

NUCLEAR POWER DEVELOPMENT IN NIGERIA: PARTNERSHIP BUILDING AMONGST NATIONAL INSTITUTIONS FOR SUSTAINABLE PROGRAMME IMPLEMENTATION

Being a Public Lecture

Delivered by

**F. Erepano Osaisai, PhD NucE, FNIP, FNSE, FAEng
Chairman/Chief Executive Officer
Nigeria Atomic Energy Commission
(NAEC), Abuja.**

at the
**FEDERAL UNIVERSITY OF TECHNOLOGY,
OWERRI**

**during the occasion of the Formal Opening of
The Centre for Nuclear Energy Studies and Training (CNEST),
Federal University of Technology, Owerri**

on April 17, 2013.

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PREAMBLE

First of all, I wish to express my profound gratitude to the Vice Chancellor and the Public Lectures Committee of the Federal University of Technology, Owerri (FUTO) for giving me the honour to deliver this public lecture as part of the activities signaling the formal opening of the Centre for Nuclear Energy Studies and Training (CNEST) recently created by the Federal Government of Nigeria under the aegis of the Nigeria Atomic Energy Commission (NAEC) at the Federal University of Technology, Owerri. I am, indeed, elated by this rare privilege of availing me the opportunity to have a genuine conversation on nuclear power development in Nigeria with this dynamic and erudite community of learning at FUTO.

The timing of this conversation is quite auspicious, particularly at a time the Federal Government, in its wisdom, has decided to establish a centre for research and development in nuclear science and technology in this citadel of learning at Owerri, as part of its long-term strategy of harnessing nuclear energy for power generation, as well as in other applications for our national socioeconomic development.

As is expected, the title of my lecture would evoke some emotions. I could see some twinkling of eyes, and also notice some element of surprise and consternation in the faces of a section of the audience, as if wanting to ask some pertinent questions before I could even start my lecture. One of such questions, seeking some form of affirmation is: Did he say "Nuclear Power Development in this our Nigeria"? Then, there is the follow-up question: Is he, the lecturer, a dreamer? With these and other questions going through our minds, comes the final exhortation: nuclear power for Nigeria; please, get real!

Yes, I do understand and appreciate that these are legitimate concerns. There are definitely major issues and challenges we will face as a country to develop and deploy nuclear power for national development. However, as a nation, we may disagree initially, but would ultimately agree that we have the capacity to confront and surmount these challenges through the evolution of appropriate mechanisms.

The mechanisms would evolve from informed and focused national discourse guided by empirical facts anchored on science and technology, within the precincts of formal research settings. However, at times, the arenas and the focus groups of a national discourse may be informal. Distinguished ladies and gentlemen, this is the kernel of our conversation today, and I am glad and privileged to be the lead discussant.

1. INTRODUCTION

1.1 The Concept of Sustainable Development

The relationship between environment and nuclear energy development can be considered from the broader perspective of sustainable development, which the Brundtland Commission, also known as the World Commission on Environment and Development (WCED), defined in 1987 as "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [1].

It is readily discernible that this definition attempts to emphasize the importance of economic development to meet human needs, and the importance of the sustenance of the natural environment as both a resource provider and waste absorber. Since the Brundtland Commission, the United Nations has through various organs and instruments made efforts to translate the Brundtland Commission's definition of sustainable development into specific policy directions.

Thus, we can infer from the WCED definition that sustainable development in any society entails the optimal harnessing and utilization of its human and material resources in the most efficient manner possible, for the advancement of its people in harmony with their environment. However, the effective harnessing of these societal resources necessitates the long-term availability of some primary and effective drivers. One major primary driver in this respect is energy.

1.2 Energy, a major driver of Sustainable Development

As we are aware, the productivity of any physical system is intrinsically linked to its driving force. In a nation states, the gross domestic product (GDP), defined as the measure of the aggregate monetary worth of the total goods and services produced by its citizenry, serves as a good indicator of productivity. The GDP, though dependent on a number of macroeconomic factors, is also principally dependent on a driving force; energy production and usage.

Table 1.1 and Figure 1.1 give a fair correlation between the per capita GDP on the one hand, and energy production and usage, on the other hand, of some countries; in the developed, emerging and developing countries. As can be observed, the highly developed and industrialized countries with concomitant high per capita GDPs are also heavy consumers of primary energy.

Consequently, as Nigeria strives to move beyond the level of a mere exporter of unprocessed primary resources to the status of an industrialized country, we must ramp up the process of power generation to meet both our industrial and domestic needs. This entails proper energy planning to ensure long term energy security, thereby driving our national development processes in a sustainable manner.

Nigeria currently grapples with the daunting problem of generating sufficient electricity to drive its developmental process. As part of the Federal Government's concerted effort to solve the problem, it has adopted a strategy which would strengthen generation as well as diversify the country's energy generation base beyond the current sources of oil, gas and hydro, to include nuclear and coal, as well as the renewable sources of solar and wind. It should be noted, however, that currently, no grid connected power plant in the country is powered by oil.

Furthermore, we must also take cognizance of the fact that optimal usage of energy entails devising strategies for conservation, and designing of more energy efficient appliances, as well as developing new technologies for alternative energy sources, in the face of global concerns on pollution and environmental degradation.

From Figure 1.1b, it is further observed that there is even a higher level of correlation between GDP and per capita electricity generation, since modern manufacturing processes depend principally on electricity, and about 40% of all primary energy consumed is in the form of electricity.

Table 1.1: Correlation between GDP and Energy

Sources: 2009 capacity and projected planned additions: US Energy Information Administration (EIA), Form EIA -860, "Annual Electric Generator Report"; International Energy Annual 2009; CIA - The World Factbook 2012. .

NAME OF COUNTRY	PER CAPITA GDP IN US\$	PER CAPITA ENERGY USAGE IN MILLION BTU	ELECTRICITY GENERATION IN BILLION KWH	POPULATION	PER CAPITA ELEC GEN IN KWH
Egypt	6,400	40.47	131.34	83,688,164	1,569
Libya	14,100	115.99	28.60	6,733,620	4,247
Gabon	15,000	27.98	1.60	1,608,321	995
Mauritius	14,100	51.02	2.89	1,313,095	2,201
Cameroon	2,200	4.82	5.59	20,129,878	278
Namibia	6,900	33.24	1.48	2,165,828	683
Morocco	4,800	18.85	20.09	32,309,239	622
Nigeria	2,400	4.91	18.82	157,580,439	119
Ghana	2,700	7.33	8.76	25,241,998	347
South Africa	10,700	112.05	232.09	48,810,427	4,755
Botswana	14,800	28.60	0.42	2,098,018	200
Tunisia	9,600	28.60	14.76	10,732,900	1,375
Seychelles	23,300	166.62	0.25	90,024	2,777
United States	47,400	340.5	4062.0	302,200,000	13,441
Canada	39,700	436.2	609.6	32,900,000	18,529
Mexico	13,900	64.8	222.4	106,500,000	2,088
Argentina	15,200	74.2	101.1	39,400,000	2,565
Brazil	11,000	50.1	396.4	189,300,000	2,094
Luxembourg	80,900	339.83	2.67	509,074	5,245
Norway	54,300	403.84	129.87	4,707,270	27,589
Switzerland	42,500	171.51	64.04	7,655,628	8,365
Denmark	37,100	142.33	34.29	5,543,453	6,186
France	34,800	169.67	510.23	62,814,233	8,123
United Kingdom	36,100	141.26	349.67	63,047,162	5,546
Germany	35,900	165.56	546.78	81,305,856	6,725
Czech Republic	26,400	150.43	77.01	10,177,300	7,567
Slovenia	28,700	163.78	15.56	1,996,617	7,793
Spain	31,000	129.16	274.69	47,042,984	5,839
Netherlands	41,900	242.07	106.90	16,730,632	6,389
Russia	15,600	194.20	929.62	138,082,178	6,732
India	3,200	18.00	847.43	1,205,073,612	703
Korea, South	29,300	203.83	425.25	48,860,500	8,703
Indonesia	4,300	24.38	146.86	248,216,193	592
Australia	40,000	253.91	245.9	22,015,576	11,167

