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ADAPTING RENEWABLE ENERGY SYSTEMS TO LOW-COST HOUSING: PLANNING AND DESIGN IMPLICATIONS

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ABSTRACT

Cost of housing construction has been on the increase for a long time now and an equally high cost in use especially that of energy has exerbated the situation. Consequently adoption of renewable energy systems for low-cost housing has been suggested not only as a cheaper alternative but also as a more environmentally friendly option. However contemporary building design is premised on conventional energy source necessitating some modifications in planning and design for adoption of the various alternative energy sources. A review of the characteristic's of the various alternative energy technologies suggests modifications in architectural planning and design in such areas as site planning/landscaping floor planning. Construction detailing, materials specification and environmental control systems at the micro level. Such modifications would imply a new building form and character which should not only be aesthetically pleasing but should in addition achieve overall cost effectiveness. At the macro level, i.e. City/regional level, a new infrastructural arrangement as well as a modified land-use planning would result

Key Words: Design, Energy, Low-Cost, Planning, Renewable.

INTRODUCTION

Efforts to solve the problems of low-cost housing have often been concentrated on reducing their cost. This is so as the critical problem of this sector of the built environment is its prohibitive cost relative to the incomes of benefiting families, Costs of low-cost housing like those of other building developments or any Project type for that matter are of two components namely the first cost, also termed capital cost and the cost- in- use aggregating to the total cost of development normally termed "life cycle cost." Economics of low-cost housing in Nigeria has almost always ignored the cost-in-use component of housing cost which could be as high as over 40% of life cycle cost. (Taiwo and Sumaila, 2004). The implication of this is that this significant cost is not provided for in the project financing profile leading to decay and un-serviceability of the facility during its service life. This is the case with the low-cost housing stock in Nigeria which lack essential facilities and are un-maintainable. This paper is particularly interested in the energy component of cost-in-us, which evidently is the most significant. For instance in 1992 survey of parts of Northern Nigeria it was discovered that 24% of house hold incomes go for energy bills. (Kyiogwam *et al*, 1992). Preliminary assessment in especially the developing nation world over reveal that energy costs can be reduced substantially by resorting to Renewable Energy Sources. (Wormster, 1978; Yaron *et al* 1996; Sambo, 1996;Taiwo and Sumaila, 2004 etc). In addition, the word wide energy situation in terms of scarcity and unstable prices further home

finiteness of the conventional energy sources. Against this backdrop the paper supports the long standing call for adoption of renewable energies for, especially, residential house. The consequence of such and eventually is that new planning and design principles and features must evolve to accommodate the changed energy services in the buildings and their surroundings. The extent and characteristics of such evolution would naturally be determined by the features of the renewable energy technologies to be adopted. Thus the paper will presently review available renewable energy technologies suitable for adoption in Nigeria.

AVAILABLE RENEWABLE ENERGY TECHNOLOGIES READY FOR ADOPTION IN NIGERIA

There is numerous renewable, energy technologies developed worldwide. However the levels of development and utilization vary from region to legion depending on their various energy sources endowments and technological development. Nigeria, Especially the northern region has a very high insolation which is the basis of all solar energy technologies. Likewise the large land mass supporting numerous varieties of flora and fauna provide the source for biogas and fuel wood energies. Consequently research and development have been concentrated in these areas by academics in various tertiary institutions and government Centres of excellence. A number of solar devices, fuel wood stoves and biogas systems have thus been developed for various end uses. These energy technologies by their level of development and characteristics are very suitable for adoption in especially low-cost housing. Their characteristics and features will be subsequently reviewed to give insight into how they will modify the building fabric and its general environment.

Solar Systems

The devices for consideration under this energy system are 'Solar Cookers.
Solar water heaters' and photovoltaic. Solar cookers and water heaters are mobile appliances that only need placement near solar heat source. Their effectiveness depends on the intensity of radiant heat. Photovoltaic are on the other hand are versatile systems mainly because of the availability of energy in the form of electricity. The PV electrical energy can be deployed as solar powered refrigerators suitable for domestic use as 'veil as solar powered air conditioners in conjunction with passive cooling designs. (Sambo, 1996). However, the more important use of PVs areas electricity power plants. Either as PV cells generating electricity directly or as a thermal power plant using solar heat to power turbines. In either case, the electricity generation is of low-wattage compared to conventional grid electricity. They are often used in conjunction with storage batteries for night time usage or periods of low solar heat intensity. The main feature of PV is its arrays of cells or collectors.

