AN OVERVIEW ON THE FUTURE TREND OF NUCLEAR ENERGY APPLICATION AND DEVELOPMENT IN INDONESIA

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Introduction

The purpose of this paper is to discuss the recent circumstances in Indonesia concerning nuclear energy program and try to anticipate the challenges and the future trend on the application of nuclear power for electricity generation. It is indispensable for Indonesia with regard to development of industries and improvement of the quality of life to establish sufficient and stable electric power supply. A national energy policy has been adopted, in its way to secure the continuity of energy supply at affordable price; to enhance the people's quality of life, and to reserve an adequate supply of oil and gas as important sources to fund national development program. It is expected that nuclear energy will reduce the dependence on a single type of fuel, economize energy utilization, as well as to support environmental program by applying clean-energy technology.

Indonesia is one of those developing countries with significant planning for nuclear energy program. However, due to the recent economy, political, and social downturns, the plans must be put on hold. Economy and political uncertainties make rational planning difficult. Indonesia has relatively advanced capabilities in nuclear technology among the countries in South East Asia. Nevertheless, the multi-crisis has forced the support for nuclear R&D undergone the reevaluation, and the introduction of nuclear energy can only be accelerated if the economy, social, and political conditions are completely restored.

People now live in a changing world. Stagnation of nuclear power programs has

forced many nuclear industries to fundamentally reassess their situation. The current global condition of nuclear industries involves many problems, but it also creates some major prospects. Therefore, there are still reasons to be optimistic. A World Energy Council study recently concluded that the total reliance on fossil fuels and large hydroelectric facilities is not sustainable, and the current reliance on nuclear power needs to be stabilized, with the possibility of future expansion [3]. In Indonesia, the government should preserve nuclear know-how and provide continuing employment, and improve public image of nuclear technology.

The society must be convinced of the importance of energy and electricity, because we believe that there is strong correlation between quality of life and the use of energy. However, the combined efforts and introspective actions must be taken by international nuclear community to introduce nuclear energy in the world in the future. Even the developing countries themselves have different interests and attitudes towards the development of nuclear science and use of nuclear technologies.

It is important to note that in the 21st century, the growth in electricity demand will be dominant in developing countries such as Indonesia. Currently, the majority of developing countries in Asia have the electricity demand growth of 4.4% per year. Nowadays, industry is more efficient and competitive, and there is a considerable safety improvement in nuclear plant design. Additionally, worldwide electricity market is deregulated. Therefore, consolidation of international nuclear industries is crucial. The following figures show the trends of annual electricity capacity additions in the world and the countries in South East Asia.

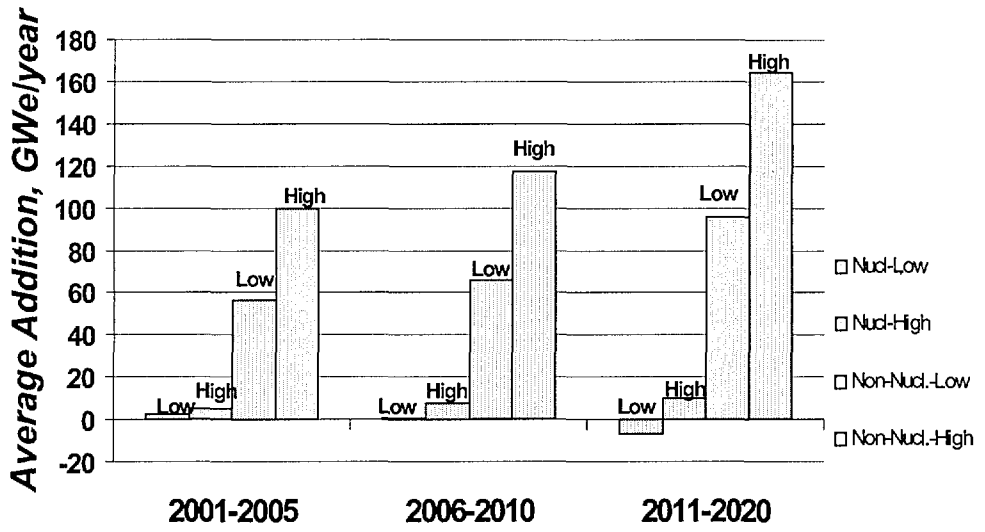

Figure 1.: World's Annual Electricity Capacity Additions (IAEA's Prediction)

