ANALYSIS OF NUCLEAR POWER GENERATION AND MANAGEMENT IN NIGERIA

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Abstract

Energy is the biggest challenge of the twenty-first century. We must lift much of the world out of poverty, which will require large increases in energy production while simultaneously curbing greenhouse gas emissions. In order to accomplish this, we must adopt solutions that are based on efficiency, renewable, nuclear energy production and safety, and if it can be demonstrated, carbon sequestration and then adopt the idea which said that "an energy future without a significant contribution from nuclear energy simply isn't an option". Since renewables are by their very nature intermittent, they cannot have a huge impact unless--and until--we develop adequate energy storage technologies and drastically improve our fragile electricity distribution network. In a developing country like Nigeria where energy demand is far more than the supply due to insufficient power generation, incessant outage of power as a result of failure of power generation plants, due to technical faults and ageing, the use of nuclear power plant provides answers to the problems of electricity generation. Since energy is important for socio-economic development considering safety, economy, reliability, sustainability and even waste management, nuclear energy as an alternative source of energy should be used. The nuclear power option once again is appealing to some opinion leaders in the world. As an alternative to fossil fuels and looming energy crisis, we can find a solution to the problem of climate change, environmental degradation, and fossil fuel dependency, while guaranteeing equitable, sustainable development. Many problems stand in the way of this so-called renaissance, not least the mammoth costs involved and the fact that no safe system has yet been devised for the long-term storage of nuclear wastes. Furthermore despite many improvements in the safety of nuclear power plants, worries persist about the risk of nuclear accidents such as those that occurred at Three Mile Island in USA in 1979 and Chernobyl in Ukraine in 1986. However, this alternative source of energy will pose a political problem in that nuclear power plant could be used for both military and economic purposes. It is observed that all attempts, so far, to produce enough electricity power for its citizens have hit the rocks in this country, Nigeria, due to various reasons including inefficiency and corruption. The purpose of this paper is to urge Nigeria (and other countries like it) not to give up its efforts to generate sufficient electric power by the usual traditional methods (coal, solar, wind, etc) but to continue to try until success has been achieved in the short term and to vigorously endeavour to go nuclear in the long term since nuclear generation of electricity is the ultimate in power supply. The paper also shows how the nuclear

program has been achieved in some other countries and how Nigeria can follow suit in the development of nuclear energy for peaceful purposes.

Introduction

The use of electric power supply has contributed immensely to the rapid development of various sectors in our society today. From technological point of view, the need for electrical power has effect on every part of the globe to the extent that almost all facets of life crave for a steady power supply for adequate improvement, for survival and for growth. The role that electricity plays in our lives by enhancing our productivity, comfort, safety, health and economy is obvious. We live with the benefits of electricity everyday so much so that we take for granted the cheap availability of power.

There are many different ways to generate electricity-including coal, oil, gas, nuclear, solar and hydroelectricity etc. Each option inherits certain advantages that merit consideration whenever there is need for a new power plant. Nuclear-generated electricity is unique in that it inherently addresses many of the shortcomings of the other means of power generation. The use of nuclear power provides answers for many problems in the areas of the environment, safety, economics, reliability, sustainability and even waste disposal.

Nuclear-generated electricity is not just produced in the developed countries like United States alone. Many developing countries world-wide have nuclear power plants generating electricity for their citizens. Also, nuclear power generation continues to grow annually with concern over the environmental effects of global warming and pollution. The challenge today is to move away from our heavy dependence on fossil fuels and utilize non-carbon energy resources more fully. Concerns about global warming are a major reason for this.

The current situation surrounding the global energy crisis and its connection with anthropogenic climate change calls for a similar gamble on technological innovation and sustainability. In too many cases, alternative energy options, such as geothermal and wind, have been discarded with the argument that they have not been proven to work on a mass scale and are far from complete development. It is exciting to talk about principles and futuristic technologies, but what about accountability and responsibility? Developing nations do have growing energy needs, but it is totally irresponsible and short-sighted to sell them nuclear reactors and fuel and then leave them with tons of toxic waste and no long-term safe storage plan.

The fundamental assumption underpinning this discussion and Global Nuclear Energy Partnership (GNEP) itself is that the world is about to embark upon a global expansion of nuclear power. The consequences of such an expansion will be an increased demand for fissile atoms and an increased amount of used nuclear fuel produced. Both of these consequences could be problematic, and both also are connected to the overarching fear of increased weapons

proliferation. The world has to watch this expansion especially its political implication and the safety of mankind and his environment.

