THE ARCHITECTS INPUT: Solar Energy As An Alternative Source Of Power In Residential Buildings.

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Abstract
Nigeria is blessed with a lot of solar radiation which can be utilised as a source of alternative power to our residential buildings. A lot of money has been pumped into the power sector and yet the demand for more megawatts of electricity keeps increasing. Therefore, it has become necessary for the architect being the first to conceive the building design to start advocating for the use of solar energy right from the design stage. This paper explains how the architect will design to suit the conditions that will allow for effective utilisation of this green energy that is yet to be optimally utilised.
Key words: ***architect, design, energy, green, solar.***

INTRODUCTION

Solar radiation has been the source that powers all life in our planet. It is made up of three components, the direct radiation from the sun, diffuse radiation from the sky and reflected radiation from the ground and adjacent buildings. Solar electric cell technology has been developing since the early 1950s. Its first application has been in space industry where it was used to power space satellites. Its application in building started experimentally in the early 1970s and since then there has been an increasing improvement in the technology worldwide. The increase in awareness to reduce the use of fossil fuel and to make the environment green has necessitated for the use of solar energy. Solar electric systems also commonly referred to as photovoltaic systems utilize photovoltaic cells to convert the photons of the solar light spectrum directly into electricity.

Photovoltaic cells are group of panels containing many palm-size cells which are powered by the sun and they convert the energy from the sun into electricity. The cells offer the possibility of freedom from public power supplies and their uncertainties. Solar electric system is the quietest power plant on earth as it costs nothing to run, has no moving parts, requires no maintenance, and produces no pollution. Madamombe (2006) cited that in the early 1990s, numerous villages turned to solar power in parts of Africa where one might least expect to stumble upon an oasis of lights shimmering in the pitch-black night. Perhaps the most ambitious project of this nature, and one that is often cited, is a Zimbabwean project supported by UNDP through the Global Environment Facility (GEF). The initiative, jointly funded by GEF and Zimbabwe installed some 9,000 solar power systems throughout the country in a bid to improve living standards, but also to curtail land degradation and pollution.

The first thing that comes into most people's mind is that a lot of panels would be required to deliver a small fraction of electrical energy. The lack of awareness of this free and green source of energy by the professionals has lead to its non utilisation and recommendation by architects. This has also made the vast majority of Nigerians to resort to the use of fuel powered generator sets which does not only pollute the environment but is also very expensive to run and maintain. It is opined by Akanmu (2007) among other recommendations that, development of alternative energy such as photovoltaic cell technology and the education of building officials will go a long way in providing economic source of energy and also reduce overall pollution into the atmosphere by 38%. This paper therefore gives an insight on the workings of this technology, the principles behind it and how it can be tapped to its maximum especially by architects.

How a Photovoltaic System Works

Typically, the cells are made of chemically treated silicon covered with an upper layer of clear protective material, such as glass. Each solar cell converts sunlight into a small amount of electricity. There are three types of photovoltaic cells which are, Single Crystal, Polycrystalline, and Amorphous. Single Crystal and Polycrystalline Cells are "loaves" of silicon that are sliced into thin layers. For the amorphous system, a thin film of vaporized silicon is deposited on glass or stainless steel. Amorphous cells cost less to produce but are slightly less efficient at converting sunlight to electricity. Photovoltaic panels create direct-current power, which are converted to alternating current to match and synchronize with the type of power delivered by utility companies. To do this, every photovoltaic system requires an inverter that's sized to its output. There are various ways in which photovoltaic cells are arrayed. The most popular and easiest to add to an existing roof are metal-framed modules, which can be mounted to brackets installed on an existing roof. Another method is integrated into a roof, doubling as roofing material or a system, which uses cells sandwiched between layers of glass.

Sizing and Installation

There is no universal photovoltaic system. The amount of energy needed varies from household to household, depending on the types of appliances, lighting, electronic devices, and patterns of living. It has little to do with a home's square footage. However, the number of panels needed can be reduced through energy conservation thus lowering the amount of energy a house will require and the cost of initial installation. The various ways in which energy consumption can be minimised is as follows

- Elimination of high wattage loads.
- The use of high efficiency electrical appliances.
- The scheduled use of certain heavy electric loads.

Certain amenities provided by high energy demand equipment and appliances are not practical on a solar electric system. In some Instances, an alternative approach to achieving the same benefit is available. The energy-intensive uses may be precluded in order to make a solar electric system work, more so houses have to be designed to enhance natural ventilation. For an example, air conditioners draw between 750 -1500 watts when it runs this will be too much of strain on the solar grid system; this can be replaced with the use of window overhangs and attic exhaust fans or window fans. Dehumidifiers also draw too much power over too many hours a day, the use of window fans to ventilate high humidity areas should be recommended. Any appliance that draws too much power should be scheduled and not to be run concurrently with other heavy duty appliance. Examples of such appliances are central vacuum cleaner, water pumps, water heater and electric pressing iron.

High efficiency electric appliances should be used where a fuel-fired appliance cannot be substitute for them or where they cannot be eliminated. The use of high efficiency lighting throughout the house and for outdoor lighting should be recommended. Fluorescent lighting is preferable to incandescent lighting since it uses about 25% (1/4) the energy of incandescent lighting. The use of timers can be recommended by the architect for lights that do not need to remain on for long periods, especially for toilets, outdoor, garage and basement. lighting. The use of high efficiency appliances such as refrigerator/freezer should be encouraged since new models even though they may be more expensive to buy; they consume about 50 % (1/2) as much energy as the older models. The operation of certain appliances should be scheduled. For example, numerous loads of clothes washing, operation of a central vacuum cleaner, and operation of power tools could be scheduled for when the main electrical power supply is available.

