Solar Power Technology (SPT) As an Alternative to Power Generation

***Dahiru Dahuwa[1] Ibrahim Bello[2] and Abdu Ibrahim[3]**
Department of Physics, School of Science,
College of Education, Azare,
Bauchi State, Nigeria
*dahirudahuwa@yahoo.com

Abstract
The study of renewable energy sources has been of universal concern to the world, and has led many institutions and organizations like the European Commission and others to undertake research on sustainable approach to meet the challenges of sustainable energy generation. The electricity generating usually begins with chemical energy and the primary energy type, and the chemical energy converted into thermal energy by combustion. And the thermal energy is then converted into mechanical energy which in turn a change into electrical energy, which also rarely occurs in nature. Virtually, all the electrical energy in use today is manmade. A critical challenge that continues to constrain the advancement of many developing countries is the prevalence of poverty. Nigeria is well positioned to up-scale the use of renewable energy

Introduction

According to B.G. Ishaku , After Food the basic essential for mankind next is the power (energy). Both of which can traced to solar energy (i.e. the renewable energy that that comes to the earth from the sun). sun heat ,sun light wind are traditionally referred to as solar energy of which their renewability occur naturally. Basically we have three types of energy namely: electrical, chemical and thermal energy. And then they are interchanged. The electricity generating usually begins with chemical energy and the primary energy type, and the chemical energy converted into thermal energy by combustion. And the thermal energy is then converted into mechanical energy which in turn changes into electrical energy, which also rarely occurs in nature. Virtually, all the electrical energy in use today is manmade. The first person to show that electrical energy can be made and controlled by man was Michael Faraday in 1821. He showed that, little motion between a magnetic field and a conductor always resulted the generation of electrical energy. This manner of producing electricity by way of mechanical energy still remains the most widely method of generating electrical energy. Electrical power generation is therefore, perhaps described as the method of converting various form of energy mostly mechanical energy into electrical energy. Since the oil embargo in 1973, oil prices have persistently skyrocketed to levels that have threatened the economy of many countries. The quest to develop a cheaper and non-polluting source of energy has been on the front burner of the agenda of several countries. Ever since the 1973 crisis, the study of renewable energy sources has been of universal concern to the world, and has led many institutions and organizations like the European Commission and others to undertake research on sustainable approach to meet the challenges of sustainable energy generation.

From the onset, it is important to remark that the five renewable energy sources used most often are: Biomass (including wood and wood waste, municipal solid waste, landfill gas

and biogas, ethanol and biodiesel), Water (hydropower), Geothermal, Wind and Solar and other sources of energy that are obtained from sun energy and that are renewed indefinitely as a course of nature. Renewable energy is a viable alternative for GHG emitting sources of energy. Renewable energy is a clean energy system that has no effect on the environment during or after generation. This fact has led to the drive by nations to strive towards the use and continuous improvement on solar energy as an appropriate approach and strategy to reduce greenhouse effect in the future. This scenario has also helped developed and developing countries to take full advantage of this free gift of nature to promote ecological and social innovation that will ensure more sustainable economy growth, conservation of the environment and stability of the social system.

A critical challenge that continues to constrain the advancement of many developing countries is the prevalence of poverty. In spite of abundant solar energy, most developing nations lack stable power supply. This is due to low technological advancement, pervasiveness of poverty, pitiable corporate governance culture, and poor management of existence facilities. It is widely acknowledged that access to electricity is an essential ingredient for the growth and development of any nation's economy. It is also regarded as a vital requirement for modern economic and social development. These assertions stem from the fact that electricity opens the door to a host of technologies that promote quality education, enhanced public health, and economic development. These technologies include emissions-free light, refrigeration and communication devices. Without electricity, communities are unable to participate in the benefits of modern advances and are left isolated and literally in the dark.

Therefore, solar collectors harvest solar Power Technology in the form of heat while solar PV panels harvest solar energy in the form of electricity and are manufactured with varying electrical outputs ranging from a few watts to more than 100 watts of direct current (DC) electricity. For the developing countries (such as Nigeria) where there is an acute shortage of conventional source of energy, solar radiation data is still very scarce. However, many attempts have been made to develop models that can predict the amount of solar radiation available at a given place from a few input parameters.

