 1964 which have become inappropriate. In this new Act, the authority in executing and regulating nuclear energy is separated into two different institutions to guarantee the control of nuclear energy to be more credible in order to suffice the nuclear safety.

According to this new Act, Chapter II Article 3, the responsibility to promote the application of nuclear energy is vested to the “Promotional Body” (National Nuclear Energy Agency [NNEA] or BATAN) and, as stated in the Chapter II Article 4, the responsibility to regulate and control is vested to the “Regulatory Body” (Nuclear Energy Control Board or BAPETEN).

The institution which has responsibility to promote the applications of nuclear energy is vested in the promotional body, and the new President Decree No.197 of 1998 was also issued to established the National Nuclear Energy Agency (NNEA, also known as BATAN) which has responsibility to execute, and to promote the research and the use of nuclear energy in Indonesia.

In the year 2000, the Government of the Republic of Indonesia issued Presidential Decree No. 178/2000 concerning the new structural organization of Non Ministerial Government Agency where BATAN is one of its components. For the implementation of the Presidential Decree, the Chairman of BATAN issued Decree No. 166/Ka/IV/2001 concerning structural organization of BATAN. In this recent organization BATAN is headed by a Chairman with four Deputies and one Executive Secretariat.

One of the responsibility to regulate and to control nuclear energy is vested in the regulatory body, and in April 1998 the new President Decree No.76 of 1998 was issued to established the Nuclear Energy Control Board (NECB, also known as BAPETEN) which has been responsible for regulating and controlling the use of radioactive materials, radiation sources, nuclear reactors and nuclear materials in Indonesia. BAPETEN as an independent regulatory body has responsibility to assure that any activity related to the use of any nuclear energy is obligated to maintain the safety, security, and peace, as well as the health of the workers and the public, and also the protection of the environment.
BAPETEN which is headed by a Chairman, 2 Deputies, one Safety Committee, and one Safeguards Unit, has 6 Directorate, and one Secretariat which is to regulate, and control the use of radioactive material, radiation, nuclear reactors and the nuclear material in Indonesia and these are located at Jakarta, the capital city of Indonesia. Figure 4 shows the organizational structure of BAPETEN based on the Decree of the Chairman of BAPETEN No.01/K-OTK/VIII-1998 and the BAPETEN is directly responsible to the President.

Considering the manpower resources, there are many universities engage in technical education. At Yogyakarta, Gadjah Mada University has been engaging in nuclear engineering education since 23 years ago. Whereas Institute for Nuclear Science and Technology has started operation since 2001 under the direction of the management of National Nuclear Energy Agency (BATAN). Another high-level educational institution engaging in technology with profound infrastructure is Bandung Institute of Technology and University of Indonesia in Jakarta. These institutions also provide vocational training in various disciplines including engineering and safety aspect for industrial purposes.

6. Non Proliferation Treaty (NPT)

The Preamble of the Indonesian Constitution stipulates among others, that Indonesia will take part in maintaining the world order based on freedom, eternal peace and social justice. Therefore when the Treaty on Non Proliferation (NPT) entered into force in 1970 the Government of Indonesia immediately acceded to the Treaty on the same year, as part of its commitment to take part in maintaining the world order based eternal peace. The Treaty was then ratified in 1978, in the form of Indonesian Law No. 8 of 1978. The ratification was then followed by signing Safeguards Agreement with IAEA in 1980. This Safeguards Agreement is a legal basis for the implementation of internationally controlled safeguards in Indonesia and the establishment of State System of Accounting for and Control of Nuclear Material or SSAC. Please note that in 1967 (13 years before the signing Safeguards Agreement with IAEA), Indonesia has already signed three lateral agreements on Safeguards between Indonesia, USA and IAEA for the nuclear fuel of TRIGA MARK II Research Reactor in Bandung.

This milestone explicitly reflects the initial step towards the fulfillment of the Indonesian commitment to establish the world free of nuclear weapons. This step was further followed by joining the IAEA program on strengthening the safeguards systems such as Early Notification of Design Information (1992), Reporting Scheme (1995) and others. In addition, Indonesia joined the others in approving the Indefinite Extension of NPT in 1995.

Other development with regard to the NPT was the establishment of the Southeast Asia Nuclear Weapon-Free Zone (SEANWFZ). As maybe noted the 10 Heads of States of Asean Countries signed in Bangkok on December 15, 1995 the Treaty on the South East Asia Nuclear Weapon-Free Zone. Indonesia then ratified the Treaty in 1997 in the form of Law No. 9/1997. Since the signing, Indonesia has been actively pursuing the implementation of the Treaty.

