SOLAR ENERGY: A NECESSARY INVESTMENT IN A DEVELOPING ECONOMY

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ABSRACT
Electrical Energy is the pivot of all developmental efforts in both the developed and the developing nations. Due to the fact that sources or conventional means of energy generation arc finite and fast depleting, most industrialized countries have started research on solar energy as a renewable sources or energy.
This paper presents the present state of conventional energy generation in a developing economy like Nigeria. The efforts made in solar energy research .and utilization arc highlighted. A case is made for a systematic and coordinated financial investment in solar energy research and adaptation to complement the generation from conventional sources.
KEYWORDS: Solar Energy, Investment, Developing Economy, Cost analysis.

1.0 INTRODUCTION

Electrical Energy has always been one of the vital requirements of human societies, and presently its demand is far more greater than ever in both developed and developing nations. This is buttressed by the fact that electrical energy is vital to human life, for his technological advancements. Today, major electricity generation takes place at a central power stations which utilize coal, oil, water .gas or fossil nuclear materials as primary fuel sources. There are problems facing the further development of generating methods based on any of these conventional fuels. The continued large-scale use of oil and gas in countries not blessed with indigenous reserves is particularly doubtful because supplies are expensive, rapidly diminishing, and politically regulated [1, 17]. Hydro-electric power generation is restricted to geographical suitable areas where reserves of coal, oil gas exist. These energy resources although presently plentiful are finite and not renewable. Figure 1 shows the preponderance of these energy reserves in Nigeria.
Electrical energy production in Nigeria over the last 35 years varied from gas- fired oil-fired, hydro-electric power stations to coal-fired station. Of all these however, the development of hydro-electric power system and gas-fired system have taken precedence over all other sources of energy systems in Nigeria. This, however, is because of the readiness with which they can be harnessed and operated at a minimal cost. The energy production and consumption pattern in the country within the past thirty five years has been on the increase [2]. Due to the phenomenal increase in the energy production and consumption pattern and also for the fact that energy sources are finite, it becomes imperative to research on how to develop the non-conventional methods of energy generation. The main thrust of this paper is to present the state of conventional energy generation in a developing economy like Nigeria. The paper proposes a systematic and coordinated financial investments in solar energy research and adaptation to complement the generation from conventional sources.

2.0 CONVENTIONAL ENERGY GENERATION IN NIGERIA

The bulk of the supply for Electrical energy in the country has been the main task of National Electric Power Authority (NEPA) and in terms of increased facilities NEPA expands annually in order to meet the ever increasing demand [2]. The energy production and consumption pattern in the country has been on the increase. Figure 2 clearly depicts this trend in electricity generation and consumption by classes of sectors from 1987 -1993. At present, the installed and available electrical capacity in the Nigerian generating stations are shown in Table I. According to Table 1, despite a total grid capacity of 5924.7MW, only 4586 MW were available. This implies that about 22% of the installed capacity was unavailable. This may be due to operational inadequacies and inability of units to operate at full capacities of the generating stations and their respective percentage contributions to the total energy products. The total energy contributions to the energy need of the country by the nation's Hydro and Thermal Power Stations is shown in Figure 3.

2.1 MERITS AND DEMERITS OF CONVENTIONAL ENERGY GENERATION

The use of conventional methods in electrical power generation has a number of advantages among which are the following:

I.Hydro plants have lower operating and maintenance costs since no fuel and steam generator are needed.

2.Hydro plants are quicker to start up on load and are also quicker to shut down for maintenance.

3.Hydro plants are less prone to fire outbreak as a consequence of the absence of fuel.

4.Thermal power stations which are built on much smaller areas of land than hydro stations have less resettlement and compensation problems.

5.Thermal stations have lower installation costs

6.Installation can more easily be brought closer to a land centre for thermal plants.

7.Nuclear Fuel is charged to a power plant infrequently and has a relatively long life, usually measured in months or years.

8.The use of nuclear fuel does not require combustion air, thus obviating thermal stack losses and related problems.

