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The Nigeria Energy Challenge and the Nuclear Energy Option

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ABSTRACT

Nigeria and other nations are looking for solution to their energy crisis and nuclear energy seem to be an option as Federal Government have mandated NAEC, an apex arm of government charge with development of nuclear energy programme for the country to look at the possibility of using nuclear power to generate electricity. The study investigated risk management of nuclear project so as to guide against wastage or loss in the economy. More also, this paper look at the challenges involved in nuclear power industry, assessed the prospects in Nigeria, examined nuclear power plant safety in the country by taken cognizant of Nigeria maintenance culture and environmental challenges. Furthermore, the study examined the advantages of nuclear power plants because historically they are highly complex and prime innovators of new technology. The research implication was that adequate preparation on nuclear safety, education, strong public sensitization, foundational public awareness creation and acceptances, and then coupled with strong legislative nuclear power policy are necessary factors for the development of the sector in Nigeria.

Keywords: Nigeria energy crisis, nuclear energy option for Nigeria, nuclear power plants challenges and prospects, safety aspect of nuclear power plant in Nigeria, maintenance culture and environmental challenges, nuclear power plants advantages and cost implication.

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1. Introduction

Power supply is highly correlated to economic growth, and Nigeria is a developing country. So if the country is to experience any significant economic growth, it must have efficient, reliable, and effective electricity supply in place. The Nigeria energy challenge has been a great problem to her development since her population has more than doubled since 1980 and is expected to increase by 40% by 2050. Report of Nigeria's National Population Commission on the 2006 Census the country figure is put at 140 million[1], and currently the country population is put at 170 million according to National Population Commission (NPC)[2]. This situation is critical, with increasing population not balanced by an adequate energy development programme. The power supply failure has grossly affected the economy, seriously slowing down development in urban, rural and sub-rural settlements, with present energy policy mainly benefiting urban dwellers. Globally, energy projections stipulate that between 2002 and 2025, global energy needs may rise by over 34%, with that of developing nations doubling this percentage. Nigeria's electricity generation capacity has declined from the peak generation level of about 4,517.6 Mega Watts (MW) recorded December, 2012 to about 3,781.80 MW in October, according to the power generation fact sheet of the Presidential Task Force on Power as at 20th October 2013.

The electricity generation report showed that though the country's peak demand level forecast was 12,800 MW of electricity, energy generation capacity stood at about 3,559.46 MW hour per hour (MWH/H), while actual electricity sent out into the national grid was 3,487.85 MWH/H[3]. In South Africa's the National Energy Regulator (NERSA) announced on 31 March 2009 the introduction of a system of feed-in tariffs designed to produce 10 TWh of electricity per year by 2013, this is happening in a country that is far less than Nigeria population, South-Africa population is less than 52 million. Again, in South Africa the government expects to "conclude the procurement" of 9,600 MW of nuclear energy, the power company has now embarked on massive schemes to build three coal-fired stations which will see the country's generation and transmission capacity grow by 17,000 megawatts from the current 40,000 MW[4]. Therefore, an applicable solution must be found to end the Nigeria's energy crises.

According to the United Nations, the population of Nigeria will reach 440 million by 2050[5]. Nigeria will then be the 3rd most populous country in the world. According to the United States Census Bureau, the population of Nigeria will reach 402 million by 2050. Nigeria will then be the 4th most populous country in the world [6]. (Adrian Raftery et al., 2011) said by 2100, the largest expected population increase in Africa is in Nigeria, projected to rise from 184 million now, to 914 million in 2100[7].

2. Nigeria Energy Challenge Historical Overview

Electricity generation in Nigeria began in 1896. The Nigeria Electricity Supply Company (NESCO) commenced operations as an electric utility company in Nigeria in 1929 with the construction of a hydroelectric power station at Kurra near Jos. The Electricity Corporation of Nigeria (ECN) was established in 1951, while the first 132KV line was constructed in 1962, linking Ijora Power Station to Ibadan Power Station. The Niger Dams Authority (NDA) was established in 1962 with a mandate to develop the hydropower potentials of the country. However, ECN and NDA were merged in 1972 to form the National Electric Power Authority (NEPA). In 1998, NEPA ceased to have an exclusive monopoly over electricity generation, transmission, distribution and sales.

3. Aim and Objectives of the Research

The aim is to find a way of increasing energy production in Nigeria by introducing nuclear energy as an added advantage. The objectives are;
(i) To assess energy need for Nigeria and to seek economic advantages of having nuclear energy as an option
(ii) To help Nigeria meet its international obligations to use nuclear technology for peaceful means
(iii) To assess the safety aspect of nuclear power plant for Nigeria taking cognisant of nuclear power plant risk factor and Nigerian inadequate maintenance culture and poor management culture.
(iv) The study is to provide a good, novel approach and method for multi-objective decision-making based on six dissimilar objectives attributes**:** evolving technology, effectiveness, efficiency, cost, safety and failure.

4. Motivation of the Research

The interest of this paper is to assist Nigeria in meeting her energy needs for greater economic development. Therefore, we evaluate the growth of energy development and seek for more effort in the development of the sector especially by looking at nuclear option for further strategy. Also, the studies intended to provide economic advantage of nuclear option for national development. Moreover, the study is to provide a good, novel approach and method for multi-objective decision-making based on six dissimilar objectives attributes**:** evolving technology, effectiveness, efficiency, cost, safety and failure. Furthermore, this is to help Nigeria meet its international obligations to use nuclear technology for peaceful means.

5. Research Problems

The Nigeria energy crisis phenomenon has shown that there is scarce production of electricity to meet the rising demand in economy, environment and social responsible ways. Therefore, this necessitated the need for nuclear generation power option in the sector to meet with the rapid rise in economy.

6. Research Questions

From the research problems derived the following research questions. The major questions are
What is the problem with energy growth in Nigeria?
What is the solution to energy growth problem in Nigeria?

7. Power Generation In Nigeria

Nigeria's biggest power generating plant, the Egbin Thermal Station, has been shut down creating a 1,080 Mega Watts drop in power generation in the country. The source said that the hydro component of the power station, called the "bi-minerasation plant" and which had been poorly maintained over the years, caused the collapse of the entire station. Electricity generation, transmission and distribution account for less than one per cent of Nigeria's Gross Domestic Products [GDP], but fifty-four per cent of the share of Utilities (electricity and water supply) in the GDP. They constitute a small economic activity in Nigeria in relation to her size and population. However, it is a growth industry which, permitted to operate with minimal Government intervention, could be a major contributor to the national economy. The Table 1 showed the lists of power stations in Nigeria.

Table 1: Fossil fuel power stations - natural gas

Power station	Community	Coordinates	Type	Capacity	Status	Year completed	Additional description
AES Barge	Egbin	6°33′33″N 3°36′54″E	Simple cycle gas turbine	270 MW	Operational	2001	Independent Power Project. Light inside: the experience of independent power projects in Nigeria. Nine gas turbines are mounted on barges.

