A REVIEW OF THE COSTS OF NUCLEAR ENERGY AS A SOURCE OF ELECTRICITY: IMPLICATIONS FOR NIGERIA

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ABSTRACT

This paper reviewed the various costs implications of nuclear as a source of energy to Nigeria. Comparison was made between the alternative sources such as geothermal, hydroelectric, coal, oil and gas and nuclear. Despite the claims by the nuclear construction firms such as Areva of France and Westinghouse of USA that nuclear technology has improved and it has more green virtue than the other sources, its construction cost is still higher e.g. America's Watts Bar in Tennessee costs $6.9 billion, South Africa's generation 3 facility (2008) costs $6 billion and Laguna Verde plant in Mexico in the late 1980s cost $7.2 billion, Other fears that have not yet been alerted are waste disposal and health hazards related to radioactivity. Moreover, there is an inevitable link between civil and military use of nuclear. Therefore, it is vulnerable to terrorists attack and stealing the technology. Available data method was used as a method of data collection, were data was obtained through secondary sources. Descriptive method of data analysis was used. It was suggested that Nigeria should use both renewable and non-renewable energy sources such as solar, wind, coal, oil and gas as well as thermal and geothermal which are abundant in the country instead of nuclear which Nigeria has not acquired its technology to handle efficiently.

INTRODUCTION

The nuclear proliferation in the world in the 1990s was as a result of replacing the exhaustible fuels (gas, coal, etc) that have conceivable definite future with a cheap "clean" energy that is potent symbol of development and as an armoury for security or aggression. The possibility of operating a nuclear rector plant was first discovered in 1942. Since then, many countries produce a large fraction of their electricity needs from nuclear power. For instance, France generates around 80% of its energy needs from nuclear (Tom Nevin, December, 2007). In the 1990s, as many as 17 3rd world countries already had it or planned to have nuclear power plants by the turn of the century. By the time they discovered just how expensive it would be to build a reactor and its danger to the environment, they had invested too much to call a halt (Parera *et al*, 1989). The 3rd world countries that were involved in this race to nuclear power were mostly Asian and Latin American.

However, the danger of nuclear power to the environment and human life through radioactive contamination is a common place. Nuclear fission discovery coincided with the World War II; the first application of nuclear energy as for military purposes. The destruction of Hiroshima and Nagasaki by a nuclear weapon brought about the idea of the destructive power of "the atom". The link between the nuclear energy and nuclear war results in widespread opposition to even the most benign application of this new form of energy and its by-products. This, however, increased tension in the public and Parliaments, consequently rising costs of building nuclear power plants.

For the past 20 years, the urge for nuclear reactor acquisition tendency of the 1970s through the 1990s was temporarily put to rest. This was due to its disastrous records in Three Mile Island in Pennsylvania (USA) in 1979, Chernobyl (Ukraine) in 1986, etc. But now America has initiated a revival to the nuclear race on the claim by power companies that technology has improved nuclear's economics. The tide seems to be turning in other countries such as Britain, Finland and Australia in the West and South African, Ghana, Nigeria etc on the other side of the development divide. In January 2004, the Nigerian Government announced that North Korea agreed to sell its missile technology, but a month later Nigeria rejected the

agreement under US pressure (Adesegha, 2011). The West is taken to the nuclear revival for the concern that most of the world's oil and gas is in the hands of hostile or shaky governments while much of the nuclear industry's raw materials, uranium is conveniently located in friendly places such as Canada and Australia (The Economist, Sept. 8th, 2007).

As in the past, now countries in the developing/emerging world are just joining the bandwagon without reasonable recourse to their lean purses or technology deficiency. Nuclear power stations are largely expensive to build than gas-fired or geothermal as well as hydro power stations (The Economist, 2007). It is only claimed by nuclear construction firms such as Westinghouse (USA) and Areva (France) that it is cheaper to run/operate than the other energy sources. Another claim is that it is environmentally friendly (green) than any of the alternatives. But how safe is this 'cheap' and 'clean' energy? Despite these positive claims "the economics of nuclear still look uncertain. That's partly because its green virtues do not show up in its costs,…" nuclear waste is difficult to dispose of" (The Economist, 2007). Also easy accessibility to civil nuclear technology will create the chance of weapons proliferation. Worst still terrorists could attack plants or steal nuclear fuel.

