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# *Combating Climate Change Impacts on Water availability and Energy Production*

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## Abstract

Energy and water systems are closely inter-connected and need each other. Hydroelectric power (HEP) generation remains an important source of energy in Nigeria. Notable inefficiencies and deficiencies in cash generation have compelled the Power Holding Company of Nigeria (PHCN) to rely on fuel subsidies and government subvention for funding of capital projects with the resulting ever accumulating energy supply deficits. Incidentally, the energy sector is one of the main drivers of GHG emissions, hence of global warming and climate change. It contributed 140% increase during 1970-2004 to the growth of GHG emissions. Climate variability and change caused reduced inflows into dam reservoirs resulting in the drastic and steady drop in the hydroelectric power generated by dams the Kainji and other dams in Nigeria between 1973 and 1994 and in 2003. The phenomenon has exacerbated competition for water between energy and other sectors of the economy such as agriculture. Projected temperature increases during the 21st century are expected to increase the energy demand for cooling.

The national energy mix regime with less carbon intensive economy and with a decisive transition from crude oil to gas and, increasingly renewable, is the pathway to be pursued vigorously. An integrated water resources management (IWRM) approach should be followed. In particular, climate proofing of infrastructure should be applied at all stages in the project cycle: planning, design, construction, operation, and decommissioning. It will apply relevant adaptation and risk-management strategies as a necessary component of sustainable socio-economic development. The country's policy makers should make renewable energy development a priority policy of government at all levels. Lawmakers should also develop appropriate legal, regulatory and institutional frameworks that de-emphasize over-dependence on fossil fuels and promote demand management for water and energy.

**Key words**: Energy, water, climate change, mitigation,- adaptation, IWRM, infrastructure.

## Introduction

Energy and water systems are connected. Energy is needed to pump, transport, and treat drinking water and wastewater. Enormous volumes of cooling water are needed to run many of today's power plants (Fig.1). On the average, production of a kilowatt-hour of electricity requires 112 liters of water to be withdrawn from rivers or lakes. Hydroelectricity remains an important source of power in Nigeria and West Africa. Hydroelectric power plants are sensitive to the volume and timing of stream flows. Moreover, maintaining stream flow for hydroelectric dams could present conflicts with other activities.

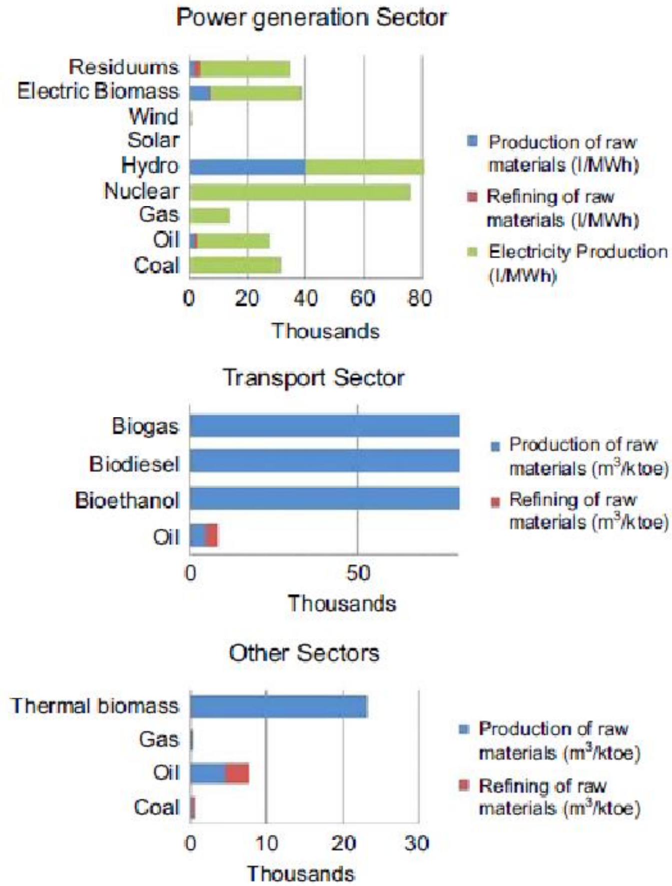


Fig. 1: Estimated water withdrawal per unit electricity or primary energy (Spanish Model)
Source: Rio Carrillo *et al.* (2009)

