PRESERVATION AND ENHANCEMENT OF NUCLEAR KNOWLEDGE TOWARDS INDONESIA'S PLAN TO OPERATE FIRST NUCLEAR POWER PLANT BY 2016

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Abstract. Indonesia will need a nuclear power plant (NPP) to overcome the lack of power supply due to increasing consumption of electricity while the traditional power supply, including crude oil, has been decreasing. The recent study under IAEA technical co-operation project titled "Comprehensive Assessment on Different Energy Sources for Electricity Generation in Indonesia" showed that an energy mixed scenarios has to be applied in Indonesia in order to reduce amount of oil used for transportation and electricity generation. The medium to large scale of NPP would be techno-economically feasible to be operated in 2015-2016 for Java Island. In the past, efforts to launch nuclear power programme based mainly on economic justification have failed for various reasons; ones of the most important reasons were due to the lack of public support because of repeated accident on NPP. As a government owned institute having the task of promoting peaceful utilization of nuclear science and technology as well as doing research and development, the National Nuclear Energy Agency (BATAN) has to initiate the endeavor to launch the utilization of nuclear energy and prepare human resources to support construction, operation and maintenance of the future NPP in Indonesia. Meanwhile the BATAN nuclear workforce is aging because of more and more nuclear workers are approaching retirement age, without a corresponding influx of appropriately qualified younger personnel to replace them. This situation happens due to zero growth policy in government employment or more precisely negative growth policy on BATAN employment. This paper outlines the important of the establishment and maintenance of a formal human resources policy and nuclear knowledge management strategies to ensure that an organization maintains adequate numbers of competent and motivated personnel, and the availability of essential technical information for research and development in reactor technology, nuclear fuel cycle, nuclear safety, radioactive waste management, and also in the supporting activities.

1. Introduction

Indonesia is the largest archipelago in the world which consists of five major islands and more than 17,500 islands (6,000 inhabited). The five main islands are: (1) Sumatra, which is about 473,606 sq. km in size; (2) Java is the most fertile and densely populated islands, 132,107 sq. km; (3) Kalimantan, which comprises two thirds of the islands of Borneo and measures 539,460 sq. km; (4) Sulawesi, 189,216 sq. km; and (5) Irian Jaya, 421,981 sq. km, which is part of the world's second largest island, New Guinea. Indonesia's other islands are smaller in size. The archipelago is on a crossroad between two oceans, the Pacific and the Indian, and bridges two continents, Asia and Australia. This strategic position has always influenced the cultural, social, political, and economic life of the country. The territory of the Republic of Indonesia stretches from 6°08' north latitude to 11°15' south latitude and from 94°45' to 141°05' east longitude. The Indonesian sea area is four times greater than its land area, which is about 1.9 million sq. km. The sea is is about 7.9 million sq. km (including an exclusive economic zone) and constitutes about 81% of the total area of the country.

The total population is approximately 214 millions but more than half of Indonesia's people live on the island of Java. The Java Island has large population and industries, which constitutes the major area of energy demand. The problem is not that Indonesia lacks

resources, but that they are far from Java. Most energy resources are located outside the island of Java, much of the coal, oil, natural gas and other assets are hundreds of miles away in the northern part of the island of Sumatra or Kalimantan. Nuclear power is needed to sustain economic development in the world's fourth most populous country. The increase of population, especially in the rural areas, those are not yet have an adequate access to electric power, is an indication of an expected high-growth rate of electricity demand. Indonesia, like other South East Asian developing countries, currently has low living standards and low energy consumption. Energy consumption per capita per year is relatively low even as compared to other ASEAN countries. The reality, therefore, is that substantial increases in energy use in general, and in electricity use in particular, will be needed in order to reach national development goals. Careful planning for wise development and use of national resources, and cost-effective participation in international energy markets, is crucial for assuring the adequacy, resilience and independence of the country's energy system. Rapid increases in domestic energy demand make it more difficult to depend on Indonesia's existing increasingly limited resources. Consideration must therefore be given to developing and deploying all available energy technologies including fossil fuels, renewable and nuclear energy.

