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Innovation and Industrialization in the Energy Sector: The Way Forward

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Abstract: *Energy issues and climate change are rarely out of the news, indicating the paramount importance of these challenges, and highlights the growing need for Engineers who command the appropriate skills and knowledge to make a difference in the society. The technological challenges to be met to ease the energy problem are enormous. It is necessary to provide the planet with cost-effective energy, while diversifying supplies and massively reducing CO_2 emissions. We cannot limit ourselves to a single technology. A wide range of technologies must be developed simultaneously: technologies to improve energy efficiency for buildings and transport, technologies for renewable energy and nuclear energy, and technologies to promote more environmentally friendly use of fossil fuels. Therefore this paper highlights the role of Government, Scientist and Engineers in the development of these new technologies to satisfy Nigeria's growing and voracious demand for energy.*

Keywords: *Biomass, Solar energy, Wind Energy, Industrialization.*

I. Introduction

The importance of energy in our everyday life cannot be overemphasized. Energy contributes greatly in the Gross National Product of a country. One significant factor that is generally recognized as the best indicator of any nation's level of development, industrial strength and wealth is the amount of energy that is available and used by that country. This is because, in most cases, there is a strong statistical correlation between a country's energy consumption and its economic output [1]. The reason for this relationship is the reliance of the majority of the world's economic activities on the availability of energy [1].

For many years now, Nigeria has been besieged with perennial and regular power outages which have serious consequences on the citizenry and the economic development of the country. And over the last two decades, population surges in the cities have translated into overwhelming demands on electricity [2]. Therefore, radical change in the energy system is essential in the decades immediately ahead in order to address effectively the multiple economic, social, environmental, and insecurity challenges posed by this energy shortage. This can come about only through concerted effort of all and sundry to speed up the rate of technological innovation worldwide for technologies that offer promising opportunities for sustainable energy development. Suffice it to say that, innovation involves not just the development of new technologies, but also their demonstration in real-world contexts and their deployment at significant scale. Therefore, Innovation occurs through a complex set of interactions, most of which occur in the private sector. The best way to sustain innovation is to have technologies deployed in the field, where engineers and scientists can then begin to optimize existing technologies and work to improve them. Simply transferring technologies from developed countries to industrializing countries does not accelerate innovation. Industrializing economies need to develop their own innovation capacity and can best benefit from incremental improvements made in their industrial processes. That is why the Nigerian government, the academia and the private sector need to come to terms in ways of fostering innovation and industrialization.

II. Developing New Energy Sources

Currently, Nigeria's energy mix is dominated by the fossil fuels, i.e. oil and gas. However, to attain the vision 2020 intent, Nigeria needs to diversify its energy mix with renewable energy sources. Nigeria has vast renewable energy resources including hydro (small and large hydro power), solar, wind and biomass. Utilization of the nation's renewable energy resources will reduce the country's dependence on fossil fuels and provide an economically stable source of energy to the power generation mix [3].

The country needs to develop a technologically driven renewable energy sector that will harness the nation's resources to complement its fossil fuel consumption and guarantee energy security.

2.1 Developing Solar Energy Technologies

Studies relevant to the availability of the solar energy resource in Nigeria have fully indicated its viability for practical use. Nigeria lies within the tropical region between latitude 4^{o} N and 14^{o}N, where there is abundance of sunshine energy all year round [4]. The sun radiates its energy at the rate of about 3.8×10^{23} KW per second. Most of this energy is transmitted radially as electromagnetic radiation which comes to about $1.5kW/m^2$ at the boundary of the atmosphere. After traversing the atmosphere, a square meter of the earth's surface can receive as much as 1KW of solar power, averaging to about 0.5 over all hours of daylight [5].

Nigeria receives about 4.851×10^{12}KWh of energy per day from the sun. This is equivalent to about 1.082 million tonnes of oil equivalent (mtoe) per day, and is about 4 thousand times the current daily crude oil production, and about 13 thousand times that of natural gas daily production based on energy unit [6].

