Solar Energy for Sustainable National Development

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Abstract: Solar energy technologies (SETs) can help reduce poverty, energy shortage and environmental degradation such as desertification, biodiversity depletion and climate change effects in Nigeria. The country is short of electricity supply. Over-exploitation of gas in meeting energy needs of the people has caused environmental degradation. SET can help solve those problems if it is widely used in Nigeria where people primarily reside in rural area. Nigeria has enough renewable to mitigate such energy crisis and its adverse consequences. In this paper attention is drawn between solar energy and sustainable national development in the Nigeria, Rural Energy Needs, Hybrid Conversion of the Sun Irradiation and Factors of Success

Key words: Solar energy, Renewable energy, Solar cells, Solar collectors, Sustainable development

I. INTRODUCTION

Nigeria has major problems with energy crisis, persisting poverty and environmental degradation. With only 49% of Nigeria having access to electricity, the per capita energy use is only 180 kWh [1]. Moreover, the people who are connected with the national grid are experiencing frequent load shedding. At present, the country can generate about 4600 MW electricity, while peak demand is about 6000 MW (USAID, 2011) [2]. Therefore, the supply is unreliable. Most of the supply is limited to urban areas; access to electricity in rural areas is less than 10% [3]. SET can solve this problem by harnessing energy from country's free flowing renewable such as sunshine, wind, tidal waves, waterfalls or river current, sea waves or biomass. Use of renewable energy, increased energy efficiency and enhancement of energy security constitute a sustainable energy strategy approach.

Renewable forms of energy emit far smaller amounts of greenhouse gases compared with fossil fuels and increased energy conservation facilitates the reduction of primary fossil fuel use, thus mitigating climate change impacts while contributing to the provision of energy services and enhancing security of energy supply.

The energy crisis, which has engulfed Nigeria for almost two decades, has been enormous and has largely contributed to the incidence of poverty by paralyzing industrial and commercial activities during this period. The Council for Renewable Energy of Nigeria estimates that power outages brought about a loss of 126 billion naira (US$ 984.38 million) annually [4]. Apart from the huge income loss, it has also resulted in health hazards due to the exposure to carbon emissions caused by constant use of 'backyard generators' in different households and business enterprises, unemployment, and high cost of living leading to a deterioration of living conditions.

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Moreover, according to the Central Bank estimate in 1985, Nigeria consumed 8,771,863 tonnes of oil equivalent [5]. This is equal to about 180,000 barrels of oil per day. Since then, oil consumption in Nigeria has drastically increased. The effect of this increase on the economy relying solely on revenue from oil is tremendous. Also, the Department for Petroleum Resources [6] reported an amount of petroleum of more than 78% of the total energy consumption in Nigeria. In the present predicament as a nation, it is obvious that depending mainly on fossil fuel (petroleum) is not enough to meet the energy needs of the country. Since Nigeria is blessed with abundant renewable energy resources such as hydroelectric, solar, wind, tidal, and biomass, there is a need to harness these resources and chart a new energy future for Nigeria. In this regard, the government has a responsibility to make renewable energy available and affordable to all.

Many indigenous researchers have looked into the availability of renewable energy resources in Nigeria with a view to establishing their viability in the country. Onyebuchi [7] estimated the technical potential of solar energy in Nigeria with a 5% device conversion efficiency put at 15.0×10^{14}kJ of useful energy annually.

Akinbami [8] reported that the total hydroelectric power potential of the country was estimated to be about 8,824MW with an annual electricity generation potential in excess of 36,000 GW h. This consists of 8,000MW of large hydropower technology, while the remaining 824?MW is still small-scale hydropower technology. Presently, 24% and 4% of both large and small hydropower potentials, respectively, in the country have been exploited.

Akinbami et al.'s assessment [9] indicated that the identified feedstock substrate for an economically feasible biogas program in Nigeria includes water lettuce, water hyacinth, dung, cassava leaves, urban refuse, solid (including industrial) waste, agricultural residues, and sewage. The authors' views include the following: Nigeria produces about 227,500 tonnes of fresh animal wastes daily. Since 1kg of fresh animal wastes produces about 0.03m3 gas, then Nigeria could produce about 6.8 million m3 of biogas every day. In addition to all these, 20kg of municipal solid wastes per capital has been estimated to be generated in the country annually.

II. SYNERGY

The relationship between energy and economic development is crucial; the process of economic growth requires the substation of energy mix in the performance of agriculture, industrial and domestic tasks. The lack of adequate energy in rural Nigeria has economic costs not just at the individual and household level but at the national level as well. Development in Nigeria without corresponding increase in per capita electricity and gas consumption is, therefore, not feasible. Everyone needs

energy in one form or another, for day-to-day life, for cooking, lighting, heating and so on. Consequently, energy is to be considered as a basic need along with food, water, shelter and others [10].