OBJECTIVES OF THE STUDY

The main objective of the paper is to review the human and environmental costs of nuclear energy as a source of electricity to Nigeria assessing accidents/incidents and waste disposal. Other objectives include:

i) To examine the costs of building a nuclear reactor;

ii) To compare the costs of nuclear with other sources of electricity.

METHODOLOGY

The paper used the "available data method" of data collection (Ogunnika and Okafor, 1993). The data for this research are always obtained from public documents, official records, private documents, mass media and archival materials. The researchers, therefore, examined available records on nuclear power plants by journalists, environmental conservationists, anti-nuclear associations and other stakeholders in the nuclear industry in analysing the data. Descriptive method was used.

COSTS OF NUCLEAR REACTOR

As in any other economic activities, nuclear plant has both implicit cost and explicit cost. The implicit cost includes the time taken to complete a plant and other opportunity cost while the explicit cost can be measured mainly by accounting for the construct cost (capital cost). For example, America's most recent nuclear plant of Watts bar in Tennessee, started operation in 1996. But it took 23 years to complete at a cost of $6.9 billion; a second reactor at the site has been under construction, on and off since 1973 (The Economist, 2007).

However, in South Africa, two nuclear construction firms, Westinghouse (USA) and Areva (France) submitted an estimated cost of $6 billion in their bidding for the construction of generation 3 facility of 3500mw in 2008 (African Business, April, 2008). A further 5 in various parts of the country taking the spend on nuclear new build in South Africa to around $40bn between now and 2025, by which time the government wants nuclear to be generating at least half of the additional 40,000mw it will need to sustain itself economically.

Another example is the cost of the Laguna Verde Plant in Mexico in the late 1980s.

The cost explosion (Mexico's Laguna Verde Plant)

Capital Cost	**(US$M)**
Construction (including delays & design changes)	3,500
Decommissioning	2,000
Disposal of radioactive waste	700
Financial cost (interest)	1,000
Total)	7,200

How its power compares with alternatives

(unit costs per kilowatt hour at 1980 prices)

Geothermal	0.37
Hydroelectric	0.48
Coal-fired	0.47
Oil-fired	0.46
Nuclear	0.80

Source: South (Magazine) June, 1989

From the above monetary and opportunity costs of building nuclear reactor 3rd world countries such as Nigeria must seriously consider all odds and alternatives before venturing into the construction of nuclear plants. However, the decision to build a reactor once taken almost irreversible as huge outlays will be incurred even at the initial stage.

Another cost implication of nuclear plant is the health hazard that it imposes both to the worker and the people near the reactor due to radiation effects of uranium. The occupational hazard in nuclear plant is so great. Prof. Martin Gardner showed a greater link between childhood leukaemia in West Cumbria, UK and parents employed in the nuclear plant (Atom, October, 1990).

The Environmental Effects of Nuclear Reactors: Whenever the emotive term 'nuclear" is mentioned three things readily come to mind: atomic bomb, nuclear waste disposal (dumping) and nuclear accidents/incidents. All have an incalculable devastating effects on the environment and lives.

i) Atomic Bomb: Initiated in August 1942, the "Manhattan" project invented and tested in July 1945 the world's first experimental atomic bomb (code-named Trinity) in the New Mexico desert at Socorro, about 80 miles (128km) from Alamogordo (Blowers et al. 1992). The organisational arrangements were so secretive that only a small number of the 150,000 of the Manhattan Project staff knew they were working on the production of an atomic bomb at all.

The destructive capacity of the A-Bomb was ever tested over the two Japanese cities of Hiroshima and Nagasaki towards the end of the Word War II in 1945. Thousands of lives were lost, lands were contaminated and its generic mutation effects are apparent in many abnormal offspring. The link between 'peaceful' and destructive purposes is a singular source of fear and public opposition (Atom, Oct. 1990) to nuclear energy.

ii) Nuclear Waste Disposal (Dumping): The World Health Organisation (WHO) experts discussion on 'hazardous waste" defines waste as 'something which the owner no longer wants at a given place and time and which has no current or perceived market value' (Gourlay, 1992). A hazardous waste is that form of waste whose physical, chemical or biological characteristics post a risk to health and/or the environment. At the extremes lie the domestic and radioactive wastes, in between lies a spectrum of dangerous or toxic waste of agro-industry. Waste takes the form of solid, liquid and gas. Waste makers range from individual human beings to multi million dollar industrial corporations, from the solitary gold miner sifting his spoilt to the nuclear power station discharging radioactive effluent.