The demerits are also outlined hereunder:

1. Hydro plants depend for sustained operation on in-flow of water into the storage and this in- flow can be affected up stream by drought and outside the borders of this nation, by political or other considerations.
2. The pollution arising in the case of thermal combustion of fuel is not environment-friendly due to the fact that sulphur oxides, heavy metals, radio-active elements, hydrocarbons and large quantities of carbon-dioxide are emitted which leads to acid rain.
3. Fossil and nuclear fuels are finite and non-renewable energy sources. The world oil and gas reserve are running out, nuclear power has turned out to be prolematic and the use of coal is constrained by the adverse environmental impacts of its extraction and burning [13].
4. Burned nuclear fuel is radioactive, it requires remote handling and special processing and disposal of toxic waste.
5. Special system designs are required to prevent radioactivity release during normal operation or due to accidents.
6. Major portions of a nuclear plants are radioactive during and after operation, requiring special precautions and advanced technology for maintenance of much of the plant.

3.0 SOLAR ENERGY RESEARCH IN NIGERIA

Solar energy research is not new in Nigeria and has continued to gain popular acceptance nationwide. Several solar energy research works as evident from the literature [3, 4, 5, 6, 7, 8] have been carried out and all point to the fact that optimism on the conventional method of electrical power generation is at a low ebb. Davidson and oni [3] are of the opinion that since the fossil and nuclear fuels are depletable energy sources, that over-dependent on them is tantamount to a severe energy crisis as the world's energy demands remain doubtful. The paper highlights the seemingly way out to avert the looming danger. Consequently, a call was made for measures and adequate policies in effective management, conservation, exploration, exploitation and utilization of Nigeria energy sources, and minimally reduce her dependence on oil by developing more fuel alternative in Africa.

The prospects and problems of applying solar energy in transport technology in Nigeria has been reviewed by Fagbenle [4]. The prospects of solar energy application in road, air, sea, rail and military transports were enumerated. The paper underscores the importance of producing solar photovoltaic cells, modules, and arrys locally if the large scale application of solar energy type transport systems is to be feasible. The paper concludes by bringing the attention of goverment to bear in the area of establishment of more solar energy rechnology centres and encouragement of research on the local production of solar cells.

The work of Ishaku [5] gives a nod to an independent power generating system for use in rural areas that incorporates solar energy in the form of sunlight, wind and running water as primary energy sources. The paper however warns that such proposition may not be necessarily cheap, the primary energy sources (Solar) not withstanding because .albeit solar energy is free, its conversion devices and production remain cost intensive. He called on Engineers and Scientists to acquire skills that will enable them to fabricate energy conversion devices in order to meet the needs of millions of Nigerians in their yearning to enjoy the numerous benefits accruing from electrical power generation. Fagbenle [6] using meteorological data estimates the total solar energy radiation in Nigeria. The paper observes that total solar radiation In Nigeria generally increases with latitude. The month of August, irrespective of the zone, was seen to witness the least total solar radiation throughout the country. The work is indeed important as it shows the possibility of the development of solar energy in Nigeria.

Mike' ilu and Kamaluddeen [7] configured the solar energy senario for Nigeria from a purely economic perspective. The result of the study reveals that economics just like technology will play a vital role in the success or failure of a solar energy system. The paper advocates an alternative energy sources for the country and earnestly employ the policy makers of the need to channel resources along that direction. This becomes imperative, the paper noted, because of the increasing cost of fuels, dwindling resources at

the disposal of government, despoliation of environmental quality and depletion of fossil fuels.

Apart from the theory and prospects of solar energy research in Nigeria, pragmatic efforts have been put to bear in order to construct photo voltaic (PV)modules which provide simple, reliable and independent electrical power source at remote locations[.9, 10, 11] Most recent work on the use of phoiovoltaic plants to supply modest amounts of power to efficient end use equipment in areas where a connection to the electricity distribution network is not possible or is prohibitively expensive was carried out by Jenkins [10]. Jenkins noted that phorovoitaic equipment is very robust and costly but has low maintenance requirement. He is of the view that high capital cost can be minimized and the power supply made cost effective if the overall system is carefully designed.

As research on this vital area of alternative energy resource continues to gather momentum, the nation's policy makers should be prodded into action to ensure that any research findings are converted into concrete terms through adequate funding. It is only by so doing that the efforts made in this area could be meaningful and thus combat the impending world energy crises attested to by the escalating fuel prices and high rate of depletion of oil and natural gas. Our environment will be best for it as emphasis is shifted from fossil fuels to renewable energy sources

3.1 APPLICATIONS OF SOLAR ENERGY

The basic applications of solar energy are in the following areas: .Agriculture, engineering. Medical Sciences, Power generation and Recreation.