The government has adopted a policy of promoting development of these natural and energy resources in a way that will maximizes economic efficiency and provides regional development and employment opportunities. The recent study has been realized in 2001 under IAEA technical co-operation project titled "**Comprehensive Assessment on Different Energy Sources for Electricity Generation in Indonesia**" and the main objective is to support the national planning and decision-making process in Indonesia's energy and electricity sectors, and is taking into account key economic, social and environmental factors. The study is intended to comprehensively assess the potential contributions of various energy options to the optimal long-term development of Indonesia's energy supply and demand consistent with sustainable development. However, the conclusion showed that an energy mixed scenarios has to be applied in Indonesia in order to reduce amount of oil used for transportation and electricity generation. The medium to large scale of NPP would be techno-economically feasible to be operated in 2015-2016 for Java Island. Even if the innovative technology such as small and medium reactors can be realized before, introduction of the NPP with small scale capacity can be realized some what earlier not only for Java Island but also for the other islands. Sensitivity analyses indicate that above results are indeed sensitive to variations in nuclear cost and performance parameters across a reasonable range for post-2010 technologies, with earlier nuclear introductions becoming optimal for a number of plausible cost and performance assumptions.

Towards Indonesia's plan to introduce nuclear power, in 1997 an Act No. 10 was issued concerning nuclear energy as a replacement for Act No. 31 year 1964, which stipulates the separation of the supervisory or regulatory for nuclear energy from the implementing agency, by the forming of two separate agencies, the Nuclear Regulatory Agency (BAPETEN) and the National Nuclear Energy Agency (BATAN) as the promoting body. According to Article 13, Act No. 10 year 1997, the development of any commercial nuclear reactor in the form of a nuclear power plant, shall be established by the Government after consulting with the People's House of Representatives of the Republic of Indonesia. Since the decision to build nuclear power plant has to be consulted to the Parliament, it is indeed necessary to have always excellent communication with members of Parliament, to be understood by them and has to be supported by the society at large. In the past, efforts to launch nuclear power programmes based mainly on economic justification have failed for various reasons; ones of the most important reasons were due to the lack of public support because of repeated

accident. The first attempt in 1980 was triggered by the Three-Mile Island-2 accident, the second one in 1986 due to the Chernobyl-4 accident and the crash of oil price, while the third one in 1997 because of the Asian economic crisis. Indonesia is pushing ahead with nuclear power at a time when the commercial use of nuclear power is in decline after 40 years of expansion. It is being rejected because of escalating costs, faulty technology and continuing public concern about accidents and radioactive waste disposal.

Nuclear issues at present are no more technical and scientific matters but socio-cultural and political issues. Financing requirement, participation by national industries, security for the fuel supply, regulatory framework, human resources, environment, proliferation, and public acceptance are an essential issue to introduce NPP into the electricity grid in Indonesia. The security for nuclear fuel supply has become one of the big issues because Indonesia has already the problem continuation of supply of low enrichment uranium (LEU) for our research reactors. BATAN as the main organization that is responsible for research and development programme in nuclear energy for peaceful utilization, also responsible for the development of human resources and infrastructure of national participation in NPP project. The development of nuclear power plants in Indonesia requires careful attention to several important aspects. These include nuclear reactor safety, the availability of human resources, environmental issues and sitting for the nuclear power plant. In this day and age of the Internet, the quantity and quality of explicit knowledge that can be accumulated have expanded exponentially. BATAN need to make better use of advanced information technology, software capabilities, and computerized management systems to accumulate, store and disseminate nuclear knowledge throughout the organization.

2. Current State and Future Projection of Energy Demand

The comprehensive assessment of different energy sources for electricity generation study in Indonesia consists of two phases. The energy demand and supply analysis using the MAED and MARKAL models is Phase I of the study and was carried out in 2001. The assessment of environmental impacts and externalities of electricity generation using the SimPacts model have been done in Phase II of the study in 2002. This study is performed by taking into account the national and regional data to obtain a consistent comprehensive picture of the Indonesian energy economy, such as: the population projection (shown in Figure 1), and the future economic growth estimation (shown in Figure 2).

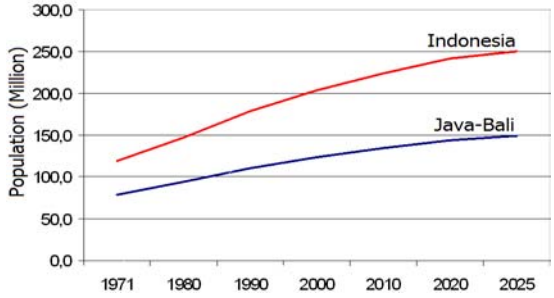


FIG. 1. The population projection

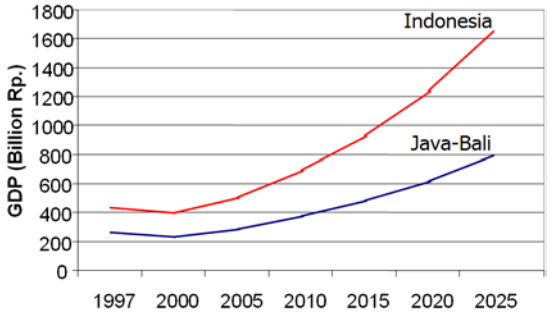


FIG.2. The future economic growth estimation

The economic growth in 2005 is estimated 5.6% and the average economic growth estimation from 20006 to 2025 is between 5.5% to 6%. Based on the projected future gross domestic product per capita in Indonesia (GDP/capita), the total Indonesian energy demand is estimated for four regions: Java-Bali-Madura, Sumatra, Kalimantan and Other Islands (Figure 3). Electricity demand is estimated in terms of useful energy (Figure 4).

