THE IMPERATIVE OF INCOORPORATING PASSIVE SOLAR COOLING, PHOTOVOLTAIC LIGHTING AND ENERGY SAVING LIGHTING BULBS TO THE HOUSING POLICY IN NIGERIA

Ndinechi M. C
National Agency for Science and Engineering Infrastructure
NIGERIA.
mikez4god@yahoo.com

Ogungbenro O. A
National Agency for Science and Engineering Infrastructure
NIGERIA.
Ogungbenroakin@yahoo.com

Onwusuru I. M
National Agency for Science and Engineering Infrastructure
NIGERIA.
ijedona@yahoo.com

ABSTRACT

Solving the energy problem in Nigeria has remained a puzzle. Applications of proven technology with reasonable policy shift in our housing policy will go a long way in ensuring more availability of energy for desired purposes. This paper explored the introduction of passive solar cooling, photovoltaic (PV) lighting and energy saving lighting bulbs in houses costing over twenty million naira as a national housing policy. It presented the erection of energy efficient building as a great strategy for reducing energy consumption in households thus making surplus energy available for greater populace. Solar passive cooling is hereby presented as a pure structural and mechanical issue compared to the generally used electromechanical cooling system. This implies that there will be no energy demand from the utility power source. The photovoltaic lighting coupled with energy saving lighting devices on the other hand utilizes solar cells to tap energy from the sun and stored same in an accumulator for house illumination in the night. The effective implication of having both house cooling and lighting energized from other sources rather than the insufficient and presently unreliable power supply is hereby presented as a means of solving major household energy requirement as well as making the national grid more available for other uses.

Keywords: Energy, Policy, Photovoltaic Lighting, Solar, Passive, Cooling, Structural, Energy Saving

INTRODUCTION

The energy problem in Nigeria and its attendant effect on the economy and other aspects of our national life has left every one searching for lasting solution. Several administrations tried to no avail in solving this polyhydric problem. Nigerian Minister of Power and Energy resources is currently quoted saying that the 40,000 Mw expected power generation by the year 2020 cannot guarantee uninterrupted power supply [1]. This paper opined that drastic reduction in domestic energy demand from the national grid (without necessarily reducing the home comfort) will make more energy available for industrial applications. This of course will have positive impact on our economy. Introduction of proven techniques like passive solar technology (for cooling and heating) as well as photovoltaic lighting nicely fits in to this assertion. Both technologies are expected to form part of mechanical/structural design and electrical design respectively. With government policy insisting on the inclusion of both for houses costing over twenty million naira, the authors opined that more power will be made available for other productive purposes.

PASSIVE SOLAR DESIGN

Passive solar design refers to the use of the sun's energy for the heating and cooling of living spaces [2]. In this approach, the building itself or some element of it takes advantage of natural energy characteristics in materials and air created by exposure to the sun.

Passive solar technologies include direct and indirect solar gain for space heating, solar water heating systems based on the thermo siphon or geyser pump, use of thermal mass and phase-change materials for slowing indoor air temperature swings, solar cookers, the solar chimney for enhancing natural ventilation, and earth sheltering.

The scientific basis for Passive Solar Building Design has been developed from a combination of climatology, thermodynamics (particularly heat transfer: conduction, convection, and electromagnetic radiation), fluid mechanics / natural convection (passive movement of air and water without the use of electricity, fans or pumps), and human thermal comfort based on heat index, psychometrics and enthalpy control for buildings.[3].

Passive Solar Cooling

Passive cooling refers to technologies or design features used to cool buildings without power consumption. The term "passive" implies that energy-consuming mechanical components like pumps and fans are not used. Passive cooling building design attempts to integrate principles of physics into the building exterior envelope to low heat transfer into a building. This involves an understanding of the mechanisms of heat transfer: heat conduction, convective heat transfer, and thermal radiation (primarily from the sun) [3], [4]. In mild climate with cool dry nights, removing unwanted heat from a building can be done with ventilating. In hot humid climates with uncomfortable warm / humid nights, ventilation is counterproductive, and some type of solar air conditioning may be cost effective. Figure 1 shows an example of building designed for self cooling. Apart from the ventilating windows, the ventilation chamber is embedded in the roof. Various methods can be employed in achieving this, but the fact remains that they are all structural.

