Recent Global Concern And Basic Considerations For New Entrance Of Developing Countries To Nuclear Power Programme

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ABSTRACT

Over the years, coal, oil and natural gas have been playing the key role as largest sources of energy in both developed and developing countries. Since these energy resources are unevenly distributed in the world, the continued heavy reliance on them has increased dependence on energy imports for a number of countries with consequent balance of payments difficulties, caused rapid replenishment of such valueable resources of supplier countries in tens to hundred of years and thus reduced energy security. Such reliance has also severely degraded the local and regional environment, leading to increased emissions of green house gases. Unfortunately, clean and renewable energy technologies such as photovoltaics, fuel cells, etc are not much developed yet except for commercial applications. On the other hand, an adequate source of energy is one of the major requirements for improving and sustaining human progress, thus the demand for energy, especially electricity, in developing countries is expected to grow more faster compared to developed countries in the coming decades as they seek to develop the economy, human welfare and improve the living standards of their growing population. Recently, these afore-mentioned global energy and environmental pictures put pressures on many developing and developed countries of the world to think and rethink for nuclear power in their overall energy supply mix. By this time, developing countries like China and India, nuclear energy has become an inevitable energy option. Other developing countries like Bangladesh, Indonesia, Poland, Thailand, Turkey and Vietnam have strong plans to introduce nuclear power by 2020 and more than twenty new countries in different regions such as Algeria, Australia, Bahrain, Cameroon, Chile, Croatia, Egypt, Georgia, Ghana, Greece, Jordan, Kenya, Malaysia, Mexico, Morocco, Namibia and Nigeria plan to introduce nuclear after 2020 or later. At the same time, the September 11, 2001 terrorist attacks on the USA has introduced a new dimension, the protection and security of nuclear power plant against terrorists to the axiology of nuclear energy to realize the global circumstances, especially those concerned with global security. This new issue has been augmenting the existing concern over nuclear proliferation, nuclear fuel cycle and nuclear spent fuel management and the developing countries are often encountering or may encounter changed environment for introduction of nuclear power plant for their peaceful purposes. Thus, the new entrances of developing countries to nuclear power need careful planning to overcome the vital socio-political issues like nuclear proliferation, safety and security of nuclear materials/facilities, spent nuclear fuel and radioactive waste management, public dispute and the financial risk of nuclear power plants under liberalized market conditions, etc. at the initial decision-making stage of the programme in order to materialize their nuclear goals. In this article, some socio-techno-political issues and necessary basic considerations at initial planning phase for a new entrance of the developing countries that can make parity between black- and-white dualism of nuclear energy are addressed.

1. INTRODUCTION

Energy is a vital infrastructure for attaining goals of socioeconomic development, human welfare and standards of living. The availability of reliable and quality energy at reasonable prices on a long term perspective is recognized as having the same importance as any other form of security of any country. Safe and consistent energy in economically acceptable ways is essential for political, economic and social need. Thus, energy occupies a central role in the general policy structure of the governments. However, much of the world energy is currently provided and used in ways that would not be sustainable in the long-term.

Presently, levels of economic development, standard of living and access to modern energy services are distributed distinctly around the world. Disparities in energy availability mirror the economic disparities among regions. The richest 20% of the world's population use 55% of the final and primary energy and producing and consuming 80% of the value of all goods and services globally, while the poorest 20% use only 5% of the energy and dispose of only 1% of the global GDP [1]. Of all energy carriers, the disparities are largest for electricity. The richest 20% use 75% of all electricity, while poorest 20% use less than 3%.

World population is expected to double by the middle of the 21st century and economic development needs to continue, particularly in the developing countries. According to the projections of the International Energy Agency, the total demand for commercial energy would increase from 10,110 MTOE (Million Ton Oil Equivalent) in 2000 to 24,835 MTOE in 2050 in the High Scenario [2]. In the terminal year, the demand is estimated at 19,831 MTOE in the Low Scenario and 14,246 MTOE in a scenario that envisages extensive conservation measures. It has been realized that the supply of fuel would have to be doubled globally over this period even if the low scenario of growth is attained. It has also revealed that the demand for energy in developing countries would increase more rapidly in the next five decades compared to developed nations because per capita

income in most of the currently developing countries will have reached and surpassed the levels of the today's developed countries. The International Institute for Applied System Analysis and World Energy Council jointly projects electricity requirements of developing countries to increase by a factor of 2.5 to 3 over the next 20 years and the demand for primary energy will increase 3 to 5 fold by 2050, with an accompanying 5 to 7 fold increase in electricity demand [3].