Among other things this paper deals with the origin of nuclear energy in electricity generation and in war fare; the science involved in nuclear energy generation (that is the nuclear reactor); the safety and hazards/dangers associated with nuclear reactors; the advantages and disadvantages of nuclear energy processes; the diplomatic and political intrigues related with nuclear energy; the problems of waste management and the application of the above issues to Nigeria as well as recommendations and conclusion.

The Origin of Nuclear Energy in Electricity Generation and in Warfare

Nuclear energy is that energy resulting from the fission or fusion of atomic nuclei. This energy which is greater than that from either chemical or mechanical sources results from the conversion of mass directly into energy (Mass Energy Equation). The real import of nuclear energy is best imagined if we realise that one pound of uranium during fission releases energy equivalent of 2.5 million pounds of coal during combustion.

We cannot discuss nuclear energy adequately without first mentioning the word atom. The atom is the least fundamental unit of matter; the smallest portion of matter displaying the characteristic properties of a particular chemical element. The atom consists of a heavy nucleus composed of protons and neutrons held together by extremely strong nuclear forces surrounded by a cloud of electrons. The term atom has its etymology in the Greek word “atomos” which means indivisible-the ultimate which is incapable of being reduced to any other form or unit. Even though the Greek Epicurus (341-270 BC) was a philosopher of pleasure, he touched on the word atom which the Roman Lucretius (99-55 BC), an academician of a sort, eulogised in his epic poem “De rerum natura”. However those ancient philosophers could not split the atom nor could they detonate the nuclear energy. They simply could not fully appreciate what they were talking about.

The nuclear age was born on December 2nd 1942 in a squash court at the University of Chicago in the United States of America (USA) when the Henrico Fermi led group of scientists successfully operated the first nuclear reactor. Seven months later, precisely on 16th July 1943, nuclear energy was released in an uncontrolled manner. Thus as a test case, the first atomic bomb was detonated in the isolated desert of Southern New Mexico in the USA. It was effective. The Second World War (1939-1945) had ended in Europe, America, Africa, in fact all over the world in May 1945, but the Japanese who were in the same group as Hitler’s axis held out as unconquered and continued fighting. Consequently, the American army dropped two nuclear/atomic bombs on Hiroshima and Nagasaki both in Japan on 6th and 9th August, 1945 respectively and brought Japan to a complete silence. The war ended. Thus nuclear energy was first used as a weapon in warfare.

Since the end of the Second World War, scientists have been trying to apply nuclear energy to other uses such as medicine, agriculture, weather etc other than military. As a result electricity was generated for the first time by a nuclear reactor on 20th December 1951 at the EBR-I experimental station near Arco Idaho in the USA and it produced initially about 100 kilowatts (International Energy Agency Handbook). On 27th June 1954, the then Union of Soviet Socialist Republics (USSR) nuclear power plant became the world's first nuclear power. As at 2004 nuclear power provided about 6.5% of the world's energy supply and 15.7% of the world's electricity with the USA, France and Japan accounting for 57% of nuclear-generated electricity. By 2007 the International Atomic Energy Agency reported that there were 439 nuclear power reactors in separation in the world, operating in 31 countries: the USA provides 19% of its power needs from nuclear sources, France 78% while the rest of the European Union (EU) provides 30% of their needs from electricity.

Nuclear Power as an Alternative Source of Energy Worldwide

Many countries have for many years been using nuclear energy to produce electricity eg: The USA, France, China, Japan, Russia, India, Britain, Germany etc. These major countries even plan to increase their reliance on nuclear power thus adding to the global spread of nuclear reactors. Electricity problem is a major problem confronting every nation including the ones mentioned above. Electricity is a pre-requisite for socio-economic development of any nation. Many countries are actively developing nuclear power, especially the ones mentioned above. In the USA and throughout Europe, investment in research and in nuclear fuel cycle has continued and it is expected that electricity storages, fossil fuel price increases, global warming and heavy metal emission from fossil fuel application will eventually occur. New technology such as passively safe plants and national security will renew the demand for nuclear power, will expand globally, raising the danger of increased proliferation. Other aspiring/emerging nuclear nations are scattered worldwide and include Italy, Poland, Portugal, Yemen, Jordan, Mongolia, Iran, Indonesia, Australia, Chile, Venezuela, etc. These countries are at various stages of the development of nuclear energy for electricity and other peaceful uses.

In Africa it is not only Nigeria that is planning to harness power by nuclear means. Others include Egypt, Tunisia, Libya, Algeria, Morocco, Ghana, Senegal, Uganda, Namibia, etc. In fact the African Union (AU) has recently formed a club of about 20 African countries ready and eager to embark on the generation of electricity by nuclear means. Among them South Africa is the most developed. It has already two nuclear power plants producing between 15 and 20% of its total electricity needs.