Passive solar technologies use sunlight without active mechanical systems (as contrasted to active solar). Such technologies convert sunlight into usable heat (water, air, and thermal mass), cause air-movement for ventilating, or future use, with little use of other energy sources [5]. A common example is a solarium on the equator-side of a building. Passive cooling is the use of the same design principles to reduce summer cooling requirements.

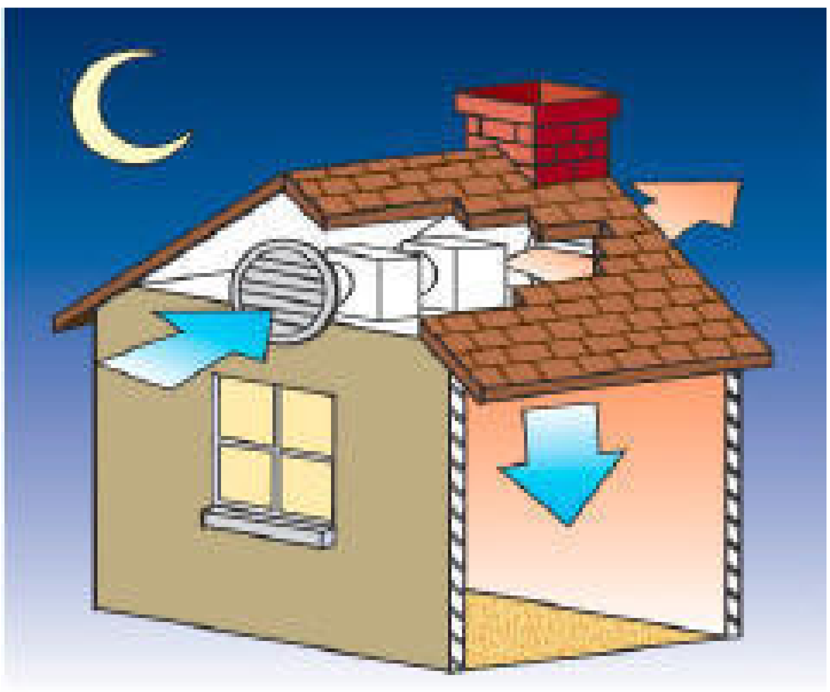

Figure1. Example of Passive solar cooling techniques [Robinson N. “Solar Radiation” Elsevier publishing company, Amsterdam, 1996]

THE ADVANTAGES OF PASSIVE SOLAR DESIGN

Advantages of solar passive cooling include: High energy performance; lower energy bills all year round etc. Since the design is purely structural, it has a sustained efficiency without continuous energy bill. Secondly, this investment is independent from future rises in fuel costs, continues to save money long after initial cost recovery. Thirdly, the value is high with great owner satisfaction, high resale value. Fourthly, it has low Maintenance activity, durable, reduced operation and repair. Also, the unwavering comfort derivable from using this technology such as quietness (no operating noise), warmer in winter, and cooler in summer (even during a power failure) are of immense benefit. Lastly, the techniques are environmentally friendly: clean, renewable energy doesn't contribute to global warming, acid rain or air pollution.

PHOTOVOLTAIC (PV) LIGHTING

Photovoltaic (PV) lighting, or PV-powered lighting, is lighting that is at least partially powered by electricity generated from PV panels (often called solar panels). These PV lighting systems are usually off-grid, or "stand-alone" systems; their only power source is solar energy. This Lighting method considers only stand-alone/off-grid PV lighting technologies that are intended mainly for night time lighting applications. A popular example of PV lighting is the solar garden or pathway light. Other examples include post-top luminaries and parking lot luminaries carrying a solar panel on top. A PV lighting system collects solar energy using one or more PV panels, stores that energy in a battery or series of batteries, and then releases the energy to power light sources at night. Typically, PV lighting system components include PV panels, batteries, electronics (including battery charge controller, inverter or ballast/driver, and timer or switch), light sources (lamps), and luminaries