The greenhouse (GHG) emissions include $CO_2$, CH4, N2O, HFCs, PFCs, and SF6 and they are weighted by their global warming potential and measured in Gigatonnes of $CO_2$ equivalent. The more recent trends in percentage growth rate of greenhouse (GHG) emissions are as follows (IPCC, 2007):

- 1970-2004 - 70%,
- 1990-2004 - 24%, and
- 1990-2004 - $CO_2$ only - 28%

The following increases and their sources account for the 1970-2004 growth (IPCC, 2007):

- Energy supply sector - 140%
- Transportation & infrastructure - 120%
- Agriculture - 27%
- Residental & commercial buildings - 26% (stabilised at that level since 1990)
- Waste management -?

Thus the energy sector is one of the main drivers of GHG emission, hence of global warming and climate change.

This paper examines how energy supply can be increased in an environmentally sound approach that mainstreams climate change impacts and employs appropriate demand management technologies.

## Energy Demand and Supply Projections

Nigeria's power sector has high energy losses (30 - 35 % from generation to billing), a low collection rate (75 - 80 %) and low access to electricity by the population (36 %). These inefficiencies and deficiencies in cash generation have competed the Power Holding Company of Nigeria's (PHCN) to rely on fuel subsidies and government subvention for funding of capital projects.

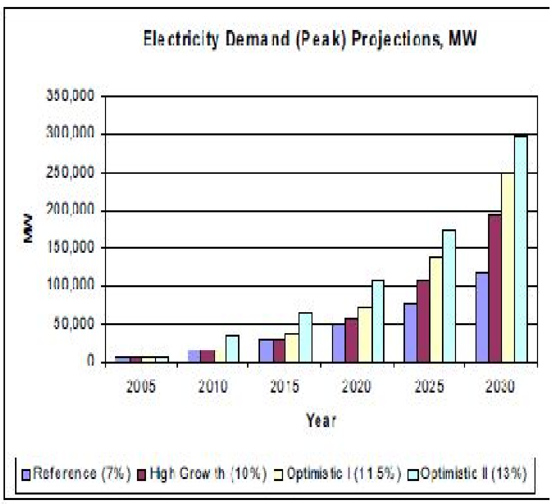


Fig. 2: Electricity Demand Projection, MW

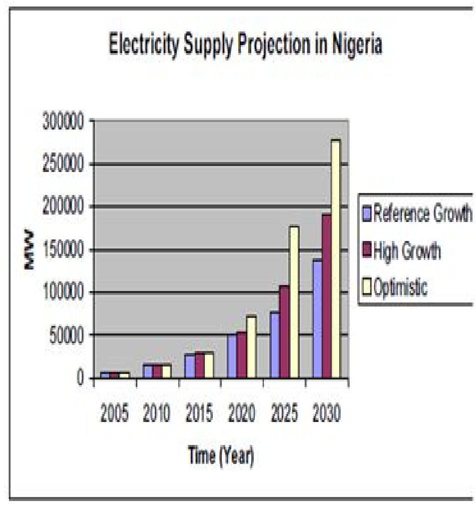


Fig. 3: Electricity Supply Proction, MW

Source: ECN (2007)

Figs. 2& 3 show the projected electricity demand and supply (at unrealistic 13% GDP growth rate). The demand rose from suppressed demand of 5,746MW in the base year of 2005 to 297,900MW in 2030 which translates to construction of 11,686MW every year to meet the demand. Supply estimates on the other hand for GDP rate of 11.5% would rise from 6440 MW in 2005 to 276,229 MW in 2030.

## Drivers of Climate change - Impacts on Water Availability and Energy

The West African drought has resulted in drastically changed annual mean rainfall patterns and a southward shift of rainfall isohyets/zones by 100 km as well as reduction of about 25-40 % of average rainfall supply (1974-1994) to the Niger River, as compared to the period of record of 1907-1973. The corresponding decreases in river flows reached 40-60% Oyebande *et al* (2002). This fall in flow has had direct consequences on the replenishment of the dams built in the 1960s and 1970s because the hydrological data used for their design were based on the preceding wet periods. The non-replenishment of reservoirs resulted in the drastic and steady drop in the quantum of hydroelectric power generated by dams (e.g. the Kainji dam on the Niger and Akosombo Dam on the Volta. This water deficiency no doubt would also negatively constrain the cooling of coal-fired power stations.