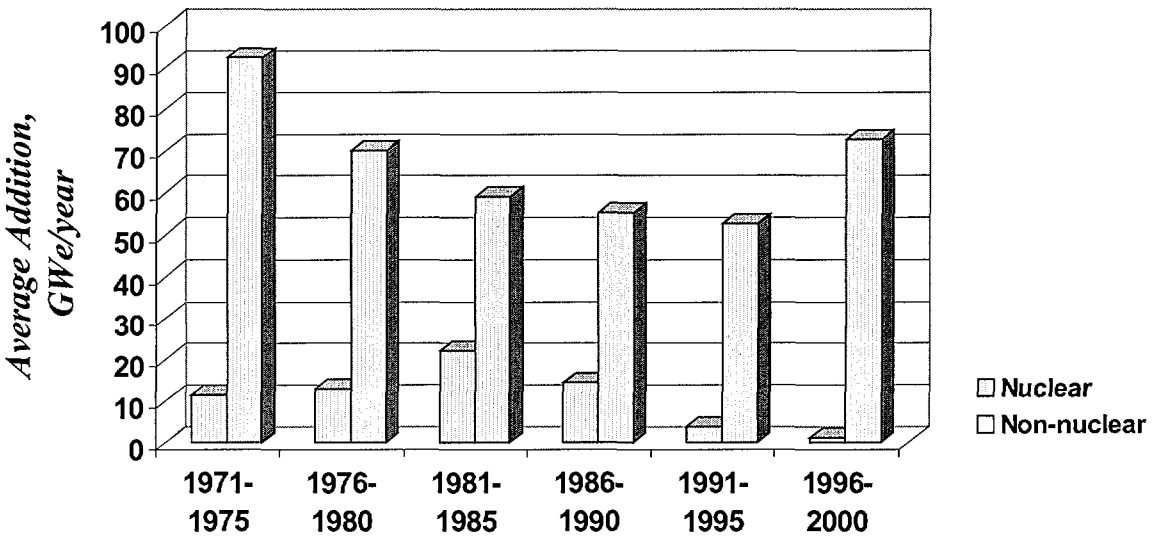

Figure 2.: World's Annual Electricity Capacity Additions (History)

