NANOTECHNOLOGICAL SOLUTIONS FOR NIGERIA'S ELECTRICITY SUPPLY PROBLEM*

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(*Recieved*: November 2007; *Accepted*: June 2008)

Abstract

It is no more news that Nigeria's electricity supply is epileptic and erratic. This affects production outputs and productivity in every sector of the economy. Various governmental efforts have so far proved abortive. The option of using generators have high cost of maintenance, and other alternatives are either not feasible in the near term or are politically sensitive, as in nuclear power generation. Also, conventional solar cells are still prohibitively high.

This paper proposes cheap and efficient nano-based photovoltaic cells for electricity generation and supply in Nigeria – *a nano photovoltaic cell for every roof.* The energy generated from the sun would be stored in inverters or other energy storage facilities like supercapacitors and superconductors during the day and would be useable during the night.

Keywords: *Nanotechnology,nano photovoltaic cells, Electricity Generation and Supply, Hybrid Energy Building*

1. Introduction

Energy consumption tracks with Gross National Product (GNP) in any country. The consumption level is highest in the United States (US) with 11.4kW per person. It is 6kW per person in Japan and Germany, and the lowest figures are among the developing countries – 0.5kW in India. (There is no figure for Nigeria, but it may be around 0.0025kW!). The lack of access by the poor in the developing countries to modern energy services contributes one of the most critical links in the poverty cycle. This in the long term is a hindrance to national development and in fact to 'Sustainable Development'.

Electricity is a major factor in energy utilization. In Nigeria, the generation of electricity is overseen by the Power Holding Company of Nigeria (PHCN).

For a brief history; the Electricity Corporation of Nigeria (ECN) was established by ordinance No 15 of 1950 and was responsible for controlling all the existing diesel/coal isolated power plants in Nigeria, then. Decree No 24 of 1st April 1972 later merged the Niger Dams Authority (NDA) with ECN to form the National Electric Power Authority (NEPA). In 2004, the Federal government carried out some power sector reforms in which PHCN was established after NEPA was re-organized into six succession generating companies, one transmission and eleven distribution companies.

The then NEPA and now PHCN have not been able to deliver uninterrupted power supply to the country. The problems are numerous, viz;

Location	Current (MW)	Installed Capacity (MW)
Kainji	122	760
Jebba	166	578.4
Shiroro	376	600
Egbin	179	1320
Ajaokuta	70	-
AES	68.2	300
Sapele	67	1020
Okpai	480	480
Afam	260	969.6
Omoku	74	150
Delta	353	912
Total	2215.2	

Fig.1: Power generation distribution in Nigeria (Guardian 2007)

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* Presented in part at the First Faculty of Science Conference, Obafemi Awolowo University, Ile-Ife, July 3-5, 2007.