Fuel wood Stoves

In spite of government campaigns to minimize the felling of trees and use of timber as fuel wood, a substantial population of households which cut across both the low and high income earners as well as rural and urban dwellers still uses it as a major source of cooking fuel. For instance in a survey in Bauchi and its environs it was discovered that household energy budget for fuel wood was as high as between 52.48% and 88.62%., (Ali *et al,* 1995). This is so and, beyond enlightenment campaigns. Government is unable to provide any real

alternative to fuel wood as a cooking fuel source. The pragmatic approach in the circumstance is to use the fuelwood in a more efficient and sustainable manner. To this end fuel wood stove whose efficiency is many times higher than the traditional hearths have been developed. (Akinhode. 1991; Danshehu *et al*, 1992; Garba *et al,* 1997). This along with sustainable forest management such as development of 'fast growing tree species' for fuel Wood should mitigate the worst effect of fuel utilization.

Biogas

This is a very viable alternative energy especially for developing nations. A number of Southern and Eastern African Countries have developed the system as a major source of cooking and lighting energies. It also has the advantage of integrated solid waste management as well as improved agricultural production through composting. In Nigeria, availability of abundant *raw* materials (cattle dungs. crop residues and human waste) (Itodo and Kucha, 1997) has instigated researches in the area. It has been found useful in reducing dependence on fuel wood for cooking. The foregoing renewable energy technologies if developed for low-cost housing in appropriate mix should go a long way in improving the energy supply and energy economy of beneficiaries. However the planning and design of low-cost housing as currently practiced may not give the results with these alternative energies. The paper shall currently highlight the salient planning and design features of these houses and subsequently, how they can be modified for integration with the renewable energies.

HIGIILIGHTS OF CONTEMPORARY HOUSING PLANNING AND DESIGN FEATURES

Although majority of housing in Nigeria have been developed by private entrepreneurs the government has often reiterated her responsibility to provide houses for especially the vulnerable low-income families. This she has tried to demonstrate by a number of low-cost housing estates developed all over the country by successive administrations. Government housing showing some consistency through formal design can be conveniently adopted for description of features peculiar to this building typology under the following headings.

Site Planning and Landscaping

Government housing are normally developed in large estates sharing some common facilities like schools, utilities etc. the individual plots are not normally demarcated although individual occupants usually delineate their boundaries with hedges, Chain links and similar features. The built-up area to open space ratio of 3:2 is normally followed although this is altered with time by additional developments by occupants. No conscious attempt at landscaping is carried out except by some concerned individuals in their own areas.

Floor Planning

The planning is of various types ranging from row-housing to single family detached units and on one or more floors. There are few cases of high-rise developments in Lagos. The low-cost houses are usually of one-bedroom to three bedroom

units with such other spaces as the living/dining area, kitchen and bathrooms. There is usually verandah adjoining the living rooms. Total living area ranges from about $50m^2$-$70m^2$. Generally, the planning is patterned after western traditions with little provision for outdoor activities.

Construction Materials and Detailing

Normally the walls are of Sandcrete blocks or fired clay bricks and roofed in some metal sheeting. Occasionally asbestos corrugated sheeting has been used. The finishing is normally of sand/cement rendering and painted over with individuals improving upon it as their income level rises. Plumbing and sanitary fittings ate usually installed although lack of adequate water supply makes them unsustainable over time. The key materials for the building envelope are poor insulators.

Environmental Control Systems

Although theory of the climate and its control system is known this is hardly applied in practice due to a number of constraints. Adequate window openings are usually provided for ventilation but lack of adequate spaces around the buildings especially the private developments, make them hardly effective. Proper orientation is often constrained by the layout of the larger area. Use of shading devices is usually avoided because of the significant extra cost involved. The alternative of wide eaves is also made impracticable by land constraints around the buildings. Micro-climate that can be created through dense planting and other landscaping features is usually not considered in the case of public estates and not feasible with the inadequate plot areas of private developments.
Effects of these conventional planning and design features on the energy efficiency and the associated comfort level of the buildings may be summarized as follows:

- ✓ The building is not insulated against heat by use of heat insulating building envelope; neither is this done by plantings to shield direct solar rays nor by use of various sun shading devices.
- ✓ Provision for natural ventilation is normally made ineffective due mainly to the severe limitation of the plot size, especially in case of private developments.
- ✓ Consequently adequate comfort level can only be maintained by mechanical means which in turn requires high wattage electricity to run. It is for this reason that this paper proposes alternative planning and design of low-cost houses that will effectively run on low wattage renewable energy.