PHOTOVOLTAIC LIGHTING DESIGN
(Block Representation)

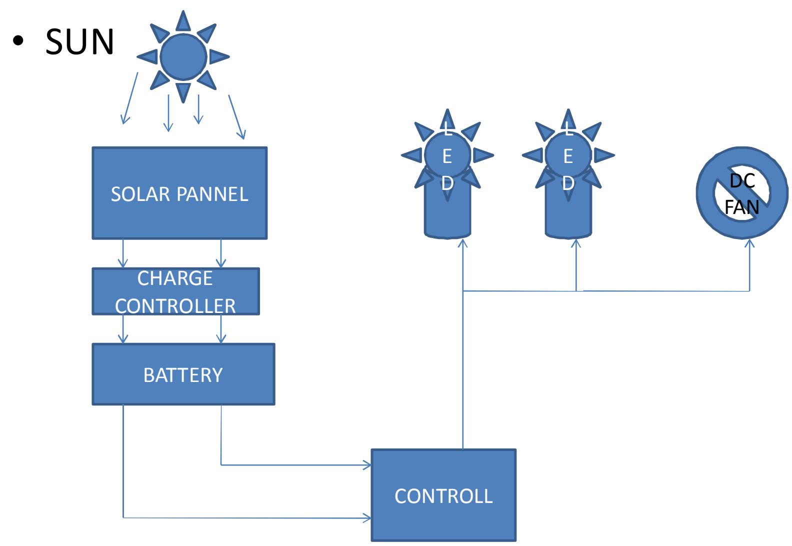

Figure 2.Block diagram of photovoltaic lighting design

The design of photovoltaic lighting is exemplified in the block diagram above. Here, light emitting diode lighting devices is recommended because of its good color rendition, good illumination and energy saving capability. This bulb conveniently replaces both the incandescent and fluorescent ballast lights in the homes. They could be ac or dc operated.

Photovoltaic cells convert sun energy to electrical energy and save same in the accumulator through the solar charge control. The conserved energy is used in the night through the control system for necessary illumination. Other energy saving appliances like direct current operated fan is equally attached.

ENERGY EFFICIENT BUILDING

Figure 3.Energy efficient Building [7]

As shown in figure 3, a typical energy efficient building (apart from the passive solar ventilation techniques) has photovoltaic cells cladding on its roof. The ratings and the total number of which is determined by the maximum energy requirement of the building. Polycrystalline P.V. panels are commonly used for applications where sizable energy is required. On the other hand, the amorphous type can be deployed were only lighting of few energy saving bulbs are required.

In 2005, National Lighting Product Information Program, (NLPIP), New York administered a survey as depicted by figure 4 to assess common beliefs among the public about photovoltaic (PV) lighting systems. The survey was sent via email to all subscribers of NLPIP Online. A total of 442 subscribers responded to the survey. These respondents felt that light-emitting diodes (LEDs) were the most suitable light sources for PV lighting applications, followed by fluorescent lamps. Incandescent lamps were not considered to be suitable for use in a PV lighting system [8]. This is understandable from the high energy requirement of incandescent lamps. But much more than huge energy demand and low efficiency of the same, a survey conducted in Nigeria with attendant implication suggest that incandescent lamps is used by the majority for lighting and as such has a huge demands on the entirenational energy consumption.