Agriculture

Tremendous efforts have been made in area of application of solar cells in agricultural sector. This can be seen in the areas of solar water heating for dairy farms and micro irrigation [9, 10, 11,] Solar crop dryers have since been in use. In order to facilitate harvesting, storage, feeding, germination and milling, crops need to dried. In Ghana [12] the solar dryers were used for drying of mainly Okro and Pepper and in some few occasions. maize. Drying was averagely three days with the solar dryers as compared to one week with sun-drying. The products of the solar dryers were more beautiful, cleaner and fast -selling than sun-dried ones. Solar cells are being widely used in agriculture as a primary source of energy to drive water pumps. These PV-powered portable pumps can be used by those engaged in dry season cultivation of high value market crops for micro irrigation. In [8] design criteria of solar water pumping systems for Agricultural production was presented. The author enumerated the merits of solar water pumps to include:

(a) Their no-fuel requirement, no-noise pollution free and little or no maintenance requirement.

(b) They are compact and light in weight, etc.

Engineering

The contribution of wind energy, photovoltaic energy .geo thermal energy, waste heat and biomass amounts to only a few tenths of one percent on the world list of power sources [12]. Phorovoltuic solar cells, however, are becoming more and more popular. They were first used in electronic calculators, which thus no longer needed a battery- and became environmentally more, friendly. But since then photovoltuic cells have gradually replaced other power sources also in battery re-chargers, portable radios, emergency roadside telephones, buoys and even homes. Solar **PV** generator can be used to power long distance relay telecommunication stations that arc linked by one part of the country to the other [12.13] This has the potential for not only reducing road transport trips and consequently fuel consumption by the transport sector but also efficiently improving the internal communication system considerably.

Another important application of the solar energy in engineering is in the area of heat pumps and solar furnaces. A heat pump is used for heating purposes rather than cooling, and it can operate in such a way that in the cold season of the year it will take the colder air from outside the building and give up the energy as warm air inside the building. By using large radius convex lenses or large-curvature paraholic reflectors, the solar radiation can be concentrated upon a very small area to generate very high temperatures. Solar furnaces can therefore be built by employing radiation concentrators. A solar furnace built in Puran in Yugoslavia used a 1.5m diameter searchlight reflector with a 65cm focal length to produce temperatures exceeding 2000°C for the purposes of studies on the growth of crystals and the production of pure minerals [13]

Medical sciences

One of the most important amenities to be provided in rural areas is small health care facilities. The most basic equipment to such a centre, located in remote rural areas, is the ability to meet its cold-chain requirement necessary for vaccines storage. Advancements In solar technology have made available in the markets efficient and portable solar refrigerators that can be used for storage of medication, vaccines, etc. Solar powered refrigerators can also provide chilled and frozen storage for bulk meat, vegetable, and dairy products.

Power generation

Majority of the country's population dwells in the rural areas. Most of these people do not have access to electrical energy from the national grid.

Consequently, Kerosene-powered lamps becomes a predominantly power source for most rural dwellers. The alternative solution to this, calls for extension or the nations central power grid system to the vast majority of the rural areas or to establish a diesel generating set system (DGSS) to supply the teeming rural community. The alternative solution may not be realised due to its affordability and for the fact that the energy demand accruing from such exercise may outweigh power generation capacity (PGC)- which presently is saddled with load demand crisis (LCD). This inherent problem of the above methods could be solved by the provision of electrical power to remote locations through solar powered plants.

Photovoltaic (PV) equipment is now available to provide a very reliable power supply at locations remote from the electricity network and where conventional fuel supplies are unavailable. In order to use this technology in a cost -effective manner it is essential to understand the resources, the component and system aspects of the photovoltaic plant and also to have a load served by efficient end- use equipment with a high-value service [10]. Solar energy can also be applied in vehicular road transportation system. As noted by Fagbenle [4], three options are open in applying solar energy to vehicular road transport namely:

(a) Solar energy to provide 100% motive power of the vehicle.

(b) Solar energy to provide only electric power requirement of the accessories (i.e. a solar energy generator)

(c) Solar energy to drive a key sub-system such as air conditioning, air compressors (trucks), radiator and AC condenser cooling fans, etc.

Recreation

Solar powered systems provide essential recreational facilities for remote dwellers. Solar energy can be used particularly for heating swimming pools in which large -area unglazed collectors are mostly commonly employed. Solar powered systems can also be used to provide reliable power to very high frequency (VHF) transceivers for communicating with the flying doctors and other important service. Power for a communal Television/Video set can also be supplied using solar energy.

