

Exploration Of Solar Energy Utilization For Power Generation In Yola.

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ABSTRACT

The paper presents a study of the viabilities of sun's energy utilization for power generation in Yola. Solar-thermal and photovoltaic options were discussed. It highlights the basic science for the design and selection of components for successfully harnessing solar power. Requirements for solar panel placement and orientation were also highlighted. It emphasizes that the knowledge and experience gained in solar energy as an abundant and convenient energy source, can play a role in steering the Yola, and Adamawa States toward a permanent and sustainable economic development. The energy demand in Yola greatly outweighs the National Power Authority's supply which is epileptic in nature. Thus, acute electricity supply experienced in Yola have been hindering the City's development despite the availability of vast natural resources in the said area. Our ability to continue the trend for affordably and unsustainable energy will be severely tested in the coming decades, as experienced by the widening trade imbalance, collapse of big and small scale manufacturing companies, sharp increase in the cost of doing business just to mention but a few. Hence, the issue of utilizing the free sun's energy which is silent, inexhaustible, and non-polluting resource for power generation in Yola has been addressed to stands as the long-range review of sustainable solution to energy problem.

Keywords: *Solar energy, solar-thermal conversion, solar electric (photovoltaic) conversion, panel placement and orientation*

Date of Submission: 03-10-2018

Date of acceptance: 15-10-2018

I. INTRODUCTION

The growing human population with an intensive exchange of materials and energy with its environment and the Earth's limited resource system for support, prompt the need for a growing awareness to achieve a more sustainable societal use of solar power (Karlsson, 1999). The earth receives energy directly from the sun. It is silent, inexhaustible, and non-polluting (Eastop, et'al, 2002).

Solar energy utilization depends on its availability and appropriate technology applied (Nasir, 2001). The idea of using the sun's power has held scientist in its grips for centuries (Bradley, 1995). Also, for most of its evolution, mankind relied for its sources of energy on constantly replenished materials. When the use of fire was discovered for the provision of heat and for the processing of food, the additional demand for energy was met by constantly renewed sources. Likewise, when water and wind powers were harnessed to the service of mankind, the new sources were also of a renewable nature. Thus throughout the early phase of development, the availability of the readily renewable sources of energy was a key constraint which greatly affected the size and distribution of human population (sambo,2001; &Chindo, 2002).

The sun being the most widely and readily available renewable energy source capable of meeting the energy needs of whole world. It can provide more power than any fossil fuel on the planet (Rochell, 2010). Sun's power reaching the earth is approximately $1000\text{W}/\text{m}^2$, total amount of energy received daily by the earth $1353\text{W}/\text{m}^2$ (Hoff, et'al, 2000); While about 4 million tons of the sun's matter will continue to be changed into energy every second (David, 1983). The solar short wave radiation including its visible spectrum arrives the earth at a maximum flux density of about $1\text{kw}/\text{m}^2$ in wave length of band between 0.3 and $2.5\mu\text{m}$. For habited areas, fluxes received vary widely from about 3 to $30\text{MJ}/\text{m}^2/\text{day}$, depending on place, time and weather. The quality of radiation is characterized by the photon energy of around 2eV as determined by 6000K surface temperature of the sun (John, et'al, 1987).

Solar cells which are an array of photovoltaic cells (PV) made up the solar panels; as any type of equipment used to convert sunlight into energy is considered solar cell or panels (Rai. 2012). The technology behind Solar panels has varied widely throughout about six decades and while Sola cells were the true origin of modern solar panels, today researchers are shifting to new platform and approaches to gathering energy from sunlight which including crafting solar cells from silicon semiconductor configured to trap and convert sun energy which are coated in an antireflective coating and contained under a glass cover plate to protect the cell from the elements (Jonathan, 2010).

Silicon, as a semi-conductor has since 1950s been discovered for well performance in various aspects of Engineering; today, silicon is what solar cells and panels are generally made up of (Clark, 2010).