Figure 1.1a: Interrelationship between GDP and Energy Usage

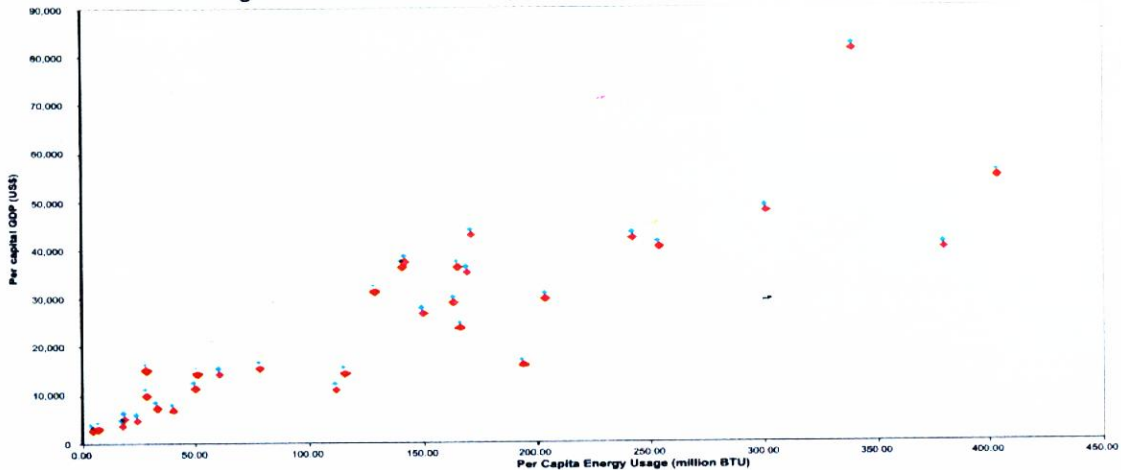
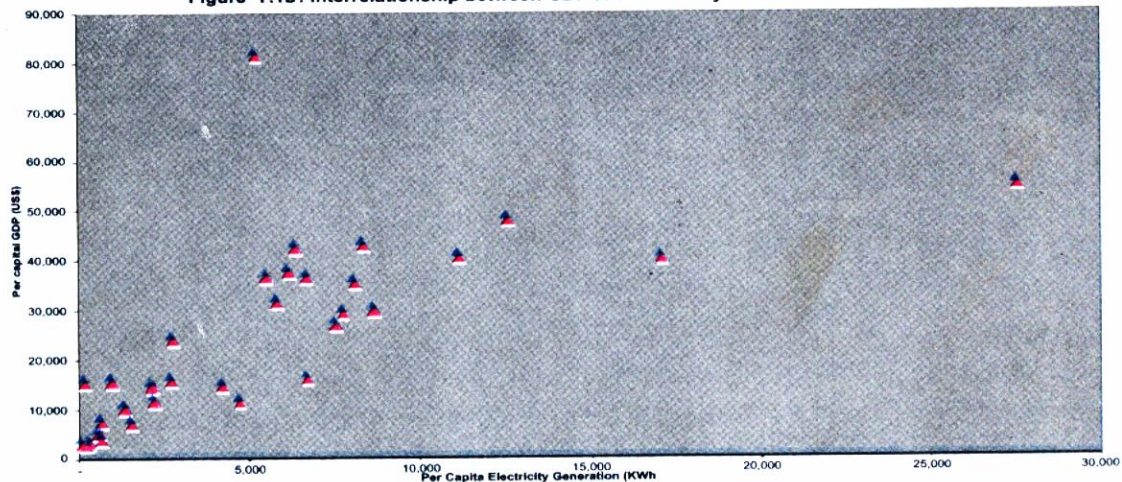


Figure 1.1b: Interrelationship between GDP and Electricity Generation



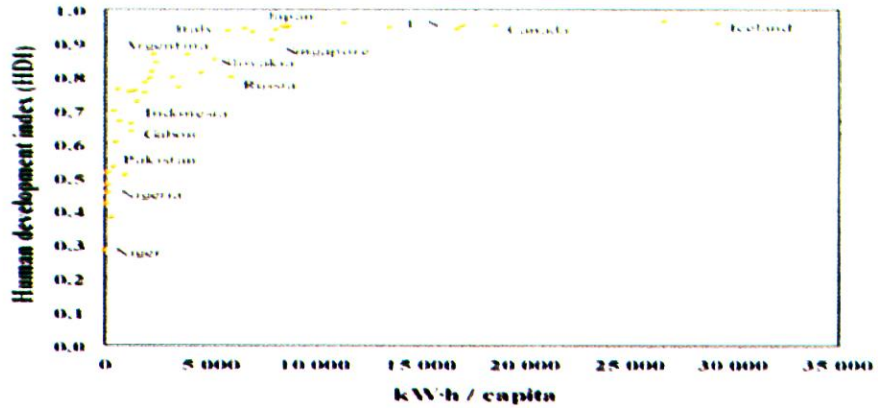
Both figures show a clear one-to-one correspondence between productivity measured by way of the GDP with energy consumption within the country as the driving force, and also the distinction in the spread of data between the undeveloped countries of Africa and the industrialized and emerging countries.

These observations are no new revelation. It is a fact that is common knowledge. It simply amplifies the important fact that energy generation and consumption must be considered as key factors in realizing the aspiration of any nation's development agenda. This is amply captured in Figure 1.2 which shows the interrelationship between per capita electricity consumption and wellbeing as documented by the UNDP.

Figure 1.3 illustrates the illumination due to electricity generation in the respective continents as seen from space. The near total absence of illumination on the African continent throws one's mind back to the age-old reference to Africa as the "dark continent".

The latter chart in Figure 1.4 depicts a graphical representation of the per capita energy generation in some selected countries which shows that Nigeria's per capita centralized electricity generation is less than 40W compared to over 1000W in the Republic of South Africa. There is no doubt therefore that Nigeria's per capita GDP is only about one-fifth that of the Republic of South Africa. It is also instructive to note that Ghana's per capita electricity generation is 50W; higher than that of Nigeria.

Figure 1.2: Interrelationship btw Per Capita Electricity Consumption and Wellbeing



Human development index and per capita electricity consumption (UNDP (2005)).

Figure 1.3: Illustration of illumination of Planet Earth by Electricity Generation as seen from space: Compare Africa with the other continents! (Source: IAEA, Vienna).