Nuclear waste arises as a result of atomic bomb or electricity generation in the nuclear reactors. Radioactive waste is only part of the unwanted product. Waste is broadly classified according to the danger it presents from radiation, that is, the discharge of different types of rays which inevitably accompanies all nuclear activity. All radiation is harmful in that, depending on the intake and uptake quantity, nearness to the source and the means by which the radiation is absorbed, e.g. internally or externally, it can affect living creature, including human beings. There are three levels of nuclear waste: Low-level waste (LLW) consists mainly of discarded clothing, gloves, wrappings and worn-out equipment; intermediate-level waste (ILW) includes irradiated cladding from around nuclear fuel, reactor components and various process residues, resins and filters which emit more powerful and penetrating gamma rays; and high-level waste (HLW) which includes reactors spent fuel which is lethal.

A person standing 20 feet away from a small amount of such waste for ten minutes would have only a 50% chance of survival (Gourlay). More so, HLW other components include plutonium, strontium and cassium whose rate of radioactive decay ensures that the waste remains dangerous for thousands of years.

From this perspective, HLW becomes a distinctly more sinister component of our future. Getting rid of the reactor and any stored waste both during operation and after decommissioning, at the end of its useful life, has been the source of environmental contamination and the greatest problem owners of nuclear power stations are faced with. The cost of decommissioning spent reactors and carrying out essential environmental clean-ups at numerous sites is estimated at "anything between $10bn and $120bn" (Gourlay, 1992). It is also estimated that by the year 2000 and beyond there will be over 160,000 metric tons of spent fuel accumulated in the countries belonging to the organisation of Economic Cooperation and Development (OECD). Existing utility holding ponds are not large enough to accommodate "away-from-reactor storage techniques are unlikely to be sufficiently developed" (Gourlay, 1992) and permanent depositories (i.e. deep underground mines in appropriate geological strata, will probably be stalled by political and technical obstacles.

During about 40 years of its existence, the Japanese nuclear industry, for instance, has accumulated about ¾ -a-million 200 litre drums of LLW and stored at sites pending the building of a repository. HLW, growing at the rate of 700 tons a year and at present sent to the UK or France for reprocessing and returned to Japan where the plutonium produced will be used for its fast breeder-rector programme. The major problem is the ensuring the safe return of the processed plutonium. Since 1969, ships have carried spent fuel to Sellafield, but returning the plutonium is a different matter.

Since the 1972 Stockholm UN Conference on the Human Environment, governments throughout the world were forced to pay more than lip-service to the environmental deterioration. In western Europe, where public opinion polls placed environmental issues at the top of the agenda (Gourlay, 1992), the emergence of Green Political Parties, e.g. in Germany could not be ignored, even the most laissez-faire governments could no longer escape the challenge to their concepts of growth posed by calls for 'sustainable development' or 'alternative' modes of living. The ideologues of unfettered growth, opposed on principle to regulation on the confidence that, through some undiscoverable mystique, the market will make all things well, were faced with calls for positive action that could no longer be ignored.

While the industrial world remains the major producer of the nuclear waste, in its quest for comfortable energy to its relatively affluent population, the 3rd world equally remains the major recipient of these wastes. For instance, on 31st August 1986, the Liberian-registered Khian Sea, left Philadelphia, US with 13,476 tons of toxic waste to Bahamas. But rejected by Bahamas and in turn by Bermuda, Honduras, Guinea Bissau and Dominican Republic, it passed the Panama Canal to Colombia in mid-1987. On 26th October, it reached Haiti describing its consignment as 'fertiliser'. On 29 January 1988 the government rejected offloading the imported foreign waste. On 4th February, the ship left about 3,000 tons behind and sailed out in the middle of the night. After 18 months at sea, "the vessel was sighted off Singapore, its holds were empty" (Gourlay, 1992:3).