PLANNING AND DESIGN FOR RENEWABLE ENERGIES.

As stated earlier, adoption of renewable energies makes a new planning and design approach imperative. The new planning and design will aim at two broad objectives namely a greater emphasis on the energy efficiency of the building and secondly a new plan and form that will accommodate the renewable energy systems and devices and at the same time achieve a new aesthetics. The task of modification will be carried out at both the macro and micro levels.

Planning at Macro Level

This refers to planning at the level of the city/town or a neighbourhood. The physical plan of the cities and their suburbs will have to be reviewed in such a way as to take a greater advantage of the geology and the general site potentials. Specifically the minimum plot size of I 5m x 30m for high density residential areas have to he enforced. It is only then that the stipulated ratio of 3:2 for built up area to open space can be realized. The layout of the plot should be such that the longer side is oriented along the East-West axis to allow for similar orientation of the building on it.

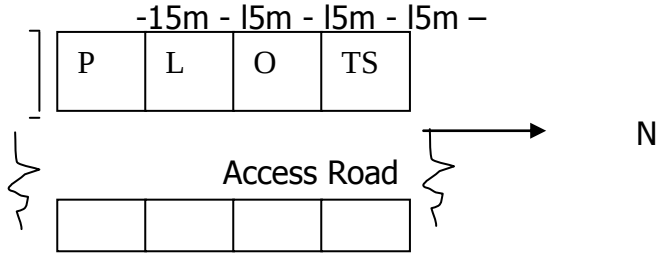

Fig. I Plot layout orientation proposal

The 'Garden city' planning concept should be revisited not only for its aesthetic quality but in addition for purposes of providing conducive micro-climate and as a fuel wood resource among others. Finally provision should be made for accommodation of some new infrastructure e.g. communal biogas digesters, photovoltaic electricity plants. This may be achieved by ample and strategic provision of open spaces within neighbourhoods and the entire city/town.

Planning and Design at Micro Level

This on the other land refers to planning and design at the level of individual buildings and shall be discussed under the following:-

Site Planning and Landscaping

The gains from the general area planning should now be carried on to the layout of the building and its landscaping. Where the building form is elongated, it should be oriented lengthwise along east-west axis. Where however the building is squarish or tends towards it then heavy planting should be done on the East and West sides as solar heat shield/absorber.