In Nigeria the Nigerian Atomic Energy Commission (NAEC) was established by Act No. 46 of 1976, as a specialised focal agency with the mandate to develop and deploy nuclear energy for the nation's socio-economic

development. The federal government endorsed the Commission's road map which aimed at generating 2000 mega watts by 2007, 3000mw by 2009 and 9000 mw by 2010, but this plan did not materialise. However, in 1997, the Commission succeeded in establishing the only nuclear reactor and neutron generator in Zaria for research purposes with only licensed radioactive, waste management, various analytical and radiation management facilities for various applications.

Another nuclear energy research station is currently being developed near Abuja. The approval for the reactor was obtained in 1994 with the aid of a technical co-operation agreement with the International Atomic Energy Agency (IAEA). Thus Nigeria ranks 6th after South Africa, Egypt, Ghana, Morocco and the Democratic Republic of the Congo in the quest for the acquisition of nuclear power for peaceful purposes in Africa. .

The Science Involved in Nuclear Energy Generation: The Nuclear Reactor

The vast majority of nuclear reactors operating today, (and probably those of the immediate future,) are light water reactors fuelled with enriched uranium. Therefore, more reactors will require more uranium and more enrichment capacity. Enrichment technology can be used to produce nuclear fuel (or at higher enrichment levels), weapon-grade materials.

Nuclear energy (energy derived from the nucleus of an atom) [is the energy in the nuclear core of an atom]—atoms are tiny particles that make up every object in the universe. The neutron of the atom is usually speeded ($2x10^3$ m/s) to strike the nucleus of the uranium atom. They penetrate through the electrons orbiting round the nucleus and eventually leading to disintegration of the nucleus. The disintegrated nucleus from other neutrons from other atoms add to the further breaking of the nucleus of the atom. The energy formed in this process is usually very large and can be harnessed for power generation. There is enormous energy in the bonds that hold atoms together. Nuclear energy must be released from atoms in two ways: Nuclear fission (which produces energy for nuclear power and to drive the explosion of nuclear weapons) and nuclear fusion [which involves the release of millions-volts (mev) by fusion of two light nuclei as when two heavy hydrogen nuclei deuteron (2H) combine in reaction] and a third one called radioactive decay. Nuclear fission is used by nuclear power plants to produce electricity.

Nuclear energy is used to generate power thus: Nuclear fission makes heat—heat from nuclear fission makes water to steam—steam turns turbine—turbine turns generator—thus electrical power is sent around the country. In other words, in electricity generation, most power plants produce electricity by first boiling water to produce steam. The steam is used to spin a turbine. The shaft of the turbine spins the generator (a large coil of wire) between two magnets. The spinning coil of wire generates electricity. The main difference between a nuclear power plant and other kinds of power plants lies in the way the water is heated to

steam. In a nuclear power plant, heat is produced by splitting atoms rather than, for example, the combustion for oil, gas or coal in a respectively oil, gas, and coal fired plant.

The major material needed in the generation of electricity with nuclear power is uranium. It is not necessary to have uranium reserve to run a very successful nuclear power programme. The introduction of $^{235}_{92}U$ atom into the reactor is accompanied with the bombardment of the nucleus of the atom using slow moving neutrons of other atoms (uranium) in the system which when bombarding the neighbouring nucleus cause a chain. The enormous heat energy released from the reaction is used for electric power generation.

The other source of fissile atoms is the used fuel from light water reactors that contain not only residual unfissioned uranium 235 but also fissile plutonium. It is possible to recover the residual uranium and plutonium from used fuel by a process generically referred to as reprocessing. Again we are confronted with a dual-use technology because reprocessing can separate plutonium from used fuel to create new fuel or to construct a nuclear explosive device. Global Nuclear Energy Partnership (GNEP) as originally conceived, advocated for the development of ''proliferation resistant'' reprocessing technology to deal with this problem.

The nuclear reactor is a device in which nuclear chain reaction is initiated, controlled and sustained at a steady rate. It is of different types: pressurised water reactor (PWR), boiling water reactor (BWR), breed reactor (BR), pressurised heavy water reactor (PHWR) , light water graphite moderated reactor (LWGMR) and fast neutron reactor (FNR). Most of today's nuclear plants were originally designed for 30 to 40 years operating lives. However, with major investments in systems, structures and components, their lives can be extended up to 70 years.

