Nuclear Power Development in Nigeria: Catalyst for Sustainable Development

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Discussion Outline

i. Energy and Sustainable Development

ii. Diversification and Long-term Energy Security

iii. Why Consider Nuclear Power?

iv. Requirements for Building the Critical National Nuclear Power Infrastructure

v. Ownership, Funding and Financing

vi. Medium-Term Project Deliverables, Spin-Offs and Challenges.

vii. Summing Up and Parting Thoughts

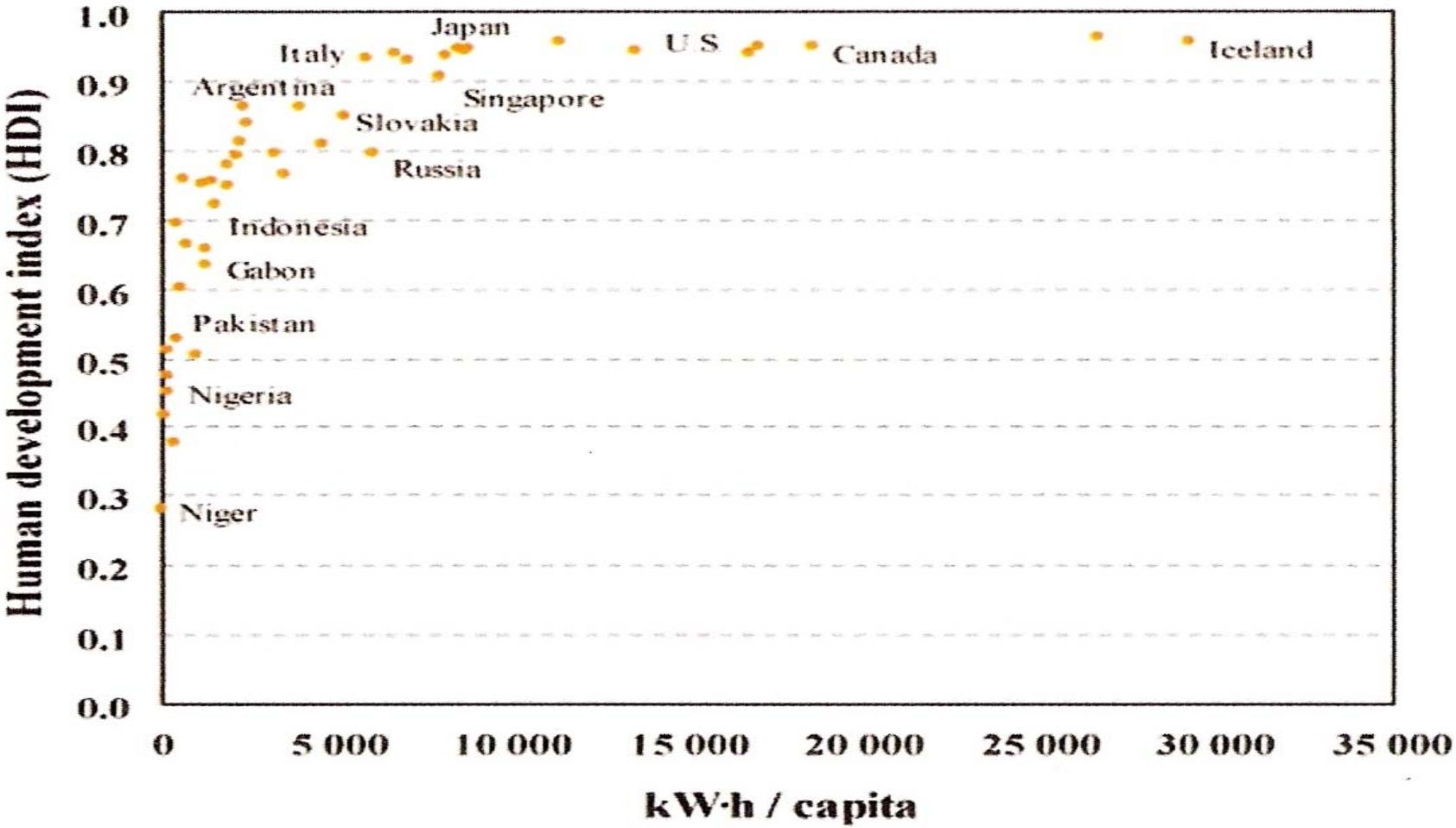
I
Energy and Sustainable Development

1 Energy and Sustainable Development

- Energy resources exploitation strategy and development should take into consideration the broader perspective of sustainable development.
- Sustainable development as defined by the World Commission on Environment and Development (WCED) in 1987 is “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.
- Policy and strategy for economic development to meet human needs should be synergized with the importance of the sustenance of the natural environment as both a resource provider and waste absorber.

- Consequently, sustainable development entails optimal harnessing and utilization of human and material resources in the most efficient manner possible, for societal advancement in harmony with the environment.
- Energy self-sufficiency and long-term energy security are key promoters of sustainable development.
- Achieving Long-term Energy self-sufficiency is imperative for the attainment of national, regional and global developmental aspirations – NEEDS, NEPAD, MDGs.
- Require detailed energy planning - entails 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, using appropriate modeling tools.