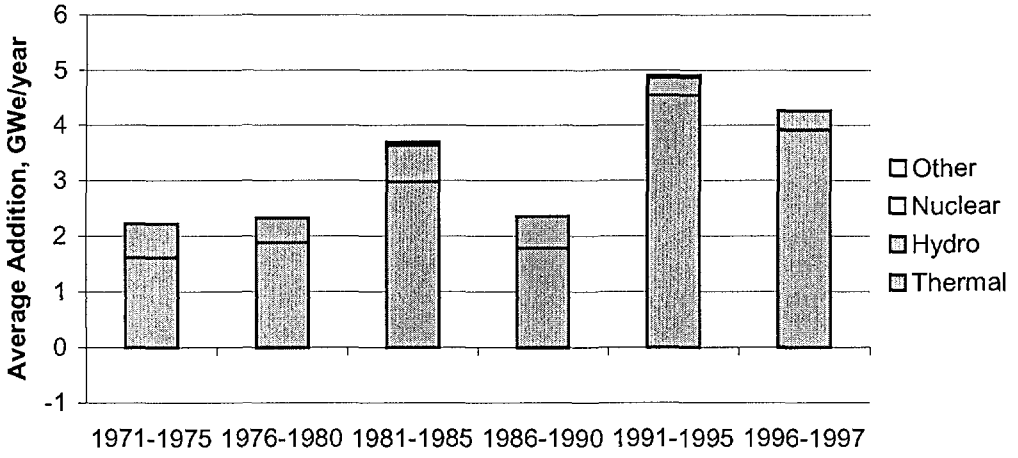

Figure 3.: South East Asia & Pacific Annual Electricity Capacity Additions

In the well-developed countries in Europe, as well as Japan, Korea, and the United States, there is a growing awareness in the society of the environmental benefits of nuclear power application. *This is not always the case in the developing countries such as Indonesia.* It should be realized that public support is the most essential issue that should carefully be addressed upon the planning of nuclear power plant introduction in any countries. Currently, Indonesia's economy mostly depends on fossil power plants. Environmental benefit of NPP is excellent reasons to introduce it to Indonesia, in the sense that NPP does not emit greenhouse gas.

Indonesia's Preparedness for Nuclear Energy Application [1], [3], [5]

During the next decade Indonesia forecasts that the peak electric power demand on the Java-Bali grid will increase by over 15,000 megawatts [5]. The greatest part of this requirement will be met through the addition of about 13,000 megawatts of coal-fired generating capacity. In furtherance of Indonesia's power supply diversification policy and to address environmental concerns related to over reliance on fossil fuels, BATAN on behalf of Indonesian Government commissioned a Feasibility Study for the first Indonesian Nuclear Power Plant by NEWJEC, Inc. of Japan to assess the technical and economic feasibility of nuclear power for Indonesia.

The Study was carried out over a five-year period (November 1991 – June 1996). The Final Feasibility Study Report (FFSR) published in May 1996 assessed the technical and economic feasibility of implementing Indonesia's first nuclear power

plant project. This study concluded that nuclear power was technically feasible and could generate electricity at costs generally competitive to electricity from existing coal-fired power plants [1].

The Study also includes a Financing Schemes Study, which assumed a conventional, sovereign credit financing structure using a lump sum turnkey (LSTK) contracting approach. In parallel with the FFSR development, a Final Bid Specification (F-BIS) was also prepared in anticipation of an open tender for the construction of Indonesia's first nuclear power project.

Challenges for Nuclear Energy planning and development in Indonesia

The future utilization of nuclear power in Indonesia depends also on the ability of nuclear designers and operators to further improve the competitiveness of NPPs while meeting increasingly stringent safety requirements. Deregulated electricity markets and increasingly competitive natural gas mean that NPPs must be built in shorter times at lower capital costs and with simpler and more reliable operation.

Indonesia, as a developing country, has been interested in introducing nuclear power through the use of small and medium sized reactors for electricity generation and desalination. For this purpose, balanced and objective information on advanced nuclear technologies from the NPP countries are highly needed. It is obvious that Indonesia has only put limited research and development funds for nuclear research. Consequently, sharing in the global activities in technology development and will be very beneficial.

In addition to nuclear community, there are many educated people in Indonesia who are aware of NPP advantages which are among others: providing security of energy supply, long life time, low pollution, proven technology and of course high tech employment. On the other side, they are also aware of the disadvantages of NPP that include: complex buying decision, long policy lead time, difficult to finance, long construction, high up front capital cost, high interest during construction, lack of public acceptance efforts, regulatory uncertainty, and waste disposal.