In social aspects, energy plays a key role in achieving social justice including gender justice. Low level of energy service is a serious obstacle to raising social, health and nutritional status of community. Dependence on human energy and primitive technologies for survival introduces a whole range of obstacles to social and gender equality. The rural people in general, and rural females in particular, are tapped in an unceasing cycle of works that condemns them to poor health, little or no education and deprives them in equal participation in local development programs (i.e. education, income generating activities, etc.), self governing bodies and political movements. Improved energy services can be at the centre of any strategy to mitigate the gender disparity.

The availability of adequate, reliable and reasonably priced source of energy is, therefore, prerequisite for the development of rural Nigeria. Suggestions can now be made to the extent that the usage of SETs would launch a new era of appropriate technology, sustainable socio-economic and environmental development in the country.

III. RURAL ENERGY NEEDS

More than 70% of total populations of the country live in rural areas. At present major portion of total energy needs for cooking is met by the available fire wood. The rural electrification program meets a small portion of total energy needs. For overall national development there is a need to pay special attention so that the energy needs of rural areas for subsistence and productive requirements (e.g. agriculture, industries, and transport) are met on a sustainable basis. Different types of renewable energy technologies are suitable for Nigeria example of such is solar energy.

IV. SOLAR ENERGY

Sun is one of 400 billion stars in the Milky Way Galaxy. Astronomers classify it into "yellow" dwarfs. Sun contains more than 99% of the whole matter in the Solar system.

The temperature on the surface of the Sun is 5500 °C. In the Sun nucleus the pressure is 10^7 Pa, and the temperature is $15 \cdot 10^6$ K. Sun energy is generated in its nucleus mainly through the thermonuclear reaction of hydrogen fusion into helium. In the form of electromagnetic waves this energy is then transmitted from the nucleus towards the surface of the Sun and further on in the surrounding space. Only the half -billionth part of the Sun energy reaches the Earth [11].

Two components of the Sun irradiation reach the Earth. One comes directly from the surface of the Sun (direct irradiation) and the other generated by the Sun irradiation dissipation on the impurity particles in the atmosphere (diffuse irradiation). On the intensity of the incoming energy substantial influence is exerted by meteorological conditions and the angle under which Sunrays reach the Earth. If the sky is crystal clear 10% of the total energy reaches the Earth as diffuse irradiation.

Sun energy is clean, inexhaustible and can be transformed into other forms of energy: thermal, electric, chemical, mechanical, etc.

V. PASSIVE INTAKE

Modern solar architecture is based on a direct (passive), indirect (active) and a combined (passive and active) Sun irradiation intake.

Passive sun irradiation intake on the given object is performed without application of any auxiliary devices for the sun irradiation intake and its transformation into other forms of energy. To make this type of sun energy use efficient it is necessary to rightly orient the object towards the sun and to pay attention to: location of the windows, glass veranda, etc. thermo-isolation of the object, color of the walls and furniture, shade, thermal shutters, floor storage of heat, etc.

Passive solar objects design implies knowledge of the local climate conditions and their immediate influence on the level of the use of the sun energy in the given object. Most important climate parameters are: number of sunny days in the given area, temperature and air humidity, fog, wind, etc.

VI. ACTIVE INTAKE

Active sun irradiation intake is performed by means of devices for thermal, photovoltaic and hybrid sun irradiation conversion.

For thermal conversion the following is used: flat collectors (water and air), vacuum collectors, concentrators, solar ovens, heliostats, etc.

For photovoltaic conversion of the sun irradiation the following is used: mono-crystal, poly-crystal and amorphous solar cells made of silicium and other materials. Solar cells generate direct current and voltage.

VII. HYBRID CONVERSION OF THE SUN IRRADIATION

Hybrid conversion of the sun irradiation means simultaneous conversion of the sun irradiation into thermal and electrical energy. For hybrid conversion of the sun irradiation one uses hybrid collectors which differ from thermal collectors in the absorber construction.

Hybrid collector absorber is made of metal stem, water flow tubes and solar cells made of mono-crystal or amorphous silicon mechanically fixed to the metal stem. Hybrid collectors can be used in private houses, block of flats, tourist objects, hospitals, schools, sanitary water heating objects and electric energy generation objects. Heated water is by means of thermo-siphon or circulation pump taken to the solar boiler. Electric energy is through battery charging regulator taken to the battery and then directly or through DC/AC inverter submitted to the end user. Hybrid collectors make possible better space usage, savings during supporting construction building and simultaneous conversion of the sun irradiation into thermal and electric current in one device. Hybrid collectors are contemporary, ecologically clean, integral source of thermal and electric currency [1, 2].