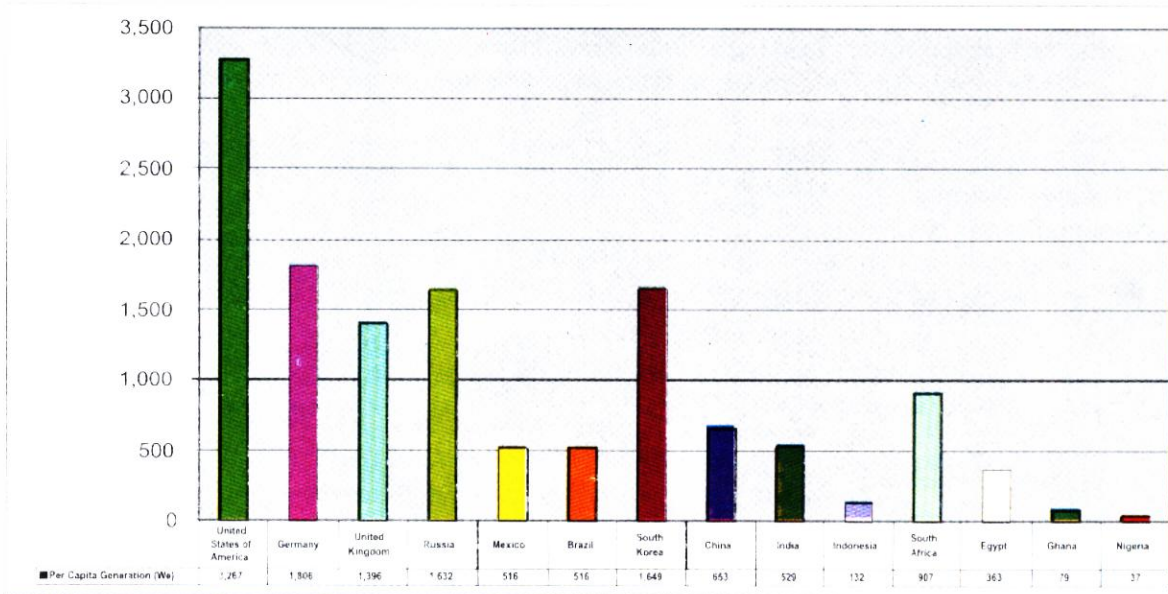
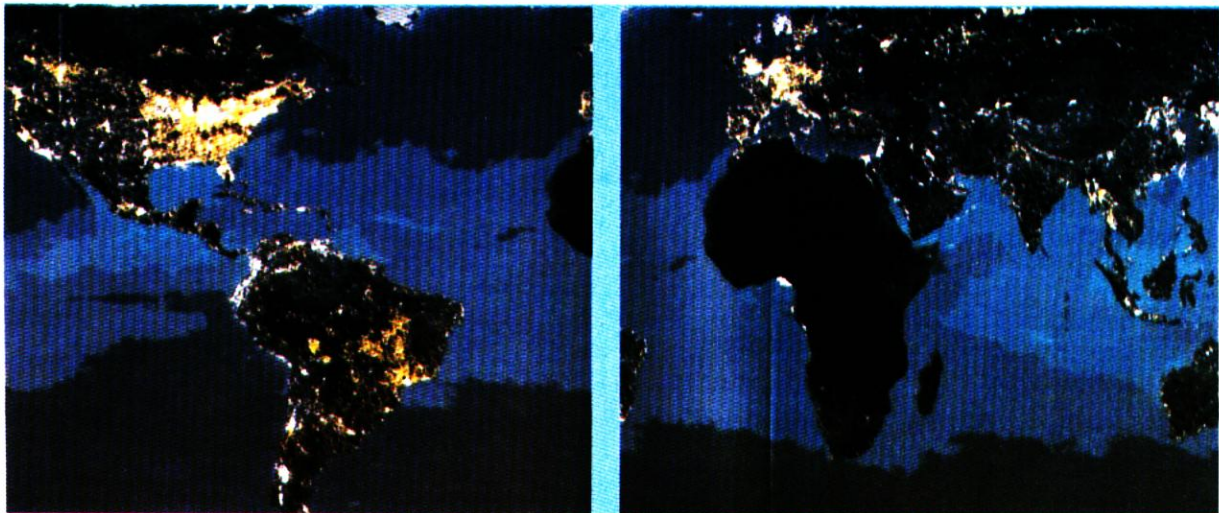


Figure 1.4: Current Relative Per Capita Electricity in some Countries

2 LONG-TERM ENERGY SECURITY AND THE NEED FOR DIVERSIFICATION

The significance of the very low per capita energy consumption in the developing countries may be attributable to one of two major factors. First, is the possible lack of adequate natural energy resources, and the second is, the absence or the lack of a long-term national commitment to wisely invest in and deploy the requisite science and technological base, as well as the relevant industrial infrastructure to effectively explore, exploit and harness the available natural energy sources.

However, our national pathetic situation is attributable to the fact that the growth in demand for electricity in Nigeria has far exceeded supply for the past two decades due to:

- i. Rapid population growth characterized by high rate of formation of new households;
- ii. Increasing level in the expansion of industrial activities with the concomitant increasing energy requirements;
- iii. Inadequate investment in the development and maintenance of electricity infrastructure;
- iv. Extended period of controlled monopoly of the electricity power sector by Government and its agencies; and
- v. Undue emphasis on political considerations in the choice of the location of electrification projects rather than economic, technical and other social considerations, among others.

Energy self-sufficiency and long-term energy security are key promoters of sustainable development. For any country, achieving long-term energy self-sufficiency is imperative for the attainment of national and regional developmental aspirations in conformity with the key objectives of the respective development frameworks such as National Economic Empowerment and Development Strategy (NEEDS), the New Partnership for Africa's Development (NEPAD), and the Millennium Development Goals (MDGs).

Assurance of long-term energy security require detailed energy planning which would entail analysis of the supply side (available energy resources, exploitation strategies, and deployment schedules) as well as a realistic projection of the energy demand over time. Our national capacity for detailed studies on modeling the national energy needs and developing the needed energy master-plans has been significantly enhanced with assistance from the International Atomic Energy Agency (IAEA) in the use of appropriate analytical tools such as Model of Energy Supply Strategy Alternatives and their General Environmental Impacts (MESSAGE), Model for Analysis of Energy Demand (MAED) and Wien Automatic System Planning (WASP).

Quite a number of countries, particularly African countries, depend on fossil fuels and hydropower for their national energy needs. However, it should be noted that fossil fuels are finite and will be depleted over time, and also that there are physical and technical limitations to the harnessing of hydropower.

Based on reports of the African Energy Commission, and using the model of peaking and eventual depletion of any primary energy resource, fossil energy resources in Africa, particularly oil and gas will be depleted in not too distant time as shown in Fig. 2.1. For instance, for petroleum, only three African countries may remain net exporters by 2035. For, Nigeria, except there are other finds, we would only be able to produce for domestic needs in another 30 to 40 years.

