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CONFERENCE PAPER

Renewable energy investment in Nigeria: A review of the Renewable Energy Master Plan

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Abstract
Data for investment into renewable energy resources in Nigeria is mainly unavailable due to over reliance on conventional resources for energy generation. However, recent developments in the energy sector have portrayed gradual attention to investments in renewable energy resources. This paper reviews the Renewable Energy Master Plan (REMP) which identifies this improvement and presents a draft on how an increase in investment in renewable energy resources, which will in the long run balance the national energy equation, ensure energy security and promote sustainable development.

Keywords: investment; Nigeria; Renewable Energy Master Plan; renewable energy resources; sustainable development

1. Introduction

Perhaps the greatest challenge faced by Nigerians today is the comatose energy sector. With anticipated development of coal power plants, the content of the Nigerian energy consumption pattern is increasingly fossil-based. Oil accounts for about 20% of GDP, 95% of export earnings and 85% of budgetary revenues (Malumfashi, 2007).

However, Nigeria is endowed with sufficient renewable energy resources to meet its present and future development requirements as well as complement its current oil-dependent economy. Table 1 shows various renewable energy sources and their estimated reserves in Nigeria.

Table1: Nigeria's energy reserves/potentials
Source: Renewable Energy Master Plan (2005)

Resource	*Reserves*	*Reserves billion toe*
Hydropower	10000MW	
Hydropower	734MW	Provisional
Fuelwood	13071464 has (forest land 1981)	Estimate
Animal waste	61million tonnes/yr	Estimate
Crop residue	83million tonnes/yr	Estimate
Solar radiation	3.5-7.0kWh/m^2-day	Estimate
Wind	2-4m/s (annual average)	

Energy poverty is entrenched in Nigeria; about 85 million, representing approximately 60 percent of the population have no access to electricity services. Less than 20 percent of rural areas have some form of electricity service coverage. In all, the electricity consumption per capita is about 100 kWh when compared to 4,500 kWh, 1934 kWh and 1379 kWh in South Africa, Brazil and China, respectively. Presently, the government has embarked on a massive investment programme to increase the capacity of the electricity supply industry. This is expected to double the generation capacity from fossil sources. Even though attention is beginning to be paid to renewable electricity, it is only an insignificant fraction of the total public sector energy investments. Consequently, prior to 2004, and even up to 2008, a databank on renewable energy investments in Nigeria is either unavailable or inaccessible.

To this end, one of the reasons why the Nigerian energy sector is highly vulnerable to shocks is due

to its overdependence on fossil sources. Similarly, the reliance on large hydropower for about a third of electricity supply is usually under pressure as dams dry up, especially in the dry seasons. There is also the challenge of bad policies and unprofessionalism demonstrated in poor energy administration. This means, therefore, that the resilience of the Nigerian energy system is weak as climate change, bad governance and widespread poverty intensify the vulnerability of the energy economy. The challenges of energy security and access are compounded by inefficiency and poor environmental governance, while by-products like oil pollution and gas flaring have continued to damage agricultural land and marine ecology irreversibly.

Large incomes from oil and abundant energy resources including, gas, coal, hydro, biomass, and solar radiation, have not necessarily translated to growth and development. As a matter of fact, the relationship between energy and economic development has been a tremendous paradox in Nigeria (Renewable Energy Master Plan, 2005).

Switching over to the utilization of renewable energy resources in Nigeria is long overdue because of the increased recognition of the contribution renewable energy makes to rural development, lower health costs (linked to reduced-air pollution), energy independence, and climate change mitigation. Interests in shifting renewable energy from the fringe to the mainstream of sustainable development are recently growing (Martinot et al; Mfune and Boon, 2008). At the same time, commercial markets for renewable energy are expanding, shifting investment patterns away from traditional government and international donor sources to greater reliance on private firms and banks (Kammen, 1999; Reddy and Goldberg, 1990; Anderson, 1997; Goldberg *et al*., 2000).

