International Journal of
Emerging Research in Management &Technology
ISSN: 2278-9359 (Volume-3, Issue-7)

Research Article **July 2014**

Nuclear Energy and Bangladesh

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Abstract—

Bangladesh is an over populated country, who is suffering from insufficiency of energy. The per capita energy consumption in Bangladesh is very low among the world. Lack of investment and maintenance, the existing power plants cannot provide desired output energy. The government tries to overcome the energy shortage by quick rental power plants, which is not a permanent solution to the energy crisis. So they needed a stable and reliable source of energy. Bangladesh has small reserves of oil and coal but very large reserve of natural gas. The main source of natural energy is its natural gas resources, 55% of it goes to the power generation while 27% goes to industries, 10% to household, 5% in the automotive sector and rest of it goes to other purposes. Due to underdevelopment and mismanagement of energy infrastructure of Bangladesh, establishment of nuclear power plant is highly desirable. Nuclear power can produce much more energy than of other kinds of energy resources without producing CO_2. Nuclear power plants can provide cheap electricity, with smaller amount of global problems than fossil fueled power plants. However, the future nuclear power plant will be safe and small producing radioactive waste. If the safety can be ensured, nuclear energy will play a vital role in energy sector.

Keywords — Nuclear Power, Fission, Energy, Nuclear Accidents, Nuclear Power in Bangladesh.

I. Introduction

Wealth of humankind is closely related to energy. The progress and the welfare of a society always depend on supply of energy in convenient form. Global energy and electricity demands are set to grow for decades. No credible short or long term energy assessment indicates otherwise. A growing world population and development aspirations in the current developing world, where large part of population still lack access to electricity, translate into even faster growth rates for electricity than for total primary energy demand. All studies agree that most demand growth will occur in the developing countries. So it is a strong challenge to overcome the crisis of electricity for a developing country like Bangladesh. Efficient policies need to be taken to ensure a stable and healthy economy. Bangladesh faces a significant challenge in revamping its network responsible for the supply of electricity. For this reason it is high time to use the alternative resources of power generation for Bangladesh for increasing the supply of electricity. Nuclear energy can be used as one of the alternative resource. Nuclear energy offers the opportunity of meeting a significant part of the anticipated increase in electricity demand whilst reducing the potential global environmental and economic concerns associated with fossil fuels. Bangladesh produced 44 billion kWh gross in 2011 from some 6.1 GWe of plant giving per capita consumption of 250 kW/year. Over 40 billion kWh in 2011 was from natural gas. Electricity demand is rising rapidly with peak demand 7.5 GWe and the government aims to increase capacity to at least 7 GWe by 2014, meanwhile importing some 250 MWe from India. New small coal-fired plants are envisaged for 2 GWe of that and for 3 GWe more by 2016. However, about half the population remains without electricity and the other half experience frequent power cuts. Some 5% of government expenditure is being allocated to power and energy. The capacity target for 2021 is 20 GWe [1]. As of March 11, 2014 in 31 countries 435 nuclear power plant units with an installed electric net capacity of about 372 GW are in operation and 72 plants with an installed capacity of 68 GW are in 15 countries under construction [2]. So, Bangladesh should have the same experience to introduce nuclear power plant. Nuclear energy supplies about 6% of the world's total primary energy and about 11.5% of all electricity. [3]

II. Source of Energy

Energy is available in various forms from different natural sources such as pressure head of water, chemical energy of fuels, nuclear energy of radioactive substances etc. All these forms of energy can be converted into electrical energy by the use of suitable arrangement. Nuclear energy and hydropower are the only two major established base-load low-carbon energy sources. Efforts to reduce CO_2 emissions are thus a major factor in the renewed interest in nuclear energy that has become apparent in recent years. Concern over security of energy supplies, arising from the concentration of oil and natural gas resources among relatively few suppliers, is also a consideration in some countries' energy policies that can be partly addressed through nuclear energy. The production of electricity in 2011 was 22,158.5 billion kWh. Sources of electricity were coal 41.2%, gas 21.9%, hydro 15.6%, oil 3.9%, nuclear 11.7%, other renewable 4.2% [4]. In Bangladesh the sources of electricity are quite similar. According to Bangladesh Power Development Board 10241 MW power capacity, power plants installed.