The evolution of the energy demand is primarily linked to increases in population and the level of economic activity. But the temperature increase will stimulate an increase for cooling space, thus an increase in energy demand. The major problem will be the management of the country's multi-purposes dams. Apart from the decrease of storage capacity discussed above, the increase of water demand for irrigation and the need for maintaining a minimum level of water in the rivers for navigation and environmental flow will compete with energy production.

Temperature increases are very likely during the 21st century, with increases of 1-3$^{o}$C by 2050 depending on the emission scenario. Also increasing consensus that rainfall events will become more intense, as the energy of the climatic cell increases and greater amounts of moisture are transported in the atmosphere. An important part of the Nigeria's energy infrastructure is its concentration in the coastal zone, which is at risk from sea level rise, more intense storms, and larger storm surges due to climate change. Short term adaptation strategies will likely focus on increasing resistance to impacts—building and maintaining barriers that can protect coastal energy infrastructure.

## Two Responses to Climate Change Impacts: Mitigation and Adaptation

### Mitigation of climate change

- Energy related mitigation concerns the measures that Nigeria could take to reduce the emissions of greenhouse gases (GHG). The measures include:
- Inclusion of policy and market interventions in sectors such as energy and transportation;
- Intervention in the energy sector: markets, energy policy, or reform; clean/renewable energy programmes (solar, gas, wind, hydroelectric power (large and small), bio-energy and geothermal) and electrification schemes; climate friendly investment programmes in the sector;
- Interventions to ensure greater energy efficiency; public and commercial energy-efficiency programmes; supply and demand management schemes;

75% of the gas produced in Nigeria was being flared in the past. However, gas flaring was reduced to about 36% as a result of great efforts by the Government to monetize natural gas. Greater effort is required to eliminate gas flaring completely. Domestic utilization of natural gas is mainly for power generation which accounted for over 80%, the remainder being for the industrial sector and very negligible portion for domestic or household purposes.

The following response defines a national energy mix regime with less carbon intensive economy and transition from crude oil to gas and, increasingly renewables. It should be pursues vigorously.

In Nigeria, large hydro accounted for about 31.30% of grid electricity generation by 2005 while natural gas accounted for the balance of 68.30%. One of the objectives of a study conducted under the auspices of the IAEA was to find the optimal mix of fuels for the diversification of electricity supply in Nigeria (Sambo, 2008). In the study, different fuel types excluding oil (Table 1) were used for an optimization. The shares of the different power generation technologies in the total installed capacity for the Reference Case are shown in Table 1.The share of hydropower (large and small) would decrease from 31.30% in 2005 to 8.6 in 2030, while the share of natural gas based power capacity will increase from 68.30% in 2005 to 78.6% in 2010 and thereafter decrease to 59.0% in 2030. Coal and nuclear, which are not currently used for power generation, will account for 15.6 and 6.7% by 2030, respectively. Solar and wind are also projected to account for 8.3% and 1.8% respectively by 2030.

Table 1: Future Installed Electricity Generation Capacity by Fuel, (Reference case), % (Source: Sambo (2008)).

| Fuel Type | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|
| Coal | 0 | 9.9 | 13.8 | 15.3 | 15.6 |
| Gas | 78.6 | 48.5 | 53.5 | 53 | 59 |
| Hydro | 21.3 | 18.9 | 13.6 | 10.7 | 8.6 |
| Nuclear | 0 | 9.4 | 5.3 | 8.3 | 6.7 |
| Solar | 0.1 | 13.1 | 11 | 10.4 | 8.3 |
| Wind | 0 | 0.1 | 2.9 | 2.3 | 1.8 |

Hydro consists of large and small HEP projects

Estimated total investment to meet the demand for the Optimistic Growth Scenario is US$ 484.62 billion (figs. 2 & 3). The Federal Government alone cannot provide this level of funding. Indeed, the state governments, private sector and foreign investors must be involved. Moreover, all the country's energy resources need to be deployed in order to achieve matching of supply with demand on a continuous basis.