Figure 1.2c: Interrelationship btw Per Capita Electricity Consumption and the Wellbeing



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

There is a serious Power Supply deficit!

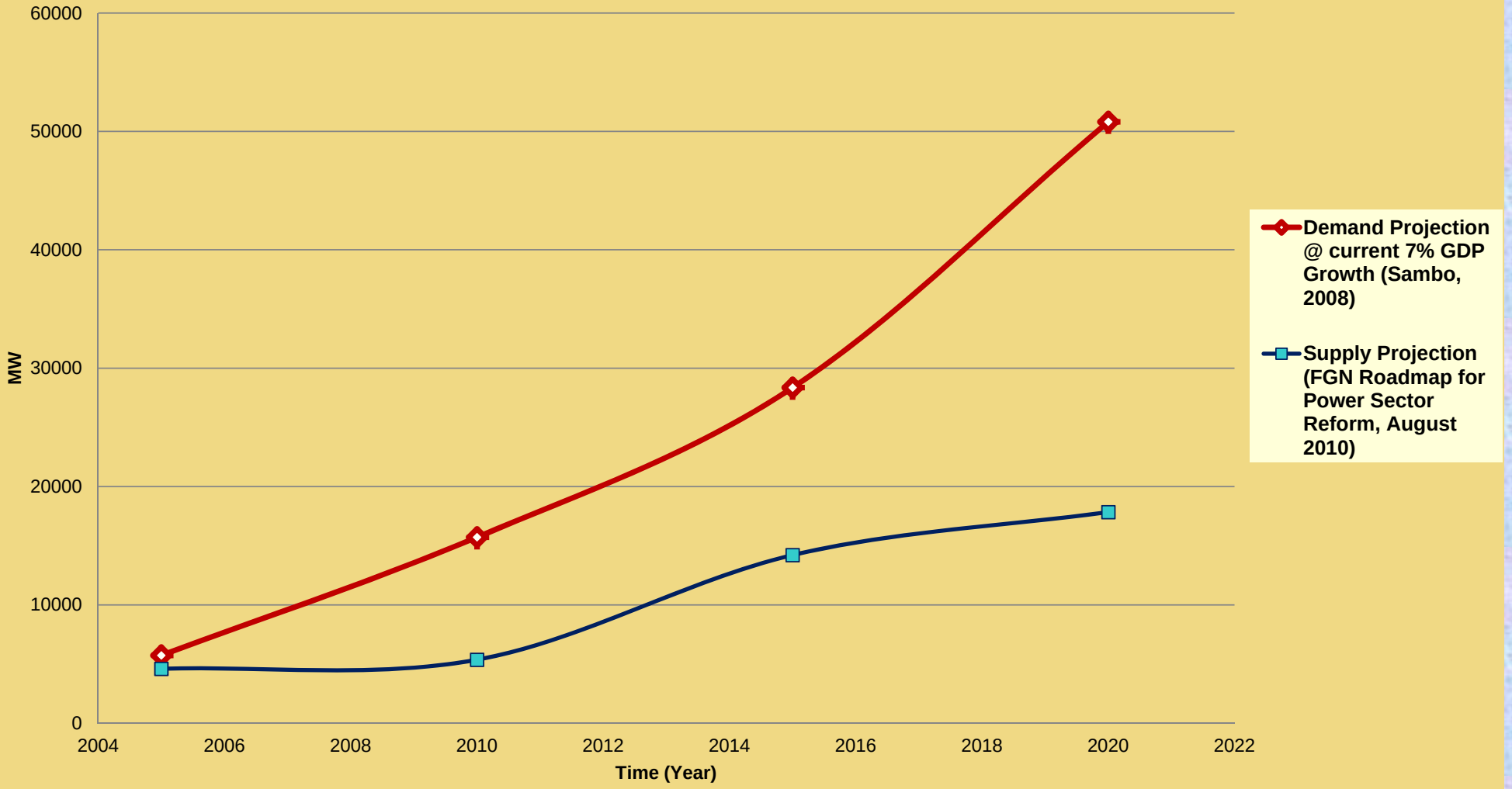
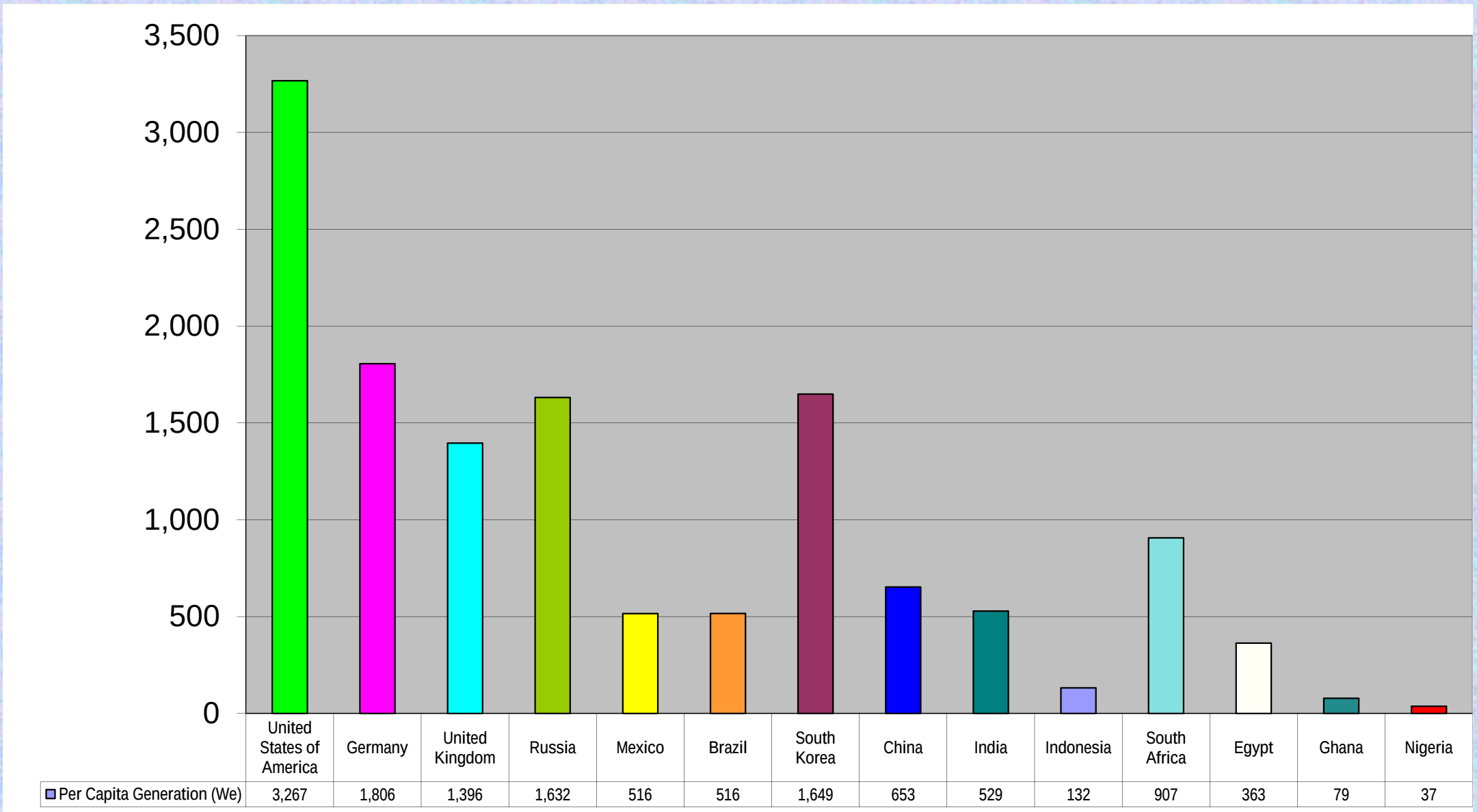