Power station	Community	Coordinates	Type	Capacity	Status	Year completed	Additional description
Aba Power Station	Aba Abia State	5°09′11″N 7°18′38″E	Simple cycle gas turbine	140 MW	Taking off (I quarter 2013)	2012	It is private integrated power project being built by Geometric Power Systems.
Afam IV-V Power Station	Outskirts of Port Harcourt	4°51′05″N 7°15′17″E	Simple cycle gas turbine	726 MW	Partially Operational	1982 (Afam IV)- 2002 (Afam V)	Afam IV -6 x 75MW (GT 13-18), Afam V -2 x 138MW (GT 19-20),
Afam VI Power Station	Outskirts of Port Harcourt	4°50′58″N 7°15′24″E	Combined cycle gas turbine	624 MW, Shell.	Operational	2009 (Gas turbines) 2010 (Steam turbines)	
Alaoji Power Station (NIPP)	Abia state	5°04′00″N 7°19′24″E	Combined cycle gas turbine	1074 MW NDPHC.	Partially operational (225MW). The Nation	2012-2015 Abia state.	4 x 112,5MW turbines and later 2 x 255MW steam turbines. Plant is delayed due to evacuation capacity and securitization for Shell. NDPHC Presentation.
Calabar Power Station (NIPP)	Calabar		Simple cycle gas turbine	561 MW [9] NDPHC.	Under Construction	2014 NDPHC Presentation.	5 x 112,5MW turbines, Gas supply will available from 2014. NDPHC Presentation.
Egbema Power Station (NIPP)	Imo State	5°33′56″N 6°44′18″E	Simple cycle gas turbine	338 MW NDPHC.	Under Construction	2012-2013	3 x 112,5MW turbines. Plant is waiting for evacuation infrastructure. NDPHC Presentation.
Egbin Thermal Power Station	Egbin	6°33′47″N 3°36′55″E	Gas-fired steam turbine	1320 MW	Partially Operational (994MW)	1985-1986	Has six 220-MW independent units.Egbin - Thermal Power Station in Egbin, Nigeria Mbendi Information Services
Geregu I Power Station	Geregu		Simple cycle gas turbine	414 MW	Unknown	2007	The plant is during privatisation process
Geregu II Power Station (NIPP)	Geregu Kogi State		Simple cycle gas turbine	434 MW Siemens	Taking off (I quarter 2013)	2012	Has tree 146-MW turbines

Power station	Community	Coordinates	Type	Capacity	Status	Year completed	Additional description
Omoku II	Omoku		Simple cycle	225 MW	Under	2013 FMI	2 x 112,5 MW

Power station	Community	Coordinates	Type	Capacity	Status	Year completed	Additional description
Ibom Power Station (NIPP)	Ikot Abasi	4°33′53″N 7°34′06″E	Simple cycle gas turbine	190 MW	Partially Operational (60MW) ThisDayLive	2009	The plant's overall generating capacity is technically constrained by existing transmission and distribution facilities of PHCN and the Transmission Company of Nigeria (TCN), to only 60mw.
Ihovbor Power Station (NIPP)	Benin City	6°24′20″N 5°41′00″E	Simple cycle gas turbine	450 MW NDPHC.	Under Construction	2012-2013	4 x 112,5MW turbines, Plant can't be launched due to delayed evacuation capacity. NDPHC Presentation.
Okpai Power Station	Okpai		Combined cycle gas turbine	480 MW	Operational	2005	Independent Power Project. Light inside: the experience of independent power projects in Nigeria.
Olorunsogo Power Station	Olorunsogo	6°52′55″N 3°18′52″E	Simple cycle gas turbine	336 MW	Partially Operational	2007	8 x 42 MW Sepco3, Working below capacity due to gas supply issues.
Olorunsogo II Power Station (NIPP)	Olorunsogo	6°53′08″N 3°18′56″E	Combined cycle gas turbine	675 MW NDPHC	Partially Operational	2012	4x112,5mw and 2x112,5MW steam turbines. NDPHC Presentation. Working below capacity due to gas supply issues. Sweetcrude.
Omoku Power Station	Omoku		Simple cycle gas turbine	150 MW Rocksonengineering.	Operational	2005	6 x 25MW gas turbines

Table 1: Fossil fuel power stations - natural gas continue

Power Station (NIPP)			gas turbine		Construction		gas turbines emails and other details are not available at the moment.
Omotosho I Power Station	Omotosho	6°44′09″N 4°42′39″E	Simple cycle gas turbine	336 MW;	Operational	2005	8 x 42 MW
Omotosho II Power Station (NIPP)	Omotosho		Simple cycle gas turbine	450 MW	Operational fully by NDPHC The Nation Partially operational (375MW) By China Machinery Engineering Corporation.	2012	4x112,5MW, The plant is build and operated by China Machinery Engineering Corporation.

Table 2: Coal power station

Power station	Community	Coordinates	Type	Capacity	Status	Year completed	Additional description
Itobe Power Plant	Itobe Kogi State		Circulating Fluidized Bed technology	1200 MW	Planned	2015-2018 (first phase 600 MW)	The first phase consist of four 150MW units. Actual effort is focused on development mining to establish additional coal resources. Zuma Energy presentation.

Table 3: Hydroelectric (In Service)

Hydroelectric station	Community	Coordinates	Type	Capacity (MW)	Year completed	Name of reservoir	River
Kainji Power Station	Near New Bussa		Reservoir	800	1968[1]	Kainji Lake	Niger River
Jebba Power Station	Jebba		Reservoir	540	1985	Lake Jebba	Niger River
Shiroro Power Station	Shiroro George		Reservoir	600	1990	Lake Shiroro	Kaduna River
Zamfara Power Station			Reservoir	100	2012	Gotowa Lake	Bunsuru River

Table 4: Hydroelectric Under Construction or Proposed

Hydroelectric station	Community	Coordinates	Type	Capacity (MW)	Year completed	Name of reservoir	River
Kano Power Station	Hadejia		Reservoir	100	2015		Hadejia River
Zamfara Power Station	Gotowa		Reservoir	100	2012	Gotowa Lake	Bunsuru River
Kiri Power Station	Kiri		Reservoir	35	2016		Benue River
Mambilla Power Station	Gembu, Sum Sum and Nghu	6°41′46″N 11°09′16″E	Reservoir	3050	2018	Gembu, Sum Sum and Nghu Lake	Donga River

From the Tables 1 to 4 with the entire capacity (MW) put together Nigeria do not provide up to 5,0000MW Capacity.

8. Literature Review

The theory informs our world view and shapes our observation of a given problem, and is of utmost importance when we wish to understand what we see and what we felt. Therefore, the literature covered the background on "The world energy challenge, nuclear power production, world statistics on nuclear energy, world nuclear power plants in operation. Others are nuclear energy future, Prospects of Nuclear Power Generation Programme in Nigeria, safety concern of nuclear power plants for Nigeria and the advantages of having nuclear power plants.

8.1. Background of Nuclear Option

In the year 2007, the Nigeria Atomic Energy Commission (NAEC) was called upon by the then president, Chief Olusegun Obasanjo, to meet with other stake holders in energy sector to seek nuclear energy option for Nigeria energy crisis. Also, in some developed countries like France, Great Britain, Germany, USSR, China, Japan and the United States of America the political axe, system engineers and program managers are traditionally pressured to meet performance requirements, design and build within budget, and adhere to schedule. New programs and follow-on contracts have been won, lost, renewed, or canceled based on these three principles. However, a fourth dimension is rapidly gaining importance. New programs and follow-on contracts can now be lost or canceled because they are judged not innovative enough or not transformational enough. This consideration is driving designers to "engineer" or "innovate" in the greatest possible amount of new technology.

8.2. Challenges for the Nuclear Industry

The opportunity for growth in the nuclear power generation industry is offset by a number of major challenges faced by countries around the world operating nuclear power plant**:**

a) economic, technical and regulatory issues in building and refurbishing nuclear reactors;
b) environmental and health risks associated with radioactive material, especially long-term waste management;
c) concerns regarding nuclear safety and liability;
d) the maintenance of research and development capacity in the nuclear sector, including the availability of the required expertise and skilled workforce; and
e) public perception and acceptability of nuclear technologies.

8.3. Nuclear Power Technology

The nuclear sector is growing around the world as demand for energy increases. Though, nuclear power promise to be the best method so far of achieving electrical generation in sufficient quantity, which in turn will enhance both technological and socio-economical growth of mankind, this nuclear energy through which nuclear power is generated has been from the very discovery, been accompanied with very serious and fatal accidents. In avoiding such accidents the industry has been very successful. As in over 14,500 cumulative reactor-years of commercial operation in 32 countries, there have been only three major accidents in the 50-year history of civil nuclear power generation, these are**:**

1. Three Mile Island Reactor Unit 2 (TM1-2), USA, March 28, 1979 the reactor was severely damaged but radiation was contained and there were no adverse health or environmental consequences.