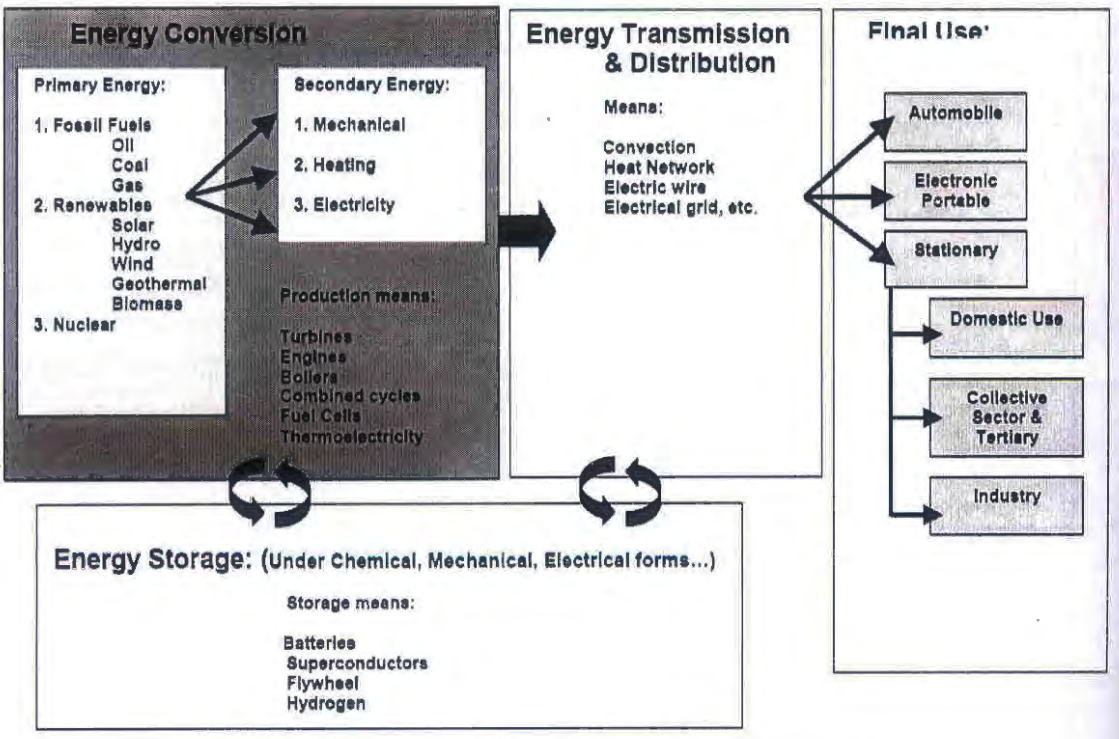

Fig. 2: Primary and Secondary Energy Sources (Nanoforum 2007)

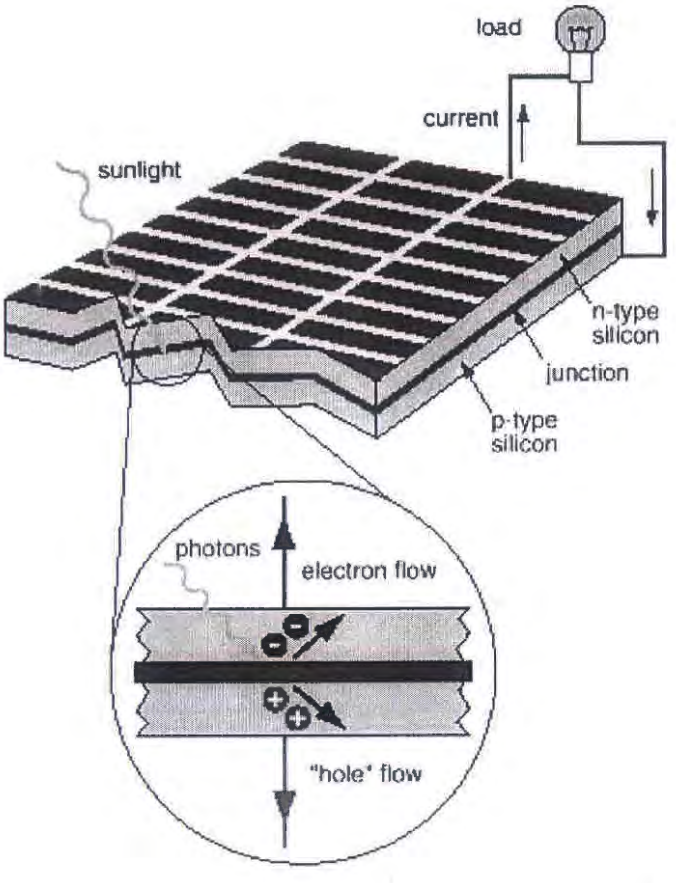

Fig. 3: The working principle of a Solar Cell (Acre 2003)

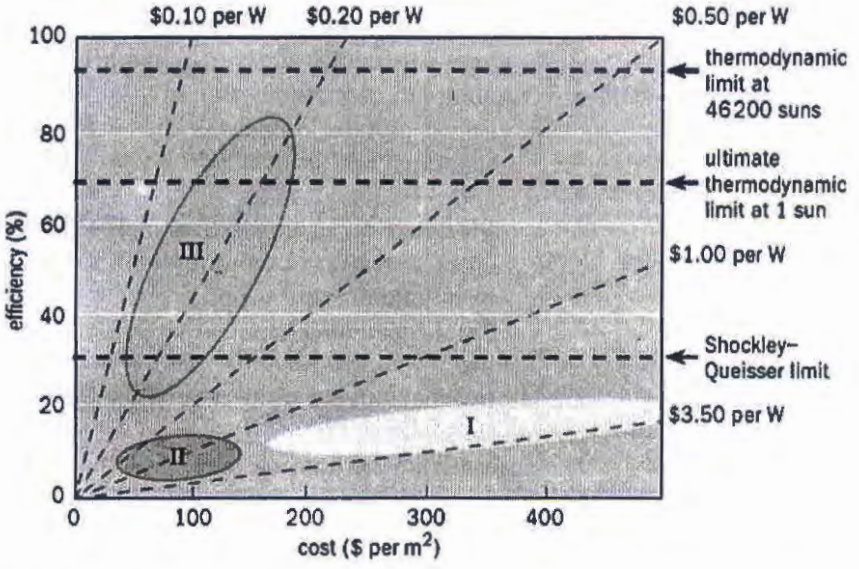

Fig. 4: Efficiency versus cost for the three generations of solar cells (Cartlidge 2007)