Energy Demand and Supply

Nigeria is a country in West Africa with rich energy resources such as petroleum natural gas, coal, tar sand, and biomass. Its economy is majorly dependent of revenue accruing from oil production and export. Also, Nigeria relies heavily on fossil fuel to meet her energy needs. For instance in Nigeria, electricity produced from fossil fuel and hydro power account for 61.9 percent and 38.1 percent, respectively. From a financial viewpoint therefore, and since Nigeria is endowed with massive fossil fuel reserves, and also since the majority of the power generating systems in Nigeria rely on petroleum products, it is very likely that the use of fossil fuels will remain an attractive source of energy for Nigeria for a long time to come. The nation should however recognize that the emissions of greenhouse gases from the use of fossil fuels such as coal and petroleum products has led to increasing concerns worldwide, about global climate change. While Nigeria is well endowed with renewable energy resources that can be sustainable alternatives to fossil fuels, so far, these have remained largely untapped.

The Nigerian government has the potential to strengthen the role of renewable energy as an alternative source. Electric power is the most widely used form of power in the industrialized countries. However, the situation in developing countries is different. People are struggling to receive enough power even for their basic needs. It is believed that Nigeria has problems with her power sector, which operates well below its estimated capacity. It is also estimated that about

20 percent of the total electricity generated by the Power Holding Company of Nigeria (PHCN) is lost through transmission and distribution before reaching the customers, and that as a result of the inadequate electricity supply.

The Nigerian commercial demand for energy is projected to continue its upward trend, Consumption growth is mainly driven by industrialization, as it is a common perception that a nation's economy and use of energy will always grow hand-in-hand. The Nigerian government has included renewable energy in the country's energy supply mix (portfolio) to diversify its energy source.

It is recognized that energy is central to all human activities and that it is needed to support development. Access to energy is inevitable for poverty alleviation, and if Nigeria is to achieve development targets and meets the millennium development goals (MDGs). The National energy supply is at present almost entirely dependent on conventional energy sources, which are depleting fast.

The Oil and Gas Journal (OGL) stated that Nigeria's proven reserves of oil in January 2007 accounted for 36.2 billion barrels and it is likely to expand to 40 billion barrels by 2010 (Sambo 2005).

Potential for Solar Power Technology in Nigeria

Photovoltaic, or "PV" solar panels and other devices capture the energy in sunlight and convert it to electricity produce solar power. This electricity can then be fed directly to a consumer, an electric power grid, or a storage device. Typically, solar panels are installed on the roof of residential or domestic buildings, and use the power generated to meet the owner's energy needs and provide surplus electricity to the grid. Other applications include heating water and providing power in areas where electricity connections are not available.

Nigeria has several advantages for the development of a solar power technology industry. Nigeria lies between a high sunshine belt and thus has enormous solar potentials. The nation is endowed with an annual average daily sunshine of 6.25 hours, ranging between about 2.5 hours at the coastal areas and 9.0 hours at the far northern boundary (Solar Energy International 2011). Similarly, Nigeria has an annual average daily solar radiation of about 5.25 KW/ m2/day. This varies between about 3.5KW/m2 /day at the coastal areas and 7.0KW/ m2/day at the northern boundary.

it can be estimated that only about 3.7 percent of the national land area is needed to be utilized in order to annually collect from the sun an amount of energy equal to the nation's conventional energy reserve. Nevertheless, Nigeria needs to generate fourteen to fifteen gigawatts of power but as at march 2008, it only had the capacity to generate four gigawatts of electricity. Knowing that Nigeria has an annual average daily solar radiation of about 5.25 kWh/m^2/day, and average sunshine hours all over the country of about 6.5 hours (B.G.danshehu*et al.* 2005). Some amount of certainty has been created suggesting that implementing a solar strategy is a great opportunity to implement infrastructure in previously difficult areas.