2. Chernobyl RBMK Reactor 4 in Russia in April 26, 1986, the destruction of the reactor by steam explosion and fire killed 31 people and had significant health and environmental consequences. The death toll has since increased to about 5
3. Fukushima Daiichi 1-3 Nuclear power plant accidents in Japan on the 11th March 2011, the three old reactors, dating from 1971-75 (together with a fourth) were written off.

As in other industries, the design and operation of nuclear power plants aims to reduce the likelihood of accidents, and avoid major human consequences when they occur. The paper focuses on nuclear power plants advantages because historically they are highly complex and prime innovators of new technology.

8.4. Regulatory Authorities and Stakeholders

In Nigeria there are three identified government establishment that are in charge of nuclear development strategy:

(1) The Nigeria Atomic Energy Commission (NAEC)

It was established through the enactment of Act 46 of 1976 as a specialised agency for the promotion and development of nuclear technology. It has the mandate to develop the framework and technical pathway to explore, exploit and harness atomic energy for peaceful application in all its ramifications for the socio-economic development of Nigeria and to meet international obligations to use nuclear technology for peaceful means.

(a) The objective of NAEC is among others:

- To streamline, harmonise, promote and coordinate research and development activities for capacity building and infrastructure development in nuclear technology.
- Fast-track and catalyse the process of development and deployment of nuclear power plants for electricity generation in Nigeria.

(b) The Legal Framework on Nuclear Energy for Nigeria

In 2010, NAEC produced a draft Atomic Energy Bill that would constitute the legal framework for the Nigerian nuclear industry [8]. A number of activities have been put in place for the enactment of the Atomic Energy Law in order to successfully implement the nuclear power programme. The legal framework is made up of the following elements as highlighted in Table 5.

Table 5: The legal framework elements

S/n	Elements
i	Nuclear security,
ii	Radioactive materials and radiation,
iii	Nuclear civil liability,
iv	Radioactive waste management,
v	Spent fuel and decommissioning,
vi	Environmental protection,
vii	Radiological emergency management,
viii	Notification of nuclear accidents,
ix	Foreign investments, and
x	Safety of nuclear installations

A final draft of the law has been developed in collaboration with all relevant stakeholders. It also contains technical inputs from the IAEA and is to be submitted to the national assembly for passage into law [Osaisai, 2011a]. NAEC is also developing a national policy on radioactive waste management in consultation with the Nigeria Nuclear Regulatory Authority (NNRA) and other stakeholder institutions. Meanwhile, the regulatory authority, NNRA is also developing a draft regulation on the safety and regulatory requirements for licensing of sites for nuclear power plants. A framework to establish a national nuclear insurance policy and a plan to properly deal with the civil liability component of the nuclear power industry is to be put in place together with the Federal Ministries of Finance, Commerce & Industry, and Justice.

(2) Nigeria Nuclear Regulatory Authority (NNRA)

The Nigeria Nuclear Regulatory Authority (NNRA) was established following the enactment of the Nuclear Safety and Radiation Protection Act of 1995 and began operations in 2001. It was established as the national regulator and licensing authority saddled with the responsibility of developing and enforcing all regulations that would govern the operations of the nuclear industry [NNRA, 2011]. NNRA is currently developing procedures for the licensing of nuclear power facilities. A draft regulation for the licensing of nuclear power plant site has been developed and is being reviewed. Other relevant national agencies established include the Energy

Commission of Nigeria (ECN) with responsibility for energy policy and planning; National Electricity Regulatory Commission (NERC) for electricity pricing; National Environmental Standards and Regulations Enforcement Agency (NESRA).

(3) Energy Commission of Nigeria (ECN)

The ECN was established by Act No. 62 of 1979, as amended by Act No.32 of 1988 and Act No. 19 of 1989, with the statutory mandate for the strategic planning and co-ordination of National Policies in the field of Energy in all its ramifications. It commenced operation in 1989 after the meeting of the Heads of ECOWAS in 1982 at Conakry, where a declaration was made that each member state should establish an Agency called Energy Commission charged with the responsibilities for coordinating and supervising all energy functions and activities within each member state. The Energy Commission of Nigeria (ECN) is charged with the responsibility for the strategic planning and coordination of the nation's policies on energy in all its ramifications and, without prejudice to the generality of the foregoing, the Commission shall perform other eleven (11) functions as follows:

The Mandate Energy Commission of Nigeria shall:

1. Serve as a centre for gathering and dissemination of information relating to national policy in the field of energy;
2. Serve as a centre for solving any inter-related technical problems that may arise in the implementation of any policy relating to the field of energy;
3. Advise the government of the Federation or a State on questions relating to such aspect of Energy as the Government of the Federation or a State may from time to time refer to it;
4. Prepare after consultation with such agencies of government whose functions relate to the field of Energy development or supply as the Commission considered appropriate, periodic master plans for the balanced and co-ordinated development of energy in Nigeria and such plans include:

i. Recommendations for the exploitation of new sources of energy as when considered necessary,

ii. Such other recommendations to the Government of the Federation relating to its functions under this Decree as the Commission may consider to be in the national interest;

5. Lay down guidelines on the utilization of energy types for specific purposes;
6. Inquire into and advise the Government of the Federation or of the State on the adequate funding of the energy sector including research and development, production and distribution;
7. Collate, analyze and publish information relating to the field of energy;
8. Carry out such other activities as are conclusive to the discharge of its functions under this Decree;
9. Monitor the performance of the Energy sector in the execution of government policies on energy;
10. Promoting training and manpower development in Energy sector;
11. Liaise with all international organizations in Energy matters.

8.5. International Agreements

NAEC has worked out the signing of international agreements to speed up international nuclear cooperation and develop capacity[9]. Nigeria signed a Memorandum of Cooperation with Iran in 2008. In 2009, two international agreements to assist in the development of nuclear technology and exploitation of uranium resources were signed with Russia (World Nuclear News, 2009). Co-operation agreements were also signed with India and South Korea in 2009[10].

Nigeria was one of the first countries that signed and ratified the 1968 Nuclear Non-Proliferation treaty (NPT). The IAEA Convention on Nuclear safety (IAEA, 2008a) was ratified in 2007. In the same year, the 1997 Joint Convention on Safety of Spent Fuel Management and Safety of Radioactive Waste Management (IAEA, 2009c), the Convention on the Physical Protection of Nuclear Materials (IAEA, 2009d), and the Vienna Convention on Civil liability for Nuclear Damage (IAEA, 2008b) were all signed but are yet to be ratified. The 1986 Convention on Early Notification of a Nuclear Accident has been ratified (IAEA, 2008c), and also the Revised Supplementary Agreement Concerning Provision of Technical Assistance by the IAEA (IAEA, 2007), and the 1968 Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency (IAEA, 2008d). A Comprehensive Safeguards Agreement and Additional Protocol with the IAEA, allowing the agency access to a nation's facilities to ensure that peaceful nuclear technology and materials are not diverted to weapons development has been concluded (IAEA, 2009e). The treaty of Pelindaba, establishing an African nuclear weapon-free zone was ratified in 2001 (Centre for Non-Proliferation Studies, 2009).

8.6. The World Energy Challenge

To support economic growth the world will need vast amounts of extra energy. The challenge is to meet the rising demand in economically, environmentally and socially responsible ways.

With a continuation of the current trend, the next century will see global electricity demand grow faster than overall energy demand as electricity provides the greatest flexibility in use at the point of consumption. Already Turkey, an example of a rapidly industrializing developing country, has seen its electricity capacity increase ten-fold in the past 25 years from some 2200 Megawatts electric (MW(e)) to 21 000 MW(e). The 1997 DOE energy outlook report projects a possible 75% global increase in electricity demand from 1995 to 2015 - equivalent to 1500 new 1000 MW(e) plants. The Figure 1 is a pie chart showing a clear picture of world electricity production in percentage as at year 2008 as presented by World Nuclear Association.