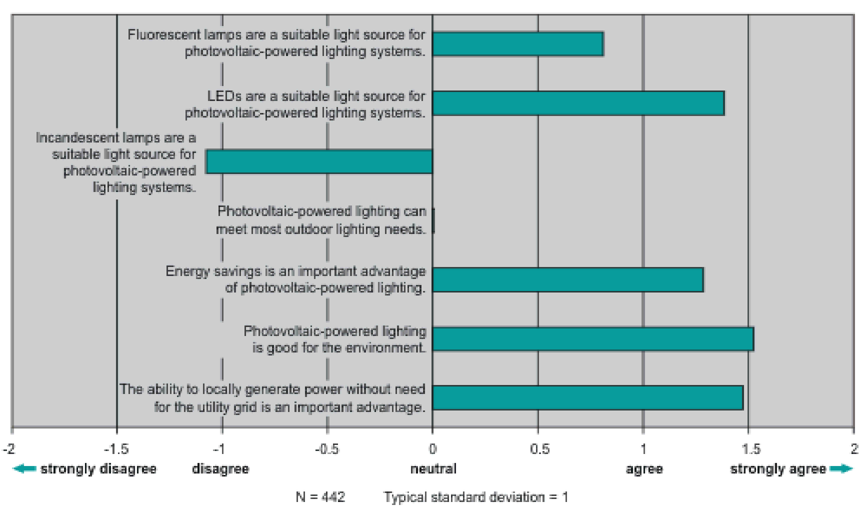

Figure 4.Survey responses: beliefs about PV lighting systems [8]

Figure 5a shows the example of an already designed energy saving L.E.D light. While 5b shows the picture of solar powered multiple cell phone chargers. Both are designed and developed by Electronics development institute, Awka, a parastatal under National Agency for Science and Engineering Infrastructure, (NASENI), Federal Ministry of Science and Technology, Nigeria.

Figure.5a and b Some of ELDI's Indigenous Solar Based Products

CASE FOR USE OF ENERGY SAVING LIGHTING BULBS

Questioner was given out to 100 buildings in Awka town in Anambra state and 100 buildings in Owerri, Imo state, Nigeria to determine the pattern of lighting and incandescent bulb usage. The average data per state is presented below. Those utilizing energy saving bulb are very negligible, hence the table below did not reflect them at all.

Table 1. Incandescent bulb usage pattern per 3-bed room flat in Awka, Anambra State

HOUSES	*40WATTS BULB*	*60 WATTS BULB*	*100 WATTS BULB*	*200 WATTS BULB*	*TOTAL POWER*
1	0	240WATTS	400 WATTS	400 WATTS	1040 WATTS
2	0	480WATTS	300 WATTS	0 WATTS	780 WATTS
3	0	0 WATTS	1100 WATTS	0 WATTS	1100 WATTS
4	0	660WATTS	0 WATTS	0 WATTS	660 WATTS
5	0	660 WATTS	100 WATTS	0 WATTS	760 WATTS
6	0	300 WATS	500 WATTS	200 WATTS	1000 WATTS
7	0	480 WATTS	300 WATTS	0 WATTS	780 WATTS
8	0	480 WATTS	300 WATTS	0 WATTS	780 WATTS
9	0	300 WATTS	500 WATTS	200 WATTS	1000 WATTS
10	0	360 WATTS	500 WATTS	0 WATTS	860 WATTS

Average lighting power consumption for 3 bed room flat = 8760/10= 876 watts

Table2.Incandescent bulb usage pattern per 3-bed room flat in Owerri, Imo State.

HOUSES	*40WATTS BULB*	*60 WATTS BULB*	*100 WATTS BULB*	*200 WATTS BULB*	*TOTAL POWER*
1	0	240WATTS	400 WATTS	400 WATTS	1040 WATTS
2	40	480WATTS	300 WATTS	0 WATTS	820 WATTS
3	0	0 WATTS	1100 WATTS	0 WATTS	1100 WATTS
4	0	660WATTS	0 WATTS	0 WATTS	660 WATTS
5	0	660 WATTS	100 WATTS	0 WATTS	760 WATTS
6	0	300 WATS	500 WATTS	200 WATTS	1000 WATTS
7	0	480 WATTS	300 WATTS	0 WATTS	780 WATTS
8	160	280 WATTS	200 WATTS	0 WATTS	640 WATTS
9	0	300 WATTS	500 WATTS	200 WATTS	1000 WATTS
10	0	360 WATTS	500 WATTS	0 WATTS	860 WATTS

Average lighting power consumption for 3 bed room flat = 8660/10= 866 watts

Getting the average between the two states, (876+866)/2 watts= 871 watts

With this, one can assume that an average 3 bed room flat on incandescent bulbs will consume about 871 watts energy.