Finally, to answer the need for more transparency in peaceful uses of nuclear energy, by 29 September 1999 Indonesia signed and entered into force the Protocol Additional to the
Safeguards Agreement, joining others to become the first seven states to implement the Additional Protocol.

Seven Indonesian Nuclear Installations are now under safeguards controlled, namely the 2000 kWt TRIGA MARK II Research Reactor (RI-A) at Bandung, the 100 kWt Kartini Reactor at Yogyakarta (RI-B). The 30 MWt GAS Reactor at Serpong (RI-C), the LEU Fuel Element Fabrication Installation at Serpong (RI-D), the Experimental Fuel Element Installation at Serpong (RI-E), the Radio-metallurgy Installation (RI-F), and the Interim Storage for Spent Fuel (RI-G). At this point, it was mentioned in the statement of Director General of IAEA during The Forty-Seventh Regular Session of the IAEA General Conference in September 2003, that Indonesia is one of only three countries in the world who has already implemented the integrated safeguards developed by IAEA.

7. Prospects of NPP Introduction

Ever since the economic crisis in 1997, one of the most important efforts was the recovering of the economic growth. Efforts to reconstruct the economy have given rise to prioritize activities responding public needs, e.g. food, health, environment, small and medium industries. As a nuclear research and development government owned institute, the National Nuclear Energy Agency (BATAN) have been repositioning its temporary mission accordingly meaning more dissemination of proven technologies being resulted from the R&D activities that leads to greater outcome and impact to the society in shorter time period. This is done due to the facts that most people perception on nuclear technology application is still confused, confusing, and tend to be negative since they have received unbalance, misleading, and incomplete information.

The economic crisis since last 1997 have changed important parameters were used for long term energy planning, i.e. GDP, economic growth, FDI, etc. One thing that has been recognized during the worst period of our economical crisis last 1998 – 1999, the energy demand especially as final energy forms are still high. This evident should be considered further carefully since it might cause more serious effects for the Indonesian economy. Indonesia is an exporter of the primary energy, while in the other hand the domestic energy demand is increasing and also the primary energy reserve actually is not large enough in comparison to its population.

The increasing of energy demand based on fossil fuels, in parallel will also increase the environmental damages. People’s environmental awareness nowadays have increased, so that energy supply technologies which are not environmentally friendly will be abandoned, which environmentally friendly energy supply technology will be included in their choice of use. However, the consideration of only the environmental aspect is not sufficient. Technology choice has to be made on the basis of economic aspects and its efficiency, so that the type of technology that is chosen is the most optimum as viewed from all aspects of the economy and the environmental. Green house gases emission reduction will also be enhanced by the operation of nuclear power plants. From this point of view, it is indeed very important for decision makers and politicians to objectively consider the synergy of fissile and fossil plants in optimal electric expansion systems.

The largest challenge in the electric power sector in Indonesia is how to meet the electricity demand while the resource of funds is limited. Financing of nuclear power projects in the
developing countries, due to high investment capital cost, is a major hurdle. That is why, at present, to develop the financing strategy, BATAN has been studying various possible schemes to finance the construction of nuclear power project in Indonesia. The financing scheme should achieve two objectives: minimal costs to the government and at affordable electricity prices.

Therefore, the general prospect for nuclear power, have been discussed earlier, rely on two main driving forces, as follows:

1. Public acceptance, including political factor
2. Economic competitiveness and financing scheme.

8. Conclusion

The energy problem in Indonesia will cause the utilization of nuclear energy could not be avoided in the second decades of 21st century, and the first NPP will be planned to be in operation around 2016. From the techno-economical point of view, the medium or large commercial and proven NPP will be applied for Java Grid.

The History of nuclear power program in Indonesia has already taken a long time since 1956 until now. Some political, economical, social and technical efforts have been done to realize the introduction of the first NPP in Indonesia, in order to support the national program, as well as to make collaboration with the international activities. But apparently some preparation studies, assessments, and specific works still needed to conclude the objective.

In spite of the complete, comprehensive and long-time preparation has been already made, actually two main driving forces i.e. public-political acceptance, and economic-financing scheme are still critical for the prospect of the first NPP introduction in Indonesia.

REFERENCES