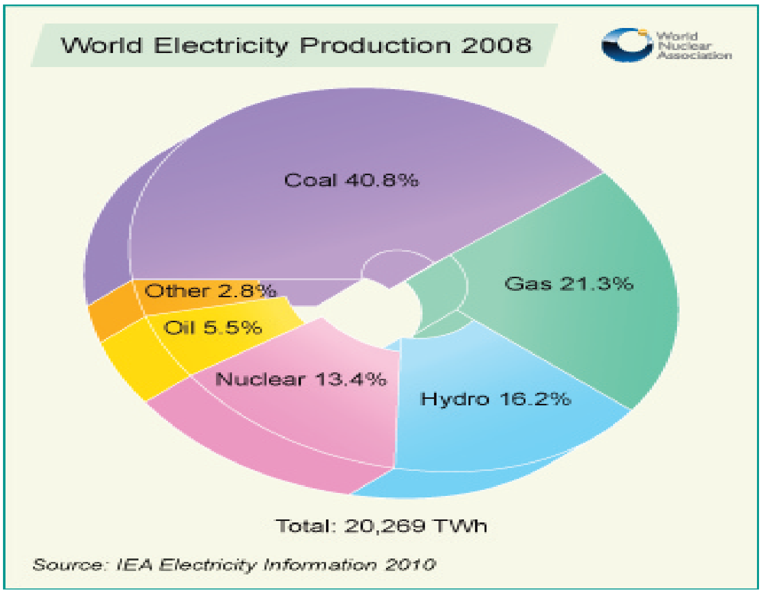

Figure 3. The world energy challenges in pie chart

8.7 Nuclear Power Production

Nuclear power is the use of sustained nuclear fission to generate heat and electricity.
In the year 2007, the International Atomic Energy Agency (IAEA) reported that, more than 150 naval vessels using nuclear propulsion have been built. The first commercial nuclear power reactor began operation some 45 years ago, with a rapid expansion in reactor units taking place during the 1970s and early 1980s.
As of December 2009, the world had 436 nuclear power reactors. Since commercial nuclear energy began in the mid 1950s, 2008 was the first year that no new nuclear power plant was connected to the grid, although two were connected in 2009. Annual generation of nuclear power has been on a slight downward trend since 2007, decreasing 1.8% in 2009 to 2558 TWh with nuclear power meeting 13–14% of the world's electricity demand. From 2003 to 2008, coal was the fastest growing fossil fuel. After the oil shocks of 1973 and 1979, during which the price of oil increased from 5 to 45 US dollars per barrel, there was a shift away from oil. *Coal, natural gas, and nuclear* became the fuels of choice for electricity generation and conservation measures increased energy efficiency. From 1965 to 2008, the use of fossil fuels has continued to grow and their share of the energy supply has increased. The Figure 3 presents main types of commercial reactor in use worldwide and energy consumption in percentages.

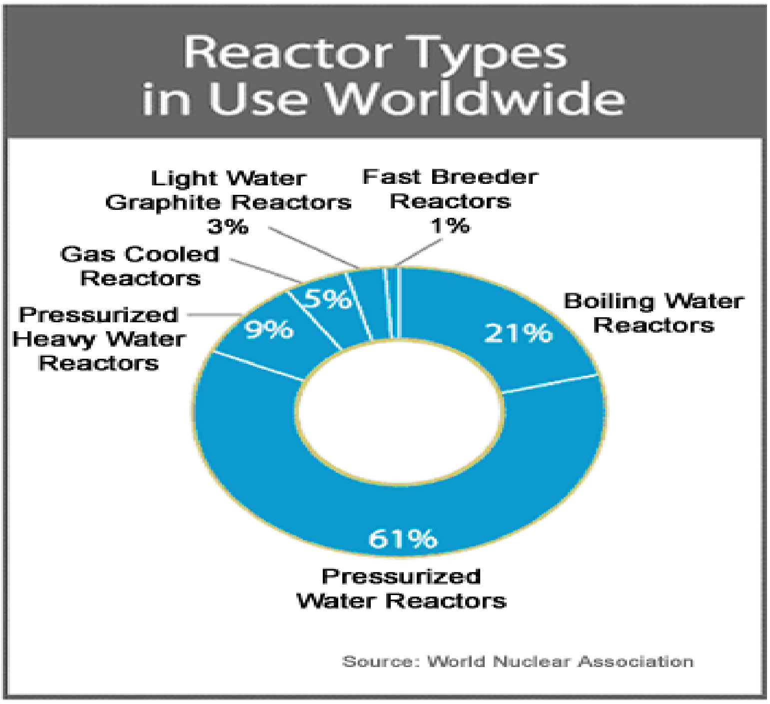

Figure 3: The main types of commercial reactor

9. Methodology

Risk management techniques are tool for improving nuclear power plant performance (IAEA, 2011). Risk management techniques could be used to approach actualization of nuclear power plant design or building. The 2013 risk management embedded topical meeting - **Risk Management for Complex Socio-technical Systems (RM4CSS).** The role of risk management in the system design process is significant. The work and time between starting the design of nuclear power plant on Level 1 and finishing level 5. Managing this work is handled in the Nuclear Power Plant building by spreading the engineering and development effort across the first three stages of a six-stage Nuclear Power Plant lifecycle.

The six stages are:

1. Conceptual design;
2. Preliminary design;
3. Detail design and development;
4. Production, fabrication, & construction;
5. Nuclear power plant operations;
6. Nuclear power plant retirement and disposal.

This aspect requires risk management to continue throughout the reactor's entire lifecycle.
This life cycle is illustrated in **Figure 4**

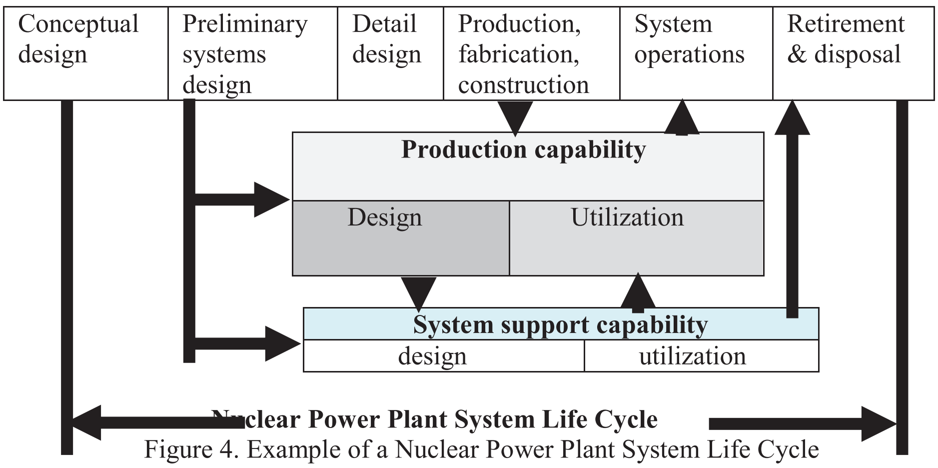

Figure 4. Example of a Nuclear Power Plant System Life Cycle

10. World Statistics on Nuclear Energy

As of January 2014, 32 countries worldwide are operating 440 nuclear reactors for electricity generation accounting for 17% of the global supply of electricity and 72 new nuclear plants are under construction in 15 countries. Electricity generation from nuclear power worldwide would increase by 73%, from 9.36 EJ in 2007 to 16.2 EJ in 2035. According to the World Nuclear Association, an additional 158 reactors are in the planning stages and a further 326 have been proposed. Africa, China, India and Russia are expected to have the strongest demand for new energy supply, making them potential markets for new reactors.