VIII. SOLAR ENERGY AND SUSTAINABLE NATIONAL DEVELOPMENT

Serious problems of the air pollution are connected with the use and combustion of natural fuels, first of all solid (coal) and liquid (oil and oil derivatives).

Having in mind ever-growing importance of the use of sun energy on Earth a world congress on sun energy was held in September 1996 in Harare (Zimbabwe). This congress was held in the year proclaimed by UNESCO's World movement for the use of solar energy (WSSP) as the beginning of a "Solar decade". The congress has gathered together 117 Prime Ministers and 20 representatives of the leading international and regional governmental and non-governmental organizations as well as representatives of the leading industries and experts on the energy worldwide.
The congress has pointed out that 79% of mankind in a developed part of the world disposes with 30% of the global energy consumption and that more than two billion people has almost no energy for other needs. At the same time developed world comprising 21% of the world population consumes 70% of the commercially produced energy. This is 17 times more than the average energy consumption of the poorest world population. For the current population number of 5.5 billion to have the same average energy consumption per capita world energy production should be quadrupled.
The congress issued two documents: Solar Declaration and World solar plan of action for the period of 1996-2005.
In order to establish sustainable development, prevent over consumption of conventional energy sources and to preserve environment it is necessary to provide for sustainable energetic. This means that future technical-technological development should be based on the strict control and lowering of the pollutant emission into the environment, extended use of eco-technologies and renewable energy resources.
Development and expended use of renewable energy resources (SET) in energetic is essential for the establishment of sustainable development on Earth.

IX. FACTOR OF SUCCESS

SET is the technology of the Future. But unless this technology can reach the most deprived and vulnerable group in the world today - the millions of rural people who suffer most from the energy crisis - this technology will neither reach its full potential, nor will the economic and social problems of the world be solved. In the early stage when very few started to promote renewable among the rural people, village electrification was considered the domain of government programs and development aid, leaving a legacy of inefficiency and squandered subsidies. Eventually some innovative financing scheme had been created to make SET affordable for rural people.

A. Innovative Financial Schemes to make the Technology Affordable at the same cost as Kerosene

SET is still expensive relative to traditional energy sources. One of our initial challenges was to bring down the high upfront cost of a solar system. An innovative installment based financial scheme worked fantastically which reduced the cost of a system to monthly kerosene cost. This is at the central core of our success story. It also allowed us to expand our market and reach economies of scale which further allowed us to bring down our costs per unit and engage in a profitable, sustainable business. Instead of renting, we focused on ownership which translates into better care and longevity of the system. As the price of traditional energy sources rises, renewable energy technology is becoming more and more viable, especially due to its low per unit cost. But, the high upfront cost of the technology is still a major obstacle in generating the shift away from traditional fossil fuels and must be dealt with.

B. Focus on Empowerment, Income Generation & Cost Savings

Tiding the technology with income generation, cost savings, higher standard of living, and especially social and economical empowerment is very important. In rural Nigeria, solar power became synonymous with social status, better living and more income. A rural business could double its turnover by using solar while minimizing energy cost. Solar power especially helped improve connectivity, increase the sales of electronic goods, create new business opportunities such as mobile phones charging shops, electronics repair, maintenance shops, community television centers etc.

C. A Strong Grassroots Network to provide after sales service, right at the doorsteps of the rural people

Rural people are unlikely to invest in a technology which is not durable and no after sales service is available. We focused on creating a vast network of rural engineers who developed one to one rapport with their customers**.**

D. Building Institutional Capacity

Fully developing the infrastructure for renewable in Nigeria requires more than just putting solar systems on the market. Many projects in the country also work to remove the barriers to more widespread use of renewable systems and build the skills along with the partner organizations. These facilitate a package of interventions to support Nigerian institutions in overcoming major market barriers. These institutions include rural electricity cooperatives, community-based organizations, NGOs, microfinance institutions, and private-sector groups.

X. CONCLUSION

In the light of the above mentioned it can be concluded that a great attention is drawn to the use of clean sources of energy and sustainable development in the Nigeria.
The cleanest source of energy is the Sun that for the 5 billion years has been enabling and sustaining life on Earth. In biosphere sun energy through the process of photosynthesis is used for the growth and development of plants. Besides, sun radiation can be transformed into thermal energy in passive and active photo-conversion systems. Passive photo-conversion systems encompass building objects constructed on the solar architecture principles. In active photo-thermal conversion systems we classify flat collectors, vacuum collectors, concentrators, etc. For the conversion of sun radiation into electric energy solar cells are used. For the simultaneous conversion of sun radiation into thermal and electric energy hybrid collectors are used.

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