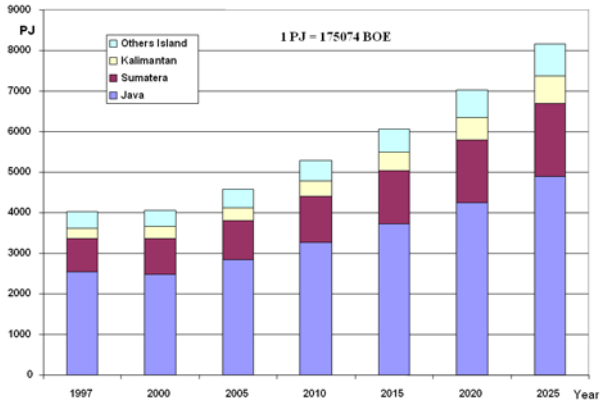


FIG. 3. Total energy demand by region

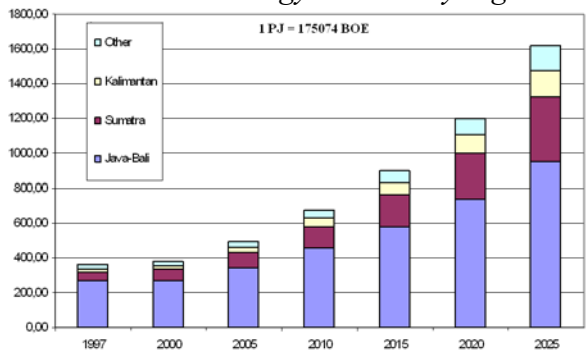
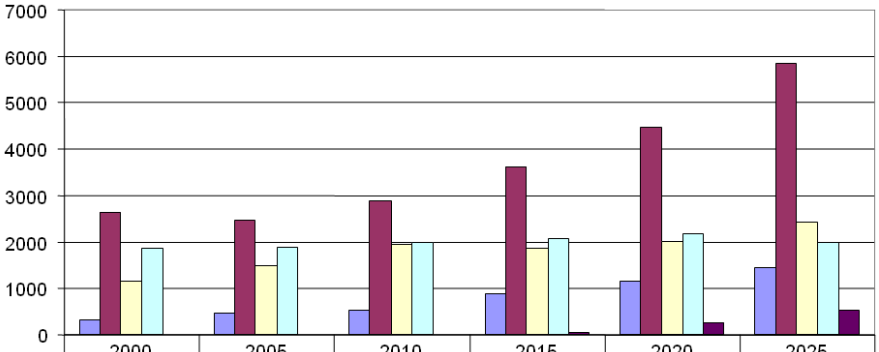


FIG.4. Total electricity demand by region

The most prominent change facing the Indonesian energy sector over the study horizon is a shift from being a net energy exporter to becoming a net importer. Once a major oil exporter, Indonesia begins to import substantial amounts of crude oil during the first decade of the 21st century. Domestic demand for oil products greatly exceeds projected indigenous oil production capacity. Expanding coal production and fluctuating gas exports cannot prevent this change, which appears to be unaffected by the underlying oil market price scenario. Natural gas and renewable take the lead in electricity generation while oil products remain an important source for decentralized electricity generation. In the absence of environmental constraints, nuclear power does not enter the cost-optimal solution. The imposition of small emission reduction requirements, however, immediately tilts the balance in favor of nuclear.



	2000	2005	2010	2015	2020	2025
Coal	310	477	541	904	1158	1453
Oil	2632	2458	2889	3616	4480	5841
Gas	1168	1486	1937	1866	2014	2410
Renewable	1852	1870	1993	2088	2164	1995
Nuclear	0	0	0	36	270	530

FIG.5. Primary energy supply (PJ/a) 2000 - 2005

The results of this study provide a realistic projection of energy demand in Indonesia taking into account the economic crisis of 1998, projected population and economic growth and changes in lifestyles and technology (Figure 5). This projection is consistent with other projections and reflects current Government policies. Gas and coal are already in use in Indonesia for centralized electricity generation. Nuclear power is the only alternative at present for replacing the fossil base load generation. Its introduction into the mix is assessed as described below, under the least-cost criterion and based on assumptions about available and - for the supply of Java - accessible resources, about fossil and nuclear power plant costs, and about the development of fuel prices.