While the Khian Sea was still searching for a potential landfall, another cargo of toxic waste left Europe on a journey that would last 14 months, take it to four continents and cover 17,400 nautical miles. In February 1987 the Maltese-registered vessel Lynx left the Italian part of Marina di Carrara with 2200 tons of waste collected from various European producers by the north Italian firm of Jelly Wax. This firm is known to have shipped wastes to Guinea Bissau, Senegal, Benin, Mauritania and South Africa. On this occasion the cargoes destination was Djibouti. Jelly Wax was paid $500 a ton from the producer but paying the contractor (Gian-Franco Ambrosini, head of Intercontract) US$225 while he proposed to pay his Djiboutian cohort only US$36. But the government rejected the contact after discovering the contents of the waste. It then sailed to Venezuela dumped 10,876 barrels above ground without protection for 6 months at Puerto Cabella. After leak of waste the government ordered it out of its territorial waters. Jelly Wax hired a Cypriot-registered Makiri collected the waste with the intention of returning to Italy but changed course and headed for Tartous in Syria. Between 10 and 23 December, it arrived unloaded its cargo and, on 27 December, left. In February 1988 it was loaded back to Marina di Carrara and remained. But the crew suffered from skin inflammation and shortness of breath, so that several had to be treated in hospital.

Between August 1987 and May 1988 some 3,884 tones of chemical waste in 10,000 drums from 5 separate ship also were deposited near the post of Koko in the then Bendel (now Edo) State, Nigeria. The waste was from Italy, the Netherlands, Norway, the USA and the UK, was again collected by Jelly Wax and imported by an Italian businessman in Nigeria, Gianfranco Raffelli. The latter used false import permits and offered a local Nigerian, Sunday Nana, a sum of ₦500 for the hire of his land as a store. The story broke when Nigerian students in Italy alerted the government.

The military ruler, Babangida, reacted angrily and swiftly by recalling Nigerian ambassador to Rome, summoned the Italian Charge d'Affaires in Lagos to demand that Italy remove the waste, evacuate the village of Koko as the dump contained radioactive waste, arrested 15 Nigerians involved and announced that any suspect found guilty by a special tribunal would risk execution by firing squad. But the principal actor, Raffaello escaped without a passport by bribing officials, his associate Desiderio Perazzi saw the inside of a Lagos gaol (Gourlay, 1992).

The Nigerian government arrested another Italian ship, the MV Piave and ordered the captain to remove the waste. They also arrested a Danish coaster, the Danix for being involved in toxic dumping. Italy took back the waste through a state-owned firm ENI. ENI chartered the MV Karin B of Werner Boksiegel (Germany) and the Deep Sea Carrier to remove the waste.

At about that time another report revealed that toxic waste dumping was going on in Benin and Togo Republics. The Benin stopped further shipment and proposed to bury the already collected waste on its border with Nigeria near the Oueme River that feeds Lagos harbour. So provoked the wrath of President Babaniga that he threatened that if dumping took place, the Nigerian army would "descend on Contonou".

In 2006, nuclear waste dumped near Abidjan, Cote D'Ivoire capital claimed 10 lives and over 300 felt ill led to demonstration and legal tussle internationally.

The above examples are cited to show that nuclear power has perilous effects not only on the environment in the way of contamination but also on the already fragile global political setting, more especially of the 3rd world,. But the main fear behind nuclear waste and its associated problems lies in its danger to the biosphere. Radioactivity is a risk whatever its source.

iii) NUCLEAR REACTOR ACCIDENTS AND INCIDENTS

The reactor accident is as equally dreadful as the disposal incident. It only takes a series of minor incidents for a reactor to go out of control. At Chernobyl (Ukraine) operators ignored safety regulators" (Perera *et al*, 1989). Seven years earlier, a series of minor operators errors triggered off the Three Mile Island disaster. The risk of something going wrong in the third word is far greater: the 2500 deaths in the Bhopal, India, and chemical leak were testimony to the poor management and lack of training that can visit disaster on powerless and unprotected people.