Solar Electric (Photovoltaic) Conversion

Solar-electric (photovoltaic) conversion is the direct conversion of sunlight in to electricity through a photocell. This could be in a centralized or decentralized fashion. So-lar-electric (Photovoltaic) technologies convert sunlight directly into electrical power. Photovoltaic system is made up of a balance of system (BOS), which consists of mounting structures for modules, power conditioning equipment, tracking structures, concentrator systems and storage devices. Photovoltaic conversion could be small scale for stand-alone systems or large scale

connected to national grid Solar cell also referred to as photovoltaic (PV) cells, which as the name implies (Photo meaning "light" and voltaic meaning "electricity"), convert sunlight directly into electricity. Panel stands for a group of modules connected mechanically and electrically. A module is a group of cells connected electrically and packaged into a frame (more commonly known as a solar panel), which can then be grouped into larger solar arrays.

. In addition to that, photovoltaic solar generation is energy conversion of sun light into electricity using photovoltaic cell (solar cell) to absorb the sun light and convert it into electrical current. Solar power generation uses small rays to heats fluids, from which heat transfer systems may be use to produce steam. The steam in turn is converted to mechanical energy in a turbine and into electricity from a conventional generator coupled to the turbine. Greater levels of sophistication are aimed at reducing the amount of thermal lost from the collector surface at a given temperature. This allows energy to be collected more efficiently and at higher temperatures for various devices for collecting solar radiation thermally. At the simplest level, a plat metal blade painted black and placed on the sun will heat up until it reach the temperature where the heat loses to the air around it and also radiating itself which exactly balances the amount of energy received from the sun. This stagnation of temperature occurs at around 80^0C for a simple plat plate. (Sambo *2005).*