3.2 COST ANAL YSIS

The cost of electricity generated from solar system is high. This is due both to the high cost of components and the diffuse and variable nature or the solar resource. A balanced and fair judgement of the cost of a solar energy system will involve the following cost: initial investment costs, maintenance costs and fuel costs. For any sound economic judgement to be made also, it becomes imperative to make a cost comparison of solar power generation with other conventional energy sources. In order to actualize the cost comparison, an existing data- base as modified by Aliyu and Elegba [14] has been used. Table shows the approximate capital cost estimates for small hydro power as well as some selected conventional and renewable energy options as the pply to the Nigeria situation. The validity of the capital cost estimate for small hydro scheme is assumed for capacity greater than 50KW.

From Table 2 , it can be seen that small hydro is much favoured in terms of low foreign capital investment compared to other energy system options. This may not be plausible when the entire energy systems arc tied to performance criteria index (PCI) than the mere consideration of one particular dependent factor .The entire energy systems of Table 2 is therefore subjected to the Westgate [15] system criteria:

1. Practical, economical operating cost transferable to household and small business contexts, modular, and easily expandable.
2. Educational valid for development and application of hands on skills for young people.
3. Capable of fostering an awareness of individual energy consumption levels, and promotion or self-reliance even in urban areas.
4. Demonstration for educational and recreational programs, including transfer of technology for new markets, through interactive rather than passive exhibits.

A cursory look at the criteria index and the power options reveals that photovoltaic system has the merit of permitting phased development and therefore a gradual investment of capital. It is also likely, because of its innovative approach and ability to reduce operating costs, to attract foundations or public funding as a demonstration project. Although, wind Power system has an energy cost of zero, its maintenance cost is high and as such not appropriate as primary source. Small hydro has the ability to serve as a visible "battery" illustrating the effectiveness of conservation measures. Thermal and Diesel generators are not favoured because they could not be installed on an incremental basis and are vulnerable to long-term variation in fuel cost. If a photovoltaic system is correctly designed it can be installed in very remote and arduous environments and can be expected to function unattended for a period of years. This high level of reliability in harsh and remote environments remains an exceptional feature that demarcates it from other energy option

4.0 CASE FOR FINANCIAL INVESTMENTS IN SOLAR ENERGY

Solar energy investments in a developing economy become highly imperative when one discerns the fact that there is an impending energy crisis in Nigeria due to over-dependence in fossil fuels. The situation becomes more critical as the so-called fossil fuels are finite and fast depleting. The suggestion for financial

investments in solar energy becomes understandable if the basis for such proposition is critically analysed. This underscores the need to look at the sunshine hours in Nigeria since sunlight is primary energy source. Earlier work done by Fagbenle [6], reveals that the mean annual temperature for most localities in Nigeria is about 27°C with the mean annual solar radiation about equal to that of several cities in the temperate climate. This assertion was confirmed by Sambo and Doyle [16] who calculated the average yearly incidence of solar energy on the ground to be 2300KWh/m^2 giving a total incident energy of about 2.100 x l0el2 KWh per year for Nigeria. These studies clearly reveal that there is a preponderance amount of solar energy irradiation in Nigeria. Nigeria enjoys sufficient amount of sunshine. Its average solar insolation is greater than the world's averages. Therefore there is greater accessibility and availability of solar energy for Nigeria to develop her solar energy technology [7]. It has been noted previously that the cost of Electricity generated from a solar system is high. This is due to high cost of Phoiovoltaic modules. But solar equipment has a very low maintenance requirement compared to the conventional methods of Electricity generation. Also, with continuing research and development efforts, this high investment cost of PV modules is likely to fall and become more competitive. Even though the high investment cost of solar energy may deter willing investors, its long-term merit is quite prospecful. This is even more glaring as solar energy source is free and renewable as compared to the 'Conventional fuels that are not only costly but finite. The conventional energy sources arc not friendly to the environment. Apart from the fact that there is a day to day depletion of coal, gas and oil, the increasing problem of environmental pollution associated with the utilisation of conventional sources of energy is unprecedented. The ugly effects of conventional systems such as the wanton pollution of terrestrial arboreal and aquatic qualities through wastes and spillage add to make the expected call for solar energy investment in a developing economy apropos.