Figure 2. 1: Comparison of Electricity Demand and Supply Projections in Nigeria



	United States of America	Germany	United Kingdom	Russia	Mexico	Brazil	South Korea	China	India	Indonesia	South Africa	Egypt	Ghana	Nigeria
Per Capita Generation (We)	3,267	1,806	1,396	1,632	516	516	1,649	653	529	132	907	363	79	37

Figure 1.2d: Current Relative Per Capita Electricity in some Countries

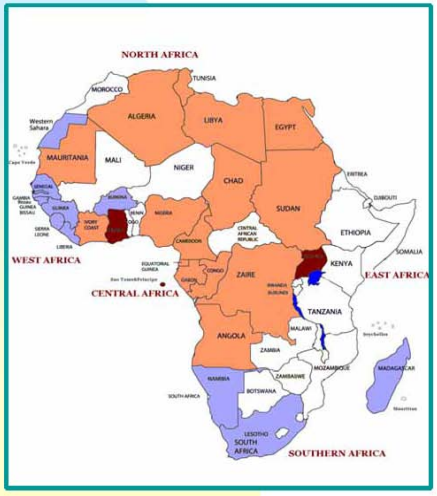
II
Diversification and Long-term Energy Security

2 Cursory Look at the African Energy Situation

- AFRECs report using the model of peaking and eventual depletion of any primary energy resource, fossil energy resources in Africa (oil, gas and coal) are limited.
- Petroleum: Only 2 African countries may remain net exporters by 2035; Except there are other finds. Nigeria would only be able to produce for domestic needs after 2035.

Oil

African oil situation as of 2010



- **Total Reserves:**
  118 B-bbl (9.5% of World)
- **Annual Production:**

2010	10.9 m-bbl
2009	10.7
2008	10.9
2007	10.8
2006	10.5

Oil

Projected African Oil Situation by 2035
(As of current proven reserves and daily production)

- Only 2 Countries will remain as oil exporters.
- Southern African block willincrease synthesis fuels (coal and gas to liquid).
- Many countries will increase biofuels production.

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- Natural gas: Only 3 African countries may remain as producers, but only 2 countries will continue to export by 2035; Nigeria will continue till about 2055. Projections may improve with possible finds, particularly from offshore drillings.