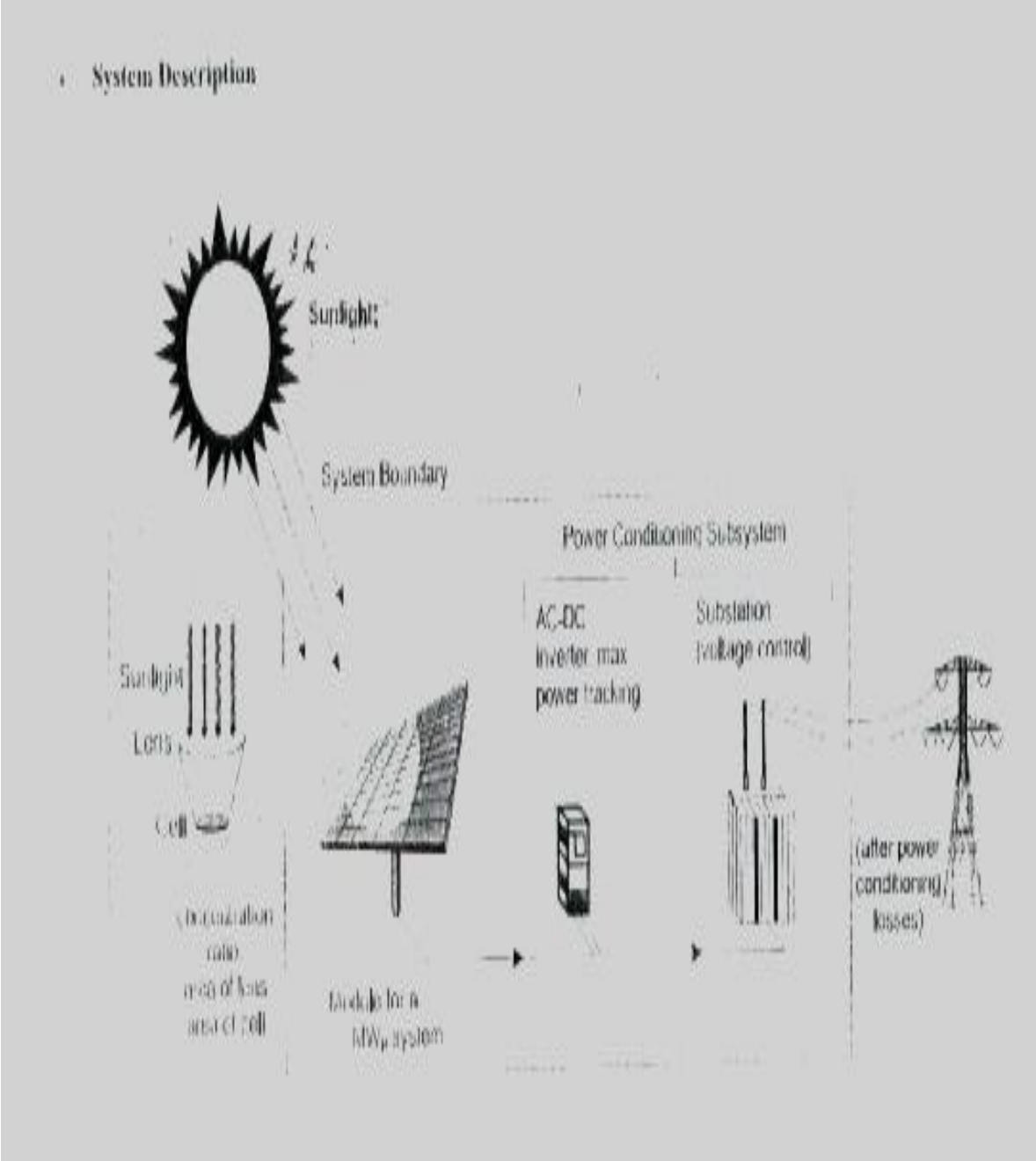

Fig. 1 Schematic of a large-scale photovoltaic system.

Photovoltaic cells are made of special materials called semiconductors such as silicon, which is most commonly used. Basically, when light strikes the cell, a certain portion of it is absorbed within the semiconductor material. This means that the energy of the absorbed light is transferred to the semiconductor. The energy knocks electrons loose, al-lowing them to flow freely. PV cells also have one or more electric field that acts to force electrons freed by light absorption to flow in a certain direction. This flow of electrons is the current, and by placing metal contacts on the top and bottom of the PV cell, we can draw that current off for external use say, to power a calculator. This current, together with the cell's voltage (which is a result of its

built-in electric fields), defines the power (or wattage) that the solar cell can produce. PV modules are integrated into systems designed for specific applications. The components added to the module constitute the "balance of system" or BOS. Balance of system components can be classified into four categories

Deep Cycle Battery store electricity to provide energy on demand at night or on overcast days. They are designed to be discharged and then re-charged hundreds or thousands of times. These batteries are rated in amp hours usually at 20 hours and 100 hours. Like solar panels, batteries are wired in series and/or parallel to increase voltage to the desired level and increase amp hours;

Inverters Required converting the direct current (DC) power produced by the PV module into Alternating current (AC) power. Most solar power systems generate Dc current which is stored in batteries while nearly all lighting, appliances, motors and so on, are designed to use AC power, so it takes an inverter to make the switch from battery-stored DC to standard power (120VAC, 60Hz);

Charge Controller: A charge controller monitors the battery's state-of-charge to insure that when the battery needs charge current it gets it, and also insures the battery isn't over charged. Connecting a solar panel to a battery without a regulator seriously risks damaging the battery and potentially causing a safety concern;

Structure Required mounting or installing the PV modules and other components. Not all systems will require all these components. For example in systems where no AC load is present an inverter is not required. For on-grid systems, the utility grid acts as the storage medium and batteries are not required. Batteries are typically not required for PV water pumping systems, where a water reservoir "buffers" short-term demand and supply differences. Some systems also require other components which are not strictly related to photovoltaic.

Solar Panel Placement and Orientation

Solar panels should also be inclined at an angle as close to the area's latitude as possible to absorb the maximum amount of energy year-round. A different orientation and/or inclination could be used if you want to maximize energy production for the morning or afternoon, and/or the summer or winter. The modules should never be shaded by near trees or buildings, no matter the time of day or the time of year. In a PV module, if even just one of its cells is shaded, power production can be significantly reduced. Optimally, the angle of the panels is set to provide the most exposure to direct sunlight. The caveat is that the optimum angle which depends on latitude, as the sun's height in the daytime sky will be different for all. To determine the optimum angle for solar panel, the following instructions are generally adhered to.