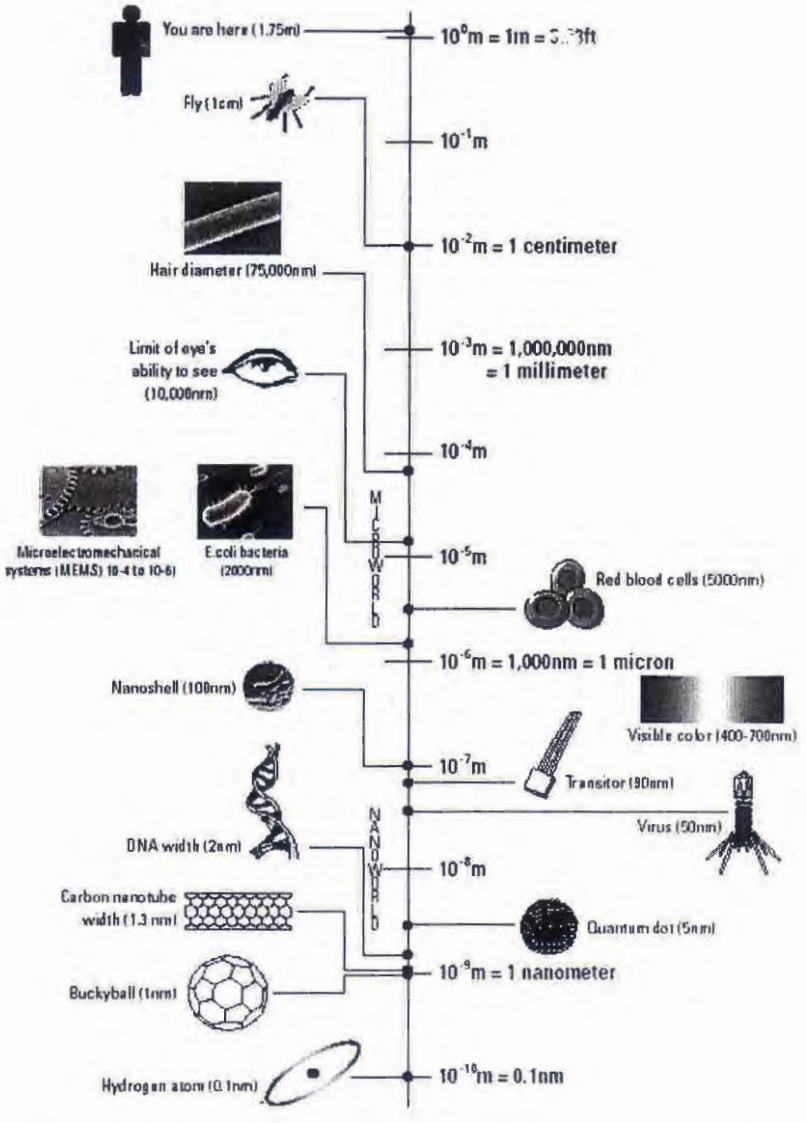

Fig. 5: Size Comparisons from the Macroworld down to the Nanoscale. (The Hitchhiker's Guide to Nanotechnology, 2006)

Low power (electricity) generation

It is obvious that Nigeria is not generating enough power. As at Thursday, 28th June 2007, the national power generation dropped to barely 2000MW, because of restriction in gas supply to some power stations. The problem has accumulated over time, because, for twenty years Nigeria didn't build new power stations. Recent distributions of power generation across the country are shown in figure 1. (The installed capacity for Ajaokuta plant is not available.)

However there are four newly built plants with installed capacity of 1234 MW, namely: Papalanto – 335MW, Omotosho – 335MW, Ibom Power – 150MW and Geregu – 414MW. With a total installed capacity of about 8000MW, this is still grossly inadequate. A country like Iran generates 42000MW of electricity, South Africa generates 36000MW and Egypt generates 23000MW. The recent twenty five-year power sector development plan for Nigeria is 25000MW and to be completely free from power outages, we need to generate 104000MW!

Corruption

Another major challenge is corruption. A national corruption survey in the Nigeria Corruption Index (NCI), 2007 and released by the Independent Advocacy Project (IAP), identified the Nigeria Police as the most corrupt organisation in Nigeria, *closely followed by the* ***PHCN***, then the Federal Ministry of Education, then Customs and Excise Department et cetera. The FRSC and the NRC were described as the least corrupt organisations.

Other challenges facing PHCN are the following, viz; sabotage, vandalism, inadequate billing and poor revenue collection practices, un-metered consumption, theft of electricity and technical losses. The question is how long would Nigerians wait for the realization of an interrupted power supply in the country?

Electricity

Electricity is the flow of charges and it is a secondary energy source. It is generated from other primary energy sources like, coal, oil, natural gas, nuclear power and so on. (See figure 2).