The availability of abundant sunshine is a positive indicator that Nigeria is an ideal candidate for investment in solar energy resource development. Therefore, Scientists and Engineers should stimulate solar energy inventions and innovations through the development of solar energy technologies such as:
(i) Photovoltaic systems (ii) Solar thermal devices (iii) Solar water heaters (iv) Solar crop, fish and Manure Dryers (v) Solar Chicken Brooders and many more.

This will go a long way in enhancing the health and wellbeing of the rural dwellers and also in stemming urban migration, which in itself will help to decongest the cities.
Some of the applications of solar energy are captured in the pictures shown below:

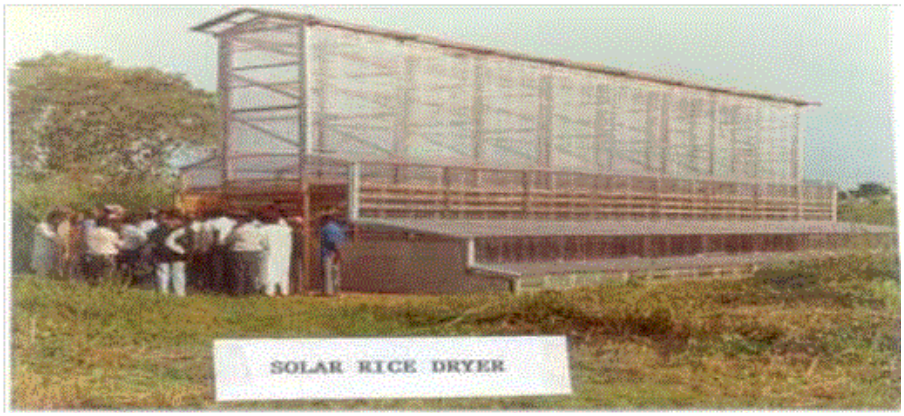

Figure 1: 2-tonne Solar Rice Dryer atAdarice Co. Enugu built by NCERD [7].

Figure 2: Solar Water Pumping for Students in Sokoto, Sokoto State [7]

2.2 Developing Biomas Technology

Biomass is a biological material derived from living, or recently living organisms. In the context of biomass for energy this is often used to mean plant based material, but biomass can equally apply to both animal and vegetable derived material [8]. Agricultural residues, animal and human wastes are regarded as biomass energy sources.

For a bio-dependent culture, it is not a surprise that much of the rural community's waste is biodegradable. This situation presents great opportunities to employ biomass technologies, such as "digesters" to generate biogas as a sustainable byproduct. The biomass energy resources of Nigeria have been estimated to be 144million tones/year. It is estimated that Nigeria consumes about 43.4x109kg of fuel wood annually. Over

60% of Nigeria's population depends on fuel wood for cooking and other domestic uses[3].The consumption of fuel wood is worsened by the wide spread use of inefficient cooking methods, the most common of which is still open fire. The rate of consumption of fuel wood far exceeds the replenishing rate to thus resulting in desert encroachment, soil erosion and loss of soil fertility.

One byproduct of biomass technologies is biogas. Biogas is described as [9] "a combustible mixture of gases produced by micro-organisms when livestock manure and other biological wastes are allowed to ferment in the absence of air in closed containers". The major constituent of biogas is methane. Plant biomass can be used as fuel in thermal power plants or converted to produce solid briquette, which can then be utilized as fuel for small scale industries. Biogas digesters of various designs are capable of sustaining household, industrial and institutional energy needs. Biofuels can also be derived from biomass and bio-waste, e.g. manure, crop residue. These are used to produce power, heat, steam and fuel through a variety of processes. These fuels are used mainly to power vehicles and industrial machines and provide heating. Biofuel is renewable and its use has expanded throughout the globe with Brazil, US, France, Sweden and Germany emerging the leaders in biofuel development.