This paper was researched in order to provide a common understanding of the current status of renewable energy investments in Nigeria and open a leeway for promoting and fast-tracking future investment patterns. The information items covered in the paper have been gleaned from available scientific publications sourced from the internet and other private collections. The draft Renewable Energy Master Plan (REMP) for Nigeria by a team of experts and stakeholders from the Energy Commission of Nigeria (ECN) and the United Nations Development Programme (UNDP) in 2005, served as the research instrument under review. The REMP articulates Nigeria's vision and road maps an increasing role for renewable energy to achieve sustainable development – anchored on the mounting convergence of values, principles and targets as embedded in the National Economic Empowerment and Development Strategy (NEEDS), National Energy Policy on Integrated Rural Development, the Millennium Development Goals (MDGs) and the international conventions to reduce poverty and reverse global environmental change.

Internal limitations include among other things, the non-availability of reliable data in most cases for renewable energy investments in Nigeria, unverified projections and numerous uncertainties in the proposed REMP.

2. Development of the Renewable Energy Master Plan in Nigeria

2.1 Definition of renewable energy

Renewable energy includes solar, wind, hydro, oceanic, geothermal, biomass, and other sources of energy that are derived from "sun energy", and are thus renewed indefinitely as a course of nature. Forms of useable energy include electricity, hydrogen, fuels, thermal energy and mechanical force.

More broadly speaking, renewable energy is derived from non-fossil and non-nuclear sources in ways that can be replenished, are sustainable, and have no harmful side effects. The ability of an energy source to be renewed also implies that its harvesting, conversion and use occur in a sustainable manner, thereby avoiding negative impacts on the viability and rights of local communities and natural ecosystems.

2.2 Rationale for the Renewable Energy Master Plan

The following have been recognized and advanced as reasons for the instituting the REMP in Nigeria (Renewable Energy Master Plan, 2005):

- The dwindling of Nigeria's oil reserves.
- The need to replace the jumbled historical development of renewable energy with properly coordinated policy and implementation.
- The need to urgently provide access to affordable electricity for the highly-dense rural populace.
- To restructure the electricity industry by encouraging competitive wholesale power markets, increase self-generation by end-users, accelerate privatization and commercialization, unbundle generation, transmission and distribution and create a competitive retail market.
- For specific technological expertise and market conditions through research and development activities.
- To promote green energy technologies by reducing pollution and environmental degradation.
- To provide a platform for a level playing ground for all stakeholders in the energy sector.

2.3 Plans for investment into renewable energy

The REMP envisioned a gradual but steady transition from overdependence to less dependence on hydrocarbons as a primary source of energy and income to Nigeria. It ventured to employ specific

stages of development in its attainment of these objectives such as, the short term (2005-2007), the medium term (2008-2015) and long term (2016-2025) (Renewable Energy Master Plan, 2005). In the short term, crude oil is expected to play a dominant role in the economic development of the country while an energy transition from crude oil to a less carbon intensive economy is anticipated in the medium term. This anticipated transition is notably indispensable. On the other hand, the long term envisages a country that will significantly be less dependent on hydrocarbons.

2.4 Specific objectives of the Renewable Energy Master Plan

The development of renewable energy technologies is a win-win strategy for a developing country like Nigeria. Increased investments on renewable energy will bring together climate protection, poverty reduction, technology development and job creation.

The overall objective of the REMP is to articulate a national vision, set targets and a road map for addressing key development challenges facing Nigeria through the accelerated development and exploitation of renewable energy. This it hopes to achieve through by developing a comprehensive platform for setting up renewable energy policies, providing legal instruments, technologies, manpower, infrastructure and markets so as to ensure that the visions and targets are realized. Among other things, the master plan has projected the following specific objectives (Renewable Energy Master Plan, 2005):

- Expanding access to energy services and raising the standard of living, especially in the rural areas;
- Stimulating economic growth, employment and empowerment;
- Increasing the scope and quality of rural services, including schools, health services, water supply, information, entertainment and stemming the migration to urban areas;
- Reducing environmental degradation and health risks, particularly to vulnerable groups such as women and children;
- Improving learning, capacity-building, research and development on various renewable energy technologies in the country; and
- Providing a road map for achieving a substantial share of the national energy supply mix through renewable energy.