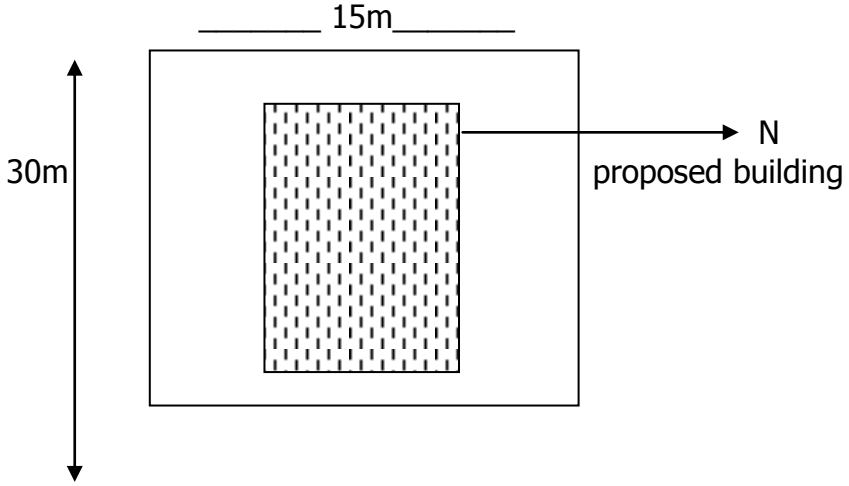

Fig. 2 Elongated building site orientation proposal

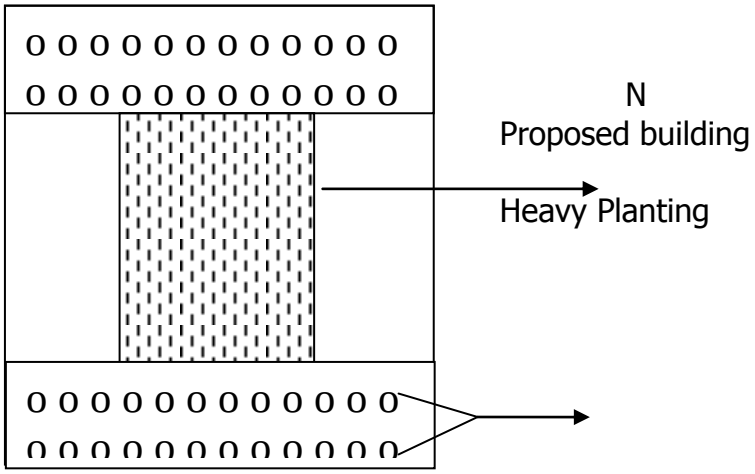

Fig. 3 Squarish building site orientation proposal

Provision should also be made far on site equipment/facility such a biogas digester, stand alone PV array, fuelwood storage etc according to proposed energy mix.

Floor Planning

As much as possible there should be tendency towards elongated form to reduce solar heat gain and improve natural ventilation. Where economy allows planning should he done on more than one floor to free ground space for landscaping and creation of conducive micro-climate as earlier discussed. The disposition of the various functional spaces should be dictated by climatic considerations such that day rooms arc best located on the north and south sides as suggested by Dauda, (2006). Where they must be located on the east or west sides, deep verandahs should be provided as sun buffers. Kitchen should as usual be at the rear and accessed via a rear service entrance. This assumes greater significance where fuel wood is to be cooking fuel source. Where the programme and space allows planning around a courtyard, it will further enhance climatic control as well as provide 'energy free' space for some household activities.

Construction Systems, Materials and Detailing

Here greater exploration of alternative materials for the various elements becomes imperative as the conventional Sandcrete and metal sheet roofing is demonstrably poor insulators. The insulating potential of earth walls and their possible use for elements such as roofs demands urgent investigation. Another area of the building system that needs modifications *for* adoption of renewable system is the sewerage system where the various 'ecosan' systems developed elsewhere may be adaptable, (Austin, 2005). The possibility of designing the sewage system (septic tank specifically) as biogas digester, as human waste is a proven biogas source, is indeed an appealing prospect. (Garba *et al*, 1998). A revolution should also result in the roofing form and material should be photovoltaic cells and be roof mounted.

Building Form and Aesthetics

Aesthetics remains an intrinsic quality of Architecture and any artifact devoid of it has indeed lost the essence of architecture. In an attempt to modify the building to accommodate a new energy device, the aesthetic quality which Allsop, (1953) referred to as 'emotional inspiration' that elevates design above device may be lost. There is also the fear with low-cost houses, as suggested by Suleiman (2006). Of viewing and treating aesthetics as secondary factors to the sufficiency of accommodation. In the light of these, conscious efforts must be exerted from onset to place aesthetics in its appropriate place. Incidentally the modifications proposed present some basis for new aesthetic. Opportunities presented by the reviewed site planning and landscaping must he fully utilized. Likewise other proposals on the building fabric must he handled coherently to achieve a likeable building form. Colour, texture and other elements of aesthetics.

CONCLUSION AND RECOMMENDATIONS

The paper lends credence to calls for appropriation of the renewable energies into the national energy mix and eventually replaces the conventional energies. Specifically three of the many renewable energy technologies, namely: the Solar Energy Systems (Especially photovoltaic), Fuel wood Stoves and Biogas have been proposed for adoption in low-cost housing, in appropriate mix to enhance energy supply and economy. The planning and design of low-cost housing currently is only suitable for high wattage grid electricity so that adoption of alternative energies implies a comprehensive review in so may many aspects of the building and its environment.

The paper concludes that time is ripe for a mix of renewable and conventional energies for low-cost houses in Nigeria and complete replacement of conventional sources is only a matter of time, However profound changes in the planning and design 'of this house typology are necessary for successful adoption of alternative energies. Consequently it recommends as follows:

- ✓ Research and Development should still be intensified especially on the economies of renewable energies as well as planning and design of buildings suitable for their efficient performance.

- ✓ There is the need to carryout pilot projects of low-cost houses powered by various renewable energies so that detected shortcomings become subjects for further research and development.
- ✓ The laws on land tenure as well as planning regulations need urgent review to make feasible some suggested modifications in planning and design.

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