An ambiguous study has already started, where a solar satellite which is continuously in direct sunlight direction to collect the energy, convert into electricity and direct a microwave beam to a receiver on earth where it would be reconverted to electricity (Eastop, et'al, 2002). However, the cost of such a scheme is likely to prohibit its realization

II. METHODOLOGY

The Energy Demand, Crisis, And Utilization In Yola

Yola, the capital of Adamawa state of Nigeria is one of the states of the country whose land mass is about 225sq. Kilometer, enjoying an average daily sunshine of 6.45 hrs. (Bala, et'al, 2000). The electrical energy consumption in the year 2001 is about 18,000 kWh. Two main seasons; the dry season lasting from October to April and the rainy season lasting from May to October is experienced averagely with temperature ranging between 32°C and 42°C, humidity about 95% and the terrestrial radiation on Yola's land area 2.079 x 1015 kWh/year (Ojo, 2000; & Falade,1995).

The economy of Yola can be disaggregated into industry, transport, commercial, household, and agricultural sectors, with the household sector dominating energy consumption (Akinbami, 2001; &Oladosu, etal, 1994). The energy consuming activities in the household sector still remain mainly cooking, lighting, and operations of electrical appliances (i.e., non-substitutale electricity). The percentage distribution of the total final consumption in 1989 in this sector and in terms of the major energy carriers is Kerosene (11%), Electricity (4%), LPG (3%), and Wood/others (82%) (Oladosu, etal, 1994).

This therefore, made Yola's economy face deepening challenges: a widening trade imbalance, growing competition from developing states, a collapse of big, medium and small production firms, and a sharp increase in the cost of doing business, all owing basically to energy and its related infrastructural costs. Energy demand far outweighs the supply which is epileptic in nature. It is still pertinent to note that Yola, and the Countries energy consumption is projected to grow geometrically (Figure 1) while the ability to sustain our growth through energy generation, transmission and distribution continues to dwindle (Figure 2). Our capability to continue the trend for affordable energy have, is and will be severely tested in the coming decades if no prompt action is taken.

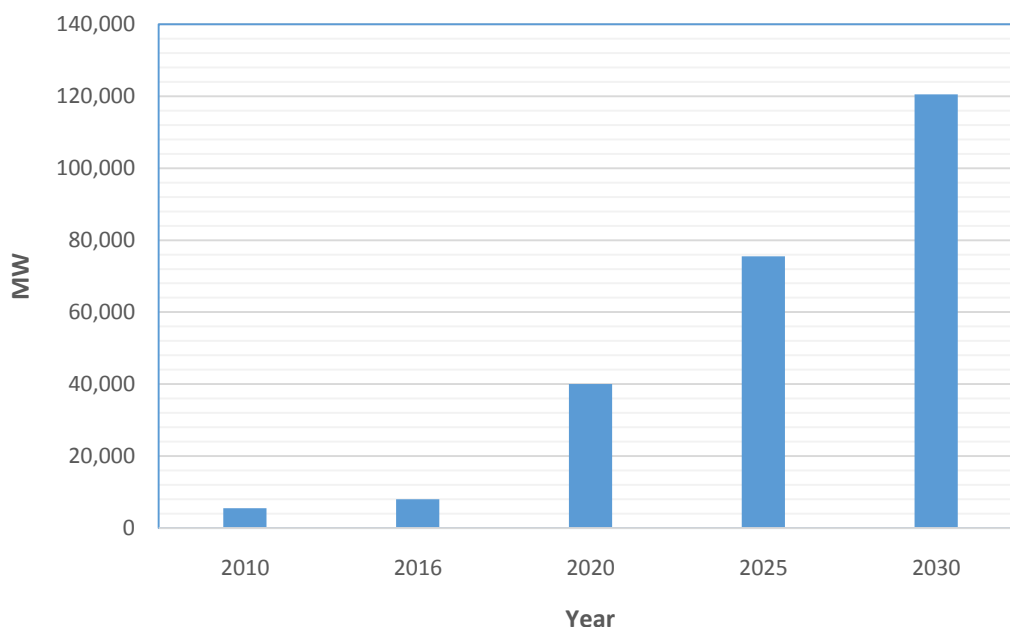


Figure 1. Electricity Demand Projection in Yola, Adamawa State. Source: (Chiemekaet'al, 2009)