**Adaptation to Climate Change impacts**

Climate change adaptation is a multi-dimensional and multi-stakeholder challenge that calls for much awareness raising and cooperation of efforts from public, private and civil societies across sectors and boundaries. An integrated water resources management (IWRM) approach should therefore be followed.

Climate Proofing Infrastructure

Climate proofing is a term for identifying risks to a development project, or asset as a consequence of climate change, and ensuring that those risks are reduced to acceptable levels through durable and environmentally sound, economically viable, and socially acceptable changes implemented at one or more of the following stages in the project cycle: planning, design, construction, operation, and decommissioning. Climate-proofing of infrastructure through relevant adaptation and risk-management strategies is thus a necessary component of sustainable socio-economic development. Relevant infrastructure includes water, electricity, dams, gas and oil wells and refineries, power stations and other energy-related extractive industries.

Power is one area where creating "climate proof infrastructure" could play a major role in the national and regional development. With so much of Nigeria suffering from a shortage of power already, the opportunity is there to not only help to expand the national power grid, but to do so in a sustainable, long term and carbon efficient way. This would necessarily create challenges for the current power supply in the country, through fossil fuels, but also provide opportunities for future power provision. This is where investigating the potential for climate proof, renewable forms of power – such as solar and wind power could be effective. While there would be cost and logistical challenges, the installation of renewable energy would also help to reduce the reliance on fossil fuels.

In the coastal and many inland areas flooding and erosion as well as severe storms are causing increasingly severe damages. This brings risks for the country's road, rail and even air networks, and the disruption that results from these events could have a strong negative impact on infrastructure and development in these areas.

The following focus questions provide a useful tool for shaping the conceptual and practical issues facing Nigeria with respect to climate change and infrastructure. How can national climate change governance arrangements be improved to facilitate infrastructure planning processes and outcomes that incorporate adaptation to climate change?

What is the vulnerability of infrastructure to existing and predicted climate change conditions at various spatial scales, considering average and extreme weather conditions (i.e., disasters)? How can climate-induced service or structural failure thresholds for infrastructure and services be integrated into decision-making, in light of the inherent uncertainty in climate projections? What impacts on key infrastructure could have downstream or cascading impacts during climate disasters, and how might these impacts be avoided? How can information, knowledge dilution and engagement with civil society and the private sector be optimised for adaptation implementation in those sectors and also to support adaptation actions by government with respect to infrastructure?

## Conclusion

Enhancing energy security and reducing climate change intensity and its impacts are conflicting objectives that require tradeoffs. As long as the quality, quantity and accessibility of water resources are declining, the promotion of supply of reliable, affordable and sustainable energy mix is also at stake. Therefore, water security is an additional dimension that must be taken into account when planning future energy systems. Thus the challenges surrounding water and energy consumption in the production of energy include developing and making available new technologies and demand management approach that will:

- reduce the energy sector's need for fresh water, including higher thermal efficiency;
- improve methods for predicting water-energy related impacts of climate change;
- increase the use and reuse of impaired waters for cooling and process requirements;
- decrease the energy required for water treatment; and
- remedy situations in which water supply limits energy production (inter-basin water transfer, rainwater harvesting, desalination, water treatment and recycling, evaporation suppression on reservoirs, lakes, increased irrigation efficiency, etc.).

It is obvious that Nigeria is endowed with abundant renewable energy resources like solar radiation (3.5 – 7.0 kWh/$m^2$-day), wind (2 – 4 m/s (annual average at 10m height), large hydro power (11,250MW), small hydropower (735MW) as well as biomass among others, which have minimal or zero supply logistic problems (ECN 2007). Hydropower should also target more micro and mini projects as they are more environment friendly, though perhaps less financially attractive.

Proper harnessing of those resources could lead to decentralized use and local implementation and management, thereby making sustainable rural socio-economic development possible through self-reliance and the use of local natural resources. For this to happen, the policy makers should make renewable energy development a priority policy of government at all levels. Lawmakers should also develop appropriate legal, regulatory and institutional frameworks that de-emphasize over-dependence on fossil fuels. Establishing and maintaining Information system which provides answers to the questions in 4.2.1 is also imperative.

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