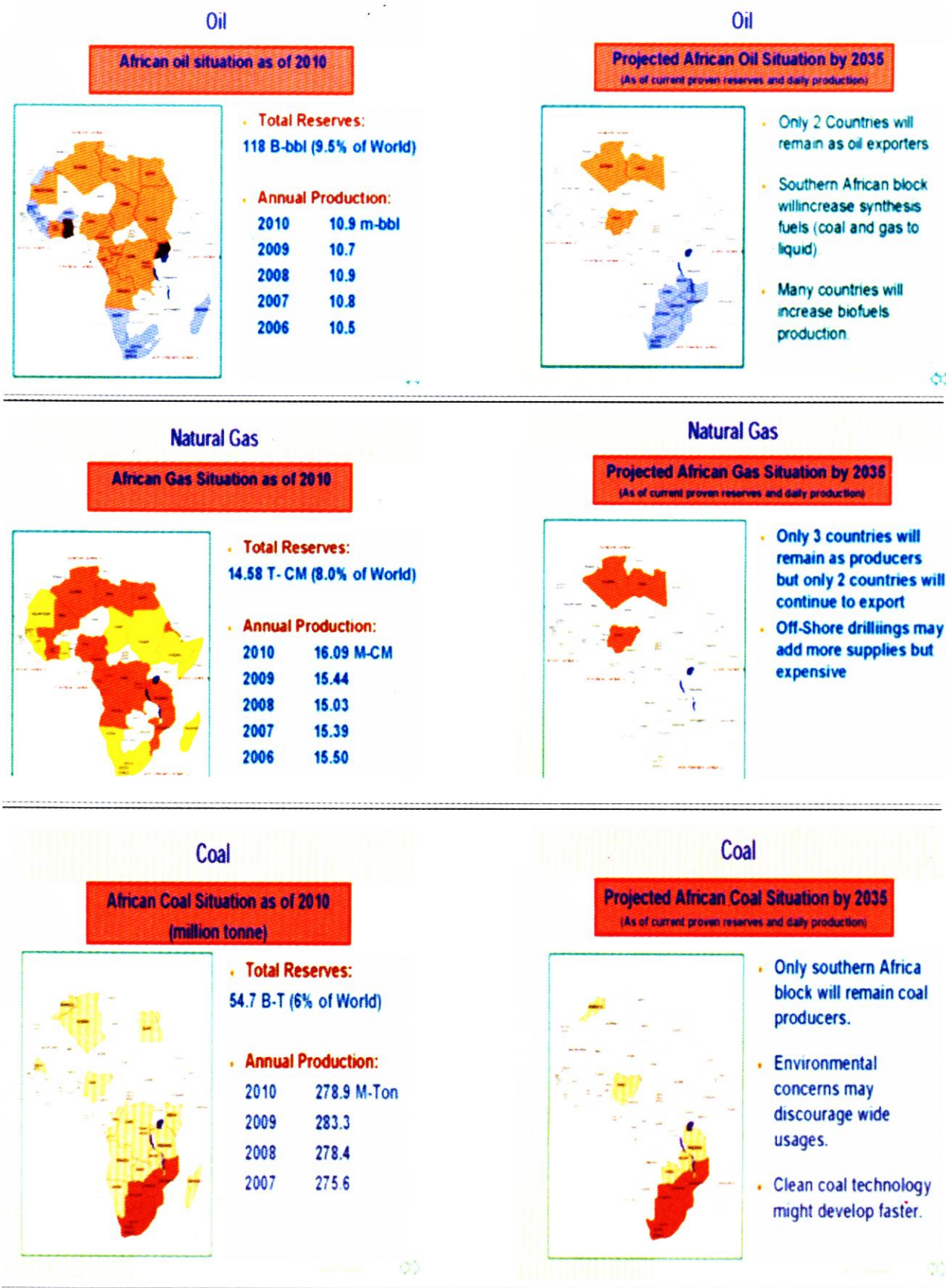
For natural gas, only three African countries will remain as producers, but only two countries will continue to export beyond 2035. Nigeria will continue for maybe another 50 to 60 years. However, projections may improve with possible finds, particularly from offshore drillings.

With respect to coal, only the South African block will remain as producers by 2035. Nigeria may have reserves which will not meet national need if relied upon. However, projections may improve with possible finds and the prevailing market conditions.

Conservation of resources and resource exploitation in harmony with the environment have effectively become the key elements and indicators for effective development planning for sustainability. Thus, long-term energy security must take into account the dilemma of global

Figure 2.1: Estimated Reserves of Fossil Energy Resources in Africa.

Source: ELHAG, Hussein, Executive Director, AFREC, being a presentation at the 2nd Regional Conference on Energy & Nuclear Power in Africa; May 2011, Cape Town, RSA



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warming and climate change. This also entails formulation of energy policies so as to optimize management of the exploitation and utilization of finite assets such as fossil fuels, ensuring that every country must evolve an optimal and realistic energy mix.

Consequently, sustainable socioeconomic development and preservation of the environment are dependent on access to a diversified basket of energy options, taking into consideration natural availability, competitiveness, technology infrastructure and strategic considerations, as well as national capacity and preparedness.

A proactive and sustainable national electricity generation policy should therefore be futuristic in content, and have as an important component, resource conservation and management in order not to mortgage the welfare of future generations.

3. THE HARNESSING OF NUCLEAR ENERGY FOR POWER GENERATION

3.1 Global Trends in Nuclear power Development

The generation of electricity from nuclear sources dates back more than sixty years. Electricity was generated by a nuclear reactor for the first time ever on December 20, 1951 at the EBR-I experimental station near Arco, Idaho in the United States. On June 27, 1954, the world's first nuclear power plant to generate electricity for a power grid started operations at Obninsk, USSR [4]. The world's first commercial scale power station, Calder Hall in England opened on October 17, 1956 [5].

As at the end of 2011, there were over 431 commercial nuclear power reactors operating in 31 countries with a total installed capacity of 372,000 MWe, and provide about 13.5% of the world's electricity as continuous, reliable base-load power, with increasing efficiency. Also, 56 countries operate a total of about 240 research reactors and a further 180 nuclear reactors power some 150 ships and submarines [6].

During 2009, nuclear power produced 2558 billion kW-h of electricity, using only about 65,000 metric tonnes of uranium fuel. The industry now has more than 14,000 reactor years of experience. The majority of these plants are located in the industrialized countries of the world. For instance, the USA generates 19.4% of its electricity from 103 nuclear power plants; France, up to 78%; Russia, 16%; Sweden, 48% and South Korea, 39%, although quite a number of other emerging economies such as South Africa, India, Brazil, etc generate significant electricity from NPPs.

Several North African and Gulf countries such as Egypt, Tunisia, United Arab Emirates (UAE), Kuwait and Saudi Arabia have initiated plans for introducing or are already implementing nuclear power programmes to meet their energy needs. For instance, the UAE has actually awarded contract for 4 NPP units which are under construction, and became the first newcomer country in 37 years to start the construction of a nuclear power plant.

In spite of the initial potentially dampening effect of the recent Fukushima Daiichi nuclear power plant accident occasioned by a devastating earthquake and the resultant tsunami in 2011, there is continuous evidence of some strong global nuclear renaissance for electricity generation, both in terms of expanding current capacity as well as introduction in some countries.

The decision by the governments of the UAE and Saudi Arabia to embark on nuclear power may be quite instructive for us, and particularly for Nigeria as a country. You may wish to note that both countries have significant quantities of crude oil and natural gas reserves, and relatively small populations, with relatively much higher per capita income than Nigeria. These national decisions are anchored on the determination for effective resources management and the derivable benefits of nuclear technology development, and should serve as 'food for thought'.

3.2 The Basic Features of a Nuclear Power Programme

Openness and sincere public communication are some essential elements of successful implementation of a national nuclear power programme. Consequently, while attempting to layout the programmatic elements of our national programme, it would be necessary to appreciate the basic features of a nuclear power programme, so as to understand its complexity. Some of the basic features include:

- High initial capital cost
- Long construction period compared to other technologies
- Delayed investment returns (government vs private sector financing?)
- Predisposed to cost overruns and construction delays in an environment of regulatory uncertainties.
- Long term government commitment and public support (requires political and policy stability)
- Low maintenance and Operating cost
- Higher availability and capacity factors
- Longer lifetime (50-60 years)
- Least potential for contributing to climate change
- Need for technical and human resource underpinning
- Need to secure nuclear material and thus, need for high safety standards, insurance and physical security.
- Must be committed to an international regime of oversight governed by one standard of safety, security and safeguards and international treaties and conventions.