For a highly congested 3 bed room apartment accommodating 10 people, a building comprising 6 of such will accommodate 60 people. This will imply an average consumption of 871 x 6= 5226watts per building.

Nigeria has A Population of about 150 million people. If an average of 10 people reside in a three bedroom apartment, then a building comprising of six flats will house 60 people,

Then there will be an average of 150/60 million buildings (2.5million building),

This implies a total of 5226 watt energy consumption on lighting per building

A cumulative power of 5226 x 2.5 mega Watt (13,065 megawatt) power is thus consumed on house lighting if all the houses are to be simultaneously lighted.

On Assumption that only 35% of the building has power supply. Then, 0.35 x 13,065 megawatts, which is approx. 4572.75 megawatts Energy is consumed on lighting alone. If the same is done to cooling system like air conditioners under an assumption that only 2% of the 2.5 million building has it installed.

Assume 4 per building

This implies a total of 0.02 x 2.5 x 4 = 0.2 x 750 Megawatts= 150Mega watts.

Cumulatively, a total of about 4722.75 Mega Watts' power would have been consumed.

On the contrary, if the incandescent bulbs are replaced with 20 watts energy saving light emitting diode light earlier discussed, an average of 12 pieces will be used for a 3 bed room flat; this implies about

12 x 5, i.e. 72 pieces for a building of 60 people as assumed earlier. On the total, a cumulative power of

72 x 20 watts (1440 watts) per building, and a total of

= 1440 x 2.5 Mega watts

= 3600 Megawatts power for the 2,500 buildings.

Again assuming only 35% of the building has power supply, we have

3600 x 0.35

= 1260 Megawatts power is consumed.

If the 150Mega watts from the cooling system are sum up to this figure, we have about 1410 Megawatts.

The implication of this is that a total of (4722.75 - 1260) megawatt i.e. about 3462.75 megawatts energy is saved by substituting the incandescent bulbs with energy saving bulbs.

Nigeria currently claimed to have installed 8,644Mw power plant capacity with the ability to successfully distribute 3,982.7mw power [9].

Both the generated and the distributed power have not been able to solve the domestic need not to talk of industrial requirement. Saving over one third of the distributed power through the methods discussed above will not only save reasonable money for the country but will also make more energy available for industrial use.

DISCUSION

From the analysis above, if photovoltaic lighting is employed with the use of energy saving bulbs say 20 watts each. A 3 bedroom apartment housing 10 people then will require about 12 pieces; cumulatively a total lighting power of 20 x 12 = 240 watts is required for a flat.

Assuming that passive cooling technique is adopted for cooling, implying no air conditioner is used. If four fans of 65watts each is used with other electronics of not more than 200wtts accumulative power of 700 watts would have been used. This implies that photovoltaic module of say 1000 watts can be used effectively. This of course is cost effective and most reliable than relying on the national grid. If therefore the use of energy saving lighting bulbs is legislated as compulsory and photovoltaic lighting is made compulsory for houses costing ten million and above, a total of 1260 Mega watts power is not only saved from the national grid, but generated by the populace that would ordinarily have had nothing doing with independent power generation.

CONCLUSION

Adapting passive solar cooling, photovoltaic lighting and the use of energy saving lighting bulbs techniques to the housing policy in Nigeria, such that structures costing ten millions and above is required by law to incorporate these technology into the building design with a complete ban on the use of incandescent bulbs will go a long way reducing the present energy challenge in the country as well as making consumers pay little or nothing for those services. Appreciable amount of energy will be made available for other uses; as such there will be visible gain for any additional energy generation on our economy. In general, the use of energy saving devices, other than for lighting alone will positively enhance our projection of sufficient, affordable and reliable energy in the nearest future.

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