2.5 Barriers to the implementation of the Renewable Energy Master Plan

Several barriers have been confronting the development of the renewable energy sector in Nigeria, and by and large, pose a similar threat to implementing the REMP. The following have been principally identified:

- Policy and political barriers: sound policies developed by government might at the end of the day not be adopted, or when adopted may not be fully implemented.
- Market distortions: price distortions, poor regulatory environment and inadequate infrastructure characterize current energy market conditions in the country.
- International development barriers: globalization in the movement of capital, technology, goods and ideas tend to put pressure on a proposal like the REMP.
- Standards quality and control barriers: a major constraint to the development of the renewable energy market in Nigeria is the poorly established standard and quality control of locally manufactured and imported technologies.
- Research and development barriers: the long term objectives of the REMP require quality improvement in research and development in renewable energy systems to ease inefficiency and improve procurement and construction costs.
- Environment barriers: against the background that renewable energy systems provide cleaner alternative to hydrocarbons, certain environmental barriers may however persist such as distortion of plant and animal habitats, human dislocation and resettlement.

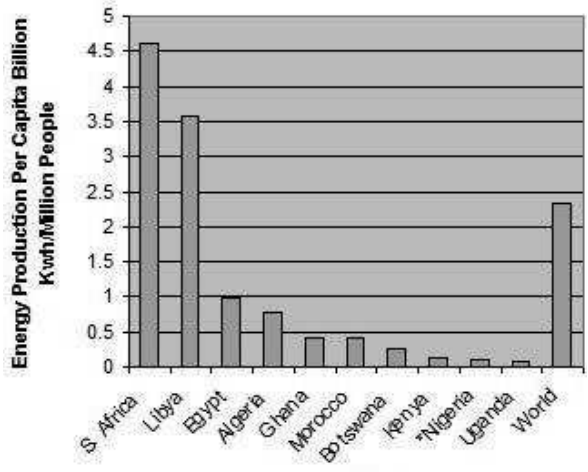

Figure 1: Electrical energy production and consumption (and other data) by country
Source: CIA Fact-book Website, December 2004

3. Investment pattern of the renewable energy master plan

3.1 Case for drafting the REMP

Certain indices underscore the imperative to develop the REMP. For instance, the reasons for the REMP, as earlier outlined in this paper, come to bare. Besides, several other factors include among others, the undue focus on centralized energy supply which has been inadequate in meeting the bur-

geoning energy demand; the decentralized nature and scale of the renewable energy scheme make it readily available to even the most remote locations; the encouragement of a balanced development of all available energy resources; and, the need to provide a level playing field for all cadre of investments as many players become involved in renewable energy development and implementation. For the purpose of this research, three basic considerations of such cases that could have necessitated drafting of the REMP have been identified and carefully examined – energy per capita, environmental sustainability and relative cost economy.

3.1.1 Energy per capita disparity

That electrical energy is the most mobile and versatile form of energy which is directly needed to run our homes and industrial appliances and machinery, light, heat and cool our living and work spaces, and for our telecommunications, cannot be overstated. Various studies have established that the relationship between energy and economic development is proportional (Okoro *et al*., 2006; Iloeje, 2007; Karlsson, 2005; Okoro and Madueme, 2004; Qurashi and Hussain, 2005). But when electrical energy production in Nigeria is compared with that of neighbouring African countries, which unlike Nigeria are lacking in huge energy resource potential, the result is rather out of place (see Figure 1).

The stated figure of 0.11 billion kWh per million people for Nigeria in Figure 1, which is roughly equivalent to having a constantly-running 11 MW of power station per million people, or a total of 1 500 MW for the country is a call for immediate action to invest in alternative forms of energy. If, for example, Nigeria were to produce electricity at the same rate as South Africa i.e. 4.2 Billion kWh per million people, it is equivalent to having power plants totalling 63 000 MW, which is over ten times what is being produced in the country at present. However, if Nigeria is to meet the world average of 2.34 Billion kWh per million people, then it will need five times its present capacity which is graciously fluctuating between 2 800 MW and 3 500 MW.

