CSCanada
Advances in Natural Science
Vol. 6, No. 4, 2013, pp. 79-83
DOI:10.3968/j.ans.1715787020130604.2861

ISSN 1715-7862 [PRINT]
ISSN 1715-7870 [ONLINE]
www.cscanada.net
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# Nuclear Energy From the Fission Process as an Alternative Source of Energy

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Received 12 August 2013; accepted 10 November 2013

## Abstract

One of the major problems hindering the development of most developing countries, including Nigeria, is energy. Over the years, Nigeria's population has continued to increase, nearly doubling in past thirty years. The energy consumption has also been on the increase, even increasing more rapidly than the population. If the trend in electrical energy consumption continues to increase, conventional energy resources used to generate electricity will be depleted; hence, there will be the need for other sources of energy. In this paper we discussed non-conventional source of energy as alternative solution to the energy crisis in Nigeria with emphasis on fission technique for the generation of nuclear energy. The study reveals that nuclear energy looks attractive and merits good consideration and support because of low operating cost particularly at this time of high price of fossil fuel.

**Keywords:** Nuclear energy; Fission; Generation; Fossil fuel; Crisis

Lumbi, W. L., Ewa, I. I., Woma, T. Y. (2013). Nuclear Energy From the Fission Process as an Alternative Source of Energy. *Advances in Natural Science*, *6*(4), 79-83. Available from: http://www.cscanada.net/index.php/ans/article/view/j.ans.1715787020130604.2861 DOI: http://dx.doi.org/10.3968/j.ans.1715787020130604.2861

## INTRODUCTION

Energy is undoubtedly one of the most important factors contributing to the economic growth and development of any nation (Mgbenu et al., 2006). The use of energy has greatly influenced man's activity since the advent of civilisation leading to improvements in physical comfort, food supplies, transportation, communication and other forms of economic activities. The net effect of this is that the quality of life has been increased far and above that of the primitive man who lived some one million years ago and consumed the energy equivalent of his food which was about eight Mega joules (8MJ) per day. Today, man's energy consumption is estimated at about fifty Mega-Joules (50MJ) per day (Mgbenu et al., 2006).

In Nigeria, the most common means of energy generation is through fossil fuels such as coal and petroleum and also the use of hydroelectric power/energy (www.nigeriabusinessinfo.com). Nigeria's usage of hydropower as its main source of energy supply has seen the country plunge into untold energy crisis due to seasonal nature of rainfall, limiting the overall energy output. A review of Nigeria's electrical energy output generation showed that in the year 2008, we were only able to generate 2,400 megawatts of electricity out of a total of 6000 Mega-watts (MW) generation output available to the country (Eperamo, 2009). This shows that our energy generating capacity is low compared to other nations such as the United States of America, Japan, South-Africa and others and hence the need for an alternate source of energy (Osaisai, 2008).

In this article, we will be discussing the potentials of nuclear energy from the fission process as an alternative source of energy in solving the energy crisis in under-developed countries such as Nigeria. This article also aims at revealing that the energy generated from fission technique is environmentally friendly, durable and cheap compared to other sources of electricity such as gas, coal, and hydro-power.

## 1. CONVENTIONAL ENERGY SOURCES IN NIGERIA

Electricity energy production in Nigeria over the last 40 years varied from gas-fired, oil-fired, hydro-electric powered and also coal-fired power systems with gas-fired systems taking the lead. This is predicated by the fact that the primary fuel sources (coal, petroleum, water, gas) are readily available (Okoro et al., 2004).

### 1.1 Wood and Coal Energy

Wood is one of the oldest and in fact the most important source of fuel before the advent of coal. It was essential, not only for domestic heating but also for all manner of industrial processes, and particularly for the iron industry, where in the form of charcoal it was used for both as fuel and as a reducing agent (Bertulani, 2007). The great demand for wood led to massive deforestations, with considerable loss of amenity and even, in some cases, severe ecological damage which has persisted to the present day. By 17$^{th}$ century there was an acute shortage of fuel wood and charcoal in England and this led to shortages of iron over a period of about 100 years. This shortage of wood compelled the domestic consumer to turn to coal as substitute but the problem was far more serious for the iron industry, which found itself unable, for technical reasons, to use coal in its furnaces. This problem persisted until the eighteenth century, when the use of coke in the blast furnaces was discovered (Murray, 1980). By the 19$^{th}$ century well over 90% of Britain's fuel supplies were derived from coal. Coal formed the basic fuel for the industrial revolution and remained the dominant fuel in Britain until "after the second world war when the comparative cheapness of oil and its greater convenience led to expansion of the use of oil as a fuel (Bertulani, 2007).