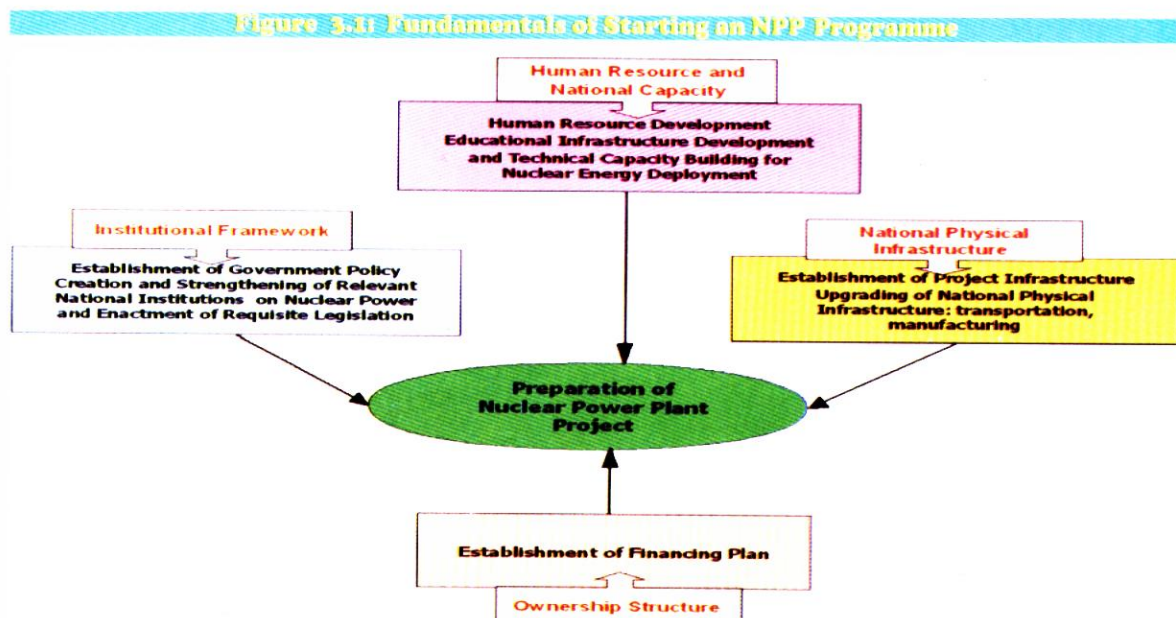
3.3 The National Nuclear Power Roadmap

The use of nuclear energy for the generation of electricity is currently non-existent in Nigeria, though we currently operate a 30kW Miniature Neutron Source Research Reactor at the Centre for Energy Research and Training (CERT), located at the Ahmadu Bello University, Zaria.

In recognition of the fact that nuclear energy is a reliable, safe, environment-friendly and economically viable source of generating electricity, and in light of the current intractable energy crisis that besets us as a nation, the Federal Government initiated the process of deploying nuclear energy for electricity generation since 1978, and revisited it recently by the approval of the National Nuclear Power Roadmap in February, 2007. The approval came shortly after the activation of the then moribund Nigeria Atomic Energy Commission (NAEC) in April 2006, some thirty years after its creation by Act 46 of 1976.

The National Nuclear Power Roadmap, referred to as the "Technical Framework", is designed to position the country to generate electricity from NPPs in 10 to 12 years. It was developed based on the fundamentals of starting an NPP Programme as shown in Figure 3.1 and was formally approved by the Federal Executive Council on February 7, 2007.

The technical framework is a 'three-phase plan' which is aimed at positioning Nigeria to generate electricity from NPPs within the designated timeframe, with considerable national participation. The National Strategy for its implementation was finalized in December 2009 with the endorsement of the IAEA, and currently being updated.



The three phases of the roadmap are:

- Manpower training and nuclear power infrastructure development;
- Design certification, regulatory and licensing approvals; and
- Construction and start-up.

The nuclear roadmap, if meticulously implemented, is expected to generate at least 1,000MW of electricity in 2020 and steadily increases to 4,000MW by 2030.

The basic features of a nuclear power programme as enunciated above are quite daunting and require a serious national commitment as well as a well structured national institutional framework to implement it in a sustainable manner. Noting also that the long timeframe; from the planning to embarking, from construction to operation and decommissioning of a nuclear power plant; on the order of a century, spanning at least three generations, the national decision process must be meticulous and painstaking.

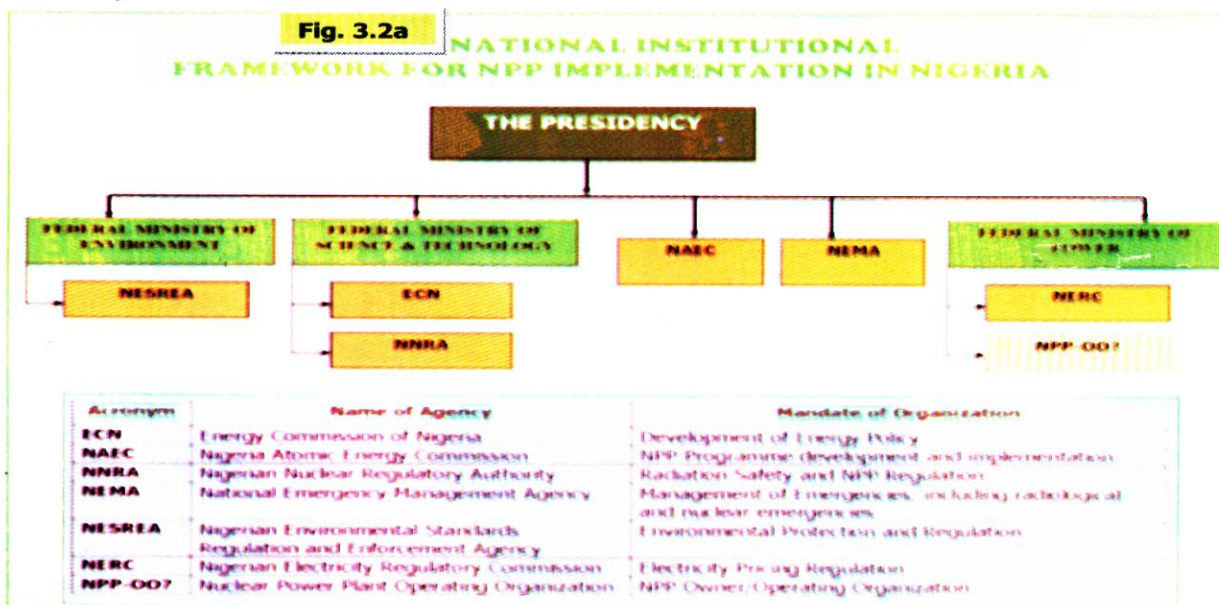
The main issues as encapsulated in the IAEA Milestone approach are 19. This is quite a cumbersome and laborious task. Thus, in keeping with the time-test principle that the solution of a complex problem lies in discretizing it into smaller components, more amenable to understanding and solution, we have coalesced the 19 Milestone Issues into four major critical frames, which would address at a policy and programming level, the sustainable and successful implementation of the national programme. These are Institutional Framework, Human Resources and National Capacity Development, National Physical Infrastructure and the Financing and Ownership Structure as shown in Figure 3.1.

3.4 National Institutional Framework for NP Development

The coordination of the national structures for the planning and implementation of a nuclear power programme is quite an intricate one. The Nigeria Atomic Energy Commission (NAEC), mandated by law as the focal national institution for atomic energy development plays the central role of coordination.

In addition, NAEC also bears primary responsibility for the development of the relevant national nuclear power infrastructure, training of the needed critical human resource base and building of the requisite national capacity for programme management and implementation. In this regard, six national nuclear energy research centres, which serve as the primary centres for manpower training and capacity building, operate under the supervision of the Commission. The 1976 Act (as amended in 2004) empowers NAEC to build, construct and operate nuclear power plants, and in furtherance of its mandate, the Commission is currently taking steps to catalyze the process of establishing a separate NPP/Operator organization.

The Nigerian Nuclear Regulatory Authority (NNRA), established by Act 19 of 1995, and which became operational in 2001, is the national nuclear regulator. It is statutorily empowered to licence and regulate the operations of the nuclear power industry and the use of radioactive sources. It bears primary responsibility for nuclear and radiation safety and assurance of nuclear security in the country.