3.1.2 Environmental sustainability

The primary concept of sustainability is to meet the needs of the present without compromising on the ability of future generations to meet their own needs (Qurashi and Hussain, 2005). The conventional energy-generation options can damage air, water, climate, land and wild life, through particulate and gaseous emissions, as well as through rising levels of harmful radiations. The results of these pollutions (e.g. emission of greenhouse gases through continued gas flaring and the depletion of the ozone) are factors which cause global warming and climate change.

Renewable Energy Technologies (RETs) which are much safer is the current driving force and perhaps, a foremost reason for drafting of the REMP.

3.1.3 Relative cost economy

The cost of setting up an energy facility is usually critical to the volume of investments that will be attracted to develop a particular resource base. In costing the generation of electricity, three types of costs are identified, namely:

- Capital costs (necessary for building a particular energy technology; and tend to be low for fossil power stations but high for renewable technologies).
- Operating and maintenance (O&M) costs – tend to be high for fossil-powered generators and low for renewables.
- Fuel costs – high for fossil fuel and biomass sources, but very low for renewables such as solar PV and wind turbines, possibly negative for waste to energy.

Table 2 presents an overview for comparing the initial costs of various electricity generating systems, while Table 3 presents a comparative assessment of operation and maintenance costs. All energy sources have unique characteristics that make them advantageous in some situations. Geography, climate and access to natural resources all play a role in their effectiveness. However, in terms of overall cost efficiency, renewable energy technologies have been identified as a very cost effective means of electricity generation, though with a high initial capital cost, aimed to be cut seriously by on-going research, but a lower operational/running cost.

Table 2: Initial capital costs of electricity generating systems

Source: Renewable Energy Master Plan (2005)

Technology	*Size (KW)*	*Initial capital cost ($ per KW)*
Gasoline	4760	
Diesel	20	500
Micro hydro	15	1700
Photovoltaic	0.19	8400
Wind Turbine	10	2800

3.2 Summary and Pattern of Projected Investments in the REMP

To ensure that the REMP targets are met, three stages of implementation of programmes and projects have been identified in short, medium and long terms. The projected electricity supply, from all sources (conventional and renewable) in the short, medium and long term is estimated to be 56MW, 746MW and 2945MW respectively as shown in Figure 2.

Table 3 presents an overview of estimated costs for these investments for all activities as outlined in the REMP. All cost estimates are in tandem with 2005 naira (Nigerian currency) value.

Implementing the REMP will demand an estimated investment portfolio of 4 billion, 178 billion and 428 billion naira, in the short, medium and long term respectively.

Table 3: Operation, maintenance, and fuel costs for different technologies
Source: Renewable Energy Master Plan (2005)

Technology	*O & M costs (cents per KWh)*	*Fuel costs (cents per KWh)*
Engine generator	2	20
Micro hydro	2	0
Photovoltaic	0.5	0
Wind turbine	1	0

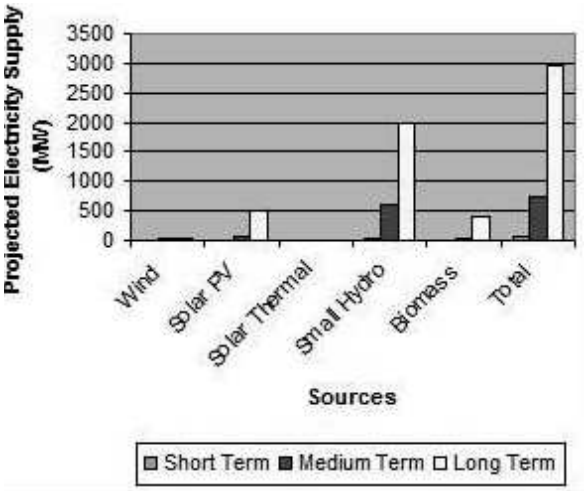

Figure 2: Breakdown of targets for each of the five renewable energy subsectors in the REMP
Source: Renewable Energy Master Plan (2005)

Table 4: Estimated costs for renewable energy investments (in million naira)
Source: Renewable Energy Master Plan (2005)

Activity	*Short term*	*Medium term*	*Long term*	*Total*
Programmes & activities	170	430	322	922
Biomass	1793	3231	11353	16377
Solar energy	1240	2525	3210	6975
Small hydro	134	1244	1726	3104
Wind energy	920	170200	410640	581760
Total	4257	177630	427251	609138

In the end, apart from milestones which were set out in the REMP, a total of about 610 billion naira was estimated for the two-decade projects, an amount fair enough to compare in MW output with close to 500 billion naira invested in largely non-renewable energy resources between 1999 and 2007, with less than 1 000 MW improvement in generation capacity (Akuru, 2010).