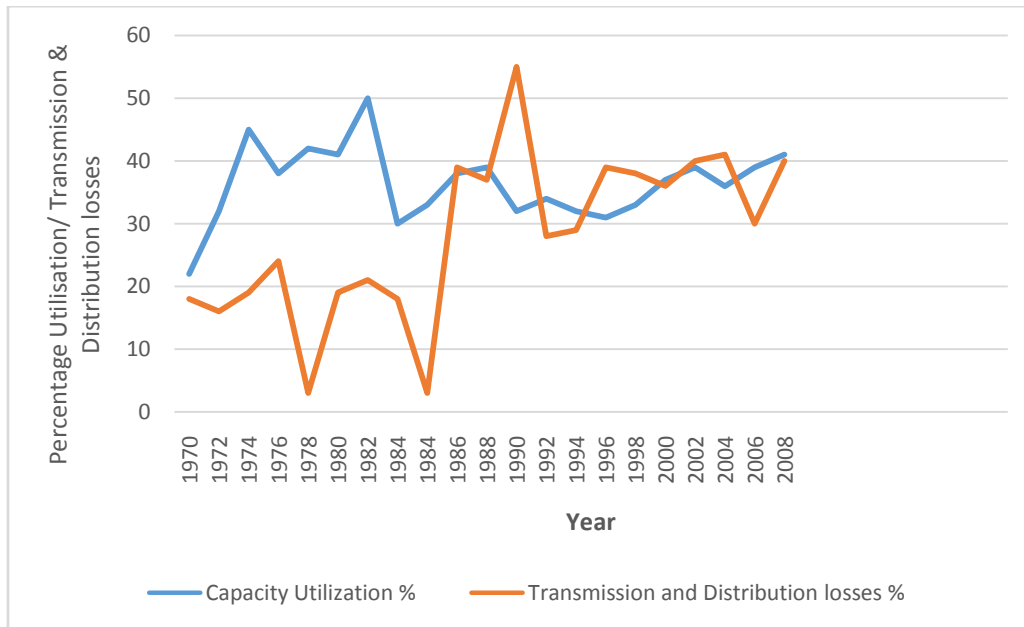


Figure 2. Indicator of Electricity Crisis in Nigeria 1970 to 2008 Source: (Iwayemi, 2008).

Figure 3 shows the variation of the total radiation per square meter per day throughout the year in Yola area, Adamawa state. The average total radiation received per day; and its variation within the period of the year in Yola north, Yola south, and Girei is also presented. Knowing that Yola has an annual average daily solar radiation of about 6.12 kWh/m²/day, gives an impression that implementing solar energy strategy is a great opportunity for Yola to get renewable energy at low cost as well as minimize dependence from fossil fuels. For example, the total radiation received per day on a 1m² surface at Yola varies from 33MJ to 37MJ per day. Using this as a benchmark, it can be seen that even the minimum power harnessed in any part of the country is more than that required for powering an average 3- bed room flat and 2-room apartment using low-power consuming appliances (Table 1 and Table 2). The need for harnessing this renewable energy supply is apparent as fossil fuels (especially oil) become increasingly expensive due to depleting reserves, population increase, and individual press for a higher standard of living in terms of material goods, especially in rural, Yola, and developing states.