Coal is also used to generate electricity as is the case at Oji Power Station but it has to be the cheapest available, because the cost of fuel represent about three-quarters of the cost of the electricity sent out from a typical plant, and any reduction in fuel cost represents a major saving. Consequently the coal is often of very poor quality and is in very small pieces, so small in fact that it is quite unstable for domestic purposes.

### 1.2 Natural Gas

This is often used to describe the mixture of hydrocarbon and non-hydrocarbon gases found in sub-surface sedimentary rock reservoirs. Its formation is quite simple and similar to the formation of oil (petroleum). Natural gas found together with oil is known as associated gas while natural gas found alone is known as non-associated gas (Alamos, 2002). It consists mostly of methane (70-95%) with small percentages of ethane, propane, butane, pentane and other heavier hydrocarbons with some impurities such as water vapor, sulphides, carbon-dioxides, etc. (Bertulani, 2007). At present, the nation's electrical energy sector is majorly run on thermal gas plants (heated natural gas) as 85% of the power generating plants is run on thermal gas (Nigeria Power Review, 1989).

### 1.3 Petroleum Energy

This is the third major source of energy generation in Nigeria and the largest contributor of energy to the Nigerian economy petroleum is generally believed to be derived from both plants and animal residue settled in rocks (sedimentary). Petroleum is formed after layers upon layers of these plant and animal debris are compressed by the size of the layers and with subsequent generation of heat and action of chemical and bacterial actions transforms the organic matter into various hydrocarbons. This process takes millions of years to occur (Serway, 2009).

At present, none of the power generating stations in Nigeria is run on crude or refined petroleum but concerted efforts are being made to put some in place in order to boost the nation's energy generating capacity (Nigeria Power Review, 1989).

### 1.4 Hydro-Power

Energy from water which is referred to as hydropower at the moment is one of Nigeria's biggest electrical energy generation point, as it provides up to one third of the total electrical energy generated in Nigeria. For years, the Kainji hydroelectric power station, the Shiroro hydroelectric power station and the Jebba hydroelectric power station were the mainstay of Nigeria's electrical power generation between them was 1,970 MW. Presently, the Jebba hydroelectric power station is not working and the Kainji power station is working at about half of its total capacity. Except for these problems, inconsistent rainfalls and drastic climatic changes are among the factors really affecting the energy generation from these power stations.

## 2. NUCLEAR FISSION AND ENERGY GENERATION

Nuclear power is obtained from any nuclear technology designed to extract usable energy from atomic nuclei through controlled nuclear reactions (Chris & Raymond, 2009). The most common, method used today is nuclear fission. Electricity was first produced/generated by a nuclear reactor on December 20$^{th}$, 1951 at the EBR-I experimental station Area in Idaho, United States of America, which initially produced about 100 KW (100 kilo-Watts) of electricity. The world's first commercial nuclear power station Calder Hall in Stella Field, England was opened in 1956 with an initial capacity of 50 Mega-Watts. It was later upgraded to 200 Mega-Watts.

Nuclear fission process occurs when large fissile atomic nuclei split into smaller daughter nuclei, releasing neutrons, kinetic energy and gamma radiation (Makhijani et al., 1996).

Nuclear fission was first experimentally achieved by Enrico Fermi in 1934 when his team bombarded uranium with neutrons (Fermi, 1935). In 1938, German chemists Otto Hahn and Fritz Strassman, along with Austrian physicists Lise Meitner and Meitner's nephew Otto Robert Frisch, conducted experiments with the products of neutron bombarded uranium (www.nuclearfiles.org).

According to Viulle (2009), typical fission events release about two hundred million electron volts (200MeV) of energy for each fission event. By contrast, most chemical oxidation reactions (such as burning coal) release at most a few hundred electron volts (eV). The energy of nuclear fission is released as kinetic energy of the fission products and fragments, and as electromagnetic radiation in the form of gamma rays.