5.0 CONCLUSION

We have attempted to look at the present state of conventional energy generation and solar energy research and development in a developing economy like Nigeria. On the whole, solar energy remains the most attractive and efficient way of Electrical energy generation in a developing economy like Nigeria where over-dependence on fossil fuels is alarming. A case is therefore made for a systematic and coordinated financial investments in solar energy research and adaptation to complement the generation from conventional sources. Nigeria has sufficient amount of sunshine and good solar insolation that favours solar energy investments. Investment in solar energy technology In a developing economy like Nigeria should be encouraged as the merits which include: Pollution free environment, free renewable energy source, high reliability and low maintenance cost are to her future technological advancement.

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NOMENCLATURE

NEPA	National Electric Power Authority
MW	Mega watts
PV	Photovoltaic
VHF	Very high frequency
DGSS	Diesel generating set system
PGC	Power generation capacity
LDC	Load demand crisis,
AC	Alternating current
KWh	Killo-watt hour
PCI	Performance criteria index
O and M	Operating and Maintenance

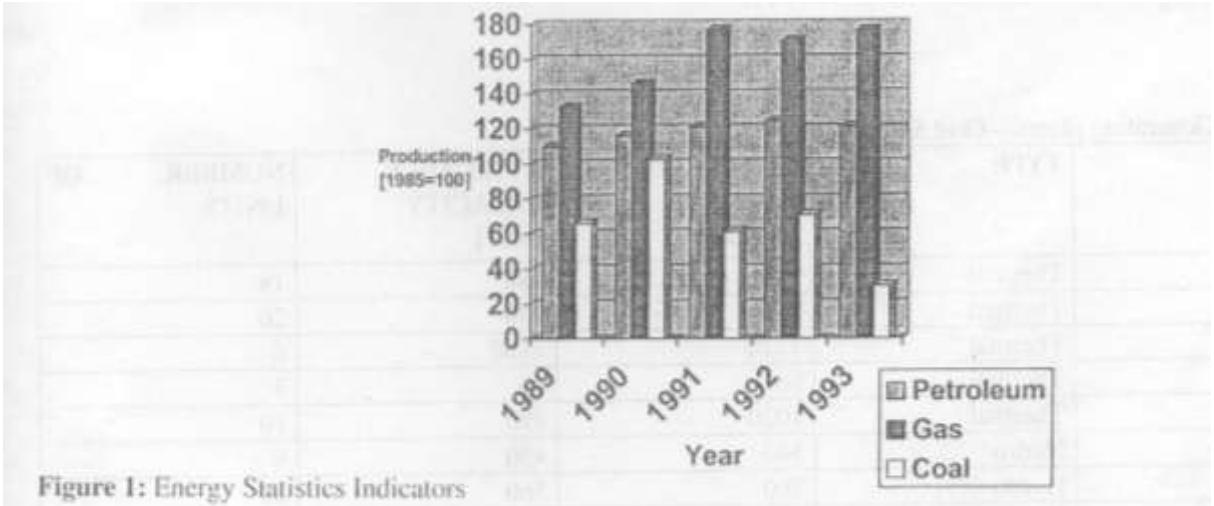

Figure 1: Energy Statistics Indicators

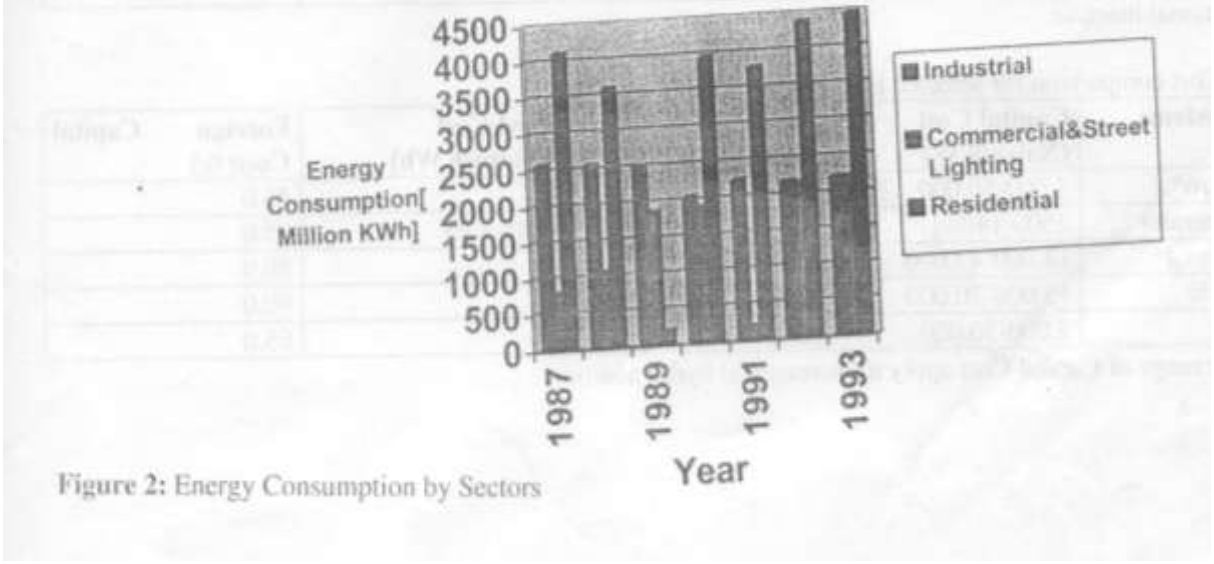

Figure 2: Energy Consumption by Sectors

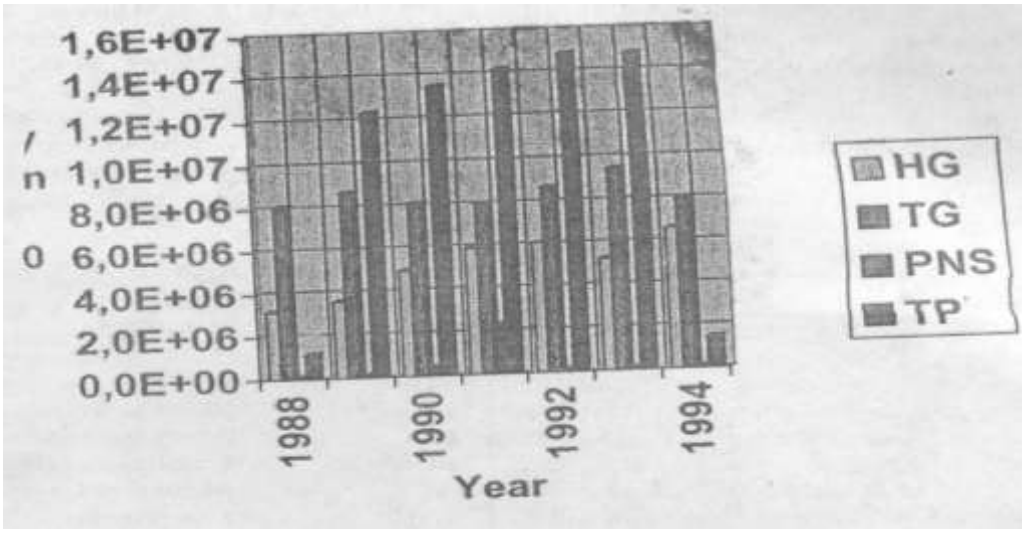

Figure 3: Electricity Production by model Hydro Generation (HG), Thermal Generation (TG), Purchase from NESCO and SHELL (PNS), Total Production (TP)]

Table 1: generation plants-grid stations

SITE	TYPE	INSTALLED CAPACITY [MW]	AVAILABLE CAPACITY [MW]	NUMBER OF UNITS
Afam	Thermal	700	488	18
Delta	Thermal	812	540	20
Egbin	Thermal	1320	1100	6
ljora	Thermal	66.7	40	3
Sapele	Thermal	1020	790	10
Jebba	Hydro	540	450	6
Kainji	Hydro	760	560	12
Shiroro	Hydro	600	600	6
+Orji River	Thermal	60	-	4
Others	Diesel	46	18	-

+ = Operational inactive

Table 2: cost comparison for selected energy systems [14]

Energy Systems	Capital Cost (Naira/KW)	o &M Cost (Naira/KWh)	Fuel Cost (Naira/KWh)	Foreign Capital Cost (%)
Small Hydro*	4,000-50,000	0.020	0	45.0
Diesel Generator	3500-14000	0.12	0.45-1.25	75.0
Solar- Thermal	14,000-42,000	0.045	0	80.0
Photovoltaic	15,000-70,000	0.02	0	90.0
Wind	7,000-30,000	0.035	0	65.0

- Lower range of capital cost apply to incremental hydro addition