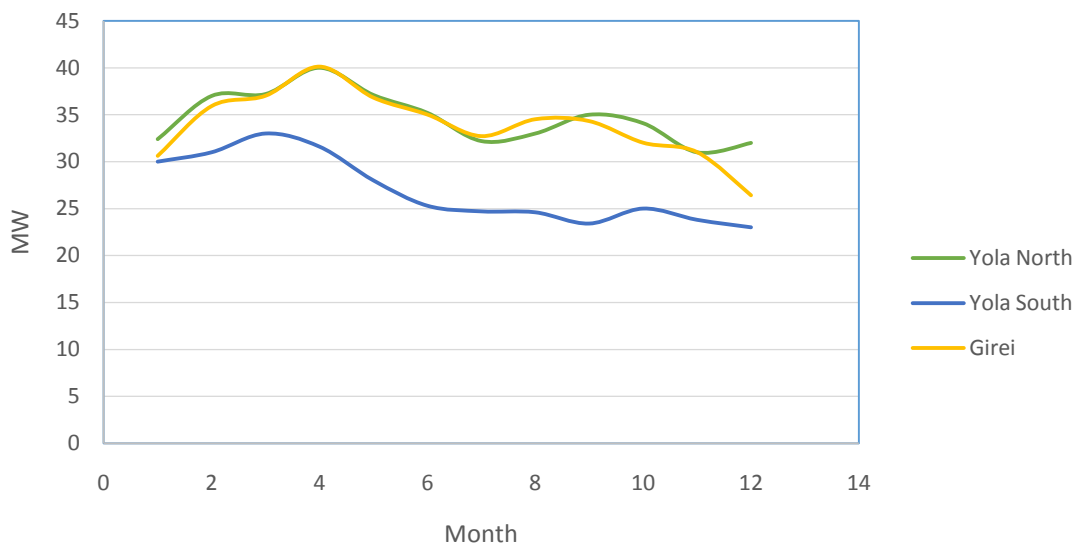


Figure 3. Variation of monthly total radiation in Yola area. Source: (Mautech, 2000).

Table 1. Power estimate for an average 3-bedroom apartment in Yolaarea.

S/N	APPLIANCE	POWER (W-h)	QTY	TOTAL POWER (W-h)
1	Light	20	10	200
2	Fan	100	4	400
3	TV	58	2	116
4	Home theatre	95	1	95
5	Fridge	850	1	850
6	Air conditioner	750	1	750
8	Miscellaneous	100	-	100
TOTAL POWER REQUIRED 2511W-h or 2.511KWh				
Note: 1J/sec=1 Watts				

Table 2. Power estimate for an average 2-bedroom apartment in Yola area.

S/N	APPLIANCE	POWER (W-h)	QTY	TOTAL POWER (W-h)
1	Light	20	4	80
2	Fan	80	2	160
3	TV	58	2	116
4	Fridge	500	1	500
6	Miscellaneous	100	-	100
TOTAL POWER REQUIRED 956W-h or 0.956KWh				
Note: 1J/sec=1 Watts				

III. RESULTS

Techno-Economics of Solar Energy in Yola Presently

At present, a liter of premium motor spirit (PMS) for running a generator (commonly called petrol) is sold at 155 per liter. Bearing this cost in mind and the fact that 70% of the Nigerian population live in rural and un-electrified settlements, a cost estimate for solar powering a 3-bedroom and 2-bedroom is presented in table 3 and 4. From the table it can be shown that cost estimate for powering a 2-bedroom and 3-bedroom apartment with generator for 1 year in a rural area not connected to the national grid is put at 126,506 and 349,016 respectively; and it has also been opined that the total cost for solar powering a 3-bedroom flat apartment is estimated to be 738,375.30 while that of a 1-bedroom apartment, comprising of 4 lighting points, 1 Television set, 1 Fan and a VCD, is 172, 349. From the above it can be deduced that in three years the individual utilizing solar energy will break-even for his energy needs. This is not even taking cognizance of efficiency of the generators which are on the downward trend as utilization increases. It has also been asserted that the major impediment militating against the widespread usage of solar energy and its related technologies is the Initial Capital Outlay (ICA)(Adeyemo, 1997).

Table 3. Cost estimate of powering a 3-bedroom apartment with generator for one year.

Particular	Description	Amount (N)
Cost price		55,000
Fueling	8 hours/day @ 8 liters/day	284,016
Servicing	15,000.00/year.	15,000
TOTAL		354,016

Table 4. Cost estimate of powering a 2-bedroom apartment with generator for one year.

Particular	Description	Amount
Cost price		15,000
Fueling	8 hours/day @ 3 liters/day	169,725
Servicing	5,000.00/year.	5,000
TOTAL		189,725

Power Generation Technologies

Power generation is the process of converting energy from an available source to electrical energy in a form that is suitable for distribution, consumption and storage. Solar energy can be used to generate power in two ways; solar-thermal conversion and solar electric (photovoltaic) conversion.