In terms of the total quantity of nuclear electricity generated, the five largest producers are the USA, France, Japan, Germany and the Russian Federation. Globally, the nuclear share of electricity is more than 20% in 19 countries. Regionally in 1996, Western Europe with a 33% share had the highest percentage of nuclear electricity - the nuclear share in France, Belgium and Sweden being 77%, 57% and 52% respectively. Two large nuclear power units in Lithuania supplied almost 85% of the country's electricity requirements. Nuclear power plants provided 12.3 percent of the world's electricity production in 2012. In total, 13 countries relied on nuclear energy to supply at least one-quarter of their total electricity.

The growing interest in nuclear energy is also influenced by the role it might play in climate-change-reducing efforts, since nuclear technology produces fewer greenhouse gas emissions than fossil-fuel-based plants. The rising global demand for energy and concerns over climate change are contributing to a possible global "nuclear renaissance." However, the nuclear industry, particularly in Canada, faces a number of economic, safety and environmental challenges. Table 2 shown the International Atomic Energy Agency's Power Reactor Information Systems Database.

Table 5: World Nuclear Power Plants in Operation

World Nuclear Power Plants in Operation				
(Non-US) Country	**Reactor Name**	**Reactor Type**	**Net Capacity (MW)**	**Date Connected**
Argentina	Atucha-1	PHWR	335	1974
Argentina	Embalse	PHWR	600	1983
Armenia	Armenia-2	WWER	375	1980
Belgium	Doel-1	PWR	433	1974
Belgium	Doel-2	PWR	433	1975
Belgium	Doel-3	PWR	1,006	1982
Belgium	Doel-4	PWR	1,039	1985
Belgium	Tihange-1	PWR	962	1975
Belgium	Tihange-2	PWR	1,008	1982
Belgium	Tihange-3	PWR	1,046	1985
Brazil	Angra-1	PWR	609	1982
Brazil	Angra-2	PWR	1,275	2000
Bulgaria	Kozloduy-5	WWER	953	1987
Bulgaria	Kozloduy-6	WWER	953	1991
Canada	Bruce-1	PHWR	772	1977
Canada	Bruce-2	PHWR	734	1976
Canada	Bruce-3	PHWR	730	1977
Canada	Bruce-4	PHWR	730	1978
Canada	Bruce-5	PHWR	817	1984
Canada	Bruce-6	PHWR	817	1984
Canada	Bruce-7	PHWR	817	1986
Canada	Bruce-8	PHWR	817	1987
Canada	Darlington-1	PHWR	878	1990
Canada	Darlington-2	PHWR	878	1990
Canada	Darlington-3	PHWR	878	1992
Canada	Darlington-4	PHWR	878	1993
Canada	Pickering-1	PHWR	515	1971
Canada	Pickering-4	PHWR	515	1973

Canada	Pickering-5	PHWR	516	1982
Canada	Pickering-6	PHWR	516	1983
Canada	Pickering-7	PHWR	516	1984
Canada	Pickering-8	PHWR	516	1986
Canada	Point Lepreau	PHWR	660	1982
China	CEFR	FBR	20	2011
China	Daya Bay 1	PWR	944	1993
China	Daya Bay 2	PWR	944	1994
China	Hongyanhe 1	PWR	1,000	2013
China	Hongyanhe 2	PWR	1,000	2013
China	Lingao 1	PWR	938	2002
China	Lingao 2	PWR	938	2002
China	Lingao 3	PWR	1,020	2010
China	Lingao 4	PWR	1,020	2011
China	Ningde 1	PWR	1,018	2012
China	Qinshan-1	PWR	298	1991
China	Qinshan 2 - 1	PWR	610	2002
China	Qinshan 2 - 2	PWR	610	2004
China	Qinshan 2 - 3	PWR	610	2010
China	Qinshan 2 - 4	PWR	610	2011
China	Qinshan 3 - 1	PHWR	650	2002
China	Qinshan 3 - 2	PHWR	650	2003
China	Tianwan 1	PWR	990	2006
China	Tianwan 2	PWR	990	2007
China, Taiwan	Chin Shan-1	BWR	604	1977
China, Taiwan	Chin Shan-2	BWR	604	1978
China, Taiwan	Kuosheng-1	BWR	985	1981
China, Taiwan	Kuosheng-2	BWR	985	1982
China, Taiwan	Maanshan-1	PWR	928	1984
China, Taiwan	Maanshan-2	PWR	922	1985
Czech Republic	Dukovany-1	WWER	468	1985
Czech Republic	Dukovany-2	WWER	471	1986
Czech Republic	Dukovany-3	WWER	468	1986
Czech Republic	Dukovany-4	WWER	471	1987
Czech Republic	Temelin-1	WWER	963	2000
Czech Republic	Temelin-2	WWER	963	2002
Finland	Loviisa-1	WWER	496	1977
Finland	Loviisa-2	WWER	496	1980
Finland	Olkiluoto-1	BWR	880	1978
Finland	Olkiluoto-2	BWR	880	1980
France	Belleville-1	PWR	1,310	1987
France	Belleville-2	PWR	1,310	1988
France	Blayais-1	PWR	910	1981
France	Blayais-2	PWR	910	1982
France	Blayais-3	PWR	910	1983
France	Blayais-4	PWR	910	1983
France	Bugey-2	PWR	910	1978
France	Bugey-3	PWR	910	1978

France	Bugey-4	PWR	880	1979
France	Bugey-5	PWR	880	1979
France	Cattenom-1	PWR	1,300	1986
France	Cattenom-2	PWR	1,300	1987
France	Cattenom-3	PWR	1,300	1990
France	Cattenom-4	PWR	1,300	1991
France	Chinon-B-1	PWR	905	1982
France	Chinon-B-2	PWR	905	1983
France	Chinon-B-3	PWR	905	1986
France	Chinon-B-4	PWR	905	1987
France	Chooz-B-1	PWR	1,500	1996
France	Chooz-B-2	PWR	1,500	1997
France	Civaux-1	PWR	1,495	1997
France	Civaux-2	PWR	1,495	1999
France	Cruas-1	PWR	915	1983
France	Cruas-2	PWR	915	1984
France	Cruas-3	PWR	915	1984
France	Cruas-4	PWR	915	1984
France	Dampierre-1	PWR	890	1980
France	Dampierre-2	PWR	890	1980
France	Dampierre-3	PWR	890	1981
France	Dampierre-4	PWR	890	1981
France	Fessenheim-1	PWR	880	1977
France	Fessenheim-2	PWR	880	1977
France	Flamanville-1	PWR	1,330	1985
France	Flamanville-2	PWR	1,330	1986
France	Golfech-1	PWR	1,310	1990
France	Golfech-2	PWR	1,310	1993
France	Gravelines-1	PWR	910	1980
France	Gravelines-2	PWR	910	1980
France	Gravelines-3	PWR	910	1980
France	Gravelines-4	PWR	910	1981
France	Gravelines-5	PWR	910	1984
France	Gravelines-6	PWR	910	1985
France	Nogent-1	PWR	1,310	1987
France	Nogent-2	PWR	1,310	1988
France	Paluel-1	PWR	1,330	1984
France	Paluel-2	PWR	1,330	1984
France	Paluel-3	PWR	1,330	1985
France	Paluel-4	PWR	1,330	1986
France	Penly-1	PWR	1,330	1990
France	Penly-2	PWR	1,330	1992
France	St. Alban-1	PWR	1,335	1985
France	St. Alban-2	PWR	1,335	1986
France	St. Laurent-B-1	PWR	915	1981
France	St. Laurent-B-2	PWR	915	1981
France	Tricastin-1	PWR	915	1980
France	Tricastin-2	PWR	915	1980