Table 1: Installed Capacity of BPDB Power Plants (As On March 2014) [5]

Types of Plant	Installed Capacity (MW)	Percentage
Coal	250	2.44%
Gas	6615	64.59%
HFO	1963	19.17%
HSD	683	6.67%
Hydro	230	2.25%
Imported	500	4.88%
Total	10241	100%

III. Development of Nuclear Power

At the end of Second World War, it was discovered that large amount of heat energy is liberated by the fission of Uranium and other fissionable materials. The production of electricity using nuclear energy was first demonstrated in the early 1950s, and the first large scale nuclear power plants entered operation before 1960. The first country to employ nuclear energy for power generation was ex-USSR in 1954. The world's first commercial nuclear power station, Calder Hall at Windscale, England, was opened in 1956 with an initial capacity of 50MW. Installed nuclear capacity initially rose relatively quickly, rising from less than 1GW in 1960 to 100GW in the late 1970s, and 300GW in late 1980s. Since the late 1980s worldwide capacity has risen much more slowly, reaching 366 GW in 2005. In 1973 oil crisis had a significant effect on countries such as France and Japan, which had relied more heavily on oil for electric generation to invest in nuclear power. During the 1973-86 period, energy growth was erratic. Overall in the US, energy grew about as fast as the population, whereas electricity grew faster than overall energy consumption, though not as fast as it had grown prior to 1973. By 1973, the cost of nuclear energy was no longer regarded as cheap as had been touted in the early days of nuclear energy development, and safety concerns were starting to have an impact on the public view of nuclear energy. Health and safety concerns, the 1979 accident at Three Mile Island, and the 1986 Chernobyl disaster played a part in stopping new plant construction in many countries [6]. In a longer perspective, from 1990 to 2010, world capacity rose by 57 GWe and electricity production rose 755 billion kWh. The relative contributions to this increase were: new construction 36%, upgrading 7% and availability increase 57%. In 2011, nuclear energy produced 12.3% of the world's electricity and 5.1% of the total primary energy used worldwide. The highest share of nuclear generated electricity was 25.7% in Western Europe and the lowest shares were 1.8% in the Middle East and South Asia. Nuclear power plants generated 2346 billion kWh of electricity in 2012. The industry now has more than 15500 reactor-years of experience. Globally the Fukushima Daiichi accident is expected to slow the growth of nuclear power but not reverse it. Among countries introducing nuclear power, interest remains high. Of the countries without nuclear power that, before the Fukushima Daiichi accident, had strongly indicated their intentions to proceed with nuclear power programmes, a few subsequently cancelled or revised their plans, others took a 'wait-and-see' approach, but most continued their plans [7].

IV. Fission

Nuclear energy is the use of exothermic nuclear process, to generate useful heat and electricity. The term includes nuclear fission, nuclear decay and nuclear fusion. The nucleus is the centre of the atom which is normally made up of the same number of protons as it has neutrons. Some very large nuclei certain isotopes have an imbalance. They can often be found with too many neutrons, and this imbalance will result in the nucleus becoming unstable. Nuclear fission is the process by which a heavy atomic nuclei split into two or more after collision with a neutron. This process produces heat and also releases neutrons. These neutrons can strike other heavy nuclei and initiate chain reaction. Uranium-235 is a radioactive substance which due to its large size and unstable state can undergo induced fission. Its nucleus can be split into smaller atoms after the collision with neutron and release two or three neutrons. The new neutrons can then initiate the decomposition of the nuclei of other atoms of Uranium. Propagation by the chain reaction release more neutrons and cause further nuclear splits. Fission can be caused by bombarding with high energy α-particles, protons, deuterons, X-rays as well as neutrons. Neutrons are most suitable for fission.

$$ {}_{92}U^{235} + {}_{0}n^{1} = {}_{54}Xe^{143} + {}_{38}Sr^{90} + 3\,{}_{0}n^{1} $$

This is the basic reaction underlying the use of nuclear energy. The immediate products of a fission reaction, such as Xe^{143} and Sr^{90} are called fission fragments, which along with other decay products (α, β, γ etc.) are called fission products. Fission products are radioactive isotopes of lighter elements. The most important fission products are radioactive forms of Bromine, Caesium, Iodine, Krypton, Molybdenum, Strontium and Xenon.

V. Fusion

Nuclear fusion is the process of combining two light nuclei to form a more massive nucleus. The nuclei of two isotopes of hydrogen, one (deuterium) having one neutron and one proton and the other (tritium) two neutrons and one proton, combine to form helium and a neutron, releasing energy in the process. Deuterium can be extracted from ordinary water. Tritium could be produced by the fusion reactor itself, through neutron irradiation of an isotope of lithium Li^6, the main producers of which are Bolivia and Chile.

$$ {}_{1}H^{2} + {}_{1}H^{3} = {}_{2}He^{4} + {}_{0}n^{1} $$

To cause fusion, it is necessary to accelerate the positively charged nuclei to high kinetic energies, in order to overcome electrical repulsive forces, by rising their temperature to hundreds of millions of degrees resulting in plasma. Fusion reactions are called thermonuclear because very high temperatures are required to trigger and sustain them.