The large disparities in the levels of economy and energy uses among different regions, conbined with future population growth, economic development and technological progress are important drivers of future energy demand. However, the major part of present global energy demand is met through fossil fuels, the future global scenario of primary energy supply is difficult to ascertain because of complex issues like economics of energy production, strategy of individual supplier country on resource extraction, international politics on energy and the dynamics of the international energy market. In addition, the global warming due to emissions of greenhouse gases from fossil fuel uses and rapid depletion of such reserves will have significant impact on the future supply-mix.

The significant expansion of global energy production and use will require the utilization of all available energy supply options as well as stepped-up efforts to further improve energy efficiencies throughout the energy system. In order to sustain the economic development and to address the environment challenges associated with poverty, the issue of sustainable energy development has become a global concern. Therefore, in this millennium, the global challenge is to develop strategies that foster a sustainable energy future will need alternative technologies to replace the present conventional sources of energy i.e. less dependence on fossil fuels. Among various environmental friendly global energy resources, the potential of nuclear and renewable energy resources is the highest one.

Nuclear power remains at the forefront of the debate about fuel security, the environmental impact of reliance on fossil fuels and the long-term cost benefits of switching to renewable power sources. Recently, there have been renewed interest in nuclear power in both developed and developing countries. There are three major reasons behind renewed interest in nuclear power. First, many existing nuclear power plants in developed countries will end their expected operating life (30-40 years) between 2010-2020. Energy utilities will thus face a decision as to whether they will re-order new nuclear power plants to replace and/or add to existing plants. Second, the global energy market is under stress due to rising oil prices and a tighter energy/supply demand balance. Especially for large energy consuming developing countries, such as China and India, it seems inevitable that they will expand their nuclear power programs in order to meet their rapidly growing energy demand. Some other developing economies, like Bangladesh, Indonesia, Thailand and Vietnam have now announced their intentions to introduce nuclear power programmes by 2020 or shortly after. Third, pressure to reduce greenhouse gases from energy consumption has made many countries to introduce policies to encourage non-carbon energy sources in order to overcome climate change problems.

On the other hand, there has also been an increased concern over nuclear proliferation, safety and secuirty of nuclear power plants/facilities against terrorist attacks. Thus a question arises in our mind, can nuclear power make significant contribution to solve the energy and environmental challenges without increasing the risk of nuclear weapons proliferation and probobale threats? Following that what can and will developing countries those are planning to introduce nuclear power programme in the mid to long-term future do to meet those challenges? In following sections, we discuss various issues that has been introduced to the axiology of nuclear energy and provide with views for solving such issues for the concerned countries.

2. UNSOLVED ISSUES RELATED TO NUCLEAR ENERGY IN THE 21ST CENTURY AND MISUNDERSTANDINGS

Over the course of human history, there has been an inseperable relationship between warfare and the develoment of nuclear energy. Nuclear energy was developed in the early 1940s and the world first witnessed its ugly face by the mass destruction and human tradegy brought on by nuclear weapons during World War II. However, the nuclear proliferation has become an unsolved issue after the maturity of nuclear power technology, even nuclear energy grew immensely in some regions of the world within the era of the Cold War. The accident that occurred at the Three Mile Island in 1979 and the Chernobyl Accidents in 1986 created a shadow over the confidence of technological safety of nuclear power reactor.

After the Cold War came to an end during the early 1990s, those who benefited from the development of nuclear energy were most likely confronted with a challenge by a new tide of civilization. Although the challenge had not been closely questioned since then, such a new movement abruptly manifested itself after the terrorist attacks on September 11, 2001. After these attacks, many began to realize that global circumstances, especially those concerned with global security, must have changed with the reordering of the world's basic structures that support political and economical developments. It is claimed that a range of means is available by which terrorists or terrorist groups might seek to disperse radioactive contamination with the goal of causing mass fatalities. The most potentially devastating radiological attack would be to sabotage a nuclear power plant or spent fuel pond. Recent studies sponsored by US Nuclear Regulatory Commission have projected, in a worst case, over a hundred thousand deaths from a beyond design-basis accident, as might be caused by successful sabotage [4]. The nuclear power plants have been the subjects of some terrorist interest; threats or attempts to blow up or penetrate nuclear reactors have been reported already in Argentina, Russia, Lithuania, Westerns Europe and South Africa. Spent fuel transports are another potential target for sabotage. The issue of protection and security of nuclear power plants against terrorists is introduced to the axiology of nuclear energy and the relationship between human and nuclear energy entered the 21st century with additional unsolved issues.