Power generation by nuclear energy provides high power output and steady power supply in the sense that high energy released during fission chain – reaction will drive turbine for a longer period of time. It is economical as the cost of fuel in nuclear reactor is cheap and readily available in Nigeria. The above analysis makes it necessary to evaluate the nuclear reactor technology especially in the application to power generation, transmission and distribution in Nigeria, comparing nuclear power technology with other means of power generation with its merits and demerits, hence investigating the current status in power generation and distribution in Nigeria.

Safety and Hazards/Dangers Associated with Nuclear Reactors:

Nuclear generated electricity is unique in that it inherently addresses many of the short comings of the other means for generation especially problems related to environment, safety, economics, reliability, sustainability and even waste disposal. The safety of a reactor is a prime concern for its owner for

several reasons; to ensure the safety of the public, the reactor operators and the investment itself, hence developing the reactor according to industrial standard by experts' committees. Some nuclear regulatory bodies such as (IAEA) International Atomic Energy Agency, Nuclear Regulatory Commission (NRC) and the Nigerian Atomic Energy Commission (NAEC) ensure the best of industrial practices (ie, are often at hand to carry out appropriate tests before the beginning of operation). Some hazards of nuclear reactor are: nuclear proliferation, terrorism, vulnerability of plants to attack, use of waste bye-products as a military weapon. Despite the Three Mile Island (in USA) and Japan hazards which were due to human error and disregard of safety guide lines during processing by plant workers, respectively, nuclear power plants still produce the best clean and safety energy generation.

The building and use of nuclear reactors leads to greater routine releases of radio activity into the environment, greater worker exposures to radiation, larger inventories of nuclear waste that must be managed, and it does not appreciably reduce the geologic repository requirements for spent fuel or high-level nuclear waste. Even though serious efforts are being made to secure permanent geological repositories, in the mean time opportunities to high jack radioactive wastes during transportation exists. For instance, it was during transportation that such radioactive wastes found their way into the ''dirty bombs'' of September 11 2001 when the USA was attacked from the air and important buildings and thousands of people were destroyed.

Advantages of Nuclear Energy over Other Sources of Energy

In these difficult economic times, nuclear power has a very important benefit--the number of jobs created per megawatt of installed capacity is far higher than for any other source of electricity generation. Though the initial capital cost of building nuclear power plants is enormous yet the maintenance/running cost and funding is small compared to others. Nuclear power produces about 18% of the total world's energy needs and produces huge amount of energy from small amounts of fuel without the pollution obtainable from burning fossil fuels. Nuclear energy also finds its uses in medical, industrial, and commercial applications, and in agriculture and food processing, as well as in weather forecasting, etc.

Nuclear power costs about the same as coal, so it is not expensive to produce. It generates huge amount of energy from small amount of fuel. It does not produce smoke or carbon dioxide, so it does not contribute to the green house effect, it produces small amount of waste. It is reliable. There is very effective waste management system.

Overall, there are several strong arguments in favour of nuclear energy. Backers argues that it brings more technological development than alternative energy sources; that it is a "proven" method for meeting large-scale energy demands, as in France, where more than 70% of the country's electricity comes

from reactors; that it provides a continuous supply of energy, unlike technologies such as hydroelectric and wind power that depend on environmental factors difficult to predict; that global stocks of uranium will outlive those of oil, solving the fuel supply problem in the medium term; and that the patterns of uranium dependency do not involve politically sensitive regions of the world, as happens with fossil fuels. Nuclear reactor provides long term electricity generation, and the most common nuclear fuels $^{235}_{92}U$ and 239Pu have half life time of about 700million and 24,000 years respectively, whereas hydroelectric power plants, for instance, can last only for hundreds of years.

Disadvantages of Nuclear Energy

Nuclear energy generates dangerous waste that is difficult to isolate, cannot be reprocessed by nature's cycles, and lasts for several thousand years--therefore posing a tremendous threat to the environment and human health. Even though the conventional sources and methods used in electricity production generate residues that have to be managed, none of them poses as many risks as nuclear energy nor do they require such a long-term management programme. (Plutonium disposition must contemplate prevention of leaks from containers and waste sites in a time frame of about 100,000 years; in contrast with climate change remediation which considers a time scale of hundreds of years). Nuclear energy is not entirely secure, as demonstrated by the accidents in Chernobyl (Ukraine) and Three Mile Island (USA). Though no energy source is inherently secure, an oil spill is not the same as a radioactive spill. As proved by Mexico and Brazil in Laguna Verde and Angra II, the construction, dismantling, and decommissioning of nuclear facilities is extremely expensive. In the case of Laguna Verde, for instance, it is estimated that the initial cost of dismantling it will be from $500 million to $1 billion.