VI. Energy Release by Fission And Fusion

The sum of masses of the protons and neutrons that comprise the nucleus exceeds the mass of the atomic nucleus. The difference in mass is called mass defect. The mass defect is converted to energy in a nuclear reaction is given by Einstein's law:

$$\Delta E=\Delta mC^2$$

Where E=energy, J; C= velocity of light= 3×10^8 m/s; Δm= mass defect, kg.

The energy associated with the mass defect is known as binding energy of the nucleus. The binding energy per nucleon determines the stability of the nucleus. Higher the binding energy per nucleon, higher the stability of the nucleus. It was found that the nuclei of the even-even type i.e., having an even number of proton and even number of neutrons are very stable. Therefore, a ${}_{92}U^{238}$ atom having 92 protons and 146 neutrons is quite stable and requires very high energy neutrons for fission, whereas a ${}_{92}U^{235}$ atom having 92 protons and 143 neutrons can be fissionable even by low energy neutrons. One of the fission products is represented as:

$$U_{235} + n_1 = U_{236} = La_{148} + Br_{85} + 3n$$

The mass equation for the above reaction is given as:

$$235.124 + 1.009 = 147.96 + 84.938 + 3.029$$

The mass deficiency on the right hand side of above mass equation is 0.207 atomic mass unit or 0.3436×10^{-27} kg. The energy release can be represented in electron volts.

1 electron volt = 1.6×10^{-19} J

1 a.m.u = 931 MeV

Equivalent energy released = 0.207×931 = 193 MeV

For fission of U_{235}, it is usual to assume that 200 MeV of energy is released. The equivalent release of energy in view of Einstein's law:

$E=mC^2=0.3436\times10^{-27}\times9\times10^{16}=3.0924\times10^{-11}$ Joules/atom

Now, one kg of uranium will have approximate 26.029×10^{23} atoms. If it is assumed that all the atoms have undergone fission, the total amount of energy released will be:

$E=3.0924\times10^{-11}\times26.029\times10^{23} = 80.49\times10^{12}$ joules/kg

The above energy released is approximately equivalent to 2.8 million kg of coal with a calorific value of 28.36×10^6 J/kg.

Considering fusion of two heavy hydrogen atoms (${}_1H^2$) to produce a helium atom. The reaction is represented as:

$${}_1H^2 + {}_1H^2 = He^3 + n + \text{energy}$$

The mass of heavy hydrogen atom is 2.01473 a.m.u. mass of helium atom is 3.016997 a.m.u. and the mass of free neutron is 1.00898, thus mass equation is,

$$D + D = He^3 + n$$

$$2.01473 + 2.01473 = 3.016997 + 1.00898$$

There is a mass deficiency on the right hand side equal to 0.003483 a.m.u. or equivalent heat energy released is 0.003483 × 931 MeV or 3.24 MeV [8].