Natural Gas

African Gas Situation as of 2010

- **Total Reserves:**
  14.58 T- CM (8.0% of World)
- **Annual Production:**

2010	16.09 M-CM
2009	15.44
2008	15.03
2007	15.39
2006	15.50

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Natural Gas

Projected African Gas Situation by 2035

(As of current proven reserves and daily production)

- Only 3 countries will remain as producers but only 2 countries will continue to export
- Off-Shore drilliings may add more supplies but expensive

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- Coal, only the South African block will remain as producers by 2035; Nigeria's may have reserves which will not meet national need if relied upon. Projections may improve with possible finds.

Coal

African Coal Situation as of 2010 (million tonne)

- **Total Reserves:**
  54.7 B-T (6% of World)
- **Annual Production:**

2010	278.9 M-Ton
2009	283.3
2008	278.4
2007	275.6

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Coal

Projected African Coal Situation by 2035
(As of current proven reserves and daily production)

- Only southern Africa block will remain coal producers.
- Environmental concerns may discourage wide usages.
- Clean coal technology might develop faster.

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- Quite a number of countries, particularly African countries, depend primarily on fossil fuels and hydropower for their national energy needs with concomitant environmental degradation.
- These resources are finite and will be depleted over time; also physical and technical limitations to the harnessing of hydropower, it is imperative to think of diversification.
- Consequently:
  - Conservation of natural energy resources
  - Diversification of energy options to achieve optimal mix
  - Mitigation of environmental degradation and global warming
- Sustainable socioeconomic development:- access to a diversified basket of energy options, taking into consideration natural availability, economic competitiveness, technology infrastructure and strategic considerations, as well as preservation of the environment.

III
Why Consider Nuclear Power?

3.1 . Rationale for NP Introduction in Nigeria

- With a population of over 170 million and annual growth rate of about 3%, the energy situation in Nigeria is quite dire.
- The currently installed capacity, (including the recently completed NIPPs)) is just about 8GWe
- Out of which only about 6GWe is available. Hydropower contributes about 1850MWe, while the balance is supplied by gas-fired plants.
- Most of the on-going new power projects are gas-fired plants, and would provide the additional capacity in the coming years.
- Hydro potential is limited; only14GWe can be harnessed from all available hydropower sources
- Currently, no coal-fired plants are under development.
- Renewables of solar and wind are under consideration, but would not be able to contribute significantly to base-load grid electricity supply in the foreseeable future.
- This is the kernel of the problem. NP progamme launched in 2007; aimed at diversifying generation base and to gradually reduce the stress on the national fossil fuel resources.

Table 3.1: Estimated Reserves of some Energy Resources in Nigeria

Resources Type	Estimated Reserves
Crude Oil	36.5 billion barrels
Natural Gas	187.4 trillion SCF
Coal & lignite	Over 4 billion tonnes
Tar Sand	31 billion barrel of oil equivalent
Hydropower (Large)	11,250MW
Hydropower (Small)	3,500MW
Fuelwood	13 million Hectares
Animal Waste	61 million tonnes/yr
Crop residual	83 million tonnes/yr
Solar Radiation	3.5-7.0 kWh/m2 -day
Wind	2-4 m/s (annual average)

Table 3.2 The National Power Generation Situation

	Generation Plant	Location	Installed Capacity (MWe)	Available Capacity (MWe)
Hydropower				
	Kainji	Niger	760	480
	Shiroro	Niger	600	450
	Jebba	Kwara	540	450
Subtotal			**1,900**	**1,380**
Oil-Fired				
	Ijora	Lagos	60	-
Gas-Fired				
	Afam	Rivers	726	60
	Ugheli	Delta	900	300
	Egbin	Lagos	1,320	1,100
	Sapele	Delta	1,020	90
	Geregu	Kogi	414	276
	Omotosho	Ondo	304	96
	Olorunsogo	Ogun	304	96
Subtotal			4,988	1,978
Gas-Fired-NIPP (NDPH) under construction			5,454	-
Mambila/Zungeru HP under construction			1,000	-
Coall-Fired				
	Oji River	**Enugu**	**30**	-
TOTAL		**Current**	**6,978**	**3,358**
		Future (5yrs)	**13,432**	
Generation by Source			**Hydro (%)**	**Gas (%)**
		Current	**27.2**	**71.5**
		Future (5yrs)	**21.6**	**77.7**

Table 3.3: Features of Nuclear Power

Advantages	Drawbacks	Inherent /Attainable
Low maintenance and Operating cost	High upfront capital costs can be difficult to finance	Need for technical and human resource underpinning
Stable and predictable generating costs	Sensitive to interest rates	High safety standards
Long life time (50-60yrs)	Long lead times (planning, construction, etc)	Security and safeguarding of nuclear materials
Supply security (insurance premium)	Long payback periods	Commitment to an international regime of oversight
Low external costs (so far no credit applied)	Regulatory uncertainties /policy risks	Accession to international treaties and conventions
Least potential for contributing to climate change	Market risks; Predisposed to cost overruns and construction delays	
Higher availability and capacity factors	Long term govt commitment and public support (requires political and policy stability)	

3.2 National NP Programme Overview

- National Nuclear Power Roadmap referred to as the "Technical Framework" (TF) was developed and approved for implementation by the FEC in February 2007;
- Three-phase TF envisages to generate electricity from NPPs in 10 to 12 years with considerable national participation.
- TF Implementation Strategy was finalized in Dec 2009 with the attainment of IAEA Milestone 1; the three phases are:
  - Manpower training and infrastructure development;
  - Design certification, regulatory and licensing approvals; and
  - Construction and start-up.
- Meticulous implementation of TF envisages commercial operation of first NPP (1,000MWe) in 2020 (2022?) and gradually increase nuclear capacity to four NPPs (4,000MWe) by 2030.
- Currently implementing major Milestone 2 activities in developing critical Nuclear Power Infrastructure (NPI) and site characterization activities.