France	Tricastin-3	PWR	915	1981
France	Tricastin-4	PWR	915	1981
Germany	Brokdorf (KBR)	PWR	1,410	1986
Germany	Emsland (KKE)	PWR	1,329	1988
Germany	Grafenrheinfeld (KKG)	PWR	1,275	1981
Germany	Grohnde (KWG)	PWR	1,360	1984
Germany	Gundremmingen-B (GUN-B)	BWR	1,284	1984
Germany	Gundremmingen-C (GUN-C)	BWR	1,288	1984
Germany	Isar-2 (KKI 2)	PWR	1,410	1988
Germany	Neckarwestheim-2 (GKN 2)	PWR	1,310	1989
Germany	Philippsburg-2 (KKP 2)	PWR	1,402	1984
Hungary	Paks-1	WWER	470	1982
Hungary	Paks-2	WWER	473	1984
Hungary	Paks-3	WWER	473	1986
Hungary	Paks-4	WWER	473	1987
India	Kaiga-1	PHWR	202	2000
India	Kaiga-2	PHWR	202	1999
India	Kaiga-3	PHWR	202	2007
India	Kaiga-4	PHWR	202	2011
India	Kakrapar-1	PHWR	202	1992
India	Kakrapar-2	PHWR	202	1995
India	Kudankulam 1	PWR	917	2013
India	Madras-1	PHWR	205	1983
India	Madras-2	PHWR	205	1985
India	Narora-1	PHWR	202	1989
India	Narora-2	PHWR	202	1992
India	Rajasthan-1	PHWR	90	1972
India	Rajasthan-2	PHWR	187	1980
India	Rajasthan-3	PHWR	202	2000
India	Rajasthan-4	PHWR	202	2000
India	Rajasthan-5	PHWR	202	2009
India	Rajasthan-6	PHWR	202	2010
India	Tarapur-1	BWR	150	1969
India	Tarapur-2	BWR	150	1969
India	Tarapur-3	PHWR	490	2006
India	Tarapur-4	PHWR	490	2005
Iran	Bushehr-1	PWR	915	2011
Japan	Fukushima-Daiichi-5	BWR	760	1977
Japan	Fukushima-Daiichi-6	BWR	1,067	1979
Japan	Fukushima-Daini-1	BWR	1,067	1981
Japan	Fukushima-Daini-2	BWR	1,067	1983
Japan	Fukushima-Daini-3	BWR	1,067	1984
Japan	Fukushima-Daini-4	BWR	1,067	1986
Japan	Genkai-1	PWR	529	1975
Japan	Genkai-2	PWR	529	1980
Japan	Genkai-3	PWR	1,127	1993

Japan	Genkai-4	PWR	1,127	1996
Japan	Hamaoka-3	BWR	1,056	1987
Japan	Hamaoka-4	BWR	1,092	1993
Japan	Hamaoka-5	ABWR	1,325	2004
Japan	Higashidori-1	BWR	1,067	2005
Japan	Ikata-1	PWR	538	1977
Japan	Ikata-2	PWR	538	1981
Japan	Ikata-3	PWR	846	1994
Japan	Kashiwazaki Kariwa-1	BWR	1,067	1985
Japan	Kashiwazaki Kariwa-2	BWR	1,067	1990
Japan	Kashiwazaki Kariwa-3	BWR	1,067	1992
Japan	Kashiwazaki Kariwa-4	BWR	1,067	1993
Japan	Kashiwazaki Kariwa-5	BWR	1,067	1989
Japan	Kashiwazaki Kariwa-6	ABWR	1,315	1996
Japan	Kashiwazaki Kariwa-7	ABWR	1,315	1996
Japan	Mihama-1	PWR	320	1970
Japan	Mihama-2	PWR	470	1972
Japan	Mihama-3	PWR	780	1976
Japan	Ohi-1	PWR	1,120	1977
Japan	Ohi-2	PWR	1,120	1978
Japan	Ohi-3	PWR	1,127	1991
Japan	Ohi-4	PWR	1,127	1992
Japan	Onagawa-1	BWR	498	1983
Japan	Onagawa-2	BWR	796	1994
Japan	Onagawa-3	BWR	796	2001
Japan	Sendai-1	PWR	846	1983
Japan	Sendai-2	PWR	846	1985
Japan	Shika-1	BWR	505	1993
Japan	Shika-2	ABWR	1,108	2005
Japan	Shimane-1	BWR	439	1973
Japan	Shimane-2	BWR	789	1988
Japan	Takahama-1	PWR	780	1974
Japan	Takahama-2	PWR	780	1975
Japan	Takahama-3	PWR	830	1984
Japan	Takahama-4	PWR	830	1984
Japan	Tokai-2	BWR	1,060	1978
Japan	Tomari-1	PWR	550	1988
Japan	Tomari-2	PWR	550	1990
Japan	Tomari-3	PWR	866	2009
Japan	Tsuruga-1	BWR	340	1969
Japan	Tsuruga-2	PWR	1,108	1986
Mexico	Laguna Verde-1	BWR	665	1989
Mexico	Laguna Verde-2	BWR	665	1994
Netherlands	Borssele	PWR	482	1973
Pakistan	Chasnupp 1	PWR	300	2000
Pakistan	Chasnupp 2	PWR	300	2011
Pakistan	Kanupp	PHWR	125	1971
Republic of Korea	Kori-1	PWR	576	1977

Republic of Korea	Kori-2	PWR	637	1983
Republic of Korea	Kori-3	PWR	1,011	1985
Republic of Korea	Kori-4	PWR	1,007	1985
Republic of Korea	Hanbit-1	PWR	959	1986
Republic of Korea	Hanbit-2	PWR	958	1986
Republic of Korea	Hanbit-3	PWR	1,000	1994
Republic of Korea	Hanbit-4	PWR	996	1995
Republic of Korea	Hanbit-5	PWR	993	2001
Republic of Korea	Hanbit-6	PWR	993	2002
Republic of Korea	Hanul-1	PWR	960	1988
Republic of Korea	Hanul-2	PWR	961	1989
Republic of Korea	Hanul-3	PWR	994	1998
Republic of Korea	Hanul-4	PWR	998	1998
Republic of Korea	Hanul-5	PWR	998	2003
Republic of Korea	Hanul-6	PWR	997	2005
Republic of Korea	Shin-Kori 1	PWR	997	2010
Republic of Korea	Shin-Kori 2	PWR	997	2012
Republic of Korea	Shin Wolsong 1	PWR	997	2012
Republic of Korea	Wolsong-1	PHWR	657	1982
Republic of Korea	Wolsong-2	PHWR	673	1997
Republic of Korea	Wolsong-3	PHWR	686	1998
Republic of Korea	Wolsong-4	PHWR	694	1999
Romania	Cernavoda-1	PHWR	650	1996
Romania	Cernavoda-2	PHWR	650	2007
Russia	Balakovo-1	WWER	950	1985
Russia	Balakovo-2	WWER	950	1987
Russia	Balakovo-3	WWER	950	1988
Russia	Balakovo-4	WWER	950	1993
Russia	Beloyarsky-3(bn-600)	FBR	560	1980
Russia	Bilibino 1	LWGR	11	1974
Russia	Bilibino 2	LWGR	11	1974
Russia	Bilibino 3	LWGR	11	1975
Russia	Bilibino 4	LWGR	11	1976
Russia	Kalinin-1	WWER	950	1984
Russia	Kalinin-2	WWER	950	1986
Russia	Kalinin-3	WWER	950	2004
Russia	Kalinin-4	WWER	950	2011
Russia	Kola-1	WWER	411	1973
Russia	Kola-2	WWER	411	1974
Russia	Kola-3	WWER	411	1981
Russia	Kola-4	WWER	411	1984
Russia	Kursk-1	LWGR	925	1976
Russia	Kursk-2	LWGR	925	1979
Russia	Kursk-3	LWGR	925	1983
Russia	Kursk-4	LWGR	925	1985
Russia	Leningrad-1	LWGR	925	1973
Russia	Leningrad-2	LWGR	925	1975
Russia	Leningrad-3	LWGR	925	1979