VII. Preparing Fuel for Nuclear Reactor

A nuclear reactor is an apparatus in which heat is produced due to nuclear fission chain reaction. A nuclear reactor consists of nuclear fuel, Moderator, Control rod, Reflector, Reactor vessel, Shielding, Coolant. Fuel of a nuclear reactor should be fissionable material. U^{235}, Th^{232}, Pu^{239} is used as nuclear fuel. Moderator is used to control the speed of the fast moving neutron produced from chain reaction. Control rod is used for controlling the rate of fission by absorbing neutrons. The neutrons produced during the fission process will try to leave the reactor core; reflector is used to send the neutrons back into the core. Reactor vessel contains moderator, reflector, thermal shielding and control rods. During fission of nuclear fuel, alpha-beta particles, gamma rays and neutrons are produced. Biological shielding is provided against them. Coolant is used to transfer large amount of heat produced in the reactor due to fission of nuclear fuel during chain reaction. Of the commercial reactors in operation, approximately 82% are light water moderated and cooled reactors, 11% are heavy water moderated heavy water cooled reactors, 3% are gas cooled reactors, and 3% are water cooled and graphite moderated reactors. The nuclear fuel cycle is the process where nuclear fuel is prepared and managed before and after its use in a reactor. It starts with mining of Uranium. The extraction Uranium ore from the earth is conducted in much the same manner as the recovery of other mineral resources. Uranium mines are open pit, underground, in situ leach, heap leaching. The process by which minerals are extracted from ore, usually at the mine site, to produce a mineral concentrate for sale is called milling. The product of milling is a powder of Uranium Oxide (U_3O_8) known as 'Yellowcake'. The Yellowcake is converted to uranium hexafluoride, which is then enriched using various techniques like gaseous diffusion, gas centrifuge etc. When Uranium is mined, it consists of about 99.3% U-238, 0.7% U-235 and <0.01% U-234. For electricity generation the portion of Uranium-235 needs to be increased from 0.7% to 3-5% and the process through which the portion of U-235 is increased, called uranium enrichment. Most reactors use uranium dioxide (UO_2) as their fuel. Its production involves the transformation of UF_6 into UO_2 powder, which is then pressed and heated up to 1400°C to produce small cylindrical pellets. These are loaded into fuel rods. The fuel rods will spend about 3 operational cycles inside the reactor, generally until 3% of their uranium has been fissioned, then they will be moved to a spent fuel pool where the short lived isotopes generated by fission can decay away. After about 5 years in a spent fuel pool the spent fuel is radioactively and thermally cool enough to handle and it can be moved to dry storage casks or reprocessed [9].

VIII. Nuclear Power in Bangladesh

Bangladesh, with its 152 million people in a land mass of 147,570 sq km, has shown tremendous growth in recent years. Presently, 62% of the total population has accessed to electricity and per capita generation is 321 kW h, which is very low compared to other developing countries. Recognizing the fact the present government has prioritized the power sector right from its election manifesto. As per the manifesto, electricity generation in the country was supposed to be 5000 MW by the year 2011and 7000 MW by 2013. The government has been successful in meeting these targets and has even been able to achieve higher level of precedents. The government aims to generate an additional 15,000 MW electricity, within 2016 under short, medium and long term plan and has already developed Power System Master Plan 2010. According to the Master Plan the forecasted demand would be 19,000 MW in 2021 and 34,000 MW in 2030. To meet this demand the generation capacity should be 39,000 MW in 2030 [10]. Presently, the power generation capacity is nearly 10,241 MW. There is no doubt that the demand for electricity is increasing rapidly. Nuclear power plant can play a vital role to cope with the demand for electricity. Bangladesh first considered building a nuclear power plant in 1961. Ruppur site in Pabna district about 200 km north of Dhaka was selected in 1963 and land was acquired to construct a 60 MW plant. In 1964 and 1966, discussion took place with the Canadian government. In 1974, the government of Bangladesh started discussion with then Soviet Union but it did not see light [11]. In 1980, a 125 MWe nuclear power plant proposal was approved but not built. Finally, the Bangladesh government again started discussuion with Russian government in 2009 and on 13 February the two governments signed a MoU. Bangladesh has been considering embarking on nuclear power for 50 years and the latest attempt is expected to come from 2 GW of nuclear provided by Russian reactors. In April 2009 the government approved the Russian proposal to build a 1000 MWe AES-92 nuclear plant at ruppur for about $2 billion, and a year later this had become two such reactors by 2017. A nuclear energy bill was introduced into parliament in May 2012, with work to begin in 2013, and setting up a Bangladesh Atomic Energy Regulatory Authority. In February 2012 the Ministry of Science and Technology signed an agreement with Russia's Rostechnadzor related to regulation and safety and the provision of advisory support to the Bangladesh Nuclear Regulatory Commission on regulation, licensing and supervision. Staff will be trained in Russia. An intergovernmental agreement for provision of a $500 million Russian loan to finance engineering surveys on the site, project development and personnel training was signed in January 2013. A future loan of about $1.5 billion is expected for the nuclear build proper. In August 2012 a financing agreement was negotiated under which Bangladesh would borrow $500 million for a 2 year technical and economic study together with design, documentation and training, at not less than 4% interest rates. Russia will then provide a second loan of over $1.5 billion for 90% of the first unit's construction. The $500 million loan will be repaid in 12 years with five years grace period, and the final construction cost will be repaid in 28 years with 10 years grace period. Site works started in October 2013, and construction of the first unit is expected from 2015, with operation soon after 2020. All fuel is being provided by Rosatom and process its spent fuel in Russia. Moreover, Russia will run the power plant in the initial years to enable a local workforce develop its skill and takeover the operations. Bangladesh government has given top priority to ensure the highest level of safety but there are some threats. The project site is located smack dab on top of a potent earthquake fault line. That alone should trigger a flashing red light and extreme danger signal. When pakistan had proposed the site, it was a sparsely populated area. In contrast, right now, it is a densely populated region. Any sign of an accident would necessitate an immediate evacuation of all the people in the 20 sq km area adjacent to the nuclear power plant. There are cyclone shelters in our coastal areas. In case of a cyclone or tidal wave, people from the danger areas are evacuated to these shelters for a short time. But to evacuate the whole population on a long term or lifetime basis from a 20 sq km area in the most densely populated country and relocate them will be a virtually prohibitive, most challenging and arduous task. As with many other countries, access to water has been identified as a potential stumbling block of the Ruppur plant, with plans to site it on the banks of the river Padma. During the first half of the year, much of the river's water resource is already withdrawn by India through the Farakka Barrage, leaving insufficient cooling water for the plant and other activities in Bangladesh. Besides, Bangladesh has no technical expertise or skilled manpower to undertake such a complex and high tech project. In spite of these threats, nuclear power plant is the best decision to meet rapidly increasing demand and reduce dependence on natural gas. But these threats should be kept in mind [12].