Solar-thermal Conversion

Solar-thermal is the heating of fluids to produce steam to drive turbines for large-scale centralized generation (figure4). Like solar cells, solar thermal systems, also called concentrated solar power (CSP), use solar energy to produce electricity, but in a different way. Most solar thermal systems use a solar collector with a mirrored surface to focus sunlight onto a receiver that heats a liquid. The super-heated liquid is used to make steam to produce electricity in the same way with coal plants (Rai. 2012).

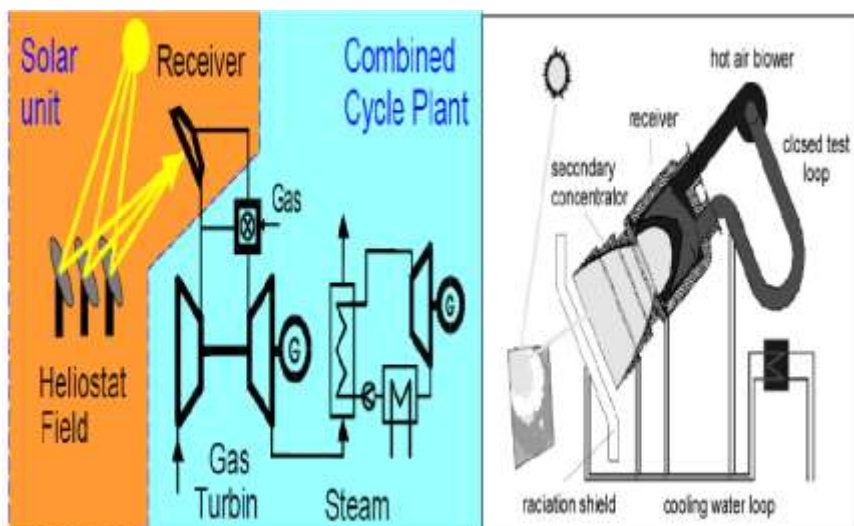


Figure 4. The REFOS-receiver for testing at the Plataforma Solar de Almería. Source: (FMPS, 2006).

Solar electric (photovoltaic) conversion

Solar-electric (photovoltaic) conversion is the direct conversion of sunlight into electricity through a photocell which could be in a centralized or decentralized fashion. Photovoltaic technologies have the ability to 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 (figure 5).

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.

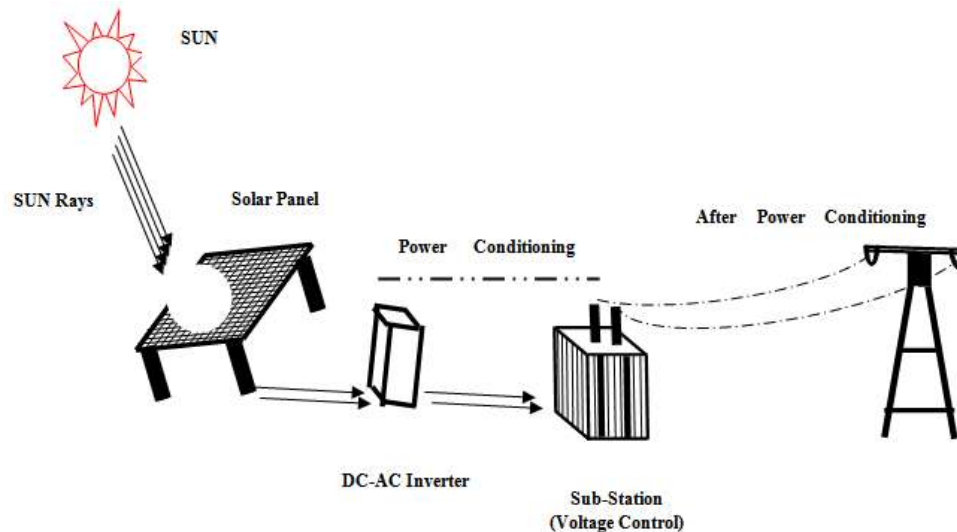


Figure 5. Schematic of a large-scale photovoltaic system. Source: (Becker, 2000).