In the interim, it is expected that financing of these investments will depend on the mobilization of resources from governments at all levels, the domestic private sector and international sources which include foreign direct investments, grants, and oil revenues.

4. Future prospects for renewable energy in Nigeria

The challenge confronting Nigeria like any other developing country (Pendse, 1979) is to achieve an orderly and peaceful energy-transition from the present economy, based primarily on hydrocarbons, and to one based increasingly on renewable sources of energy. It has to be in a manner which is consistent with the needs and options of individual sectors and is socially equitable, economically and technically viable and environmentally sustainable. The transition must be based on technological, commercial, financial and monetary modalities, consistent with the resolve of the government to establish the REMP, so as to accelerate development and to promote balanced energy distribution. An effective energy-transition should be implemented in accordance with the outlined long-term national plans and priorities.

The development of renewable sources of energy opens up the prospect of increasing indigenous energy-supply and thereby contributing to greater self-sufficiency. It also creates new options to respond to the energy requirements of the rural, industrial, transport, domestic and other sectors, in accordance with national goals and priorities, and provides for a more diversified and decentralized pattern of energy-supply. Likewise, just as obtainable in conventional energy sources or products, renewable sources of energy have been identified as both an "input" and an "output" of the development process (Qurashi and Hussain, 2005]. Therefore, encouraging investment in renewable energy resources, as outlined in the REMP, agrees with the following merits: pollution free environment, free renewable and available energy source, high reliability and low maintenance costs (Okoro and Madueme, 2005).

It is expected that by now implementation of the REMP would have reached half-way into the medium term, but the last check revealed that there has been a delay in the approval of the REMP noting, however, that an inter-ministerial committee has long been established to review the draft master plan and push for its approval (Talba, 2009).

5. Conclusion and recommendations

The Renewable Energy Master Plan (REMP) com-

mits Nigeria to ambitious but achievable commitments for the development of all major renewable energy resources. It includes short, medium and long term targets in planned activities, milestones and strategies for implementation. Successful implementation will result in the installation of 2 945 MW of wind, solar PV, solar thermal, small hydro and biomass by 2025 – roughly equivalent to the entire grid capacity in use in Nigeria today.

Achieving this vision will require the unyielding cooperation of all parties: government, private and civil society. Founded and comprised of stakeholders from all sectors of renewable energy in Nigeria. Similarly, Nigeria will become a leader in the world's fight against climate change, move towards the attainment of the MDG and NEEDS targets, ensure the development of the nation's energy resources for the achievement of national energy security, guarantee adequate, reliable and sustainable supply of energy at appropriate costs and establish an efficient delivery system with an optimal energy resource mix. It will also gain a place of renewed respect and dignified power in Africa and the world over.

Notwithstanding the fact that implementation of the REMP is yet to commence, this paper is of the view that the targets have been properly outlined in the draft, and so, remains valid for future actions or inactions as the case may be. First of all, it is hoped that against the backdrop of revising the financial projection of the REMP, thereby wasting more time and money on prolonged research, approval of the REMP should not continue to linger because of the continuing depletion of conventional energy resources which makes its adoption urgent and indispensable in the near future. Perhaps the cost of carrying out immediate action on the REMP, though seen as ambitious, will become insignificant in the long run. Already too, countries like Germany and Brazil which have put in place a reliable and efficient renewable energy programmes, such that they have credited major achievements in sustainable energy generation and economic dividends, should serve as a case in point for immediately budding Nigeria's renewable energy interests.

No doubt, the draft REMP is a proof that a white paper which targets, above all, to turn-around Nigeria's moribund energy sector by utilizing and incorporating renewable energy resources in the national supply mix is in existence, but implementation is key. Therefore, it remains to be seen, what other unseen benefits could be embedded in the REMP until implementation is achieved and the benefits start accruing.

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