In fact two years after the Chernobyl nuclear explosion, Soviet villages up to 100km away were being relocated and farm animals outside the exclusion zones were producing offspring with defects. Thousands of square kilometres of land are unusable and many European countries were suffering from contaminated soil and water. Many thousands face the prospect of death by cancer in the next 40 years from then (Gourlay, 1992). Chernobyl was located in a relatively uninhabited but accessible area. If these were the consequences in the Soviet Union, a developed country, the devastation can only be guessed at in a densely populated country such as Nigeria. And the problem of evacuation in a nuclear emergency in Nigeria where even transport would be a problem, are mind-boggling. However, no one can claim that an accident impossible in any of the 3rd world countries that have technology deficiency.

The Chernobyl disaster was devastating that the radio-active materials spewed from the damaged reactor spread throughout the northern hemisphere, sending radioactivity in all direction. Many European countries have to impose stringent restriction on the consumption of agricultural produce for many years.

A study by a group of US scientists estimated that Chernobyl will be responsible for 17,400 cancer deaths in the northern hemisphere during the life time of those affected, around 11,000 of the outside the Soviet (Gourlay, 1992).

CONCLUSION

In the past, countries embarked on nuclear programme as a symbol of development but they discovered that it is expensive to build, maintain and decommission compared with other alternative sources such as solar, wind (renewables) or coal, gas, oil (non-renewables). Also, the disastrous records in Three Mile Island(USA) in 1979, Chernobyl (Ukraine) in 1986 as well as the link between the nuclear energy and nuclear war resulted in widespread contamination and tension. Moreover, nuclear waste disposal and health hazard that nuclear radiation imposes on the workers and the people near reactors contributed to the halt on the race for nuclear programme.

Now with the claim by nuclear construction firms that technology has improved nuclear's economics and has more green virtue than the other sources of energy such as coal, gas, wind, solar, etc led to America's revival to the nuclear race. Another claim responsible for the revival is the possession of oil and gas by hostile or shaky governments while uranium, the nuclear industry's raw material is located in friendly places. Despite these positive claims, the economics of nuclear still look uncertain because it green virtue do not show up in is costs. And, nuclear waste is still difficult to dispose and its technology can easily be accessed and abused.

The irony is that if nuclear energy is needed to stave off climate change, then countries like Iran, North Korea and other developing states need it as there is no impermeable barrier between electricity and bombs (there is inevitable link between civil and military use (Bahaijoub, 2011). There is uncertainty now, as in the past, that nuclear power is the clean energy of the future when the risks of accidents and nuclear material spill are forever growing countries that could not effectively man a water treatment plant themselves should be far away from the radio-activity infested power plant. Nuclear energy is too hot to handle and a killer in waiting to human life and the environment. Other alternative sources of power such as geothermal, oil and gas-fired, hydroelectric and coal-fired have been compared with nuclear energy but proved to be more expensive than the rest. However,

other renewable source such as wind and solar energy are certainly safer and eventually cheaper.

RECOMMENDATIONS

In order for Nigeria to avert the danger of nuclear as a source of energy on both human and environment, the following suggestions are made:

1. Nigeria being the world's 7th largest gas reserves, estimated at 184 trillion cubic feet (tcf) which is high in quality, being rich in liquid and containing zero sulphur (the Africa Report, Oct-Nov. 2008 and Business World Oct. 5th 2009) should utilise its gas reverses to power its electricity plants at Delta, Egbin, Afam and Sapele and others to work at their full installed capacities instead of venturing into nuclear power which primarily use uranium whose existence in Nigeria's soil is sketchy (African Business Dec. 2007).

2. With many thermal and geothermal sites such as Mambila Plateau, Nigeria should harness them, to increase electricity generation capacity and can qualify for carbon credit under the Carbon Development Mechanism (CDM) (just as Kenya). (African Business Oct. 2007 and The Africa Report, Aug. Sept. 2009).

3. "Hot, unrelenting and free for all, the sun is a glaring answer to Africa's energy poverty" (The Africa Report Dec. 2009 – Jan,. 2010) With an abundance of natural sunlight and potential sites for hydrological and wind energy, Nigerian can adopt these sources. Government should embark on a massive subsidised scheme for people to own solar panels and wind turbines in the country as n Mauritius (African Business, March 2010).

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