Nuclear energy is intrinsically linked to the shadow of nuclear proliferation, which humanity has sought to exorcise without success since the 1950s. Against all such efforts, the nuclear bomb is being reproduced throughout the world. In 1945, only the United States had the capacity to mount a nuclear attack. Today seven countries have joined the former club of one: The United Kingdom, France, India, Pakistan, Russia, Israel, and China have offensive nuclear capabilities--and no one is sure whether the nuclear programmes at Natanz in Iran and North Korea are heading in that direction or not. There is the problem of sending investment money abroad, of buying technology from abroad and of hiring or training technicians capable of maintaining the operations for example; Mexico depended on the multinational company, General Electric and Brazil on Westinghouse. Accompanying the initial costs of the projects are the other expenses and risks in the rest of the nuclear fuel cycle, particularly in the management and utilization of the uranium that feeds the reactors. The nuclear fuel cycle is a series of complex and costly procedures that include the phases of

extraction, purification, enrichment, exploitation, and reprocessing of the nuclear fuel.

Furthermore, the greatest cost and the most pressing challenge is that of nuclear proliferation. It is undeniable that undertaking a nuclear program conjures the ghost of the atom bomb. The technology used for a crude nuclear detonator is, in the opinion of many experts, little, if any , different.. The complicated bit of the operation is obtaining highly enriched uranium or plutonium. So far no international agreement has been reached on mechanisms to control and eventually eliminate nuclear arsenals because every major nation wants to belong to the nuclear club. Nations choosing the nuclear energy path today would create tension with the existing nuclear sphere of influence. They would have to try and guarantee the security of their facilities, entering a risky, costly, and intensive diplomatic game best avoided. The danger resides in the fact that the nuclear hole is especially big and difficult to close, due to its environmental, economic, and geopolitical implications. It is also a solution that was already applied in Latin America, and failed. The nuclear energy project has failed in many other countries due to its disadvantages.

Electricity Problems Leading to the Alternative Source of Energy

As was the case in France, as oil and natural gas become scarcer, government and industry leaders push for a greater reliance on nuclear power to provide additional energy. This is a programme likely to gain greater momentum from rising concerns over global warming -- largely a result of carbon-dioxide emissions created during the combustion of oil, gas, and coal. Global population growth in combination with further industrial development will lead to a doubling of worldwide electricity consumption by 2030, according to the World Nuclear Association. Add an increasing shortage of fresh water and the increasing need for energy-intensive desalination plants, and nuclear energy offers significant opportunities to meet growing energy demands of a developing world. Because of this and other reasons, an expanding set of non-nuclear countries like Nigeria are considering deploying new nuclear power plants.

Nuclear energy also enjoys a unique position in the climate debate. It's the only carbon-free energy source that's already contributing to energy supplies on a relatively large scale and is also expandable without requiring major technological breakthroughs. In addition, it offers a hedge against the vulnerability of interrupted deliveries of fossil fuels. This is a key issue in regions such as Eastern Europe, which is subject to the whims and caprices of Russia and other supplier states.

A recent Massachussets Institutes of Technology (MIT) USA study on the future of nuclear power indicated that to be a substantial mitigation measure against future climate disruptions, nuclear energy would need to expand 1,000-1,500 gigawatts by the middle of the twenty-first century--a tripling or quadrupling of current nuclear capacity. At the same time, government incentives

to reduce carbon emissions and institute carbon-trading schemes will increase the economic competitiveness of nuclear power versus other electricity sources. It should be noted that a robust nuclear fuel supply and disposition economy will need to be provided to these emerging nuclear energy countries. Such a regime must also reduce the incentive for countries to develop new nuclear enrichment and/or reprocessing capabilities and potential sources of proliferation of nuclear materials for weapons.

In summary, it is obvious that global energy demand may double by 2030 and that the expansion of nuclear energy, especially in less-developed countries, is "inevitable" due to increased future costs for oil and natural gas and the fact that nuclear power produces no carbon emissions.

Possible Diplomatic and Political Problems

After World War 11, the fear that reactor research will encourage the rapid spread of nuclear weapon and technology combined with what many scientists thought would be a long road to development, created a situation in which reactor research was kept under strict government control and classification. In addition, most reactor researches centered on purely military purposes. The memories of Hiroshima and Nagasaki in August 1945 cannot be easily forgotten. For the above reasons many regulatory bodies such as the IAEA were created to control the proliferations of nuclear reactors and other nuclear materials.