Figure 3.1: Fundamentals of Starting an NPP Programme

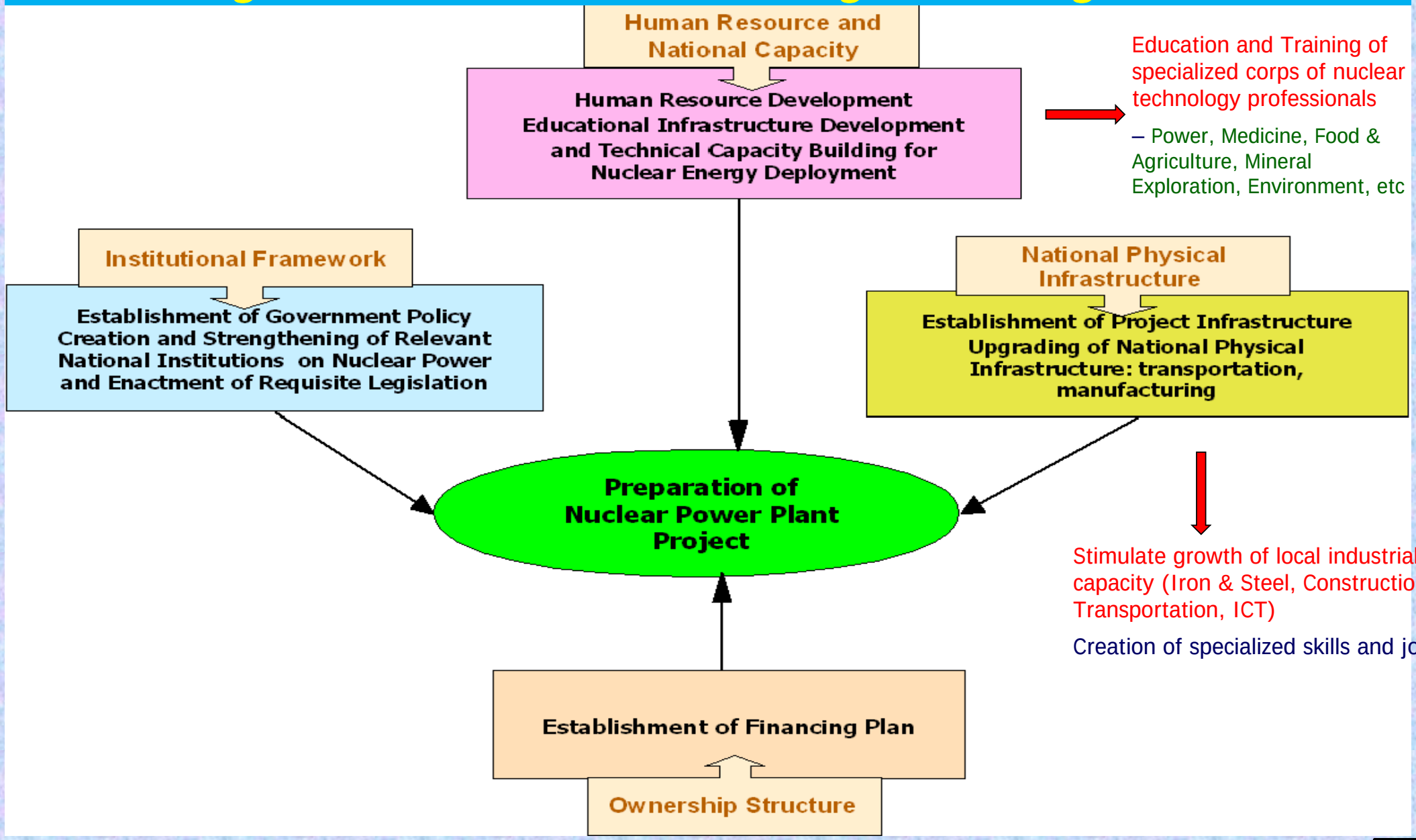
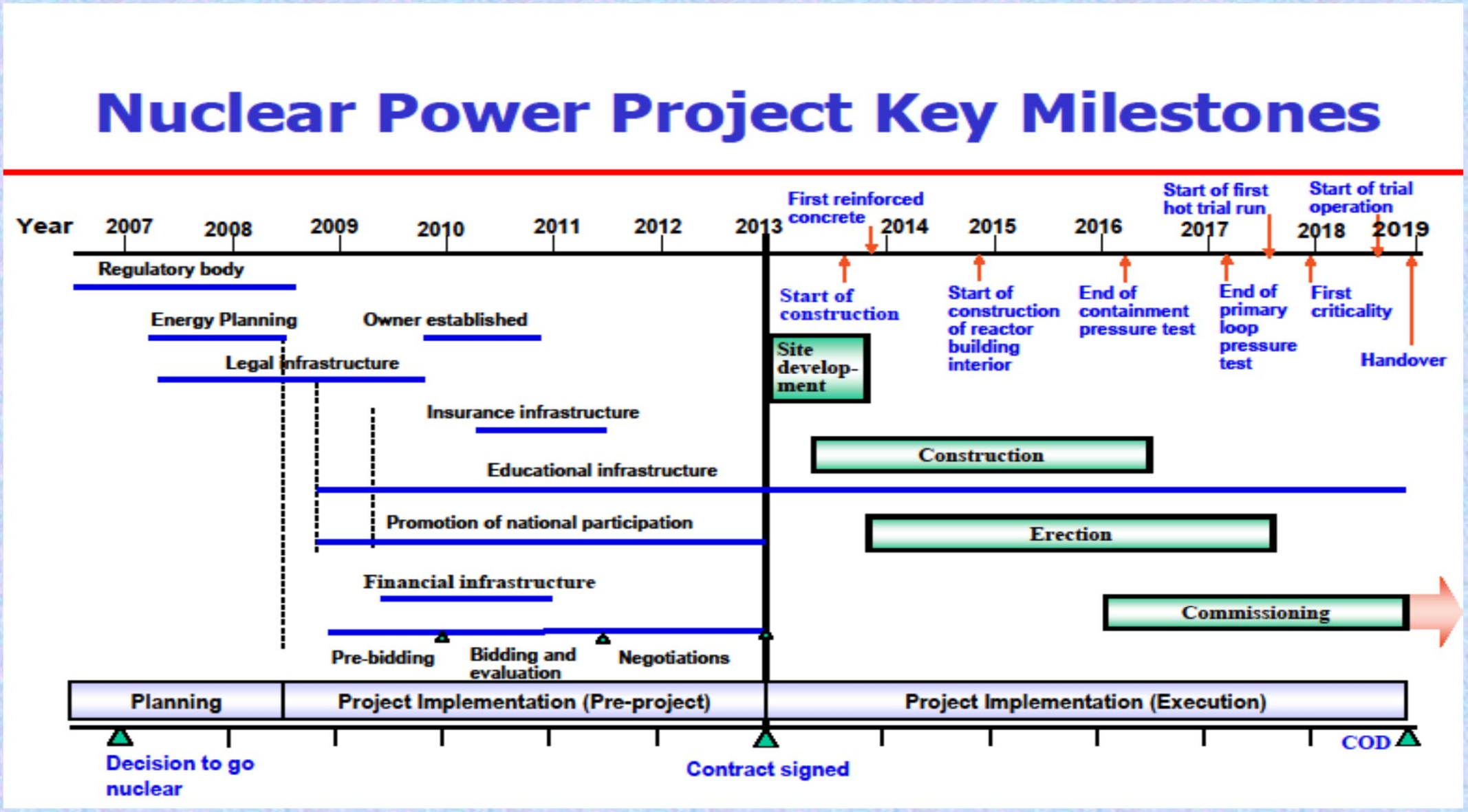