Nuclear power designers from Japan, USA, Canada and Europe have considered Asia as their current and future market. In spite of this, it should be recognized that the recent nuclear project cancellation and program termination in some of developed countries *(i.e. United States, Germany and Taiwan)* would be a major

obstacle in implementing nuclear energy in developing countries such as Indonesia. European countries and the United States presently do not plan to construct new nuclear stations because of doubts over their cost-efficiency and safety. Based on those facts, there are several factors that need to be addressed upon the application of nuclear energy in Indonesia, among others: Public Acceptance and Understanding, Human Resource and Infrastructure Development Planning, Assurance of Ultimate Safety for public, Feasible Financing Arrangement, Waste Disposal Solutions

Public Acceptance and Understanding

Public Acceptance and Understanding is necessary upon initiating nuclear energy in Indonesia. For many Indonesian communities, nuclear power plant is still frightening. And those who blindly oppose any nuclear works have always exaggerated this. The concern here is how to achieve public acceptance and understanding in Indonesia upon the introduction of nuclear energy. The growth of the nuclear power option is impeded in many countries by public concerns over the safety and environmental consequences of producing electricity by means of nuclear reactors. Historically, the main components of this public concern have been the potential for serious nuclear reactor accidents, the day-to-day operational safety of nuclear reactors, the association in the public's mind between nuclear power and nuclear weapons, and the question of what to do with radioactive waste.

We acknowledge that the scientists and engineers working on the technical aspects of nuclear reactor operation and radioactive waste disposal have developed an international consensus that the reactors can be operated safely and the waste can be permanently managed in a manner that protects the environment and public health. However, again, the general public especially in developing countries does not necessarily share this view.

There is no universal way of public acceptance because social and political systems and levels of existing public understanding and acceptance vary from country to country. However, in some ways, the fundamental principles for achieving public understanding and acceptance of nuclear power may be the same for all technologies and in all countries, since they deal with basic human nature.

Most national programs for nuclear power started with an examination of the economic, technical and scientific questions that must be answered in order to develop confidence that nuclear reactors can be constructed and operated safely

and efficiently. However, the same effort has not been devoted to the socio-political problems surrounding nuclear energy, not least because they were unanticipated and are still for the most part not well understood.

Therefore, it can be concluded that establishing scientific confidence that nuclear power plants can be safely operated does not by itself eliminate the public concern about them. Many countries, utilities and industry associations have implemented public interaction programs, the intent of which is to develop the degree of public understanding necessary to allow their nuclear power programs to be implemented and to expand as required. Such public interaction programs encompass activities that range from simply giving the public information to involving members of the public or special interest groups in the decision-making process.

Sociological research in a number of developed countries has shown that the main issue regarding nuclear power in the public mind is the fear that a major accident at a reactor will cause people to receive a radiation dose. In addition, a large land mass will be contaminated with radioactive material and will thereafter be unusable. The Three Mile Island, Chernobyl accidents, and criticality accident at JCO facility in Japan are frequently cited. Such fears are frequently associated with the idea that under worst-case conditions, a nuclear reactor will have consequences similar to the explosion of a nuclear bomb.

In the public mind, the perceived risk from the operation of nuclear power plants and from radioactive waste is very high. This public perception of the risk differs markedly from the scientist's view and from actual experience with its management. Studies that have evaluated how people perceive risks can be useful in developing and understanding this phenomenon. Many studies have shown that the general public evaluates risks not by the standard scientific computation of probability times consequence, but by a series of subjective criteria that place high-risk values on the following [4]:

- Complex technology that is not well understood by ordinary people and requires specialists for its operation.
- Projects or technologies that are under centralized rather than local control, and where the people potentially affected cannot make operating decisions.
- A potential for a high consequence as a result of a single failure. This is so regardless of how infrequently the failure might occur.
- Undertakings for which no clear need are seen, and from which no perceptible benefit is derived. This includes projects that result in one group of people (i.e.

corporations) receiving a benefit, and another group of people (i.e. the residents of the locality where the project is located) being subjected to the risks.

The research shows that risks from familiar things, which people feel they understand, control and make decisions about themselves, and from which they believe they derive a direct benefit, are perceived by the general public to be relatively low. This is so even when there is common knowledge that the technology results in a large number of deaths, as for example in transportation accidents.
In this year (2000) itself, the authors have noticed several deadly accidents started with the crash of Concorde supersonic-aircraft in France (105 victims), continued by Singapore Airlines Boeing-747 crash in Taiwan (85 victims), and 156 fatalities in funicular (Alpine-train) crash in Austria at the time this paper is written, not to mentioned the countless fatalities caused by car accidents. However, the public apparently concludes that airplanes and other transportations, even though they harm many more people than nuclear power reactors, are much less risky.