1. Calculate latitude using a global positioning system, GPS, map an Atlas or even from Google Earth. An easy to read sun map with key information such as the number of hours of sunshine, its intensity and so on is created. This will be used to calculate the optimum angle
2. Add 15 to the calculated latitude (This is the rule of thumb for even production throughout the year).
3. Ratchet systems can be installed to raise or lower the angle or panel can be adjusted manually

Effect of Temperature on PV

Like all other semiconductor devices, solar cells are sensitive to temperature. Increases in temperature reduce the band gap of a semiconductor, thereby effecting most of the semiconductor material parameters. The decrease in the band gap of a semiconductor with increasing temperature can be viewed as increasing the energy of the electrons in the material. Lower energy is therefore needed to break the bond. In the bond model of a semiconductor band

gap, reduction in the bond energy also reduces the band gap. Therefore increasing the temperature reduces the band gap**.**

In a solar cell, the parameter most affected by an increase in temperature is the open-circuit voltage. The impact of increasing temperature is shown in the Fig.2 below

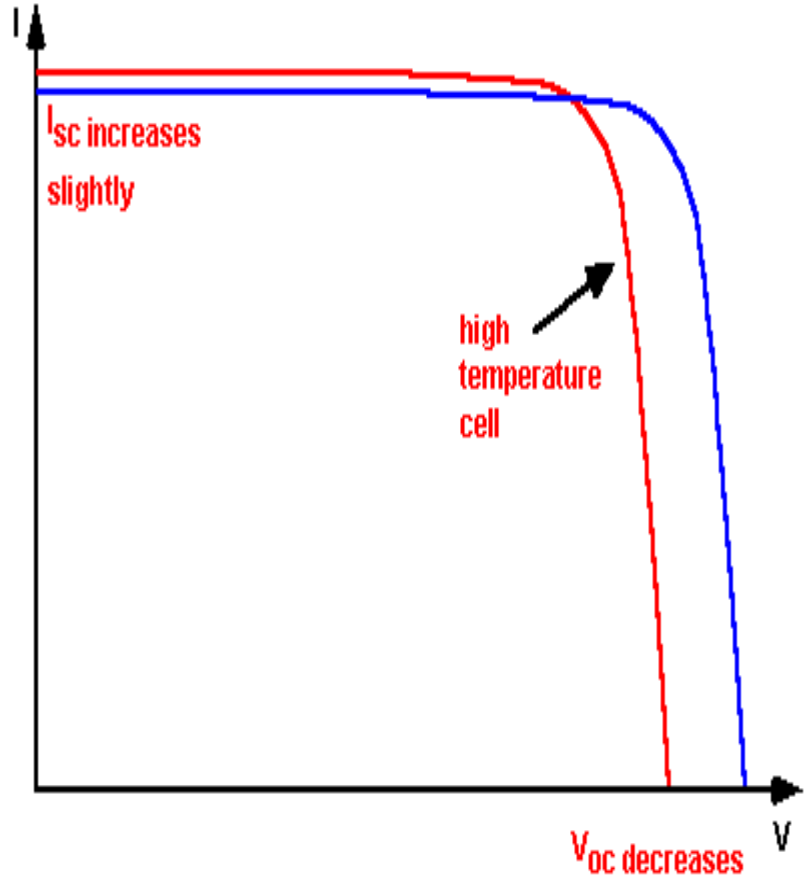

Fig. 3 The effectof temperature on the IV characteristics of a solar cell.

The open-circuit voltage decreases with temperature because of the temperature dependence of I_0. The equation for I_0 from one side of a p-n junction is given by;

$$I_0 = qA\frac{Dn_i^2}{LN_D}$$

Where:

I_0 is the saturated current

q is the electronic charge given in the constants page;

D is the diffusivity of the minority carrier given for silicon as a function of doping in the Silicon Material Parameters page;

L is the diffusion length of the minority carrier;

N_D is the doping; and

ni is the intrinsic carrier concentration given for silicon in the Silicon Material Parameters

However, temperature can affect how electricity flows through an electrical circuit by changing the speed at which the electrons travel. Also, since solar panels work best at certain weather and temperature conditions, engineers design ways to improve the efficiency of solar

panels that operate in non-optimal temperature conditions. This might involve designing cooling systems that use outside air, fans and pumps.