A nuclear power programme would comprise a number of nuclear power plants and the supporting infrastructure, to be constructed over a long time period. It should be emphasized that nuclear power would be a less meaningful option if only a single plant is considered. If additional electricity generation capacity is needed on an urgent basis, other options, such as gas, oil or coal fired power plants, can be constructed more quickly than nuclear power plants. In the long term, however, nuclear power can be more economical and beneficial of the environment, as well as to the development of the country. An economic assessment of the nuclear power option will be based on certain factors, such as the availability of other low cost energy resources; the level of technical infrastructure of the country (including the size and reliability of the electricity distribution grid, industrial capabilities and availability of qualified manpower); and assurances of the supply of equipment, fuel and others items essential for nuclear power programme. Other key economic factors to be considered include the high initial capital investment costs, low fuel and production costs, waste disposal cost, high availability factors and minimum demands on the transportation system compared with those of electricity production using other fuels.

3. The National Nuclear Energy Agency (BATAN)

Towards the plan to introduce first NPP in Indonesia, the Act number 31 year 1964 does not suffice anymore with the current developing situation, therefore in 1997 Act No. 31 year 1964 is replaced by Act No. 10 year 1997 on Nuclear Energy which separating the regulatory body from implementing agency by the forming of 2 separate agencies, the Nuclear Regulatory Agency (BAPETEN) and the National Nuclear Energy Agency (BATAN) as the executing body which have the task to execute the use of nuclear energy. BATAN as the executing body have the task to conduct research and development, general surveys, explorations and exploitations of nuclear ore, raw material production for manufacturing and fabrication of nuclear fuel, production of radioisotopes for research and development, and radioactive waste

management. In order to prepare manpower to support construction, operation and maintenance of the future NPP in Indonesia, BATAN has performed the R&D in reactor technology, nuclear safety, fuel cycles, instrumentation and control system, and radioactive waste management.

At present BATAN have 3 research reactors which are spread out in the Nuclear Research Centers in Bandung, Yogyakarta and Serpong. (1) The Triga Mark II Reactor with a power of 250 kW in operation since 1965 at Bandung Nuclear Research Center. The power of this reactor in 1971 was increased to 1000 kW and then upgraded again to 2000 kW in the year 2000 as a research facility and radioisotope production; (2) Kartini Reactor with a power of 100 kW in operation since 1979 at Yogyakarta Nuclear Research Center. The purpose of this reactor is for education and training facility; (3) The Multipurpose 30 MW Research Reactor at Serpong Nuclear Research Center. The reactors have been used mainly for material testing, nuclear analytical analysis, isotope production, neutron beam experiment, and for education. The reactors have been exploited for master and doctor programme by universities students and also have been used as basis tool to understand nuclear reactor operation and maintenance.

In order to support the nuclear energy programme, several research facilities have been built in the Serpong Nuclear Research Center, among the multipurpose 30 MW reactor. The Serpong Nuclear Research Center has research reactor fuel element production installation, experimental fuel element installation, radioactive waste management installation, radiometallurgy installation, reactor safety testing facility, informatics development facility, nuclear instrumentation and design facility, hot laboratory, and other nuclear facilities. The fuel element fabrication facility is to produce routinely fuel element for all BATAN research reactors. The Experimental Fuel Element Installation for LWR or HWR is equipped with conversion and fabrication facilities, necessary for the mastery and development of nuclear fuel element for power reactors in the future. The conversion facility is intended for the mastery and development of uranium ore concentrate purification and nuclear-degree UO2 production technology with natural uranium concentrate or yellow cake as feed. The fabrication facility deals with pelleting technology, fuel component production, and fabrication of nuclear fuel elements and assemblies for heavy water reactors. This facility is designed to manufacture fuel elements and assemblies containing UO2 pellets with uranium enrichment up to 5%, cladded in zircaloy tube. The radiometallurgy installation is designed to perform development programmes of post-irradiation examination technology for nuclear fuel for research reactors and power reactors. Serpong nuclear research center has satisfied equipment to perform the R&D activities to support nuclear energy programme in Indonesia.