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, allowing 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 (Green, 1982).

PV modules are integrated into systems designed for specific applications. The components added to the module constitute the "balance of system" (BOS). Balance of system components can be classified into four categories (Agrafiotis, 2005).

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 to convert 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 perform the switch from battery-stored DC to standard power AC (120VAC, 60Hz);

Charge Controller: A charge controller monitors the battery's state-of-charge to ensure that when the battery needs charge current it gets it, and also ensures the battery is not 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 to mount or install 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 photovoltaics (Owolabi, 2008).

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. Mounting angles for fixed solar collectors in Yola area is shown in figure 6 below.

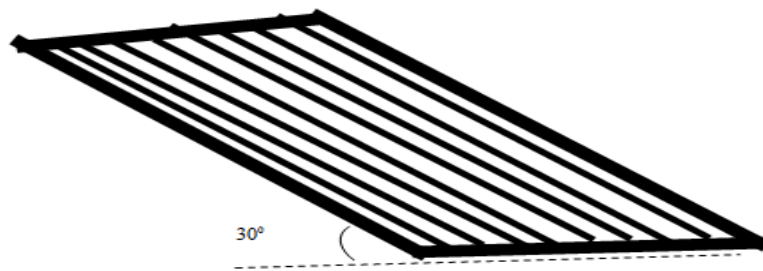


Figure 6. Mounting angles for fixed solar collectors. Source: (Ogunleye, et'al, 2010).

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.

IV. CHALLENGES

Some of the factors militating against the growth of the Solar – PV and concurrently solar thermal Industry in Nigeria, as well as Yola include:

Financial constraints: A basic barrier to the development of solar energy technology in Yola as a developing city lies in high initial costs and long payback times.

Technological incapability: Though the technologies for harnessing solar energy are being developed in Nigeria, most components have to be imported which further pushes the investment costs higher.

Absence of a Comprehensive National Energy Policy: There has not been virtually no comprehensive and functional energy policy in Nigeria until very recently. Only sub-sectorial policies relating to energy exist.

Low level of Public Awareness: The level of awareness about the immense socio-economic and environmental benefits derivable from solar energy is very low in Yola. The current flow of information about the development, various applications, dissemination and diffusion of solar energy resource and technologies is inadequate (Hankins, 1995).

RECOMMENDATIONS

For effective and efficient utilization of solar electricity in Yola, the following recommendations will be useful-

- Encourage more research works into the techno-economies involving the initial and subsequent costs of solar plants and their power efficiencies.
- Renewable Energy Technologies (RET) most especially solar PV subsidy should be put in place by Government to bring down its high cost in Yola, and entire Adamawa State.
- Private individuals and organizations should be encouraged by appropriate authorities to invest in solar technologies in the State.
- Consequently, the wide gap between research bodies (universities, polytechnics and research institutes) and manufacturing industries should be bridged.
- Government should create more awareness on the advantages derivable from Renewable Energy Technologies (RET) such as solar technologies.
- Government can also consider placing restrictions on the importation of diesel and petrol engine generators because of its adverse effects on the environment even as the global community gear towards clean (green) energies.
- Funding of solar technology researches and development initiatives in Nigerian Universities, Polytechnics and Research Institutes so as to develop solar PVs with increased efficiency that will be adaptable to our environment is advocated as is obtainable in developed countries.

V. CONCLUSIONS

the paper specifically focuses on the maximization of the sun's energy supply to generate optimum power. It has presented the viabilities for power generation in Yola by the utilization of the sun's energy through solar-thermal or photovoltaic technologies. The basic science for the design and selection of solar components as well as panel placement and orientation were highlighted. The future of solar electricity is brighter than before. Solar energy is free, it needs no fuel and produces no waste or pollution. It is only recently that mankind turned to the large scale exploitation of new, and non-renewable sources of energy and those sources have made possible the advance of industrial revolution and large increase in populations. It is clear however, that because of the finite magnitude of these sources, this phase of human development is transitory and the era of extensive dependence on finite fossil energy resources will be as something of past.

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