Now that we know the effects of temperature on the power output of PV panels, what do you think would be an ideal climate in which to set up a large PV system? (Answer: A cold and sunny climate.) Do you think there are many places in the world like this? If you look up maps on Google images of world temperatures and world solar radiation availability, you will find that most locations are not ideal for solar

PV Panels. This means engineers have many opportunities to design innovative systems to keep panels cool as solar power plants become more common, because the ideal cool and sunny climate is rare.

The Environmental and Economic Importance of Solar Power Technology

Solar energy is both environmentally and economically important to every nation. Hence it plays a key role in cost effectiveness of any nation's economy. It also creates among other benefits, direct employment of labor and fosters the development of micro- industries. Economic considerations appear to be the most important factor that drives the process of the generation of solar energy systems. Factors other than economic that are considered when deciding whether or not to use solar energy include issues of pollution, greenhouse gas generation and the security of the energy resources, among others. The cost of energy produced however appears to almost exclusively dominate design decisions. Environmental factors are however also becoming increasingly significant in such decision making procedures.

The Economic Perspective

The economic benefits of the application of solar power technology are as follows:

i- It helps to extend the productive work-day.

ii- It provides a constant and superior lighting at minimum cost compared with other energy generators or the use of power from the public system.

iii- Solar power technology helps to create enhanced direct and indirect employment opportunities.

iv- Solar power technology assists in conserving the nation's foreign exchange. This is because some of the earnings from export which would otherwise have been spent on importation of various spare parts of power generators would then be saved. Moreover, the money so saved can be deployed to other sectors like health and education that require attention.

v- Despite the challenges of power shortages and sometimes complete unavailability of same, microenterprises have still survived.

It may be added that solar energy is environmentally friendly. This is because the energy produced by the system is very clean. Besides, when compared with the economic indices of other power generating systems of similar capacity averaged over the lifetime of such systems, the economic parameters of the solar energy system is superior per unit of power produced. For this reason solar energy systems should be financially supported by the government and industrialist in order to reduce the cost of implementing the solar panel for industrial, commercial as well as residential consumers.

Abundant Supply*:* Solar power could meet today's electricity demand by PV systems covering only 0.4 percent of the nation in a high sunlight area such as the Southwest – an area about 100 square miles. These panels, in reality, will be installed across the country on roofs and other structures close where it is consumed.

Technologies such as PV roof shingles, windows, and flexible fabrics that are easily and cheaply integrated in to new and existing buildings are emerging.

***Secure and Stable Supply*:** Because solar power is generated domestically, often at the site where it will be consumed, prices and supplies are immune to blackouts, international uncertainty and do not rely on long distance supply networks.

***Cleaner Air**:* Solar power does not pollute air or water. It replaces electricity generated from facilities powered by coal, natural gas and other non-renewable fuels, eliminating threats to public health such as carbon monoxide, particulate, and toxic chemical emissions from those facilities. Additionally, when a solar power replaces electricity from coal-fired power plant, it also eliminates a potential source of sulfur emissions that is a major component of acid rain.

Reducing Global Warming: Solar power does not produce CO2 or any other greenhouse gases, thus helping to reduce the risk of climate change.

The Environmental Perspective

In this part of the paper, the economic impact of the fossil fuels will be examined. Also, the environmental advantages and disadvantages of the solar energy will be discussed.

***Fossil fuels impact on the environment**:* The largest disadvantage of the fossil fuels is the emission of carbon dioxide to the atmosphere, which creates the "greenhouse effect". Also, this type of energy not only affects the degradation and deforestation of land but as well water, air pollution, human illness and accumulation of solid waste. Those factors contribute to the current issue of the global warming, formation of the smog, endangerment of the flora, fauna and marine life, and others. Furthermore, burning coal produces sulphur dioxide that contributes to the formation of the acid rain. The open mining coals, so called "strip mining", harms the environment by destroying quite large areas of the landscape (Energy resources 2012).