Figure 3.2: NPP Deployment Timeline



3.3 NP Programme Progress Recorded (1)

Legislation

Some progress made in the revision of both the NAEC and NNRA Acts by National Assembly to ensure robust implementation of programme;

Regulations and Policies

- Finalized *Safety and Regulatory Requirements for Licensing of Sites for Nuclear Power Plants*;
- Finalized National Policy on Radioactive Waste Management has been finalized by NAEC;
- Developed framework for the establishment of a *National Nuclear Insurance Policy and Scheme* to adequately address the civil liability component of the nuclear power industry;

Ratify and Domesticate

Activated the processes to positively sensitize Government to ratify and domesticate all other relevant international statutes, treaties and conventions.

3.3 NP Programme Progress Recorded (2)

Build NPI

- Attained IAEA Milestone 1 of 3 since December 2009;
- Emplacement of the critical educational and training infrastructure for the development the national Nuclear Power Infrastructure (NPI);

Partnerships

- Strengthening of cooperation with the IAEA and other development partners;
- Signing of Cooperation Agreements with ROSATOM of the Russian Federation, and their subsequent approval and ratification by the FEC, as well as other ongoing consultations with others;

HRD

- Finalization of requisite HRD strategy in line with the workforce requirements of the national NPP programme and building of requisite facilities

NPP Sites

- Concluded preliminary site selection activities; detailed evaluation and characterization to be conducted on preferred sites on the approval of government:- Geregu in Ajaokuta LGA of Kogi State and Itu LGA of Akwa Ibom State;
- Apply for the licensing of the approved site(s) by the second half of year 2014.

IV
Requirements for Building the Critical National Nuclear Power Infrastructure

4.1: Building The Requisite National Capacity

- Develop a national strategy to build and strengthen National Preparedness which is critical for the successfully deployment of Nuclear Power Plants.
- National Preparedness in this regard entails:
  - Human Resources Development;
  - Educational Infrastructure Development; and
  - The Requisite National Technical Capacity.
- National Technical Capacity Building is dependent on the first two, and these elements constitute a component of the national Nuclear Power Infrastructure (NPI); and
- A National Human Resources Development Strategy has been developed to superintend the implementation of all of the above elements.