A. *Research*

Bangladesh has had a Triga 3 MW research reactor operational since 1986 [13].

IX. Accidents

Some serious nuclear and radiation accidents have occurred. Nuclear power plant accidents include the Chernobyl disaster (1986), Fukushima Daiichi nuclear disaster (2011) and Three Mile Island (1979). Three Mile Island power station had two pressurized water reactors. The accident to unit 2 happened at 4am on 28 March 1979 when the reactor was operating at 97% power. It involved a relatively minor malfunction in the secondary cooling circuit which caused the temperature in the primary coolant to rise. This in turn caused the reactor to shut down automatically. At this point a relief valve failed to close, but instrumentation did not reveal the fact, and so much of the primary coolant drained away that the residual decay heat in the reactor core was not removed. The core suffered severe damage as a result. The

Chernobyl Power Complex consisted of four nuclear reactors of the RBMK-1000 design. It is a boiling water reactor. The accident occurred about 1:25 am local time on Saturday morning of April 26, 1986. The accident occurred during a turbine ''run down'' test. Because Chernobyl Unit #4 was scheduled for routine maintenance, electrical engineers on the plant staff planned to conduct this test as the reactor was being shut down. They had wanted to measure how much electricity would be produced after the steam stopped flowing to the turbine generators, and the turbine ''ran down'' to slower speeds by its own momentum. To ensure that test could be completed, the operators did not follow their written procedures and blocked out both the emergency water-cooling for the reactor core and the automatic reactor shut down control rods. The operators began the test by closing the valve, which had allowed steam flow into the turbine. This valve closure caused the cooling of the reactor core to be reduced. As a result more water began to boil and the reactor power began to rise rapidly. Normally the reactor operators tried to stabilize the reactor power but the power rise was so severe that the fuel rods melted and the top of the reactor was blown off by the evolved high-pressure gases. Fukushima Daiichi is the site of six nuclear reactors constructed in the 1970s. On March 11, 2011 a 9.0 earthquake struck about 110 miles off the coast from Fukushima. At the time of the quake, only three reactors at Fukushima Daiichi were in operation, and all three began an automatic shutdown. Off-station power was lost due to the earthquake, emergency generators started as planned. Less than an hour later, the first of seven Tsunamis reached the site. The maximum height of the water was 49 feet, while the design basis for the site was about 33 feet. Water inundated the facilities, shutting off emergency power to units 1, 2, 3 and 4 as well as to waste fuel ponds. Over the next days, all three reactors suffered explosions from hydrogen. As a result of the significant fuel damage, large amounts of radioactive material were released into the environment. As of December 16, 2011, all units at the site were declared to be in cold shutdown. It is currently estimated that clean-up will take 40 years [14]. As a result, more than 150,000 people remain in forced evacuation. About 130,000 compensation claims have been filed. Radiation readings inside the reactor buildings of unit 1-3 vary between 5 mSv/h and 73 Sv/h, which makes human intervention almost impossible [15].