It is historically evident that the military development of nuclear power has acted as the cradle for the civilian use of nuclear energy. Nuclear power stations as energy sources and nuclear weapons capable of mass destruction are the two sides of nuclear energy: right and wrong, or negative and dark side versus

positive and bright side. Due to inherent dual faces of nuclear energy, the developing countries have often encountered or may encounter changed environment for introduction of nuclear power plant for peaceful purposes. Under present global changed circumstances, the following important issues have to be overcomed by the new entrance to nuclear and to realize global resurgence of nuclear power.

2.1 Protection and Security of Nuclear Power Plants against Terrorists

In the past, safety assurance of a nuclear facility has been accomplished by the concept of designing it under the ideas of design basis accidents (DBAs) and defense-in-depth. This concept of safety assurance has been independent of physical protection (PP), which consists of measures against the diversion and theft of nuclear materials and the security of nuclear power plants against external terrorist attacks. The appalling events of September 11, 2001 created a new world that calls for new approaches for protection, and securing nuclear materials and nuclear power plants which will require a far-reaching new effort for strengthening security and establishing stringent security standards in place.

2.1.1 Nuclear non-proliferation

In order to have sustainable nuclear power growth, it is essential that such expansion of nuclear power will not lead to increased proliferation risk of nuclear weapons. The biggest proliferation risk comes from nuclear fuel cycle facilities, such as enrichment and reprocessing, which can produce weapons-usable material (WUM, i.e. highly enriched uranium [HEU] and plutonium). Since expansion of nuclear power can naturally lead to proliferation of sensitive facilities and technologies, the countries those are operating and those will like to introduce nuclear power plant must have tighter control over nuclear fuel cycle activities.

2.2 Spent nuclear fuel and radioactive waste management

There are unsolved problems having to do with the by-products of reactors, nuclear wastes. These wastes result from fissioning of the uranium fuel in the reactor. Some of these of fission products are long-lived and highly radioactive and they pose a potential danger to the environment and society for generation. Another critical consideration with nuclear reactor wastes is the potential for diversion to use as weapons. The specific waste product of concern is Pu-239, a weapon grade material which can be seperated from other spent fuel elements by chemical means.

2.3 Safety and Public Confidence

Still there is a growing fear about the standards of safety of nuclear reactors and the safety concerns remain one of the highest barriers for decision makers and local communities to accept the siting of nuclear power facilities, including waste storage or disposal facilities. Basically, the Three Mile Island and Chernobyl accidents focused attention on a global issue of nuclear safety.

2.4 Higher Capital Costs

The capital costs of nuclear power plant are higher-averaging around US$ 1500 per kilowatt overnight cost. But this is in the same league as brown coal plant. These high capital costs are major hindrance to new nuclear reactor investment due to unexpected fall in fossil fuel prices. The competitiveness of nuclear power against fossil power plants (in particular coal and natural gas) is typically measured by a lifetime average power generation cost. Typically, nuclear power plants have much higher capital costs (60~70%) of total power generation costs than coal (~40%) or natural gas (~30%). Presently, there is a lot of confidence that these capital costs can be driven down to around US$ 1100 per kilowatt with series construction. Moreover, the days of fossil fuels are over.