The first two super powers, the United States and Russia being also the first nuclear energy super power nations used that equality in military power to create a diplomatic and political balance that ended their cold war stance of the 1950s and 1960s. For instance the Cuban Missile Crisis of 1962 came to a peaceful end when president Kennedy of the USA threatened missile attack on Cuba and president Khrushchev of the USSR who planted the missiles in Cuba was not prepared to hazard a nuclear war (though Russia was also a nuclear power then). The possession of nuclear capabilities enhances the prestige of a nation and some nations use the opportunity to harass their neighbours as the case between Israel and its Arab neighbours eg Egypt, Jordan, Saudi Arabia etc. Before the dissolution of the USSR in the early 1990s, Russia , the head of the union used to oppress its less opportune unionists as in the military inversion of Hungary in 1956 and Czechoslovakia in 1968.

Soon after his election in 1999, Mr. Vladimir Putin of Russia set out to convert his super abundance of nuclear energy into a sort of political clout that would restore Russia’s former super power status. His government controlled the flow of energy from Russia to other parts of Europe and other former soviet republics like Kazakhstan and Turkmenistan (whose energy is exported through Russian pipelines) in other to boost Russia’s political influence.

The US under President George W Bush invaded Iraq (the second time) a few years back under the pretext that Iraq was stocking deadly weapons of mass

destruction (nuclear arsenal) but this proved wrong when the war ended and nothing deadly was discovered. The USA army is currently occupying the Iraqi soil and tapping their crude oil mercilessly. His father, George Bush the first, as President of USA attacked the same Iraq in 1992 pretending to liberate the oil reach kingdom of Kuwait which Iraq had earlier attacked, conquered and occupied under President Saddam Hussein. On each of the two occasions the president of the USA appealed to other nuclear power nations etc for assistance and they obliged him.

At the moment there is restlessness on the part of USA-led IAEA over whether Iran and North Korea are using their nuclear power plants to develop nuclear war heads instead of for peaceful purposes. Big and reach nations use their diplomatic and political positions to supply nuclear apparatuses, nuclear knowhow, and nuclear personnel in other to extract or compel the signing of agreements by other developing countries over other issues otherwise they (the big ones) would secretly threaten the use of force or (nuclear) war. In other words the possession of nuclear power enhances the achievement of political objectives like wars, over through of governments and the compelling of weaker nuclear energy- have-nots neighbours or nations to sign international agreements.

Waste Management

Every means of producing electricity involves some wastes and environmental hazards. The nuclear industry is unique in that it is the only energy producer that takes full responsibility for the disposal of all its wastes and also the fuel costs of doing so. Nuclear energy today saves the emission of about 3.4 billion tonnes of carbon-dioxide yearly as compared with over 9 billion tonnes per year actually emitted from fossil fuel electricity generation. Also, the 2000mwe coal fire power station produces about 9million tonnes of carbon dioxide each year plus perhaps 300,000 tonnes of sulphur dioxide which in many cases remains a major source of atmospheric pollution.

There is also, from burning coal, waste products like fly ash which is typically 300,000 tonnes per year and contains toxic metals, including arsenic, cadmium and mercury organic carcinogen and mutagens (substances that can cause cancer and genetic changes) as well as naturally occurring radioactive substances. If not fully taken care of, these routine wastes can cause environmental and health damage even at great distances from the site of the power station e.g. acid rain caused by the release of sulphur dioxide may cross national boundaries and cause severe damage to lakes, rivers and forests. for instance, the Lake Nyos' (Cameroun) dispersal of poisonous gas about 15years ago.

All parts of the nuclear fuel cycle produce some radioactive waste and the cost of managing and disposing of this is part of the electricity bill which is internalised and paid for by the electricity consumers. At each stage of the fuel cycle there are proven technologies to dispose of the radioactive wastes safely.

For low and intermediate level wastes, some countries await the accumulation of it to warrant building geological repositories. The main objective of managing and disposing of radioactive or other waste is to protect inhabitants and the environment from harm. Not only radioactive wastes, but all toxic wastes need safe handling. Some radioactive wastes include Exempt waste and very low level waste, (VLLW); low level waste, (LLW); intermediate level wastes, (ILW) and high level wastes, (HLW).

Every nation handling the generation of electricity by nuclear energy is also contemplating the question of safe waste management. Even the United States is still working out details for this problem. Pending the solution of the problem which does not appear to be very near, dry storage in casks at the sites of nuclear reactor plants are used. Curies of cesium and strontium which are currently embedded within spent fuel rods would be separated through reprocessing and ‘’could be stored at the recycling center for about 300 years or transported to a future high level storage facility’’. The storage site is usually guided by legislation or by a regulatory agency like the Nuclear Regulatory Commission (NRC) in the USA.