Figure 2 Primary and Secondary Energy Sources (Nanoforum 2007)

Electricity generation

Mostly, electricity is produced at power plants with the use of steam turbines. Mechanical energy is converted to electrical energy by using various energy sources. The different fuels are used to heat water in a boiler to produce steam, which in turn is used to rotate a shaft that is connected to a generator, to produce electricity. Also, electricity can be produced using solar energy, which is the focus of this paper. Other generation methods use, solid-state generation (without moving parts), Thermoelectric (TE) devices, Thermionic (TI) devices and Thermophotovoltaics (TPV).

Current Electricity Delivery Systems

The current electricity delivery systems can be grouped under three methods, namely:

- Large generation plants that are widely separated and connected to a broad-based grid
- Moderate-sized generation plants that are close to a user community and connected by a limited-area mini-grid
- Small generation plants that serve a single user

The last two methods are known as distributed energy generation systems.

The author is of the opinion that given the various problems and challenges facing PHCN, the path to the power supply solutions in Nigeria is via the decentralized energy generation. This paper is proposing nano-based solar cells for every roof in Nigeria for electricity generation solely, or to complement the existing facilities.

Solar Energy – (Generating electricity from sunlight)

The sun that reaches the earth's surface delivers 10,000 times more energy than we need on earth. In one hour, the sun delivers the same amount of energy as consumed by all humanity in a year. In 2004, the total world wide energy consumption was 15TW (1.5x1013W). Solar energy is essentially inexhaustible and it generates neither greenhouse gases nor other harmful pollutants.

The problem is that presently, the cost of producing electricity from solar energy is high, up to a factor of ten, more that other leading methods. Electricity produced by photovoltaic solar cells costs $0,30 per kWh, by wind the cost is about $0.05 kWh and the cost is $0.03 by natural gas.

Solar cells can be categorized into different generations.

First generation solar cells

These are single layer p-n junction diodes made from monocrystalline silicon wafers.

These conventional cells are made using processes that require high temperatures, expensive equipment, high purity and controlled environment. *The process is extremely wasteful!* The majority of solar cells on the market are the first generation cells. The working principle of this type of cell is shown in figure 3. The silicon is sandwiched between two electrical contact layers. Sunlight passes through the top contact layer, and is absorbed in the silicon and generates electron-hole pairs. The electrons and holes are separated by the diode and the charges drive current in the circuit.

Second generation solar cells

Second generation solar cells use thin films of silicon and other semiconductor compounds like cadmium

telluride. They are cheaper, but are less efficient, because they suffer from structural defects.

Third generation solar cells

The third generation cells do not rely on the traditional p-n junctions. Examples are polymer solar cells, nanocrystal solar cells. (Solar 2007)

Figure 4 shows three generations of solar cells with their efficiencies.

Some nanotechnological based solar cells are the following, namely: nanowires, hybrid polymers, spray-on coatings, Gratzel Cells and quantum dots. There are considerable interests in these technologies with views of making cheap and efficient cells.

The performance of a solar cell is measured in terms of its efficiency, which is the ratio of the electrical power generated to the power of the light incident on the cell.

The efficiency of first generation cells is from 6% to 33%, for nanotechnology based solar cells, the efficiency is between 0.15% and 65%.

Nanotechnology

Nanotechnology is the manipulation of matter at the nanoscale in order to take advantage of the materials properties that dominate at that scale.

The potential applications of nanotechnology are enormous, and these include quantum computers, computers 1000 times faster and cheaper than the current models, biological nano-robots that can identify and fix cancerous cells, towers, bridges, and roads made of unbreakable diamond strands, buildings that repair themselves or change shape on commands, (Reith, 2003) and nanofactories, which would deliver products on demand

The prefix nano has its origin in Greek, which means dwarf. In modern scientific parlance, a nanometer is one billionth of a metre (See Figure5). Nanotechnology, as we know it now, was first proposed in 1959 by Richard Feynman, in an after-dinner lecture, titled, "There is plenty of room at the bottom" (Feynman, 1959).

Cost Implications

A lot of work is going on nano-based photovoltaic cells and particularly in the industry. **Kornaka** is focused on the development and advancement of nano-enabled polymer photovoltaic materials that are light weight, flexible and more versatile than traditional solar materials. **Bulovic** is fabricating quantum dots photovoltaics using microcontact printing process. Also, recently **Nanosolar** sourced for $100 million dollars for the production of cheap solar cells, with developed proprietary high-yield, high throughput thin film process technology.

To be optimistic, the cost of buying and installing the photovoltaic cell for every building should be in the neighbourhood of fifty thousand naira – depending on the requirements.

The viable storage technologies would be inverters, flywheels, supercapacitors and superconductors.

Figure 5 Size Comparisons from the Macroworld down to the Nanoscale.

(The Hitchhiker's Guide to Nanotechnology, 2006)

2. Conclusion

With the present advancement in technology, it would be possible in the next five to ten years to have disruptive solar technology with inexpensive conversion system and effective storage system. The goal would be, hopefully nano photovoltaic cells on every roof in Nigeria to have hybrid energy building!

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