4.2: Aims and Objectives of the HRD Strategy

- The national human resource development strategy is designed to meet the broadened objectives to:
  - produce indigenous scientists and engineers with in-depth fundamental understanding of nuclear technology for effective project planning, management and sustainable implementation of the national nuclear power programme;
  - 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 project implementation;
  - respond to the national needs in producing qualified human capital which is adequately equipped to optimally deploy nuclear technology in multifarious applications; and:
  - develop a specialized cadre of scientists and engineers who would be engaged in applied research, make innovations and technology domestication.

4.3: Physical Training Infrastructure

- Standard training programmes in Nuclear Science and Engineering (Graduate, undergraduate, technologists, technician) must have at a minimum level of physical facilities such as laboratories, workshops and IT facilities, and must be developed in the designated institutions in an integrated fashion:
  - Laboratories and workshops must be equipped with the requisite nuclear instrumentation facilities and training equipment;
  - Coordination and creation of linkages to develop appropriate network for the sharing of physical facilities and personnel between participating institutions in the training programmes;
  - Provision of new key functional physical equipment and relevant research facilities, as well as upgrading of the existing facilities; and
  - The various NPI training and research facilities being developed and upgraded in the seven national nuclear energy research centres are listed in the Annexure.

V
Ownership, Funding and Financing.

5.1 NPI Dev and National Funding Requirements

- A major characteristic challenge of NP Development in a newcomer country, irrespective of ownership, is long-term national (political) commitment and sustainability of the programme over the gestation period of at least 20 years;
- Overcoming this challenge requires a broad-based acceptance of the programme by the citizenry; should transcend political affiliation which would ensure programme continuity;
- The funding and financing requirements for Nuclear Power Infrastructure (NPI) development over time, and building of nuclear power plants, respectively, are also challenging (see Annexure);
- Funding refers to the initial fiscal responsibility of government in establishing the minimum NPI and is most often provided through national budgetary allocations;
- Government Commitment and the National ability to fund NPI development is a critical determinant of success: key to attract vendor/utility/private sector financing of the nuclear power plants (NPPs .

5.2 Ownership , Funding & Financing Structure

- NAEC empowered by Act as owner operating organization; but will only play a facilitating role. Structure of NPP Owner/Operating Organization (NPP-OOO) will depend on Government's Policy on NP financing model.
- FGN to create the enabling environment for NP programme sustainability; NPP-OOO would be a Special-Purpose-Vehicle (SPV) in the form of a "Joint Stock Company" (JSC) created in accordance with national laws and corporate governance with a Foreign Technical Partner (FTP).
- The JSC FTP, established NPP vendor and/or a NPP utility will hold majority and controlling stake. National entity – minority; Roles to be specified in contractual agreements.
- Globally, BOO and BOOT are becoming attractive for NPP (Russia-Turkey; The Akkuyu NPP project, and most recently, with Bangladesh & Jordan);
- For BOO(T), FTP and/or investor would provide the needed critical capital and technical input to implement the project;
- FGN and Govt. of FTP country to enter into an Inter Governmental Agreement (IGA) to streamline the modalities of the ownership structure and financing of the project;
- A major critical role of FGN in facilitating the success of the BOO(T) arrangement would entail the creation and entering into enforceable advance Power Purchase Agreements (PPAs).

Fig 5.1: Components of Funding and Financing Aspects of the National NP Programme

Time Frame	2014 t0 2018	2016 t0 2030
Elements and Components of NPP Programme implementation	Funding for NPI Development Funding for Design certifications, Legal & Regulatory Infrastructure, Site Evaluation and Licensing, Bidding, Contracting, etc	Financing of Construction of and Commissioning of NPPs -Four (4) units of 1200MW each - (Total 4800 MW) - COD of First NPP - 2022 - COD of Fourth NPP -2030
Financial Inputs for Successful and Sustainable Implementation	N6b to N8b per annum for 5years (0.8 to 1.25% of cost of NPPs)	Estimated contractual Cost of US$5-6bn per NPP unit; totaling US$20-24bn
Who shoulders the Financial Responsibility	Provided by Federal Government of Nigeria	Financed by Vendor/Operator through a BOOT Contractual Model; FGN to enter into an IGA with Government of Country of NPP Vendor Company with possible minority equity participation by FGN; and Execution of an advance PPA

VI
Medium-Term Project Deliverables, Spin-Offs and Challenges.

6.1 NPI Development and Technology Feedback

- The short- and medium-term financial requirements are to be channeled towards the funding of the building of the critical Nuclear Power Infrastructure (NPI), which includes development of education and training physical facilities, as well as HRD;
- The physical facilities include:
  - Laboratories and workshops which would be equipped with the requisite nuclear instrumentation facilities and training equipment;
  - IT facilities and communication infrastructure; and
  - Integration of facilities through creation of linkages and networking for the sharing of physical facilities and personnel between participating institutions in the training programmes;
- The development of the physical NPI elements also positively feeds back into the development of critical STI infrastructure upgrading in national educational institutions;
- Development of NT educational programmes and physical facilities will also contribute to development in non-power applications – health, agriculture, environmental management, industry, etc.