About 131 million curies of cesium and strontium are currently stored at the Hanford site in Washington in USA and this has been described by the National Academy of Sciences as “the nation’s most lethal single source of radiation other than inside the operating reactor’’ itself. The Nuclear Waste Policy Act of 1982, as amended, specified that the first US repository be located in Yucca Mountain in Nevada, but even this has not been concluded.

Every nation plans its own energy waste disposal. In New Mexico, the Waste Isolation Pilot Plant, an under ground repository for the country’s defence-related radioactive waste, has received and disposed low and intermediate level materials since 1999. A similar facility is in operation in Sweden. Currently it is not possible to transport nuclear wastes to other countries for disposal. The day is expected when some big nations can build internationally adequate deep repositories and dispose their nuclear waste there, as well as allow smaller countries with small nuclear programmes to transport their nuclear waste there either on diplomatic or on commercial basis.

Whatever has been said in this paper of the USA with regard to waste management applies mutatis mutandis to other nuclear power nations worldwide.

The Nigerian Position

Earlier in this discourse we saw that a group of about 20 African nations are eager to obtain electricity from nuclear power. The uses of nuclear power which Africans are clamouring for include medical, industrial, commercial, agricultural, food processing etc. In the African context of the pursuit of nuclear energy for peaceful purposes, Nigeria ranks 6th after South Africa, Egypt, Ghana, Morocco and the Democratic Republic of the Congo.

The Nigeria Atomic Energy Commission (NAEC) had planned that by the year 2010 some 9000mw of electricity would be harvested from nuclear power sources, but in vain. Nigeria is grappling with primary sources of energy in the form of natural resources like coal, wood, natural oil, natural gas, hydropower, saw dust, solar energy, and some crops. The sun pours abundant heat unto the earth especially in the equatorial region where Nigeria belongs. This energy is experienced in the form of solar radiation through wind and waves to trees and vegetation which converts the sun's rays into plant biomass. In addition there is enormous amount of energy of the materials in the earth's crust, the fossil fuel also storing energy from the sun.

Nigeria currently uses a limited number of the above primary sources like thermal, gas, hydropower to generates its electricity, and due to that limited input as well as the Nigerian factor (corruption), by 31st December 2009 Nigeria was unable to produce 3000 mw of electricity for its overall use. The Energy Commission of Nigeria (ECN) put the average per capita energy generation in the country at less than 35 watts per person (assuming a population of 140 million as recorded during the 2006 census).

Uranium, a rare mineral, is a sine-qua-non for the production of electricity by nuclear power. Incidentally, Africa is a major source of uranium in the world because it is found in commercial quantity in South Africa, Namibia, Democratic Republic of Congo, Angola, Nigeria etc. Despite this natural endowment of secondary energy source, no nation in Africa (except South Africa with two nuclear power plants) has attained the level of nuclear power production of electricity for peaceful purposes.

From the very distant past, power was generated in Nigeria by the electricity co-operation of Nigeria (ECN). It was not able to solve Nigeria's power problem. The name changed to Nigeria Electric Power Authority (NEPA) without a solution to the problem. Recently the name changed again to the Power Holding Company of Nigeria—a sort of consortium into which autonomous units like generation, transmission, distribution etc were created with a central holding company. Billions of naira was pumped into the industry without visible positive effects.

Another step being taken by Nigeria currently is the establishment of the independent power plants by some state governments and individuals capable of doing so. The Rivers state government has taken the lead by its establishment of electric power generation plants in two or three locations including Omoku town (which now enjoys uninterrupted power supply for 24 hours). A world renowned robotist and scientist, Professor Bartholomew Nnaji, of Enugu State is currently developing an independent power plant called Geometric Power Limited at Osisioma Town near Aba in Abia State. A few other states like Lagos, Kaduna, Akwa Ibom, Sokoto, cross River, Bayelsa, Enugu, etc are planning to achieve the same purpose.

Nigeria's current electricity supply as we saw earlier is very poor. Because of this situation power outage is in vogue. Multinational Industries are fast closing down and moving to other countries such as Dunlop that has since gone to Ghana to produce. Unemployment rate is rising every day giving rise to youths indulging in unethical behaviours like armed robbery, kidnapping, political tuggery, the blowing of oil pipelines, rape etc. Private companies supplying electric generators are having a field day and emission of poisonous gas such as carbon monoxide (CO) and other obnoxious gas like carbon dioxide (CO_2) into the environment continues with its devastating effect on human beings and on the ozone layer and occasional fatalities.