Russia	Leningrad-4	LWGR	925	1981
Russia	Novovoronezh-3	WWER	385	1971
Russia	Novovoronezh-4	WWER	385	1972
Russia	Novovoronezh-5	WWER	950	1980
Russia	Smolensk-1	LWGR	925	1982
Russia	Smolensk-2	LWGR	925	1985
Russia	Smolensk-3	LWGR	925	1990
Russia	Volgodonsk-1	WWER	950	2001
Russia	Volgodonsk-2	WWER	950	2010
Slovakia	Bohunice-3	WWER	472	1984
Slovakia	Bohunice-4	WWER	472	1985
Slovakia	Mochovce-1	WWER	436	1998
Slovakia	Mochovce-2	WWER	436	1999
Slovenia	Krsko	PWR	688	1981
South Africa	Koeberg-1	PWR	930	1984
South Africa	Koeberg-2	PWR	930	1985
Spain	Almaraz-1	PWR	1,011	1981
Spain	Almaraz-2	PWR	1,006	1983
Spain	Asco-1	PWR	995	1983
Spain	Asco-2	PWR	997	1985
Spain	Cofrentes	BWR	1,064	1984
Spain	Santa Maria De Garona	BWR	446	1971
Spain	Trillo-1	PWR	1,003	1988
Spain	Vandellos-2	PWR	1,045	1987
Sweden	Forsmark-1	BWR	984	1980
Sweden	Forsmark-2	BWR	1,120	1981
Sweden	Forsmark-3	BWR	1,170	1985
Sweden	Oskarshamn-1	BWR	473	1971
Sweden	Oskarshamn-2	BWR	638	1974
Sweden	Oskarshamn-3	BWR	1,400	1985
Sweden	Ringhals-1	BWR	878	1974
Sweden	Ringhals-2	PWR	807	1974
Sweden	Ringhals-3	PWR	1,064	1980
Sweden	Ringhals-4	PWR	940	1982
Switzerland	Beznau-1	PWR	365	1969
Switzerland	Beznau-2	PWR	365	1971
Switzerland	Goesgen	PWR	985	1979
Switzerland	Leibstadt	BWR	1,220	1984
Switzerland	Muehleberg	BWR	373	1971
Ukraine	Khmelnitski-1	WWER	950	1987
Ukraine	Khmelnitski-2	WWER	950	2004
Ukraine	Rovno-1	WWER	381	1980
Ukraine	Rovno-2	WWER	376	1981
Ukraine	Rovno-3	WWER	950	1986
Ukraine	Rovno-4	WWER	950	2004
Ukraine	South Ukraine-1	WWER	950	1982
Ukraine	South Ukraine-2	WWER	950	1985
Ukraine	South Ukraine-3	WWER	950	1989

Ukraine	Zaporozhe-1	WWER	950	1984
Ukraine	Zaporozhe-2	WWER	950	1985
Ukraine	Zaporozhe-3	WWER	950	1986
Ukraine	Zaporozhe-4	WWER	950	1987
Ukraine	Zaporozhe-5	WWER	950	1989
Ukraine	Zaporozhe-6	WWER	950	1995
United Kingdom	Dungeness-B1	AGR	520	1985
United Kingdom	Dungeness-B2	AGR	520	1983
United Kingdom	Hartlepool-A1	AGR	595	1983
United Kingdom	Hartlepool-A2	AGR	585	1984
United Kingdom	Heysham-1A	AGR	585	1983
United Kingdom	Heysham-1B	AGR	610	1984
United Kingdom	Heysham-2A	AGR	575	1988
United Kingdom	Heysham-2B	AGR	610	1988
United Kingdom	Hinkley Point-B1	AGR	435	1976
United Kingdom	Hinkley Point-B2	AGR	435	1976
United Kingdom	Hunterston-B1	AGR	460	1976
United Kingdom	Hunterston-B2	AGR	430	1977
United Kingdom	Sizewell-B	PWR	1,191	1995
United Kingdom	Torness 1	AGR	595	1988
United Kingdom	Torness 2	AGR	595	1989
United Kingdom	Wylfa Unit A	GCR	490	1971
Source: International Atomic Energy Agency PRIS Database				

11. Nuclear Energy Future

Although nuclear power is currently a significant source of global electricity supply, there is no consensus concerning its future role. While nuclear power stagnates in much of Europe and in North America, it continues as a strong option in some Asian countries and in some African countries.

11.1 Principal Considerations in the Choice of Nuclear Power

(i) Economics benefits - such as industrial and domestic development
(ii) Security of supply- have been principal considerations in the choice of nuclear power along with an awareness of its,
(iii) Environmental benefits - from mining to waste disposal and decommissioning, it produces remarkably little environmental pollution and greenhouse gas emissions.

These three factors - economics, security of supply and environmental considerations - will determine the long term role of nuclear power in a sustainable energy future.

There is an ongoing debate about the use of nuclear energy. Proponents, such as the World Nuclear Association and IAEA, contend that nuclear power is a sustainable energy source that reduces carbon emissions. Opponents, such as Greenpeace International and the Nuclear Information and Resource Service (NIRS), believe that nuclear power poses many threats to people and the environment. The (NIRS) is an anti-nuclear group founded in 1978 to be the information and networking center for citizens and organizations concerned about nuclear power, radioactive waste, radiation and sustainable energy issues. The organization advocates the implementation of safe, sustainable solutions such as energy efficiency, solar power, wind power and plug-in hybrids.

12. Challenges for the Nuclear Industry

The opportunity for growth in the nuclear power generation industry is offset by a number of major challenges faced by countries around the world operating nuclear power plant**:**

f) economic, technical and regulatory issues in building and refurbishing nuclear reactors;
g) environmental and health risks associated with radioactive material, especially long-term waste management;
h) concerns regarding nuclear safety and liability;
i) the maintenance of research and development capacity in the nuclear sector, including the availability of the required expertise and skilled workforce; and
j) public perception and acceptability of nuclear technologies.

13. Prospects of Nuclear Power Generation Programme in Nigeria
Nigeria has made progress over the years towards its goal by developing the supporting institutions and infrastructure required for its nuclear power programme. The nuclear roadmap developed by NAEC is expected to drive the national nuclear programme. A near term target has been set for the contribution of nuclear power to national electricity generation. The first nuclear power plant is expected to be connected to the national grid by 2020, the same year Turkey also expects to bring its first nuclear power plant online [Tongal, 2011].
14. Safety Concern of Nuclear Power Plants for Nigeria
Nuclear accidents raised concerns about the safety of the Nuclear power in general, and this may likely be responsible for the slowing pace of its expansion for a number of years and forcing the Soviet government to become less secretive about its procedures. The government cover-up of the Chernobyl disaster was a "catalyst" for glasnost, which "paved the way for reforms leading to the Soviet collapse".

14.1 Nigerian Inadequate Maintenance Culture and Environmental Challenges
Considering Nigeria as a nation and some third world country in establishing nuclear power industry, one can exercise a lot of fear for many reasons these spread across human, socio-economic and environmental factors such as;
1) Poor maintenance culture - in a situation where obsolete equipment is not quickly replaced
2) Vandalization of plant components and equipment parts are prominent in third world country as a result of poverty.
3) Saboteurs especially in operational efficiency – can result from selfish interest and political unrest or otherwise
4) Inadequate knowledge skill, lack of technical know-how in the area of nuclear technology
5) Poor management system especially in the area of decision making on critical issues
6) Human errors especially in the area of operation such as linkages, plant shut down.
7) Community problem such as bush burning by fire which can affect the plant site-Land ownership or land tenure crisis which can hinder sitting of nuclear power plants
8) Difference opinions on nuclear power plant and fears of radiation or accident
9) Bad collaborators in government and workers and in the area of consultancy service and job delivery will hamper development.
10) Inadequate financial commitment to project development
11) Raw material problem, such as nuclear fuel
12) Sustainability struggle and poor infrastructure development in the nation
13) Poor renumeration and persistent delay in salary of workers which can led to sabotage of the industry
14) Radiation effect problem
15) Insecurity in some places
16) Lack of inward looking solution to industrial problem
17) Foreign experts collaboration and exploitation
18) Social factors and Public opinion
19) Low level in industrial outlay
20) Transportation problem of nuclear material and the risk
21) Government abandoned project trouble
22) Ethic differences and political influence on project development
23) Political unrest in the country and increase in terror attack such as Boko-Haram insurgency
24) Radioactive waste management problem
25) Prompt response in case of accident is an issue and a problem that must address etc.