The other nuclear research facility located in Yogyakarta, has a facility to perform R&D on fuel structure and materials, such as graphite, zircalloy, heavy water, etc. The attempt to produce coated particle have done on this nuclear research center. However, this activity has not yet been optimized since the national commitment to this kind of reactor is not given. The innovation to use coated particle into the fuel pin of LWR have been studied. Although the innovation fuel element is aimed and used only in the temperature range of LWR, but in the case the safety aspect will increase due to decrease probability of fission product release. The Bandung Nuclear Research Center was constructed in 1967, and it is the place where the first reactor was built in Indonesia. The activated that are conducted are among others, the optimal use of the reactor for research and expertise development. Other facility in this area is the Nuclear Medicine Clinic which is the first nuclear medicine clinic in Indonesia through cooperation with the Hasan Sadikin Hospital in Bandung. The west Kalimantan is the area for the exploration and mining of uranium which has been opened in 1975 in the village of Kalan. The activities that are conducted in this area include research in exploration and mining of

nuclear mining materials, investigation and process technology of radioactive mineral reserves. The facilities present in this area are an underground mining unit as long as 900 meters and mineral processing unit producing *yellow cake*.

TABLE I. Reduction number of nuclear workforce at BATAN.

	2000	2001	2002	2003	2004	
Pension	33	33	49	39	16	170
Pass away	7	9	17	14	4	51
Resign	20	12	11	12	2	67
Total	60	54	77	65	22	288

TABLE II. Natural retirement in 5 years a head

	2004	2005	2006	2007	2008	2009	Total
Coming retirement	16	53	65	68	88	111	403

The main problem of BATAN is the decreasing number of employees, personal aging and the coming massive of retirement. This situation happens due to zero growth policy in government employment or more precisely negative growth policy on BATAN employment. Inflow of young specialists into nuclear area drastically decreased. During 4.5 years, from years 2000 and 2004, there were 170 retirements, 51 persons pass away, and 61 resignations leaving BATAN, the total lost is 288 employees. In that period only 40 recruitments of newer employees have been accepted. Therefore the BATAN nuclear workforce is aging - that is, more and more nuclear workers are approaching retirement age, without a corresponding influx of appropriately qualified younger personnel to replace them. In the 5 year a head, there will be 403 coming massive of retirement. The statistic shows a significant brain-drain flow from government research institutes to the private sectors or brain-drain to industrial countries.

TABLE III. BATAN Manpower Based on Education

Degree	2000	2004
Doctor	98	97
Master	233	259
Engineering	975	1004
Bachelor	502	490
Others	2025	1736
Total	3844	3596

In other to conduct nuclear research and development, in the year 2000, there were 3844 employees distributed in various fields of expertise and skill in accordance to their degree of education, 98 staff having Doctor's degree, 233 staffs having Mater's degree, 975 staffs are scientific and engineering degree, 502 staffs having Bachelor's degree, and the remaining number of technicians with various levels of education. In the mid 2004, there are 3586 employees, 97 staffs having Doctor's degree, 259 staffs having Master's degree, 1004 staffs are engineering, 502 staffs having Bachelor's degree, and the remaining number are technicians with various levels of education. Table 3 compares the employees based on education in 2000 and 2004. The strategy taken in knowledge preservation is to compensate the reduction number of employees with staff's promotion in higher education programmes to

risings the competency and qualification of the BATAN's human resources. A center of BATAN namely the Education and Training Center (ETC) has the responsibility of conducting education and training of nuclear science and technology in Indonesia. ECT has been cooperation with some Universities and colleges (such as University of Indonesia, University of Gadjah Mada, Bandung Institute of Technology, University of Dipenogoro, etc.) for education and training on nuclear science and technology, and to train Master's degree and Doctor's degree in the majors of nuclear physics and nuclear engineering. At present more than three Indonesian higher education institutions train the specialists in nuclear engineering. The undergraduate nuclear worker was mainly supplied from domestic universities.

4. Public Information and Public Education

Public Acceptance is one of the most important issues in the introduction of nuclear power. The basis of public acceptance is public understanding, in which accurate and justified actual information on the benefits and risks of nuclear power must be provided to the public. Public acceptance is derived from public understanding that the nuclear programme is indispensable and beneficial to the Indonesian economy and environment. And public understanding may results in public support for nuclear power programme. In Indonesia, nuclear energy is understood by only a small group of people or educated people. Globalization in information which exploits often the negative side or the weakness of nuclear energy is influencing educated people. Catastrophic accidents like the Chernobyl and Three-Mile Island have a large impact to the public. Reports of nuclear accidents and effective campaigns by anti-nuclear groups continue to give misinformation and misunderstanding to the public. The general public trend to have negative perceptions since they have received unbalance, misleading, and incomplete information, like: nuclear is very expensive, nuclear accident is identical with atomic bomb, and radioactive waste is a menace to the environment. The official statement that nuclear power is the last choice in the mix of energy policy does not help promote the public support to NPP. Many anti-nuclear ideas from the NGO's are also adopted by some educated people, journalists, and certain social-leaders.