6.2 Project Deliverables :Low-Hanging Fruits

- The most important quick outcome of the programme is the qualitative and well-trained national Human Resource Base created for the effective deployment of nuclear technology for national development; Nuclear Power (1000MW by 2022 and 4,000MW by 2030)
- In addition to NP development, trained personnel will be useful in other NT applications which include:
  - Human Health (radiotherapy and nuclear medicine),
  - Food and Agriculture (SIT, processing, preservation),
  - radiation protection,
  - environmental management,
  - nuclear security & nuclear safeguards, and
  - in industry and other diversified scientific applications
- Create a sustainable pool of physical, scientific and educational infrastructure in our national institutions for national capacity building and enhanced capacity for technology acquisition and innovation.

6.3 Challenges with Technology Management

- Deepening of the national technology maintenance culture and its effective application in managing nuclear technology; deepen the culture of commitment to efficiency!
- Managing and effectively containing the security issues associated with the development and operation of nuclear power plants. This will entail:
  - imbedding of security and safety culture which is intrinsic in the training of nuclear professionals;
  - interface with relevant security agencies to strengthen national security commitment to programme from the outset – establishment of a nuclear security centre; and
  - investing in requisite nuclear security infrastructure.
- Enthronement of national transparency in programme implementation, as well as commitment to safeguards, so as to earn and continuously enjoy international confidence in the purely civil nature of the national nuclear power programme.

VII
Summing Up and Parting Thoughts

- Climate change is real and incontrovertible even by the skeptics, as there exists sufficient scientific basis. Evidence abound that expansion of nuclear power may have a mitigating effect on climate change.
- That nuclear power promotes good health is also becoming less controversial. The recent study report by James Hansen, et al has further affirmed the widely held view that the worldwide use of nuclear power instead of fossil fuels saves lives (1.84m ; 1971-2009).
- In spite of divergent views on the economics of NP vis-à-vis other sources of electricity, expansion in the use of nuclear power would contribute significantly towards the effective management and conservation of finite natural assets of fossil fuels
- There is a strong desire to conserve such fossil fuels which do have uses of high utility values in other sectors of the economy. This will further engender and deepen sustainable development.
- In light of the gradual recovery from the Fukushima Daiichi accident and the apparent nuclear power renaissance, international effort should be further galvanized to ensure that it is sustained successfully over time, particularly in the newcomer developing countries.

- The success and sustainability of the various new programmes in newly embarking countries will derive from:
  - creation of a stable network of national institutions which supports the successful development of the requisite national nuclear power infrastructure and capacity building;
  - strengthening of the network of national physical and industrial infrastructure covering a wide range of activities and capabilities such as transportation, electricity grid and heavy industries;
  - putting in place a strategy for the development of a virile and professional human resource base with in-built mechanisms for effective workforce development, succession planning and nuclear knowledge management;
  - the development of a creative and pragmatic financing plan with significant private sector participation, backed-up by appropriate Inter Governmental Agreements and long-term commitment of national resources; and

- Nuclear power is not a ‘quick fix’. Consequently, there is the clear realization that the broad national strategy for fixing the energy problem in any country must be multidimensional, involving a wide array of options, and should have short-term, medium-term and long-term plans for sustainability.

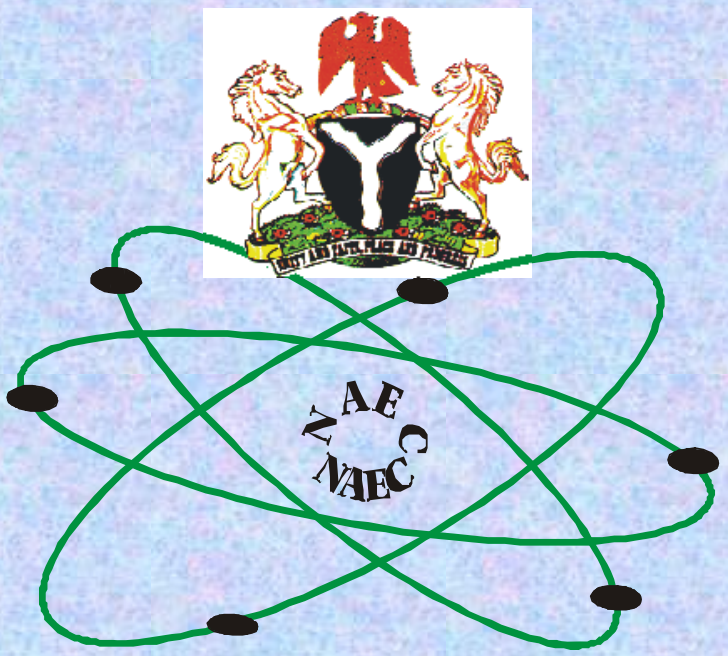
❖ In spite of all the challenges, the benefits of the successful implementation of a nuclear power programme far outweigh the difficulties.

Words of Reassurance: Late Nigerian President, Umaru Yar’adua

“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”.

Words of Hope:Former UK Prime Minister, Tony Blair

“.. 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....”



Thank you for your attention.