Consequently, a solid foundation is being laid for the building of the relevant national nuclear institutions at the inception of the programmes, backed by appropriate national legislation when necessary. This will ensure that the institutions will endure.

Capacity building evolves over time; both for the national organizations as well as the individuals who constitute the human resource base of the national institutions. These must therefore be nurtured in tandem. Furthermore, it is recognized that capacity building is a long-term continual process of development which creates conditions that optimize use of the existing knowledge and skills base and adapt to change, thereby enhancing performance to achieve set organization goals.

The collective institutional capacity is quite pivotal, thus the leadership of an institution, must play a key role in structuring institutional capacity development and its sustainability. This is built around individual capacity, and depends on the individual's personal capability and interest. The Individual Capacity is built upon and derived from two major components:

- Innate Propensities - natural, in-born preferences to reason and act in particular ways or be drawn to and succeed at particular activities and careers.
- Learned Competencies - developed skills that may be enhanced through education, training or experience.

The Organizational Capacity is built on the propensities and competencies of its workforce over time within a well-defined management framework, and geared towards achieving set goals and mandates. Thus, in the programming for the implementation of our national nuclear power programme, we strive to optimize our strategy for human resource development, which is hinged on building both the individual as well as the organizational capacities.

4.2: National Strategy for Nuclear Power HR Development in Nigeria

The human resource development strategy is designed to:

- produce indigenous scientists, engineers, managers and other professionals who would acquire an in-depth fundamental understanding of nuclear technology for effective project planning and management, technical coordination and sustainable implementation of the national nuclear power programme; and
- train specialized corps of scientists, engineers, technologists and technicians, imbued with a high level of fundamental knowledge and practical expertise, so as to create a sustainable pool of human capital for the design, operation and maintenance of the nuclear power plants.

In this regard, the requisite training and research infrastructure for the NPP project implementation are being developed in the nation's six nuclear energy research and training centres and partnering universities, for domestic training in the fundamentals. Other specialized aspects of the HRD programmes are being implemented in partnership with offshore institutions, development partners and the IAEA.

In light of the fact that, currently, there is no national higher institution with an undergraduate curriculum in nuclear science and engineering, the first leg of our national training in the fundamentals is being implemented through a post-graduate bridging programme in nuclear science and engineering. The bridging programme is designed to train and convert physical scientists and engineers in a manner that they would acquire the requisite foundation to start careers in nuclear power.

The mandate of NAEC empowers it to partner with universities and other institutions or persons in Nigeria to conduct research into matters connected with atomic energy or radioactive substances, as well as to educate and train persons in matters connected with atomic energy and radioactive substances. Consequently, NAEC has commenced the implementation of two masters' degree programmes in nuclear engineering and in nuclear science since January of 2012, in partnership with four participating universities and in collaboration with the IAEA and other offshore institutions.

As approved by the Federal Government, the HRD for NPP implementation aims to train 2000 nuclear science and technology professionals: engineers, scientists, technicians and technologists, as well postgraduate engineers and scientists over a period of ten years. These numbers represent a long term training strategy, and it is expected that some of the professionals will be involved in other non-power, nuclear technology applications in human health, food and agriculture, industry, etc;

Developing the critical HR base for the NP programme is a daunting task. Consequently, a multi-pronged approach involving a network of educational institutions is being developed in partnership with NAEC and other stakeholder organizations to implement the training programmes, so as to achieve set national objectives. In this regard, the undergraduate degree programmes and professional diploma programmes will be implemented in partnership with nine designated universities and two polytechnics (now technological universities), respectively. The graduate programmes which have already commenced, will be implemented in partnership with five universities, in which the respective national Nuclear Energy Research Centres (NERCs) under the aegis of Commission are co-located. Figure 4.1 shows the network of educational institutions.

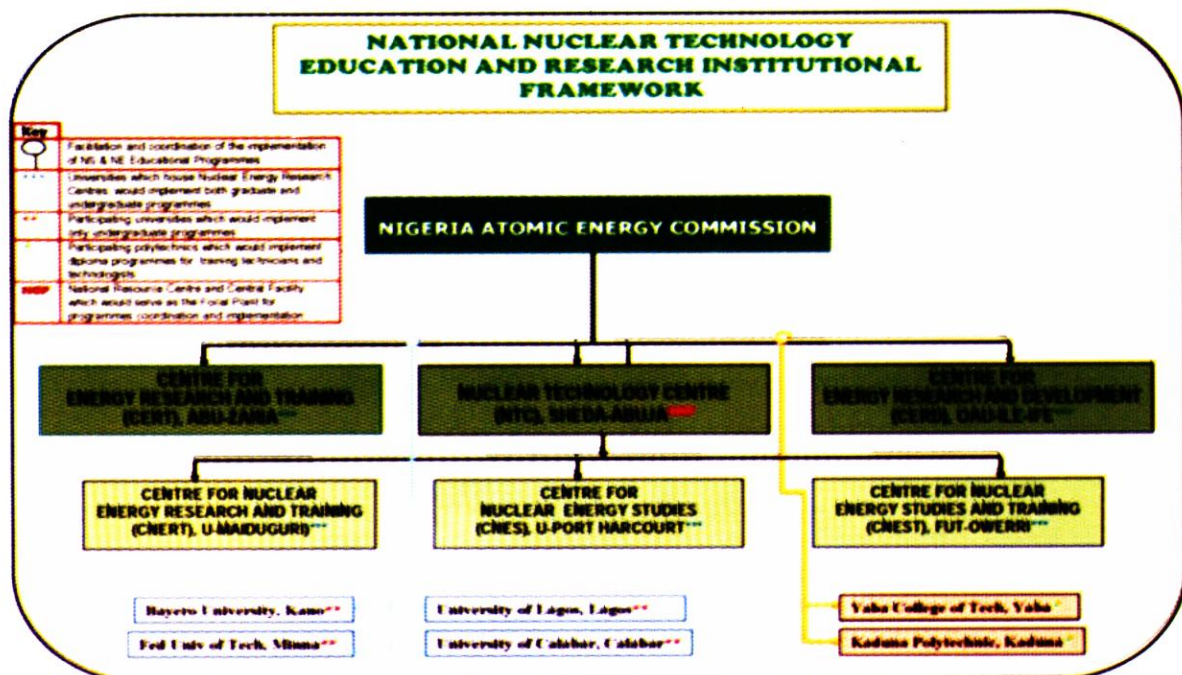
The HR requirements at the level of faculty to implement the educational programmes in a sustainable manner are quite challenging. These limitations include:

- Limited number of academic staff (lecturers) with requisite qualifications and expertise in relevant areas of nuclear science and engineering
- Lack of support staff (technologist, technicians, etc)

Currently, non of the partnering national institutions have a full complement of staff that can fully and satisfactorily implement standard degree programmes as planned. The two old NERCs in Ile-Ife (CERD) and Zaria (CERT), respectively, have some complement of staff that, with some external support, can implement programmes in a limited manner. The on-going Masters degree programmes are being implemented centrally at the Nuclear Technology Centre-Sheda, Abuja, where the requisite nuclear power educational infrastructure and facilities are been developed and ultimately pooled to service the common needs of the participating institutions.

Noting also that most of the nuclear technology professionals needed in the actual operation and maintenance of NPPs require only undergraduate level education, our emphasis is placed in creating the enabling environment to train these cadre of professionals. This requires the implementation of quick programmes to train the trainers, and to quickly grow a committed corps of young academics.