3. THE REAL WORLD SCENE ON NUCLEAR

However, a new issue has been introduced to the axiology of nuclear energy, internationally, the nuclear renaissance is gathering steam from the beginning of this century. Basically, after unexpected fall in fossil fuel prices, the outlook of new NPP has become mixed for construction in the several years in Western Europe and North America, the two regions with the largest number of operating nuclear power plants. Most of the operating NPP countries of these two regions had no firm plans from the middle of 1980s. Unfortunately, the picture of the price of fossil fuel especially oil has been dramatically changing and the issue of global warming has been gathering momentum at the end of the last century and the attitude towards NPP of those countries are also changing. However, in the USA no new nuclear power plant has been ordered during the last four years, the new US 'Energy Policy' released in May 2001, recommended Government support for 'the expansion of nuclear energy in the United States as a major component of…National Energy Policy'. The Government of Finland (January 2002) made a favorable decision in principle on utility application to build a fifth nuclear power plant. In April 13, 2007, the world's leading industrial nations, the Group of Seven (G7) have unanimously accepted nuclear as one of the potential power sources, which the Group in the past had been unable to agree primarily due to opposition from Germany. The EU leaders at a summit in March 2007 adopted a resolution-included nuclear power as a legitimate means of meeting the EU's greenhouse gas emissions reduction target.

On the other hand, only a decade ago, the environmental lobby was noisy in opposition, however, today the world's highest profile environmentalists speaking very clearly in favour of nuclear power. Presently, our world desperately needs the clean-energy revolution and every authoritative analysis points to the fact that humankind cannot conceivably achieve a global clean-energy revolution without a huge expansion of nuclear power - to generate electricity. At present, 30 nations representing two-thirds of humanity use 339 nuclear reactors to produce about 16% of global electricity. Major nuclear power expansion is underway in some countries, and it is increasingly likely that this will spread to many. By this time China and India have launched a massive nuclear power programme Japan and South Korea are steadily increasing their nuclear capacity, and Japan is very serious about boosting its nuclear share further. Finland has four reactors providing a quarter of its electricity is now building a fifth and

talking about a sixth. There is steady growth elsewhere, including Russia and Eastern Europe. By 2020, nuclear power will most likely extend to further nations as diverse as Poland, Turkey, Chile, Vietnam and Indonesia. More than twenty new countries in different regions of the world such as Algeria, Australia, Bahrain, Cameroon, Chile, Croatia, Egypt, Georgia, Ghana, Greece, Jordan, Kenya, Malaysia, Mexico, Morocco, Namibia and Nigeria are planning to introduce nuclear after 2020 or later. This broad base - representing most of world population and economic activity - will provide the foundation for a nuclear century, not by misunderstanding or ignoring unsolved issues of nuclear power, but because it is a proven technology, economically competitive with fossil fuels, capable to ensure energy security and represents much less of a problem or threat than global warming. In the following, we briefly discuss the real world sense on nuclear, which is often misunderstood through representation of unsolved issues.

First, as to the danger of nuclear weapons proliferation, we know that rogue states and terrorist groups will pose an ever-present risk. However, this cannot be the right reason to abominate even the peaceful use of nuclear technology for civilian energy sources. But strong, universal safeguards can ensure that even a 20-fold global expansion in nuclear power would not increase that risk, and in the meantime power generation is using up material from both Russian and US military stockpiles. Security for the environment and against terrorism need not conflict and the safeguards regime under the Nuclear Non-Proliferation Treaty represents one of the great success stories of the UN, even if we now wish it had been even more ambitious.

Second, it is really true that the long-term radioactive waste storage problems of nuclear power have not been fully solved and waste management is fundamentally a question of perspective. But significant progress has made in handing and storing the spent fuel and radioactive wastes. In Europe for instance, radioactive wastes comprise about one percent of all toxic industrial wastes. There have been no problems from storage, handling and transport of civil nuclear wastes in 50 years, and none are likely. For long-term storage, a strong scientific consensus favours deep geological repositories. Governments worldwide must follow the lead of Finland, Sweden, America and France by moving to construct such facilities. Presently, there are two primary policy choices with regard to spent fuel management: one is that directly disposes of spent fuel to a repository, and the other is the "Recycling" option, which recovers uranium and plutonium from spent fuel, to be then recycled into reactors while the remainder of the spent fuel is vitrified and disposed of as waste. Eventually, many nations may pursue a "mixed strategy", i.e. combination of "once-through" and "recycling" after long term "interim storage". Various technical options currently being considered, and improved decision making process might be necessary to gain public confidence.