Steps can also be taken to increase public trust in the institutions that manage and regulate nuclear power. Such steps will usually involve much more open decision-making, and a responsiveness to public concerns that goes far beyond technical and economic optimization. Therefore, the clear independence of the regulatory agency is a key parameter.

Based on the above description, the communications challenges in developing and implementing a nuclear power program can be summarized as follows [4]:

- Designing and implementing a process whereby the general population participates in determining the need for a nuclear energy program.
- Determining the public acceptability of various options for the development of the nuclear option, the construction and operation of nuclear power plants and the safe long-term management of radioactive waste.
- Providing information to those who make policy and regulatory decisions about the adequacy of the technology and about its implementation so that informed and balanced decisions can be made.
- Responding with technical and social solutions that meet the public's requirements and providing sufficient information to the general public so that people can reach informed decisions about nuclear power.
- In summary, there is a strong need to find the best methodology and techniques for communication upon the introduction of nuclear power plant

in Indonesia.

Human Resource and Infrastructure Development Planning

In this section, the authors emphasize on the importance of Advanced Nuclear Technology Education. In the last 15 years, Indonesia's Nuclear Energy Agency [BATAN] has organized the combined efforts from universities, nuclear power plant designers, and IAEA (International Atomic Energy Agency) to develop the human resource and infrastructure upon the application of nuclear power in Indonesia.

In the case of the roles of university, Research Laboratory for Nuclear Reactors at Tokyo Institute of Technology in Japan has received no less than 17 doctor and master course students from Indonesia to study nuclear engineering and technology since 1985. Advanced education plays important role in introducing nuclear energy in Indonesia. By advanced university education, it is expected that the technical leadership of the younger generation will surely be helpful to grow up the nuclear industry in Indonesia in the 21st century [2]. Currently (in 2000) there are five students from Indonesia pursuing doctorate degree in various fields of nuclear engineering at Research Laboratory for Nuclear Reactors in Tokyo Institute of Technology – Japan. The Institute generally admits about 15 Indonesian graduate students every year (some granted the scholarship from the Japanese government) studying various aspects of engineering.

Current and Future Programs [2]

Developing countries in South East Asia, such as Indonesia, Thailand, and Vietnam will introduce the innovative small- and medium-sized light water reactors in the future. Future small reactors should highly be economical, low in waste, and posses enhanced safety and stability in operation. This planning is certainly subject to the economy and socio-politics conditions. On the other hand, the universities and nuclear designers in Japan start to develop small-sized LWRs. For this reason, the First Specialist Meeting on Future Small-Sized LWRs will be held in order to promote cooperative works on the subject, to exchange the related technical information and to explore the ideal features. It is planned that Research Laboratory for Nuclear Reactors of Tokyo Institute Technology will organize this efforts together with principal Japanese nuclear designers to present the conceptual designs of the innovative small-sized LWRs. Then, Indonesia and other South East Asia countries (e.g. Thailand and Vietnam) will present their technical and economic requirements.

The Important Roles of IAEA

The International Atomic Energy Agency [IAEA] plays the significant role in establishing nuclear research activities in Indonesia. Indonesia is one of the IAEA member states in East Asia region. The Agency major role is to help ensure that the nuclear option remains open and available in Indonesia. The Agency also provides a global forum for information exchange and co-operation, and maintains up-to-date information about advanced reactor technology developments, applications and major development needs. This program brings together high-level experts in international technical working groups to mobilize R&D resources from national organizations towards common goals. National Nuclear Energy Agency of Indonesia [BATAN] is a government nuclear research institute with direct coordination with IAEA. It co-operates with IAEA in technology transfer and technical cooperation for nuclear technology.