**Table 1**
**Energy From Fission of U-235 in MeV**

| Particle from fission process | Energy quantity |
|---|---|
| Fission fragment kinetic energy | 168 |
| Neutrons | 2 |
| Prompt gamma rays | 30 |
| Total | 200 |

The total rest masses of the fission products ($M_p$) from a single reaction are less than the mass of the original fuel nucleus (M). The excess mass is given as

$$\Delta M = M - M_P \quad (1)$$

This is referred to as the invariant mass of the energy that is released as photons (gamma rays) and the kinetic energy of the fission fragments, is calculated according to the mass to energy formula given by Albert Einstein in the year 1905 (American Journal of Science 1959).

$$E = MC^2 \quad (2)$$

Where E = Energy in joules, M = mass in kilograms and C = speed of light in m/s.

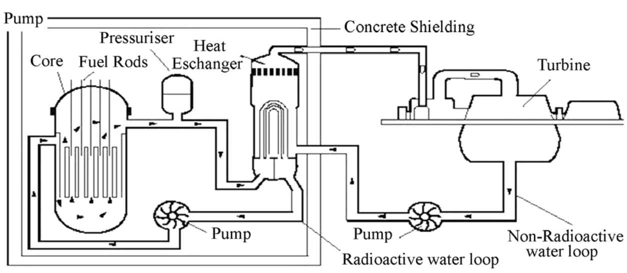


**Figure 1**
**Schematic Diagram of a Nuclear Fission Reactor Plant**

A nuclear power plant produces electricity in almost exactly the same way that a conventional (fossil fuel) power plant does. The heat is used to raise the temperature of water, thus causing it to boil. In a typical nuclear fission power plant, the energy released from fission is used to produce steam. This is done directly in the reactor itself or in the ancillary heat exchanger known as the steam generator or reactor as the case may be. This steam is then used to drive the turbine which is coupled to a turbo generator which in turn generates electricity. The steam from the turbine is then passed through the condenser where it is condensed into water and pumped back into the steam producing side of the nuclear power plant (Nuclear Energy Institute, 2002).