Indonesia needs effective and credible public information, public education and public relation organization. They have to be established first to win the heart and the mind of the public. Therefore, the public information has to be intensified in line with the dissemination of proven nuclear technology in the major application fields: agriculture, industry, medicine, space and electricity. The problem is how to create strategic planning to enhance the present public information and public education programme. Firstly, the public information has to be intensified in line with the dissemination of proven nuclear technology application activities already carried out for couple years in various provinces together with various research and development institutes and local governments, universities, private companies, and non-governmental organizations. Secondly, to enhance the present public information programme, the traditional form of one-way public relation exercises has to be replaced with more elaborate activities including contact with the general public. Information about nuclear power cannot limit itself to NPP only; rather the role of this energy source has to be explained within the context of objectives for the social, political and economic development of a country including its interconnections with global issues and international developments

BATAN has had task to conduct various studies and research in the major application of nuclear field, not only nuclear energy. In agriculture, BATAN researchers have succeeded developing better rice strains, the "Atomita-I", "Atomita-II", "Atomita-III", "Atomita-IV", "Situ gintung", "Cilosari", and "Merauke". These have helped to fulfill the need and sustain the supply of rice for the country. Besides rice strains, BATAN researchers have also succeeded in creating two mutant lines of soybeans and a mutant line of the mungbean.

BATAN researchers have also succeeded in developing a feed supplement for farm animals using by-products or molasses from sugar factories. Better quality dairy products and meat are the results. For animal husbandry and live stocks, BATAN researchers have succeeded in releasing two radiovaccines as well the koksivet supra'95. In medicine, BATAN researchers have succeeded in making and supplying radioisotopes and radiopharmaceutical needed for diagnosis and therapy for various illnesses. The BATAN research tissue bank has succeeded in producing radiated sterilized bone grafts for implementation. Ever since the late eighties, BATAN staffs have been able to manufacture their own fuel and control elements to supply the need their research reactors and 30 MW Multipurpose Reactors (RSG-GAS) where various radioisotopes have been produced and utilized by Indonesian hospitals, industries, and also exported.

Government and nuclear industry must create open and transparent policy in the nuclear decision making process to fulfill the "right to know" of the public. The participation of the public in the process should be encouraged through professional organizations or NGOs. The traditional form of one-way public relation exercises has to be replaced with more elaborate activities including contact direct with the general public through: formal education at schools, media programmes, cyber programmes, and exhibition programmes. We believe that the difference audiences in Indonesia will be reached through several events normally held each year, such as: visit to the nuclear facilities, seminars and workshop on nuclear energy and technology, opinion survey, Interactive-live on TV and radio feature programme, press releases and press interviews, Popular Publication and Newsletters, Public Information on Web Site, and so on. We have to identify the knowledge carries in Indonesia, like: teachers, journalists, government officials, political leaders, religious leaders, informal leader and artist. The training and education programme about advantage and disadvantage of nuclear energy to the knowledge carries has to be intensified. Training for the journalists must be given in the top of priority. There are more and more journalist joint environmentalist groups. These groups are more popular than scientific journalist groups because the environmentalist groups are very active in organizing seminars and campaigns for nature preservation in collaboration with environmentalist NGOs. Experiences show that the mass media has becoming an important factor in the role of forming public opinion as well as informing and educating the people. Therefore maintaining a friendly relationship with the journalist is one of the classical recipes. BATAN has organized the nuclear science and technology training programme for Indonesian scientific journalists on September 2003.

5. Nuclear Knowledge Management Strategies

The establishment and maintenance of a formal human resources policy and nuclear knowledge management strategies are important to ensure that an organization maintains adequate numbers of competent and motivated personnel, and the availability of essential technical information (explicit knowledge) in the form of scientific research, engineering analysis, design documentation, operational data, maintenance records, regulatory reviews, and other documents and data to achieve the organization's mission. In the preparation of NPP project, there is three major factors of nuclear knowledge management strategies to be applied: (1) Education, Training and Qualification Personnel; (2) National Participation; and (3) Transfer Technology.

5.1. Education, Training and Qualification Personnel

Education, training and qualification personnel are a part of the human resource strategy which should consider the science and technology demand and the safety requirement needed and recommended by regulation. The aim oh human resources development is to prepare highly skilled and qualified personnel to handle the NPP programme in every phase. From the point of view HRD strategy, training of personnel should consider the adequacy of the system

to conduct effective programme, such as the availability of training management, training facility, training material, training aid and equipment. The development of training technology is required to ensure and maintain proper and adequate levels of competencies, and staffs are aware of technological developments and new safety principles and concepts. The development of training technology cover several major concern which are: (1) Modules and References; (2) Knowledge Preservation and Enhancement; and (3) Trainer. Modules and references prepared for training participants plays important role in training implementation. Education and Training Center has to make provisions for continues upgrading and renewal of the courses and instructions by assigned expert to examine course and instruction. Instructional materials is developed and revised by an expert assigned to lecture in related area during training preparation. With regard to information exchange, international co-operations very important in the development of better training modules and references. The ageing of qualified manpower and declining of public educational interest in nuclear science and technology is the major cause of how important to accelerate the development of knowledge preservation and knowledge enhancement system. The needs of trainer for training in nuclear technology in Indonesia have been adequately fulfilled by domestic scientists and experts. Trainers mostly completed their higher education and training experience abroad. Only a few courses need to be delivered by foreign experts, such as course cover current development.