Third, for the long-term sustainable growth of nuclear power world-wide, it is essential to establish decision makers and public confidence on nuclear safety. Basically, the necessity of safe operation of nuclear power plants have been strongly emphasizing and good regulation is an essential element in ensuring safe operation. This is a complex issue and needs an appropriate balance between the level of safety to be achieved and the cost of achieving it. In reality, the industry has fostered a global nuclear safety culture that draws on almost 12,000 reactor-years of practical experience - double that if we include naval experience. A network of active cooperation on operational safety now links every nuclear power reactor worldwide and the assistance of World Association of Reactor Operators (WANO) will also be available for assistance in operating the plants safely. The nuclear industry's most fundamental responsibility now is to use it effectively to build on an already impressive record of nuclear safety. In addition, when public talks about nuclear safety, they mean simply the prevention of accidental release of radioactive materials outside the plant. It is the reality that there has never been any public harm from any reactor licensable in the west (or anywhere today) and as with most technologies, operations today have generally much enhanced safety margins compared with decades ago. In addition, there are a number of most impressive reactor designs developed from the well-proven units now providing 16% of world electricity - most are second-generation types. But early 3rd generation plants have been operating in Japan since 1996. Advanced 3rd generation reactors are now on the market and being built. These have greater standardization, simpler engineering, expedited approvals in several countries, longer operating life, and are one or two orders of magnitude safer than the workhorse 2nd generation units. Since nuclear safety is but one of the several technological risks of modern society, therefore, public confidence could be easily eroded by various chemical plants accidents or non-technical incidents such as data falsification incidents. For exaomle, a petrol tanker on a road is more of a public safety hazard than any nuclear waste in transit anywhere in the world. Technically, storage and disposal of wastes are straightforward. But we do need to build public recognition that waste is in fact nuclear power's greatest asset. Unlike fossil emissions, the volume is minimal and is reliably contained and managed. Better social decision-making process may be needed to gain long-term public confidence in nuclear policy. Cost of waste management and disposal is internalised at about one fortieth of generation cost.

Fourh, capital costs of NPP are high. But once built, nuclear power typically has lower fuel and operational cost advantage than fossil plants. In fact, most existing nuclear power plants are quite cost competitive against most fossil power plants. According to the recent OECD/NEA study, nuclear power is competitive with fossil power plants in many countries [5]. Figures from the latest OECD international survey released in March show that at 5% discount rate nuclear in the range 2-4 c/kWh (US) is comfortably cheaper than coal in seven of ten countries, and cheaper than gas in all but one. In addition, it is the fact that nuclear fuel costs are low: doubling the cost of gas and coal increases electricity production cost about 70% and 40%, respectively. Doubling the cost of ex-mine uranium increases electricity production cost about 5%. Moreover, the external costs for nuclear are very much lower than from alternatives. Thus, decision to build a medium to a large new reactor is basically an economic one.

However, under liberalized markets, where "cost-plus" rate regulations do not exist, utilities must bear financial risk of large capital costs. Utilities are under pressure to reduce capital expenditure in order to secure profits, and tend to make investments on the basis of expected return in the short term (3~5 years). As a result, it is generally believed that it would be difficult for privately-owned utilities to order new nuclear power plants in a liberalized electricity market. In order to overcome

such financial risks, governments have introduced or plan to introduce policy measures to reduce such risks for utility companies. For example, the US government has passed a new law, the Energy Policy Act (2005), incorporating policy measures to provide incentives for utilities to order new nuclear power plants. In addition, the licensing process for new reactors has also been improved to reduce time delays and uncertainties. Similar policy measures have also been announced by the UK Department of Trade and Industry in its latest "Energy Review" paper published in July 2006 [6].