The future of civilisation and development depend upon the indefinite supply of electricity. Economic stability and to a certain extent political stability depend on constant electric power supply. As a member of the energy-haves (ie, nations with sufficient domestic reserves of oil, gas, coal, hydro-power etc. like Saudi Arabia, Kuwait, Angola, Libya etc.), Nigeria should have by now been self sufficient in power supply but for the monumental corruption and lack of political will of its leaders.

However, to counteract the above shortcomings the President of Nigeria Dr Goodluck Jonathan has taken it upon himself to supervise the Power sector instead of giving the ministry to a minister. He has also announced that he is declaring ''a semi-emergency'' in that sector. He hopes to improve Nigeria's power generation to a great extent before the general election of 2011. Without Nigeria being self sufficient in local power generation, the president also appears interested in generation of electric power by nuclear reactors. To buttress this, he himself, attended a world nuclear energy summit in the United States early in April 2010 at the invitation of President Obama of USA, with whom he (Jonathan) had a one-on-one discussion during the visit.

Nigeria must not wait until she becomes self sufficient in domestic power generation with fossil fuels before thinking nuclear, if it is to keep pace with the rest of the world and to maintain stance on the millennium development of 2015 and if her ''Vision 20 2020'' is to be realised. The source of electric power supply from fossil oil will soon give way to nuclear power generation the world over because that is the surest way of generating lasting electricity.

Despite the enormous expenses involved in the establishment of nuclear reactors (about 1 billion dollars per plant) the cost of maintenance is relatively very cheap and lasts several thousand times over other sources of electric generation like coal. The disposal of deadly radioactive waste from nuclear power plants has not been resolved even by big nations like the United States, but that should not deter Nigeria from embracing the generation of electricity by nuclear power. With our petro-dollar, we can afford the cost. Nigeria's only leakage is that the same group that manipulated our resources for the generation of electricity from fossil fuel by misusing the huge allocations meant for this projects may also be the operators of the nuclear power project and will dip their

fingers into the resources meant for the project. The odds notwithstanding, Nigeria should go nuclear for the generation of electricity and for other peaceful purposes.

Conclusion

Electricity plays vital roles in our lives since it enhances productivity, comfort, safety and the economy of a nation. Overall, nuclear energy has proven to be most beneficial to our society. As a result of this technology, it holds the promise of long time energy generation with which all other sources of energy cannot compete. Nuclear energy has also proven to be a protector of the environment because of the lack of CO_2, green house gasses, and others it emits into the atmosphere. It is clear that nuclear-generated electricity is highly efficient, cheap, long lasting and can provide the required output for the social and economic growth of any country. It is unique in that it inherently addresses many of the short-comings of the other means of power generation. There are however, some major drawbacks to using nuclear energy; the waste it produces, and the atomic weapons that nuclear energy promotes. Generally, however we believe that the use of nuclear energy greatly outweighs any other source of energy.

Nuclear power will continue to play a modest role in mitigating climate change over the next 20-30 years--the most relevant time frame for addressing the climate issue. Its increased use will be predicated upon evolutionary improvements to the nuclear technology we have today, and not on some laboratory's vision of an ideal closed fuel cycle. Facing a range of renewable power options--from biogas and small hydroelectric to wind, solar, and geothermal--that are cost competitive with electricity from new nuclear plants in various parts of the nuclear power countries, a significant expansion of conventional nuclear power after 2030 is by no means assured.

Nuclear energy is very exciting: It's going to solve the anticipated energy crisis of the world and especially help developing nations (like Nigeria) meet their doubling energy demands, provided that nuclear energy countries will conduct the sale of nuclear reactors and fuel using proliferation-resistant technologies and following non-proliferation codes of conduct.

Recommendations

Despite the enormous costs involved in the building nuclear power plants, such plants must be encouraged because of their most stable reliance as a source of energy in comparison with other sources of energy supply. International and domestic regulations must be put in place to guard and control the establishment of nuclear power plants. There should be continued research with regard to nuclear power waste management as nuclear energy is a good master if adequate controls against spill are maintained but a bad servant if radioactive waste spills uncontrolled.

Africa and Nigeria in particular must endeavour to step into the path for the establishment and possession of nuclear power plants for peaceful purposes (medicine, agriculture, commerce etc) and must eventually delve into the possession of nuclear power for military purposes, with the passage of time because the possession of nuclear energy for military purposes is the in-thing and the commanding height for the recognition of nations as powerful. In this case, South Africa, Egypt and Nigeria are recommended as countries capable of joining the nuclear club as soon as possible.

However all efforts by all nations must guard against nuclear energy getting into the hands of evil organisations in the world like Osama Bin Ladin's Alcaida for if such organisations split the atom they will insist on ruling the world alone and enslaving the rest of mankind otherwise they sink it.

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