When the commitment has been made for the first NPP, it will be necessary for the utility to consider seriously the building and staffing of a training center for operations and maintenance personnel. The center should be equipped with one or more simulators; computer aided training tools, the necessary equipment and plant mock-up for maintenance training. It should be capable of expansion to keep pace with the evolving nuclear power programme. Ensuring that personnel with the necessary qualifications and experience are available for the operation and maintenance of a NPP requires firstly a national educational infrastructure (undergraduate and post-graduate university levels, technical schools) which can provide professional and technician-level individual suitably educated in both the theoretical and practical aspects of technical subjects. It is also requires that a well designed training programme incorporating the best international practices be developed and implemented at a very early stage of the nuclear power programme.

Actually, a few students go to the nuclear engineering field due to reduced job opportunities. Unpopular character of education in Nuclear Engineering area for young people is also due to aging of equipment and lack of finances for the equipment updating, and absent of new training textbooks and manuals. One Department at undergraduate level teaching in Nuclear Engineering has closed due to a lack of student. From the external environment point of view, the consequential lack of interest of new professionals to engage in the nuclear fields considers to be the major national concern. This situation is compounded by the great reduction in higher education opportunities in the field of nuclear engineering and the elimination of nuclear engineering department in some universities. Therefore BATAN establish a school for Nuclear Engineering and expertise in Yogyakarta, namely Polytechnic Institute of Nuclear Technology, as an educational institute under BATAN. This institute was inaugurated in August 2001, with the main objective is to provide education and training facilities, and to support HRD programme in nuclear science and technology.

HRD programme and activities have been conducted not only for BATAN personnel, but also with participation by various potential institution and companies, like the Agency for the Assessment and Application of Technology (BPPT), State-owned Electrical Company (PT PLN) and national engineering companies. HRD is also expected to be part of the contract bids so that vendors, who are awarded the NPP project, would include HRD programmes to

produce qualified personnel that can perform the tasks of the vendor standard personnel. The BATAN's Education and Training Center is implementing the programme in the frame of supporting the development of NPP in Indonesia. This aim is further supported by sending personnel abroad to obtain Master or Doctoral degree, and sending personnel aboard for on the job training (i.e. to General Electric and Westinghouse companies to participate in their NPP design activities or to the research institute in Japan or Republic of Korea). BATAN nominates its staff to participate in the International Training Courses organized abroad by the IAEA, RCA, FNCA or foreign institutions under the bilateral cooperation. Co-operation under the MEXT Scientist Exchange Programme can help Indonesian researchers in training leading scientists in the fields of radiation technology, nuclear analysis and reactor technology in Japan nuclear facilities. RCA Regional Office in Republic of Korea promotes Master's degree course and Post-doc. fellowship (training) programme to preserve and enhance nuclear knowledge of RCA Member States through participation in major nuclear R&D projects.

The technological, safety and reliability requirements of nuclear power also demand highly qualified and competent personnel, who can prove to be a national asset and also provide an impetus for improving national technical education and training capabilities, which will be beneficial for other industries. It is a government responsibility to verify that the education and training system can respond to the requirements of the country's industrialization process in nuclear power programme, involve a broad scope, performance based and job specific systematic approach to training (SAT), with its special emphasis on objective performance indicators, evaluation and feedback throughout all phases of the programme. The ultimate aim of such training is the professionalism of personnel at all levels of the nuclear power plant. Training is thus the means by which a safety and quality culture is implemented and maintained. To implement a nuclear power project and to achieve reliable operation of a NPP and programme, it is essential to have highly qualified and motivated personnel, who are needed to plan, construct, operate and maintain a NPP and later to expand the system with more plants.