4. BASIC CONSIDERATIONS AT PLANNING STAGE FOR NEW ENTRANCE OF DEVELOPING COUNTRIES TO NUCLEAR POWER PROGRAMME

As we discussed before, although intended for peaceful purpose nuclear technologies are tied inextricably by physics with nuclear weapons technologies. The nuclear power plants and nuclear facilities may also be the subjects of some terrorist interest for threats in creating a strong bargaining position or attempts to blow up or penetrate nuclear reactors with the goal of causing mass fatalities through killing and creating social and economic disruption. In some instances, acquisition of nuclear technology seems to be merely a question of national prestige. In others, nations those are concerned with national security or economic development may introduce nuclear power, which appears to be true both for weapons and power generation. Thus, the acquisition of nuclear technology by a nation to have a variety of motivations, the world is confronted with the awesome threat of nuclear proliferation and threats from the acts of nuclear terrorism. Undertaking a nuclear power programme by a nation requires a major commitment on strict attention to nuclear safety and control of nuclear material which is a responsibility not only to the citizens of the nation embarking such a programme, but also a responsibility to the international community. Thus, it is apparently true that any developing country with limited fossil fuel resources for a long-term basis might feel its independence threatened by too much as oil and coal exporters and plans to introduce nuclear reactor only for peaceful purposes. The country may encounter various obstacles in every stage of implementation process due to national, regional and international obligations related to safety and security of nuclear power plant under recent changed environment.

The introduction of a power programme involves a commitment from a nation of at least 100 years [7] to maintain a sustainable national infrastructure through planning (10-15 years), construction (5 – 7 years), operation (40 – 60 Years), decommissioning and waste disposal (above 20 years). The decision by a nation to embark on a nuclear power programme should be based upon the commitment to use nuclear power for peaceful purposes in a safe and secured manner. Thus, a developing country needs a careful planning for promoting the basic and fundamental research and a vision for more than hundred years in preparing, maintaining and developing appropriate infrastructure for the research, development and utilization of nuclear energy. It is also necessary to improve the intellectual base for safety and security of nuclear energy at all stages at different time frames at the initial planning phase of the programme. Since the stable national economic, social environments as well as national and regional political stability are favourable condition for a country contemplating the nuclear power programme, so a new entrance to nuclear must be concerned of these issues.

Experience has shown that the time frame from the initial planning stage to start construction of the first unit of nuclear power plant will be 10 – 15 years. Within this stage, the following two broad strings of activities needs to be performed: (a) technical, economic and financial management of the nuclear power programme; and (b) safety and regulatory aspects to overcome various issues in introducing nuclear power programme and to ensure financial viability and technical safety and security at every stages of the programme. Since the above two categories of functions are to be ultimately conducted independent of each other, the country needs to address each of these functions in planning and initial decision-making stage effectively. In the following the essential activities to be carried out at initial planning or decision-making stage are discussed briefly.

4.1 Justification for Introduction of Nuclear Power Programme

Securing a long-term stable, affordable and environment friendly supply of energy and electricity is one of the development policy issues of any nation. Any developing country that plans to introduce nuclear power program for generation of electricity needs to project the energy system expansion strategies for sustaining and accelerating the socioeconomic development over a long-term period (for 30 to 50 years) and to estimate a stable, secured, affordable and environment friendly primary energy supply alternative options for meeting the demand of energy and electricity by optimizing use of indigenous energy sources and quantifying the needs to import fuel for ensuring proper demand-supply management and energy security over the projected period. The options of imported fuels needs to be identified, especially the economical, financial and technical viability of nuclear power as one of the important components of the energy mix has to be justified. Accordingly, the national energy policy of the country has to be formulated or updated taking into consideration of nuclear power programme. The rationale for pursuing a nuclear power programme should flow from a national energy policy supporting the desired economic development goals of the country and considering the contribution that nuclear power will make to that policy.

4.2 Political Decision

If a country needs additional energy and nuclear power is found as a possible option, at this time the country would be in a position to make an informed decision on whether it is appropriate to introduce a nuclear power programme. The government should adopt a clear statement of intent to develop a nuclear power programme and communicate that intent locally, nationally, regionally and internationally. In addition, the government must streamline the energy and power sector through a serious of policy and institutional reforms and measures. Basically, the government commitment and support is vital to the successful implementation of a nuclear power programme.

4.3 Strengthening of National Nuclear Infrastructure

The intention to develop a nuclear power programme, the national Nuclear Infrastructure has to be strengthened through involvement in R & D activities in various fields of peaceful application of atomic energy. A strong leadership and adequate funding in nuclear research activities is necessary for the initial programme development and continued government support will be required throughout the life of the programme. In addition, a careful consideration has to be given to the means of maintaining the long term political, economic and social stability required throughout the life of the nuclear power programme. In the following subsections, various issues related to initial planning phase are addressed.