The objectives of the coordination with IAEA are as follows: Increased capabilities to utilize the global collection of knowledge in nuclear technology; Increased capabilities to select and apply advanced nuclear technologies; Increased capabilities in to further develop technologies to support competitive and sustainable nuclear power.

Finding the most Feasible Financing Arrangement [5]

The Final Feasibility Study Report (FFSR) published in May 1996 assessed the technical and economic feasibility of implementing Indonesia's first nuclear power plant project. This study concluded that nuclear power was technically feasible and could generate electricity at costs generally comparable to electricity from existing coal-fired power plants.

Therefore, a "modified" Build-Own-Operate structure was developed using Paiton BOO structure, the first Indonesian coal-fired private company, as a basis. This model assumes that the Government of Indonesia will take all nuclear liability risk and certain other risks in excess of a specified project Owner liability limit and provides a lender and Owner risk profile similar to that for a coal-fired BOO project. Costs to the Government of Indonesia associated with assuming this nuclear liability risk have not been evaluated. Assumption of these risks provides an indirect subsidy to the nuclear option. The resultant constant 1997-US dollar equivalent

levelized cost of electricity was calculated to be US$ 0.0846/kilowatt-hour, a BOO "premium" of approximately 70%. This premium is mainly attributable to higher debt and equity return required to attract private lenders and investors to a first-of-a-kind nuclear power plant project.

The study assumed a conventional, sovereign credit financing structure using a lump sum, turnkey (LSTK) contracting approach. Note that the LSTK contracting approach for nuclear has never been accomplished satisfactorily, and is unlikely to be viable for the first nuclear power plant in a country. Experience in Taiwan indicates a premium of 20% to 30% even in a country with substantial nuclear experience. Accordingly, we believe that a contracting approach that provides for some of the incentives to contractors to minimize costs and maximize performance but with less cost and completion risk transfer than a traditional LSTK contract will be required.

In parallel with the FFSR development, a Final Bid Specification (F-BIS) was also prepared in anticipation of an open tender for the construction of Indonesia's first nuclear power plant. This specification contemplated a lump sum, turnkey contract, Indonesian Government investment and conventional debt financing (e.g. export credits).

The Government of Indonesia's recent policy to minimize government financing support for power development and recent successes in implementing "Build-Own-Operate" ("BOO") fossil-fueled power plants prompted it to investigate the applicability of BOO to nuclear power. The summarized results of this financing schemes study are as follows:

- Implementing a BOO structure for Indonesia's first nuclear power plant will be a difficult and time consuming process without any international precedent to provide any assurance of eventual success.
- If a nuclear BOO is possible, there will be a significant cost premium that makes BOO nuclear power plants more expensive than conventional nuclear power plants.
- BOO arrangements involving foreign governments may result in lower cost premiums.
- Key determinants of BOO success will include identifying contractors willing to take lump sum, turnkey risk and experienced owner/operators willing to invest equity in the project under a risk allocation plan which is acceptable to the Government of Indonesia.

Conclusions and Recommendations

1. Economy, Social and Political stability is the pre-requisite to introduce nuclear energy.
2. Introspective action should be taken by international nuclear society by improving the methods of public acceptance, solving regulatory uncertainty, finding the safe and reliable method of waste disposal, and innovating nuclear plant technology that psychologically acceptable for Indonesian people.
3. Finding the most feasible financing schemes which is applicable for developing country is crucial
4. The advanced university education will fulfill the ultimate objective of technology transfer through technical cooperation.
5. Finding the waste disposal method *(especially for High Level Waste)* is important and difficult issue dealing directly with public trust and acceptance
6. Combined efforts from IAEA, Universities, nuclear system designers, and Indonesian Government c/o BATAN should be gradually enhanced and developed upon the application of nuclear power in Indonesia.

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