5.2. National Participation

The national participation in NPP construction is defined as the use of human resources, materials and technology resources from the country in the execution of such a programme. Nuclear power is a complex technology which makes great demands on national industry, standard quality, and qualified technical personnel. Launching such a programme, requires a governmental policy which promotes and support not only the programme, but also the relevant necessary national infrastructures and national participation goals and activities. Thus, national infrastructures are critical to the successful execution of a nuclear power programme. Infrastructure includes: organizational and regulatory frameworks; the availability of qualified personnel and education and training capabilities for producing such personnel; financial and industrial capabilities; and research and development capabilities. For a nuclear power programme to be successful, a certain level of technical and quality performance must exist in the relevant industrial, technical and management education and training infrastructures. Countries have found that the high level of quality requirements which must be attained and maintained for a safe and reliable nuclear power programme have beneficial effects for the non-nuclear industry, providing know-how and impetus for the upgrading of the quality, product value and technological level of other parts of industrial infrastructure.

Under an established programme of local participation, we can widely determine the Indonesian level of dependency on foreign resources in the development of NPP. This is essential as it involves technical as well as financial aspects. Furthermore, national participation is actually much required as the "vehicle" for promoting the capability in the

operation and maintenance of NPP, saving a part of the foreign portion in the financing, effective utilization of local work force, and gradually promoting the quality of national industry. As the development of NPP progresses through the stages, the capabilities in initiating the design and engineering, fabrication, construction, installation, commissioning, operation and maintenance of NPP are expected to be developed. The study conducted by BATAN and NEWJEC concludes that the national industry has the potential to be involved in NPP construction. The national industry organization consists of State-owned companies and private sector companies. The recommend level of local participation has been developed by an evaluation of current and projected future industry capabilities to provide the maximum benefit to both the NPP project and to the Indonesian industry. In the first phase of the NPP, the national participation is expected to have already reached 25%. This level should be increased step by step in accordance with development of the national participation programme, and should successful transfer of nuclear technology and nurturing of nuclear industries in Indonesia be achieved.

5.3. Technology Transfer

For successful transfer of nuclear technology and nurturing of nuclear power industries in Indonesia, the following conditions should be satisfied:

- National consensus on the decision of nuclear power as one of the vital resources in domestic energy mix to support the welfare and economic growth of Indonesia.
- Commitment by the Government of Indonesia to lead and support nuclear programme in Indonesia.
- Stability and sound growth of the Indonesia's economy.
- The availability of qualified personnel.
- The national industries should be classified and grouped according to their main activities.

At present, there are three big groups using radiation and radioisotopes in Indonesia; users in medical applications, users in. industrial applications and users in research applications. The ability to apply nuclear and radiological technology has a key role to play not only in the nuclear power industry, but also in health and a wide spectrum of research, development and manufacturing industry. In recognition of this, BATAN has taken the lead in the issue of nuclear skills, by coordinating other government departments and universities, including NGO's.

Sectors	Number of Institution	Number of Permit
Medical	1674	2170
Industrial	425	803
Research	9	26
Total	2108	2999

TABEL IV. List of institution and number of permit distribution in Indonesia

In order to prepare man power to support construction, operation and maintenance of the NPP in Indonesia, BATAN has performed the Research and Development (R&D) in reactor technology and also in the supporting activities, such as reactor safety, fuel cycles from front end to the back end technology. The specialists training facility has been created to meet

completely the research institute and industrial branch's demands for the specialists of all qualifications for research, engineering and production activity. The need to preserve, enhance or strengthen nuclear knowledge is recognized since a couple of years. The education and training is needed to maintain nuclear competence and qualification.

5. Conclusion

The economic development and the needs of the growing population to energy consumption are increasing demand and supply of energy to a limited number of sources of energy currently available. As a consequence, the electricity growth rate has been varied from 7% to 15% per annum. The nuclear option is inevitable in providing a secure long-term energy supply. Nuclear power is the only alternative at present for replacing the fossil base load generation, especially in Java. Studies of the economics of nuclear power in comparison with alternatives have shown that nuclear power can compete economically with other plants in a range of situations. The introduction of NPP in Indonesia is not only to reach an optimum energy mix considering costs and environment, but also to relieve the pressure arising from increasing domestic demand for oil and gas.

The other important issue in nuclear power introduction is the human resources development for the safety of nuclear facilities and technology development. It can be concluded that a comprehensive human resource development strategy is required beginning in the planning phase, construction phase until the implementation of nuclear programme. Indonesia through its nuclear energy agency (BATAN) has made and devoted special efforts to build a nuclear science and technology base in Serpong, and to prepare highly competence personnel to support our endeavor in preservation and enhancement of nuclear knowledge towards Indonesia's plan to operate the first NPP by 2016. Replacement of retiring staff and ageing of existing work force require great efforts from the government and BATAN management for establishing proper qualification and programmes. Improvement of education system, enhancement of public education, systematic re-education and re-training, and qualification management are important in the preparation of NPP project.

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