Environmental Benefits of solar energy: As solar energy is produced purely from the Sun, it does not emit any carbon dioxide (CO2) gasses. This prevents greenhouse effect. It is calculated that a one kW PV system prevents 300 lbs. of CO2 gases from entering the planet every month. Furthermore, NO and SO2 gases are not produced at all and this helps to reduce acid rains (Solar Energy International 2011).

An indirect advantage of solar energy is that when people use electricity created by solar energy plant, then they do not have to use diesel generators, kerosene or flashlights for lightning their everyday life. This is mainly an issue in developing countries. Flashlights are included, because they use batteries, which, if not disposed properly, are a huge threat for soil and underground water, as they contain lead-acid cells.

Besides all the environmental advantages, there are some advantages of other types which contribute to better quality life:

a- Solar energy plants do not generate any noise (unlike as diesel generators).
b- Very little maintenance is required because there are no moving parts
c- All the environmental advantages result in better health of citizens
d- Solar energy plants can be easily expanded by the addition of extra solar panels.
e- Solar panels have long term warranties of up to 25 years, which is much higher than alternative plants.

In terms of physical size, small or mid-sized solar energy plants are much smaller than coal or other fossil fuel-powered energy sources

CONCLUSION

In Nigeria, Despite the installed petroleum products refining capacity of 445,000 barrel/day, and electricity generation capacity in excess of 6,000 MW, it was revealed that at a

point in time, while electricity generation was about 3,000 MW; an amount that is grossly inadequate for the nation's needs. Coal and other renewable energy resources are grossly underutilized in the country despite their availability in reasonable quantities. Huge investment is required to upgrade and expand our power generation, transmission and distribution systems, which government alone cannot provide in view of other pressing demands of the economy. Good potentials exist in the upstream business in the offshore, on-shore and inland basins of the country, as well as in the downstream oil and gas business. Similar potentials exist in the power sector. The level of utilization of the nation's huge renewable energy resources is rather too low. With the vast renewable energy resource and a National Energy Policy, as well as a National Renewable Energy Master plan. Nigeria is well positioned to up-scale the use of renewable energy (Sambo 2009). Like South Korea, apart from generating clean energy, the project creates an opportunity for direct investment in the Nigerian economy that could simultaneously qualify for 'clean development mechanism' credits, allowing for trading of Certified Emission Reductions under the Kyoto Protocol. It is perhaps important to explain that the clean development mechanism (CDM) is a system or a strategy that allows emission-reduction (or emission removal) projects in developing countries to earn certified emission reduction (CER) credits. Each credit is equivalent to one tonne of CO2. These CERs can be traded and sold, and used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol. The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction targets. In Nigeria, rising atmospheric temperatures, leading to global warming, has exacerbated the challenges of desertification, desert encroachment, and drought, rise of the sea level, health problems, as well as food and energy security. Very often mitigation actions are seen as strategies to reduce emissions of greenhouse gases alone.

However, in Nigeria several of the actions needed to reduce these harmful gases are the same that would be needed to generate more electricity, create more jobs and reduce local environmental problems. The benefits of greenhouse gas emissions reductions become an added bonus.

Nigeria's best opportunity to reduce these gases is from ending gas flaring and in addition adopting a 30 percent renewable portfolio standard. Latest available statistics show that gas flaring accounts for 31.4 percent of a total 54.9 percent of emissions from Nigeria's energy sector. Making this currently flared gas available for electricity production will be the needed tonic for solving the current power crisis. Also, investments in abundant sources of renewable energy, stipulated in the Renewable Energy Master Plan would assist in addressing energy security.

References

A.S. Sambo et al Solar Steam Generation Using Parabolic Collectors`: A Review

B.G. Dan Shehu 5th September 2012 Renewable energy for sustainable development

B. Ishaku (1990) Journal of Renewable Energy Volume1, Solar Energy Generation

Sani Sambo, (2005) The Role of Renewable energy for Economic Development

B.G. Dan Shehu and A.T.Atiku 25th September, (1998) Some aspects of concentrated solar Energy technology

D.P.Kothari, K.C.Singal and Rakesh Ranjan, Second Edition. Renewable energy and imaging technologies