Figure 4.1: National Network of Educational Institutions for Nuclear Technology Education & Training



At the undergraduate level, the initial phase of implementing the national training programme to support the introduction of nuclear power entails a number of options which includes the following:

- Imbed core courses in nuclear science and engineering in existing programmes in the physical sciences and engineering;
- in disciplines where possible, develop double major programmes in which nuclear science and engineering is the second major component;
- as far as resources can sustain and based upon need, introduce appropriate diploma, undergraduate and graduate degree programmes in nuclear science and engineering; and
- enter into appropriate Memorandum of Understanding (MOU) with local and off-shore institutions for partnerships in developing programmes at the graduate level for the training of academics and researchers.

A very practical way of generating the much needed faculty personnel to teach the new courses in nuclear science and engineering would entail:

- mounting refresher training programmes (train-the-trainer) in partnership with off-shore institutions to retrain mature and experienced faculty in other physical science and engineering disciplines in the core subject areas of nuclear science and engineering;
- Develop and implement intensive 3-month bridging programmes which exposes graduates in the physical sciences and engineering to fundamental core courses in nuclear science and engineering;
- Graduands of the 3-month intensive bridging programme would then serve as feed stock for a quick but efficient implementation of the masters' degree programmes in a centralized fashion to produce young academics who can then participate as lecturers in the undergraduate programmes.

5. THE CHALLENGES, WORDS OF HOPE AND CAUTION

As expected, there are quite a number of challenges in the implementation of a nuclear power programme in a newcomer developing country like Nigeria with limited national infrastructure. Some of these include:

- The difficulty of maintaining long-term national (political) commitment and sustainability of the programme over a gestation period of at least 20 years. Overcoming this challenge requires that there should be a broad-based acceptance of the programme by the citizenry, and that the evolution of a national position to introduce nuclear power should properly reflect the true national mood;
- Implementing a nuclear power programme is human capital intensive, and the training of requisite specialized and restrictive manpower and long lead-time required to build critical mass could be challenging;
- Development of appropriate infrastructure needed to support the implementation of the programme and requisite industrial capacity to gradually domesticate nuclear technology;
- Development of the requisite financing plan, catalyzed by government, with the private sector as a partner;
- Motivating and sustaining the interest of the Nigerian Public and developing a positive attitude in the country, while maintaining the confidence of our development partners; and
- National tendency towards reliance on short-term solutions to fixing the energy problem.

In spite of all these challenges, the benefits of the successful implementation of a nuclear power programme are myriad. These include the generation of electricity, as well as other significant spin-off benefits due to application of nuclear technology in other sectors such as medicine and human health, food and agriculture and capacity building in heavy industries, transportation, as well as in water resources management, environmental management and mineral exploration and extraction.

"We need to develop the capacity to utilise nuclear power for power generation. Who knows, nuclear power may be the only source of energy in the future, and we must think of the future".

In affirming the right of nation states to deploy nuclear power for societal development, the immediate past Director-General of the International Atomic Energy Agency (IAEA), Dr. Mohammed El-Baradei, also sounded a note of caution. His words:

"Every country has the right to add nuclear power to its energy mix, as well as a duty to do it responsibly. That means adhering to the highest safety and security standards and ensuring that nuclear material is not diverted to other illicit activities...."

Former Prime Minister of the United Kingdom, Tony Blair, in his Memoir, 'A Journey', in the introduction to the paperback edition of 2011; page xiv, expresses the hope that the Fukushima Daiichi accident would not be a damper for nuclear power development: His words:

".. as a result of Fukushima, many countries will hesitate over nuclear power. In my view, it will be a tragic mistake if we allowed what happened there to close down the potential of nuclear power.. We will have to study the lessons carefully, but we should also be seeing how the technology can be further developed and improved...."

Often times, the positive impact of nuclear power on the environment is lost to emotions. This has been further quantitatively underscored by a recent landmark study which has put the figure of 1.84 million on the number of lives saved by the worldwide use of nuclear power instead of fossil fuels. The report co-authored by former NASA scientist James Hansen presents a dramatic new case for nuclear energy.

"The results are projected total emissions that would have probably led to the deaths of 1.84 million people between 1971 and 2009 based on average mortality estimates from fossil combustion pollution. This is probably an underestimate, said Hansen and co-author Pushker Kharecha, noting that the life-cycle mortality estimates are the biggest source of uncertainty in the report: Some coal units produce three times more dangerous pollution than the average they have used. The higher estimate for lives saved by nuclear energy was over 7.5 million - and these figures do not count a range of serious respiratory illnesses, cancers, hereditary effects and heart problems".

6. CONCLUDING REMARKS AND PARTING THOUGHTS

In summing up, I wish to reiterate that long-term national energy security can only be achieved through the effective development and harnessing of a diversified basket of energy options, taking into consideration the needs of future generations. In this respect, the Federal Government of Nigeria has activated a nuclear power programme, and had approved the roadmap for its implementation.

Implementing a new NP programme is a daunting task which requires a serious national commitment as well as a properly structured national institutional framework to ensure sustainability. The challenges cannot be wished away! The requisite structure for the prosecution of the national nuclear power programme are being put in place by the Nigeria Atomic Energy Commission, in partnership with other relevant stakeholder institutions and international development partners

Furthermore, Government has shown commitment by taking on the responsibility for building the relevant nuclear power infrastructure and manpower development to create the requisite enabling environment for the successful implementation of the programme in partnership with the private sector and the participation of international partners.

Mr. Vice Chancellor, esteemed professors and distinguished colleagues, for the last sixty minutes or so, I have attempted to share some programmatic elements of our national nuclear power programme with you. The essence of this conversation is to provide useful information on the national nuclear programme to the public, as well as, to enlightened 'focus groups' like yours in a most open and transparent manner. The basic message, I wish to underscore is that, the planning, implementation and management of a national nuclear power programme is a serious task, and can only be successful, if all relevant national institutions make their respective inputs, as mandated by law, in a coordinated manner.

These network of national institutions spans several sectors of national development. In the educational sector, it is gratifying and important to appreciate the fact that, your distinguished

university, FUTO, has been designated as a partnering institution with the responsibility of hosting a new nuclear energy research centre, the Centre for Nuclear Energy Studies and Training (CNEST). By being a partnering institution, FUTO has also accepted to take-on part of the national challenge.

Ladies and gentlemen, I wish to draw the curtains on this conversation in a lighter mood by sharing the experiences of a neighbourhood medical doctor who had a successful private professional practice in the Ajegunle area of Lagos. He was also a member of the congregation of the neighbourhood 'fundamentalist new-age' church. Being a member of the church, he provided various medical services for other members of the congregation, and he was appreciated for his benevolence. The congregation was also infested with the social disease of alcoholism.

On one beautiful Sunday, during worship, the Pastor of the church invited the neighbourhood doctor to perform a scientific experiment in the church. The doctor was duly introduced and the congregation watched him attentively. He stood at the podium with two beakers. One of the beakers contained water and the other contained a strong locally distilled Nigeria gin, fondly referred to in various local languages and quarters as Ogogoro, U-push-me-I-push-U, Olololo, etc. Inside the beaker containing water, there was an earthworm swimming freely. He explained to the audience, the respective contents of the two beakers and laid particular emphasis on the swimming earthworm.

After a while, he moved the earthworm from the beaker containing water and put it into the beaker containing local gin. Immediately, the earthworm slumped onto the bottom of the beaker, dead. Then, the doctor, to the consternation of the congregation quickly announced that the experiment has ended and left the podium to sit down. At this point, the Pastor of the congregation came out to the podium and asked one crucial question: What was the significance of the experiment just concluded by their beloved doctor?

There was dead silence in the congregation for a short while. Suddenly, a certain gentleman, looking quite unkempt and dazed, dressed up in some dirty and torn apparel, symptomatic of a person who is under the influence of alcohol and being pushed around by 'olololo', stood up with seeming confidence and said he can explain the import of the experiment to the congregation. He was dead right on the point! He said the fact that the earthworm died when it was put in the alcohol was an indication that drinking 'olololo' was good for the body as it will kill all the worms in the stomach.