Investment in biomass technology enterprise development will be revolutionary and will transform the urban and rural communities of Nigeria from the depths of filth and trash to a healthy and sanitary country. At the same time, it will generate sustainable biogas that will be used to power gas generators for the everyday community's energy needs. Therefore, Scientists and Engineers should gear more effort in producing biomass energy conversion devices and systems so that our community will be transformed from "waste" to "wealth". Some of the applications of biomass technology are shown below:

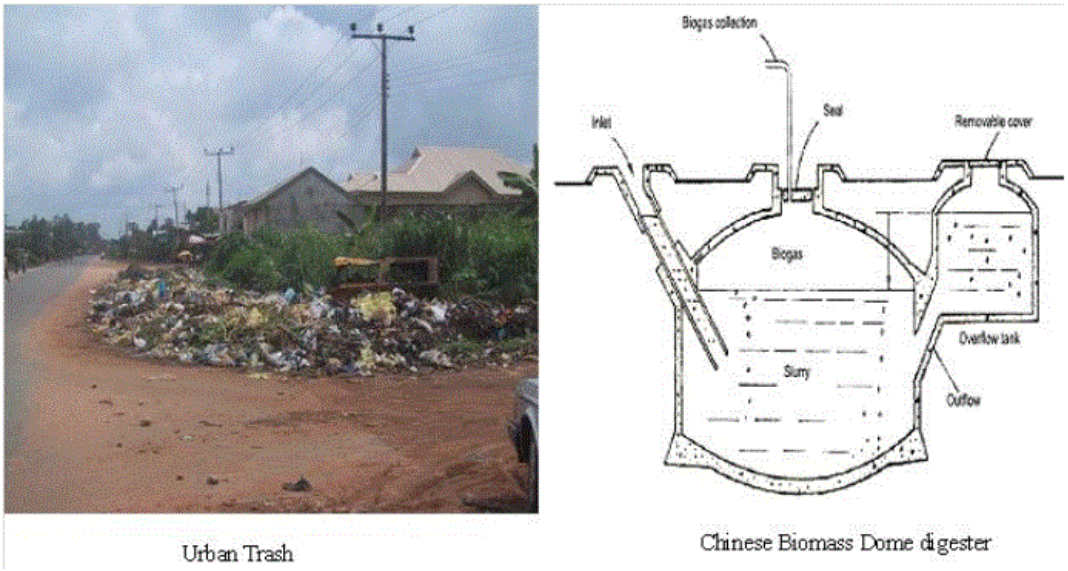

Figure 3: Biogas in China [10]

Figure 4: National Center for Energy Research and Development Biogas digester

Figure 5: A Typical 750 kW Bio-electricity Plant [11]

2.3 Developing Wind Energy Technology

Wind energy is used to generate electricity. A typical wind machine consists of blades, generator, cable, and a simple computer system. The blades catch the wind and spin, the generator converts mechanical energy into electricity, the cable carries electricity to transmission line while the computer system controls the direction of the blades. The wind flows over the airfoil shaped blades causing lift, like the effect on airplane wings, causing them to turn. The blades are connected to a drive shaft that turns an electric generator to produce electricity [12].

Utilization of wind energy is presently very minimal in the country. Already, the wind energy mapping of the country has been done. A study on the wind energy potentials for a number of Nigerian cities shows that the annual wind speed ranges from 2.32 m/s for Port Harcourt to 3.89 m/s for Sokoto. The maximum extractable power per unit area, for the same two sites was estimated at 4.51 and 21.97 watts per square meter of blade area, respectively. When the duration of wind speeds greater than 3 m/s is considered, the energy per unit area works out as 168.63 and 1,556.35 kWh per square meter of blade area, again for Port- Harcourt and Sokoto [3]

The mechanical power output of a wind machine may be expressed as:

$P_{out} = C_p$ (½ SAV^3)

Where C_p is Beltz limit (≅0.59)