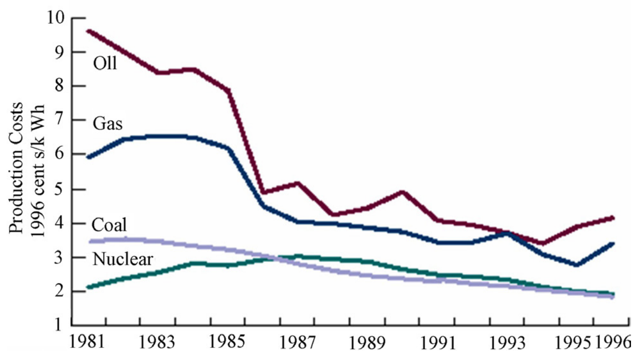


**Figure 2**
**Production Costs of Electricity Generated by Nuclear Energy**

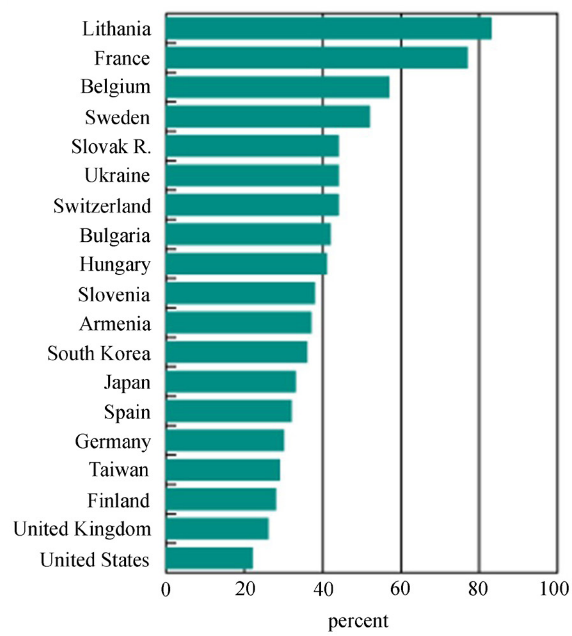


**Figure 3**
**Percentage Electricity Generated by Nuclear Energy in 1996**

**Table 2**
**Thermal and Hydropower Stations and Their Outputs in Nigeria**

| Power station Location | Type | Year of commissioning | Generation capacity (MW) | Comment |
|---|---|---|---|---|
| Lagos station at Egbin | Thermal ST (gas) | 1985-1987 | 1, 320 | 6 x 220 MW reheat steam turbo-electric units |
| Sapele station at Ogorode | Thermal GT, ST (gas) | 1978-1981 | 1, 020 | 6 x 120 MW steam (ST) 4 x 75 MW GT |
| Delta IV at Ughelli | Thermal GT (gas) | 1966-1990 | 832 (912) | Including 6 x 100 MW |
| Afam | Thermal GT (gas) | 1978-1982 | 710 (971) | After AFAM I, II, III, IV |
| Ijora station Lagos | Thermal GT (gas) | 1978 | 60 | 3 units x 20 MW (2 units working) |
| Oji | Thermal ST (dual) | 1956 | 30 | Not functional |
| Kainji | Hydropower | 1968-1978 | 760 (580) | 4 units x 80 MW 2 x 100 MW 2 x 120 MW |
| Shiroro | Hydropower | 1989-1990 | 600 | Okay |
| Jebba | Hydropower | 1983-1984 | 570 (576) | 6 x 90 MW |
| Lagos IPP (Enron/AES) | Thermal | | 170 | Maximum planned is 270 MW |
| Abuja IPP | Thermal | | 30 | |
| Total | | | 6, 200 | |

**Table 3**
**Comparison of Accident Statistics in Primary Energy Production**

| Fuel | Immediate Fatalities 1970-92 | People involved | Normalised to Deaths |
|---|---|---|---|
| Coal | 6400 | Workers | 342 |
| Natural Gas | 1200 | Workers and public | 85 |
| Hydro | 4000 | Public | 883 |
| Nuclear | 31 | Workers | 8 |

## 3. BASIS FOR THE ADOPTION OF THE NUCLEAR OPTION

- Long-term
- National energy security
- Fossil fuels are finite and will be depleted over time
- The dilemma of global warming and climate change
- Sustainable socioeconomic development dependent on access to a diversified basket of energy options
- Significant spin-off effect due to application of nuclear technology in many other sectors
- Medicine and human health
- Food and agriculture
- Capacity building in heavy industries, transportation, etc
- Water resources management
- Mineral exploration and extraction
- Environmental management

## 4. SAFETY AND ENVIRONMENTAL CONSIDERATIONS

The safety record of generation of electricity from nuclear sources is quite good; better than most of the other major sources of electricity.

In over 11,000 cumulative reactor-years of commercial Nuclear Power Plants (NPP) operation in 32 countries; only four major accidents have occurred so far: Three-Mile Island accident in Pennsylvania, USA (1979); the Chernobyl NPP accident in Kiev, Ukraine (1986); the reactor accident in Japan (August, 2004) and recently Fukushima accident in Japan (2011).

Major improvements in design, such accidents now occur most unlikely due to in-built safety systems.

Tech solutions available for NPP waste disposal; non-scientific, non-technological political considerations have slowed down construction of geologic repositories for nuclear waste disposal.

From all the available statistics, nuclear energy is safer than most other major sources.

## CONCLUSION

For a nation like Nigeria which aspires to be one of the twenty largest economies by 2020, and knowing that the prime driver of the development process is energy, it is not possible any more to ignore nuclear power as we are all aware of our dependence on fossil fuel and others that may dry up. There are lots of technical, financial and environmental issues that arise with fossil fuel use and therefore they cannot satisfy our needs. Nuclear energy looks attractive and merits good consideration and support because of low operating cost particularly at this time of high price of fossil fuel. Apart from generating electricity, nuclear energy is clean, environmentally friendly, durable and valuble, hence it meets the need of under developed-countries. Nevertheless, without critical assessment and consideration, its use may cause more problems than it is set out to solve. Therefore, careful planning and safety and security measures are required to be put in place to drive all the benefits.

## REFERENCES

Energy Commission of Nigeria January. (2008). *Energy Resources Review*, *4*(3), 23-28.

Fermi, E. (1935). Nuclear fission. *American Journal of Science*, *17*(23), 20-22.

Liu, F., & Coleman, P. (1993). *Energy and environment*. New York: Van Nostrand Reinhold Publishers.

Makhijani, A., & Saleska, S. (1996). *The nuclear power deception*. Institute for Energy and Environmental Research.

Mgbenu. (2006). *Energy and environment* (5th edition). Lagos, Nigeria: Heinemann Publishers.

Nuclear Energy Institute. (2002). *Nuclear energy: Power for people*.

Pentreath, R. J. (1980). *Nuclear power, man and the environment* (67-70). USA: Taylor and Francis Ltd.

Serway, J. (2008). *Physics for scientists and engineer* (pp.163-195) (7th edition). USA: Thomson Books.

Vuille, C., & Serway, R. (2009). *College physics* (pp.119-122) (8th edition). USA: Brook and Cole Publishing.

 