15. The Advantages of Having Nuclear Power Plants
Advantages of civil nuclear power have made it a significant part of the energy mix in most industrialized countries since the 1960s. U.S. government statistics show that in 2009, nuclear reactors produced 20.2% of the nation's electricity, worldwide, it was 13.8 percent. The following are the advantages of NPPs.
1. Environmental Friendliness
Under normal accident-free conditions, nuclear power generation is comparatively friendly to the environment and is reliable as regards both fuel supply and power delivery**.** Nuclear power plants can help preserve the environment by lessening the dependence on fossil fuels as a source of energy. The burning of gas, oil and coal is believed by some environmentalists to contribute to atmospheric problems such as global warming and acid rain. Since nuclear plants produce power without relying on these resources, they can help create cleaner air for plants and animals especially. Increased awareness of global climate change and fossil-fuel dependence issues brought increased favorable attention to civil nuclear power in the decade before the 2011 nuclear power plant accident in Japan.

2. Safety

Despite well-publicized accidents such as Three Mile Island and Chernobyl, nuclear plants have proven to be relatively safe. According to Ecolo.org, the chances of dying as the result of a nuclear power plant disaster is lower than dying from heart disease, fire, homicide or motor vehicle accident. The website also indicates that the burning of coal could lead to a widespread virus due to the chemicals produced and set free in the environment.

3. Energy Supply

Since the energy produced by nuclear power plants is man-made, it means that there is less of a need to depend on natural resources. This eliminates the concern about running out of energy due to exhausting the world's resources.

Uranium, which is the primary source of nuclear fuel is used for no other primary purpose and exists in abundant quantities, enough to last for billions of years.

4. Cost Savings

Nuclear power plants can produce energy in a more cost-effective manner. According to Public Broadcasting Service (PBS.org), the cost per kilowatt-hour of nuclear electricity is N192. By comparison, natural gas costs N268 and the cost of oil is N377. Nuclear electricity is only slightly more expensive than coal-fired electricity, which costs N188 per kilowatt-hour.

5. Waste Disposal

Though nuclear waste can be dangerous if not disposed off properly, it has the advantage of being small in quantity and can be buried deep under the ground. This virtually eliminates the danger caused by possible exposure. Nuclear power plants consume uranium, which differs from coal energy production which produces uranium as a waste product that stays at the surface.

6. Environmental Impacts

An overwhelming advantage of civil nuclear power is that, except during severe accidents, there is almost no release of pollutants into the environment. A comparative assessment of alternate energy sources by the International Atomic Energy Agency (IAEA) enumerates comparative advantages of civil nuclear power over other fuel sources. Coal-fueled power plants continuously release huge amounts of pollutants that degrade air quality, acidify lakes and produce slag heaps that must be remedied. *Hydroelectric developments submerge large areas of land under water, causing population displacements and ecosystem changes.*

7. High Energy Density

The IAEA assessment cites the statistic that 30 tons of uranium and 2.6 million tons of coal contain equal amounts of energy. The extremely high energy content of nuclear fuel brings many advantages. Large rail transport networks for fuel delivery, or pipelines cutting across environmentally fragile areas are not needed. The volume of waste produced is minute compared with the other alternatives; this leads to one of the principal cited advantages of civil nuclear power -- waste is confined rather than dispersed. Since transport of fuel -- or waste -- is easy, civilian nuclear reactors can be built close to where the power is to be used, eliminating the need for long transmission lines.

8. Reliability

According to the IAEA assessment, the world's proven uranium reserves would last well past year 2060 at the current consumption rate. The largest deposits are in reliable and politically stable Canada and Australia. These nuclear energy reserves can be extended far into the future with the use of advanced technologies such as reprocessing of used fuel or the introduction of thorium as an alternate to uranium. Civil nuclear power plants produce very large amounts of electricity with almost perfect reliability, a primary requirement for heavy industry. *Solar and wind power lack this advantage*.

9. District Heating, Propulsion and Desalination

Civil nuclear power has applications other than production of electricity. Low-temperature heat, a byproduct of nuclear power plants, is used in many countries for directly heating buildings and supplying process heat to industry; it is also used for desalinating sea water in many arid regions. Russia operates a fleet of about a half-dozen nuclear-powered icebreakers: they require refueling only about once every four years. Russia is also considering smaller "floating" nuclear power reactors, which can be moved to smaller coastal settlements to provide electricity.

16. Summary/Conclusion

A reliable and adequate supply of energy, in the form of electricity, is indispensable for economic development. Thus providing electricity safely and reliably is an essential political, economic and social requirement. The safe operation of a nuclear power plant is generally acknowledged as contributing to society's success and promoting economic performance within those Member States that have a nuclear electricity generation capacity.

A nuclear power plant must be managed in a safe and efficient manner throughout all the life cycle stages from design through decommissioning, with the overall aim of delivering socio-economic success for the nuclear power plant owner and Member State.

The consequences of management decisions about nuclear power plants can have profound economic impacts for the nuclear power plant owner, and possibly for the national economy. In addition, the consequence of a major failure or accident can have catastrophic national socio-economic effects that may be felt internationally.
Nuclear energy is an evolving technology which is expected to play an expanded role in meeting the growing demand for electricity in a safe and secure manner without contributing to global warming. Nigeria will require a secure electricity supply to meet expected future demand which is an essential requirement for economic development as envisaged under the government's growth and poverty reduction strategy. Although preparatory works to attain Milestone 2 are being put in place, it is evident that the government has shown some commitment at least to an extent in the actualisation of the nuclear power programme given its short time from 2006 when NAEC became operational. Nigeria is presently in phase two of the development of the infrastructure for a nuclear power programme getting ready to invite bids. With the signing of international and bilateral agreements with countries like Russia and South Korea and the signing and ratification of treaties, conventions and protocols, it shows that the country means it to use nuclear power for peaceful socio-economic purposes only. NAEC, NNRA and ECN are putting in place programmes to relate with the public on its various activities in order to address public perception during the successful implementation of the nuclear power programme. This is to be achieved by making the general public aware of the environmental and economic benefits of nuclear power compared to others, safety and security issues inherent in deploying nuclear power for power generation, and the various ways it intend to manage the risk involved and the waste produced. Poland, for example has its nuclear programme revived after the programme had been stopped when governments and public opinion changed [IAEA, 2010a]. Chile is also involving its general public along as they consider the nuclear power option. Therefore, as Nigeria is preparing for nuclear option she need lay emphasis on public information. Series of public seminars on nuclear power should be conducted with opinion leaders and the general public in attendance. Public confident needs to be guarantee on the propose nuclear power plant for electricity generation. It is worthy of note that the nuclear industry has an international body that regulates, approves and monitors its activities worldwide. So that of Nigeria is not an exception. The industrial and the financial sector together with the business community are to be engaged to take advantage of the opportunities that would be created with the successful implementation of Nigeria's nuclear power programme.
In conclusion, the government needs to prepare ahead by addressing the issue of poor maintenance culture, poor management culture and environmental challenges.

Suggestions for overcoming these challenges:
Nuclear option is needed in the Nigerian energy sector not only for power generation but for socio-economic development, industrial revolution and educational development of the nuclear technology.
Nigeria needs awareness in the following areas of nuclear power development strategy;
- Selection of type of reactor for Nigeria nuclear power plant
- Human resource needs
- Extent of the uranium resources in the country and impact on the fuel policy
- Public Acceptance of Nuclear Power Plant
- Nuclear Security and Safety Assurance and Insurance
- Life and Environmental Protection
- Radiation Protection

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