4.3.1 Promotion of R&D in Radiation Protection and Nuclear Safety

A country considering a nuclear power programme must develop the existing national infrastructure for radiation, waste and transport safety and the nuclear R& D activities, practices and facilities to be in compliance with international standards. Making use of the existing infrastructure together with the experience of a developing country that has introduced nuclear power, the country may build up the necessary infrastructure for a nuclear power programme. In many countries having an active nuclear power programme, the activities were initiated within the framework of the national agency responsible for nuclear research and development programmes. This strategy may be effective because of the multi-disciplinary nature of such an institution and also cost-effectiveness. As the programme grows, such an institutional arrangement may ultimately become less effective, especially in the areas related to commercial operation and safety. Thus, it becomes essential to establish separate institutions for Nuclear Safety and Regulatory matters and for construction and operation of nuclear power plants.

4.3.2 Formation of an Apex Body for Nuclear Power Programme

Nuclear power programme is very complicated and any decision on it, unless taken at an appropriate level of the government, might be rendered ineffective. Its overwhelming role is evident from the wide range of national as well as international agencies, whose concerted participation is essential for the success in realizing the decision effectively. Thus, a blanket administrative provision is essential to ensure efficient implementation of a government decision on the national nuclear power programme. In the case of a new entrant, a Cabinet Committee, chaired by the Head of the Government must be in place to take decision on the programme. This Committee must include Ministers and Permanent Secretaries of all relevant Ministries as well as the government agencies related to the nuclear R&D activities, the Planning Commission of the government and the energy sector in general. The Cabinet Committee will provide general guidelines, define policy and review progress of all matters related to nuclear power programme of the country. This Committee will also facilitate in establishing proper linkages between the macro and micro level planning. A Technical Sub-Committee, headed by the Minister of Ministry of Energy or Ministry of Science and Technology is to be formed to monitor implementation of the decision taken by the Cabinet Committee. The other Members of the Committee must be Secretaries of different Ministries and professionals of R& D organizations and universities. This technical committee will monitor the progress of the programmes and to provide recommendations to the Cabinet Committee.

4.3.3 Strengthening of the national nuclear safety legal framework

Various legal instruments are pre-requisites for successful implementation of nuclear power programme in a developing country. They are to be formulated in conformity with the existing laws of the country. Additional legal provisions may be required if the country wishes to attract private entrepreneurs to invest in the nuclear power programme. A developing country that is planning to introduce nuclear power programme must establish a national infrastructure for nuclear safety and radiation control in practices and facilities. Therefore, quite comprehensive rules for the control of radiation sources and nuclear facilities in the country needs to be formulated or existing law has to be amended at planning stage of nuclear power programme. Accordingly a national body/organization has to be empowered to enforce different provisions of the law, including formulation of regulations, policies on nuclear safety, radiation control and radioactive waste management; regulation and control; public information, advisory services and training. In addition, the country should have a clear vision to establish full-scale nuclear regulatory control on-site facilities for management, processing and intermediate storage of all types (low, mid and high level as well as liquid, solid and gaseous) of radioactive wastes that are routinely generated in the plant.

4.3.4 Formulation of a Nuclear Power Action Plan

A nuclear power Action Plan needs to be formulated at initial planning phase of nuclear power programme identifying (1) various activities needed for implementation of the nuclear power programme; (2) agencies responsible for each of these activities; and (3) enabling measures like funding, for conducting the activities. In that documents the details roles and responsibilities of relevant government agencies, such as nuclear R&D organizations or Universities for R&D support, HRD, nuclear safety, etc. and the Ministry responsible for Energy and Power generation, organizations responsible for transmission and distribution and other such institutions having the mandate in the country for power purchase, its transmission and distribution as well as to integrate the nuclear power projects into the overall electricity generation planning have to be clearly identified.

4.3.5 Setting up an Institutional framework for planning and implementation of nuclear power programme

A nuclear R& D organization or a department of a R&D organization that has professionals with educational background and training in different branches of nuclear technology such as Nuclear Engineering, Mechanical Engineering, Electrical Engineering, Civil Engineering, Heat Transfer, Control and Instrumentation, Nuclear Physics, Chemical Engineering, Chemistry (Nuclear, Analytical and Water Chemistry), Nuclear Safety, Health Physics, Radwaste Management, Non Destructive Testing and Q/A may be assigned responsibility for planning and conducting initial phase activities for nuclear power programme in the country. The responsible organization/department must

maintain core personnel for planning and conducting decision-making activities during different phases of the programme.