A is Rotor swept Area

S is density of air

V is wind speed

Maximum theoretical efficiency of wind machine is about 59% (Beltz limit). Typical practical aero generator efficiencies lie between 10% and 30%. [11]

Wind electricity can be generated both onshore and offshore. But more wind power is generated offshore due to more wind. As a result of this, Scientist and Engineers should stimulate wind energy inventions and innovations by gearing more effort in developing wind turbines necessary for offshore investment. The figures below show example of wind energy projects:

Figure 6: Harnessing Wind Energy for Electricity Generation in Brazil [11]

Figure 7: 5kW aero generator in Sayya Gidan Gada, Sokoto State [7]

III. The Role Of Government In Encouraging Innovation And Industrialization In The Energy Sector

The investments a government makes to strengthen its innovation infrastructure can have a dramatic impact on the ability to attract domestic and foreign investment. In some cases, focusing on the points explored below can spur domestic innovation that has a longer lasting effect on the local economy.

Grants for Higher Education: Research universities have long been hotbeds of innovation. Fiscal investment in innovation thus can include the indirect investments to educate and train scientists and researchers, build world-class institutions and facilities, facilitate interactions with global communities to generate fresh ideas and new perspectives, and build structures to commercialize innovations. It's not just the university institutions themselves that carry out research and drive innovation. With the transition from industrial to knowledge-based economies, a highly educated workforce is critical to support innovation in the private sector. Without skilled employees, companies cannot grow and maintain competitiveness; there is a strong relationship between the strength of a country's higher education system and its overall ability to innovate.

Grants for Basic Research: Fiscal support for R&D is critical for any government hoping to encourage the formation and success of local companies that focus on creating new technologies. Typically, this support is provided through grants, loans, or contracts, or through investment in infrastructure. The infrastructure investment can take a physical form such as universities, buildings, labs, logistics, and transportation, or an intangible form such as university graduates. Since their risk/return calculus focuses more on public interest than on short-term profits, governments are better able to support basic research. Governments should focus their stimulus spending on new technologies such as clean energy technologies.

Inclusion of our Economic Development Board in the energy project: A successful strategy for attracting foreign investment and strengthening domestic innovation often includes the active participation of a country's economic development board. Singapore and Ireland have excelled at attracting foreign investment and developing their indigenous economies over the past several decades. Their economic development boards bear some of the credit for that success. They both recruited top local business talent for their boards, ensuring a depth of expertise and knowledge that have earned the respect of the international business executives who influence capital investment decisions.

Board staff members have several roles. Some serve as a kind of economic diplomat or missionary stationed abroad. They call on executives at multinational companies to inform them of the opportunities and advantages in their countries, and also to listen to the companies' priorities and concerns. Others help companies navigate the paperwork and regulations involved in various application processes.

Economic development boards that position themselves as partners to potential investors can have a positive influence on investors once the talk turns to incentives.

IV. Conclusion

Industrialization helps countries to achieve a high growth rate, diversify their economies and reduce exposure to external global shocks. Industrialization and structural transformation lead to intensive use of natural resources at the expense of the environment. Investing massively in energy will create an enabling environment for industrialization to take place in Nigeria. Therefore, greater effort is needed to create a dynamic response to alternative energy needs and guarantee their efficient management and maintenance. Nigeria needs to make use of its comparative advantage, using its natural resources as the corner stone of industrial development.

Successful industrialization requires leadership and government commitment to industrial development that will set the right tone at the top and make industrial development a top priority. It is crucial that governments translate the strong political will for industrialization into action and provide leadership at various levels to support certain strategic sectors in the overall long-term development. First, governments need to set

up the right policies and use the right policy mix to facilitate industrial development and secondly, the private sector should be confident about its political commitment to industrialization. In terms of choosing the right strategy based on internal and external realities, governments should also emphasize the critical role that industry plays in national development and must unequivocally and fully support industry and the private sector through demonstrable commitment to private sector development and by providing visionary and effective leadership needed to carry it through.

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