Mr. Vice Chancellor, esteemed professors, distinguished ladies and gentlemen, you probably would have certainly noticed that I have truly enjoyed my one hour of conversation with you, although I cannot say it has been the case with everyone here. However, it hasn't been my intention to relegate the essence of my lecture to sundry interpretations by the audience. Although, appreciating nuclear power development in Nigeria may surely take more than one long hour of conversation, I would like to clearly state that Nigeria has come to the realization that the development of nuclear technology is essential for our societal development. We have gone past the point of decision!

For emphasis, I wish to reiterate the fact that the demonstrated firm political commitment of the Federal Government towards the implementation of the national nuclear power programme has transcended various administrations. It was started by President Obasanjo in 2006, and continued by the successor administration of late President Yar'adua. The creation of new nuclear energy research centres such as CNEST by the current administration of President Jonathan, as well as its endorsement of the programme in various international fora and the reconstitution of NAEC, are clear affirmations of the national commitment.

Finally, I would like to conclude by stating that nuclear power development is a major undertaking which will involve a large number of national institutions with varied mandates, partnering and working together with commitment to successfully accomplish, in conformity with set national objectives. It is also heart-warming that your esteemed university is now a partner in this national endeavour. It may take a while, but the collective integral sum of our national resolve and effort for developing nuclear power will be a success story in the long-run. It's just a matter of time!

I thank you all for listening and may the positive spirit of rational scientific thought and innovation guide us in this national assignment.

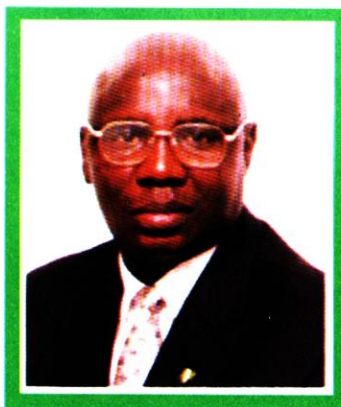
F. Erepano Osaisai
April 17, 2013.

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Profile of the Lecturer, Dr. F. Erepamo OSAISAI

Chairman/CEO of Nigeria Atomic Energy Commission



Dr. Franklin Erepamo Osaisai, born October 1, 1958 in Koluama in Bayelsa State of Nigeria is the Chairman/Chief Executive Officer of the Nigeria Atomic Energy Commission (NAEC). He is a Nuclear Engineer and Energy Scientist by professional training. He started his early secondary education at the Government Secondary School, Akassa (1973-1975), and the Government Secondary School, Ukubie (1976-77), both in Bayelsa State, and graduated with a Distinction in the West African School Certificate Examination in June 1977. He had his undergraduate training as a pioneer student in the School of Chemical Sciences at the University of Port Harcourt, and graduated at the top of his class and school with an honours degree in Chemistry with a minor in Physics in 1981. Buoyed by a merit graduate scholarship award, he received his engineering and graduate education at the prestigious University of California, Berkeley, California, where he took his Masters and Doctoral degrees in Nuclear

Engineering in 1984 and 1987, respectively, with some academic honours and awards.

Dr. Osaisai established his professional and academic career at the University of California at Berkeley, California and the University of Port Harcourt, Port Harcourt, Nigeria where he had taught and researched, with interests in the fields of Nuclear Reactor Engineering, Energy Systems Integration, Numerical Modeling, Nuclear Instrumentation and Computational Transport Phenomena.

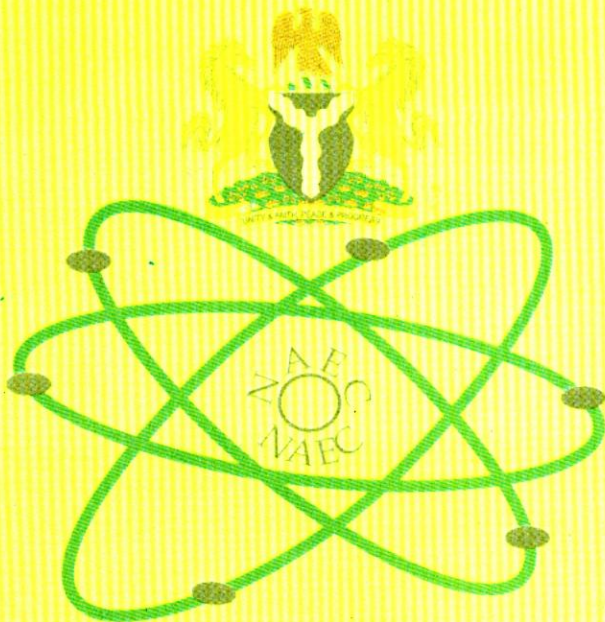
In April 2006, he was appointed by the President of the Federal Republic of Nigeria as the pioneer Director-General/CEO of the Nigeria Atomic Energy Commission. Prior to this appointment, he was the Director of the Nuclear Technology Centre at the Sheda Science and Technology Complex, Abuja. On the reconstitution of NAEC to operate as a full-fledged Commission in March 2011, as provided for in the enabling Act, Dr. Osaisai was elevated and appointed as Chairman/Chief Executive of NAEC. This has further strengthened NAEC to discharge its primary responsibility to lead the national effort in planning and development of the requisite nuclear power infrastructure for the implementation of the national nuclear electricity programme. As Chairman/CEO of NAEC, he is also responsible for the budgeting, staffing, coordination and supervision of the management and operations of six national nuclear energy research centres, and coordinates international cooperation and educational outreach for manpower training and capacity building programmes in support of the national nuclear technology programmes.

Dr. Osaisai has also had some prior public service record. These include being elected as a Senator of the Federal Republic of Nigeria in April 1998, as well as service as a Commissioner in charge of physical infrastructure development in his home State of Bayelsa. He is a Fellow of the Nigerian Academy of Engineering, the Nigerian Society of Engineers, the Nigerian Institute of Physics and the Science Association of Nigeria, and also holds membership of the American Nuclear Society, and Chemical Society of Nigeria, amongst others. He is also a recipient of the University of Port Harcourt "Distinguished Alumnus Award", and also currently serves a Member of the Council of the Nigerian Academy of Engineering.

Dr. Osaisai is currently Nigeria's Governor on the Board of Governors of the International Atomic Energy Agency (IAEA) [2012–2014]. He had also previously served as Nigeria's Governor on the IAEA Board from 2006 to 2008. He has been the National Liaison Officer of Nigeria to the IAEA since 2006. He had also served as the National Coordinator, as well as the Chairperson of the African Regional Cooperative Agreement for Research, Development and Training related to Nuclear Science and Technology (AFRA). He also coordinates the activities of the Vienna based Comprehensive Nuclear Test-Ban Treaty Organization (CTBTO) in Nigeria and served as the Vice Chairperson for Africa of the Preparatory Commission of the CTBTO for the period 2009-2010. He also served as a pioneer member of the AFRA High Level Steering Committee on Human Resource Development and Nuclear Knowledge Management. He is a member and currently, the Chair of the IAEA Technical Working Group on Nuclear Power Infrastructure.

He has also made scholarly contributions to knowledge in engineering, technology management and science education through publications in the fields Nuclear Science and Engineering. He is the author of two books and co-author of three others in specialized areas of the Physical Sciences and Engineering. He also has to his credit, a few dozen publications in journal articles, conference papers and monographs, with significant international exposure.

He is happily married to an accomplished technocrat, Emontonghan, and the family is blessed with five children.



**NUCLEAR POWER DEVELOPMENT IN
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IMPLEMENTATION**