4.3.6 HRD and Technology Transfer and National Participation

Since the availability of trained professionals is a key parameter to the planning and implementing activities, a systematic expansion of the human resource development (HRD) is an important prerequisite for introduction and implementation of nuclear power programme. Around 200 – 400 professionals in different fields would be required for successful implementation, operation and maintenance of a nuclear power plant. At the initial stage of nuclear power program, about 25 – 40 professionals are required for completion of pre-implementation phase activities (up to construction phase) and the country needs for the HRD in the nuclear power project planning such as financing related matters, site selection and evaluation, preparation of site safety related documents, preparation and evaluation of bid documents, QA/QC.

Globally, the opportunity for HRD of NPP programme is limited. A country embarking on the first NPP usually considers general guidance or outside expertise whenever needed. The outside expertise can never supplant the country's own effort to define its human resources requirements from a thorough understanding of the nature of each activity and the task in the first NPP project. Therefore, a critical and realistic assessment of the local organizations, education and industrial capabilities and determination of the requirements for developing the quality and quantity of human resources should be made before taking any decision for implementation of the first NPP. The manpower involving pre-implementation phase can be trained through regional as well as inter-regional training courses on above-mentioned aspects organized by the IAEA and through Technical Co-operation Projects of IAEA.

It is important to decide at a very early stage the mode and extent of technology transfer that the country aims at. This is no doubt that the whole planning exercise will depend on this decision, especially as this would influence the size and nature of the HRD programme. The same is also true for the desired extent of national participation in project implementation. A very careful and intensive appraisal of national infrastructure and industrial experience is required in determining the nature and extent of national participation.

4.3.7 Information to the Public

Public information and public acceptance may be considered as one of the key determinants for success of a nuclear power programme. Dialogues with the public, the people's representatives at various levels and the decision makers are considered to be important determinants in ensuring transparency and public acceptance. Nevertheless, it is apprehended that opposition groups may be encountered as soon as construction work starts. An effective public acceptance programme has to be designed and implemented in order to enhance public acceptance.

4.4 International legal framework

The country's nuclear energy program should be very transparent and fully committed to the peaceful use. Any country that is contemplating the introduction of nuclear power as part of its energy supply portfolio, it is essential to acquire a comprehensive understanding of the various obligations and commitments involved and the national strategy to discharge them, before any decision on implementation process is taken. Therefore, the country needs to sign all the international treaties, agreements and protocol prevailing in the nuclear non-proliferation and verification regimes.

Major international instruments for a nation to consider adopting prior to beginning a nuclear power project include the following.

- Nuclear Non-Proliferation Treaty
- Comprehensive Safeguards Agreement
- Additional Protocol
- Convention on Early Notification of a Nuclear Accident
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency
- Convention on Nuclear Safety
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management
- Convention on Physical Protection of Nuclear Material
- International Convention for the Suppression of Acts of Nuclear Terrorism
- Vienna Convention on Civil Liability for Nuclear Damage
- Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention
- Supplementary Agreement on Provision of Technical Assistance by the IAEA

4.5 Bilateral Cooperation Agreement

The country needs to make bilateral agreements on nuclear cooperation with the Governments of the countries of Nuclear Supplier Groups for HRD.

5. CONCLUSION

It is essential for the country to plan for introduction of nuclear power programme considering her long-term energy and electricity demand. If the country really needs additional energy and nuclear power is found to be a possible option, it must make an informed decision on whether it is appropriate to introduce a nuclear power programme through formulation of sustainable and long-term energy policy. The energy policy must encourage the use of optimal energy options including nuclear energy to enhance energy security. Development of basic infrastructure required for introduction of nuclear power has to be made so that the country can overcome all obligations to her citizen and to international community in ensuring safety and security at every stages of programme. Initiatives for strengthening and development of R& D works, upgrading nuclear regulatory framework, formation of a responsible utility for nuclear power programme planning and implementation and administrative structure for decision making level have to be set up by sharing the experiences of the developing countries those are advancing their NPP program in the justified direction. A systematic expansion of the human resource has to be made for planning and executing pre-implementation and implementation phase

activities as well as operation and maintenance of the nuclear power plant and the country may consider an innovative approach for HRD.

6. REFERENCES

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