X. Safety

Nuclear safety is a global issue. A serious event in one country may have an impact on its neighbours. Although the responsibility for ensuring nuclear safety clearly resides within each country, the international nuclear community is seeking to increase harmonisation between national safety practices via the Multinational Design Evaluation Programme (MDEP) and other international initiatives. The safety of a nuclear facility depends on the engineered protection built into it, on the organization, training, procedures and attitudes of the operator, and on the verification and inspection activities carried out by an independent regulatory body with the powers to suspend the operation of the facility if necessary. In the 1990s, performance and safety records improved significantly, and they have remained high. Well run nuclear power plants have proven quite profitable. The good safety and performance records over the past two decades, the resulting increased profitability, and the expectation of further improvements all contribute to rising expectations for nuclear power. The main issue of Nuclear Power safety is the waste disposal. Presently, waste is mainly stored at individual reactor sites, and there are over 430 locations around the world where radioactive material continues to accumulate. Besides, the engineered safety systems include the equipment and components necessary to monitor the nuclear facility's operation and to ensure three safety functions. They are shut down the reactor, provide cooling to the fuel, and in the event of an accident, ensure that radioactive material is securely maintained inside the containment of the reactor. An important step is to stop the fission process by means of neutron absorbing rods. Emergency shutdown is provided by the injection of neutron absorbing liquids, to ensure long term reactor shutdown. Heat is normally removed from a reactor by pumped circulation of coolant through the core. If the cooling system fail, emergency core cooling systems ensure that decay heat is removed. When the plant is shut down, electricity for the cooling and other essential systems is supplied from the plant's connection to the electrical grid. If this is not available, on-site emergency backup generators can be used [16]. Nuclear facilities are designed so that earthquakes and other external events will not jeopardise the safety of plant. Worldwide 20% of nuclear reactors are operating in areas of significant seismic activity. Nuclear power plants are designed to withstand specified earthquake intensities evident in ground motion. During an earthquake, ground motion transmits vibrations to a nuclear power plant's foundation and structure. The plants are fitted with seismic detectors. If these register ground motions of a set level, systems will be activated to automatically bring the plant to an immediate safe shutdown. A scram is a sudden reactor shutdown. When a reactor is scrammed, automatically due to seismic activity, or due to some malfunction, or manually for whatever reason, the fission reaction generating the main heat stops. Considerable heat continues to be generated by the radioactive decay of the fission products in the fuel. Initially, for a few minutes, this is great-about 7% of the pre-scram level. But it drops to about 1% of the normal heat output after two hours to 0.5% after one day, and 0.2% after a week. Then it must still be cooled, but simply being immersed in a lot of water does most of the job after some time. When the water temperature is below 100°C at atmospheric pressure the reactor is said to be in "cold shutdown'' [17].

XI. Results and Discussion

This research is completely theoretical. From this, the result is obtained that it is high time that Bangladesh should use alternative source of energy. So, nuclear power can be treated as a good option. The initial cost of the plant is high but it will sustain for long time. Moreover, the total amount of electricity production is higher than renewable sources. Nuclear power plants can provide cheap electricity. Bangladesh is mainly using natural gas for electricity production, and natural gas is using for other purposes. Natural gas is a good, relatively clean-burning fuel, but it will finish one day. So nuclear power should be introduced in Bangladesh. Moreover, nuclear power has an exclusively important advantage of no creating carbon dioxide and, therefore, no consuming oxygen. The main problem of thinking nuclear power is radioactive waste but all radioactive waste facilities are designed with numerous layers of protection to make sure that the environment remains protected for as long as it takes for radioactivity to decay. So, analysing all perspectives nuclear power should be introduced in Bangladesh.

XII. Conclusion

Over the last two decades, the use of nuclear energy has expanded quickly in Asia, and it is increasingly being considered by developing countries across the world to meet their rising electricity demand. The availability of adequate energy supplies at reasonable prices has long been a concern of many governments, especially where there is a high dependence on imports. Energy shortages and consequent high prices can have a devastating effect on a country's economy. As Bangladesh is a poor country, it is very important to reduce the cost of electricity. In this country, the demand of electricity is increasing, and most of the power plants are now depending on natural gas, furnace oil and diesel. Using this kind of fuels, the rate of electricity is also increasing, and the resources are now decreasing. One tonne of uranium produces the same energy as 10,000-16,000 tonnes of oil with current practice [18]. So nuclear power plants are well suited to meet large power demands. They give better performance at higher load factors. Besides, a typical 1000MWe reactor can provide enough electricity for a modern city of close to one million people, about 7 billion kWh per year [19]. So it is necessary to use alternative sources of electricity like nuclear power.

Acknowledgement

Authors are grateful to Local Government Engineering Department (LGED), Bangladesh Power Development Board (BPDB), Bangladesh Atomic Energy Commission (BAEC) and the teachers of Mymensingh Engineering College for providing information.

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