The number of panels required will be determined by the quantity of energy demand of the house hold and the initial cost implication. But the simple knowledge by the architect of how the panel are connected will help in determining their arrangement and the output. The collectors are designed to deliver more than the nominal voltage. In a 12 volt configuration, the design output voltage from the collector array is typically between 14 and 21 volts, depending upon the intended use of the collector. The output of the collector has to be higher than that of the battery it is charging in order to force a flow of current into the battery. Usually, more than one collector is required for most residential applications. The collectors can be wired in either series or parallel configuration as desired to increase voltage and or amperage. The figure below shows for comparison the arrangements of typical flashlight batteries and solar panels in series and in parallel.

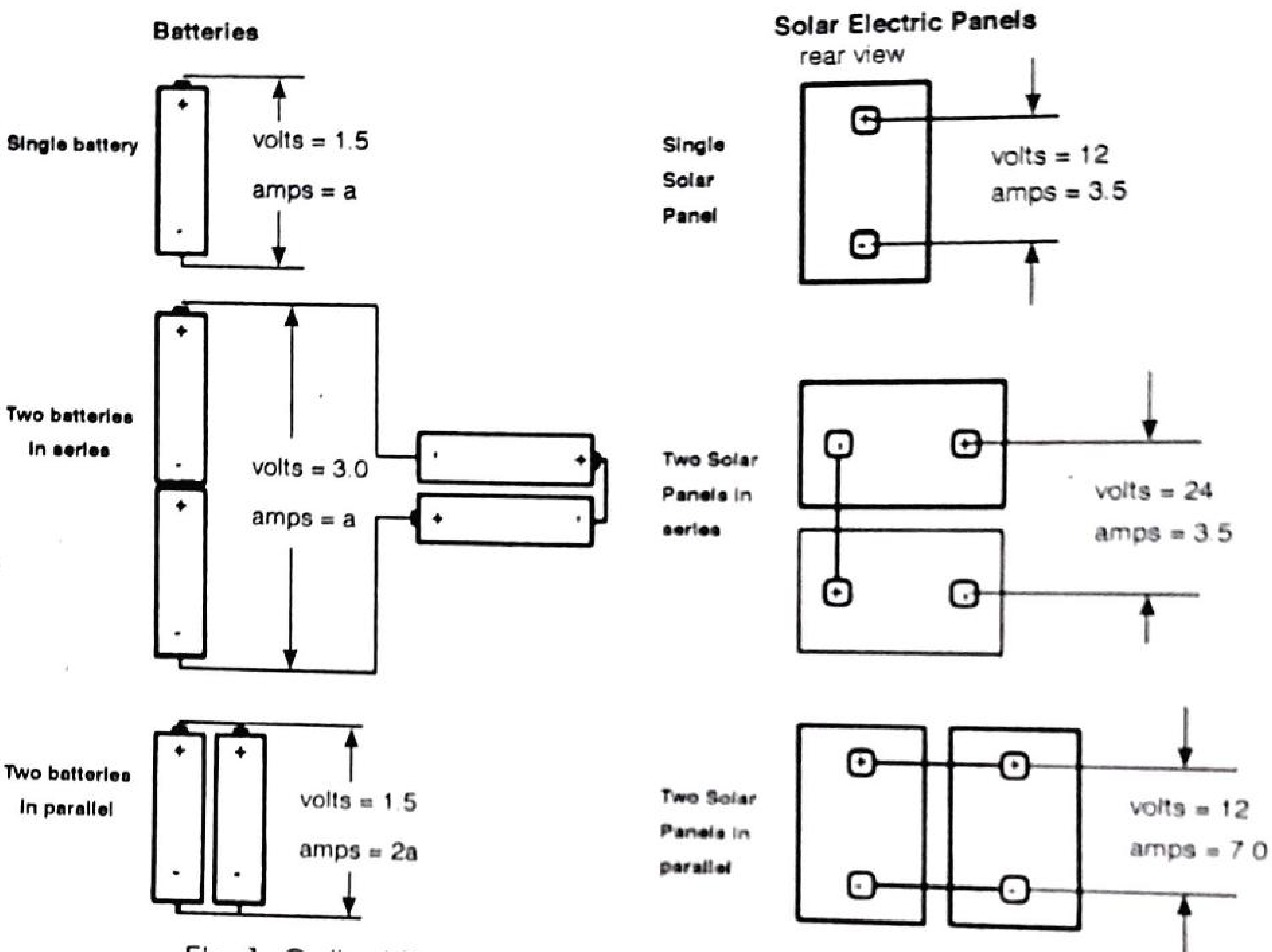


Fig 1. Culled Time savers standard page 16

Mounting of Solar Panels.

The climate, the collector tilt and collector orientation have to be considered as these factors all affect the amount of energy produced by an array of solar collectors. The roof of a house is usually the preferred place to mount the solar collectors because in that location they are least likely to receive shade from surrounding trees. In addition, a roof is often a ready-made mounting surface for the collectors thereby eliminating the cost of a separate mounting structure. A draw-back to putting the panels on the roof is that access to them may be limited. If the collectors are to be mounted on a house roof or on a ground mount, they should be faced in a southerly direction and have a tilt from the horizontal of 40 deg. or more. The southern (equatorial facing) orientation can vary as much as 30 deg. east or west. If the roof is not tilted at the optimum for the solar collectors, then a collector mounting frame can be used to increase the collector tilt.

The greater access the collectors have to the sun, the more cost-effective the solar system will be. It is advisable to slit the panels into two so that the panels are not completely affected by the shade of the roof when the sun changes direction (sun rise and sun set). The wiring of the house should be provided with at least two panel circuit breaker boxes. The main panel will serve the heavy electrical loads that will be carried only by the main power supply (PHCN), while the second panel will carry the loads served by the solar electric system. See the figure 2 below.

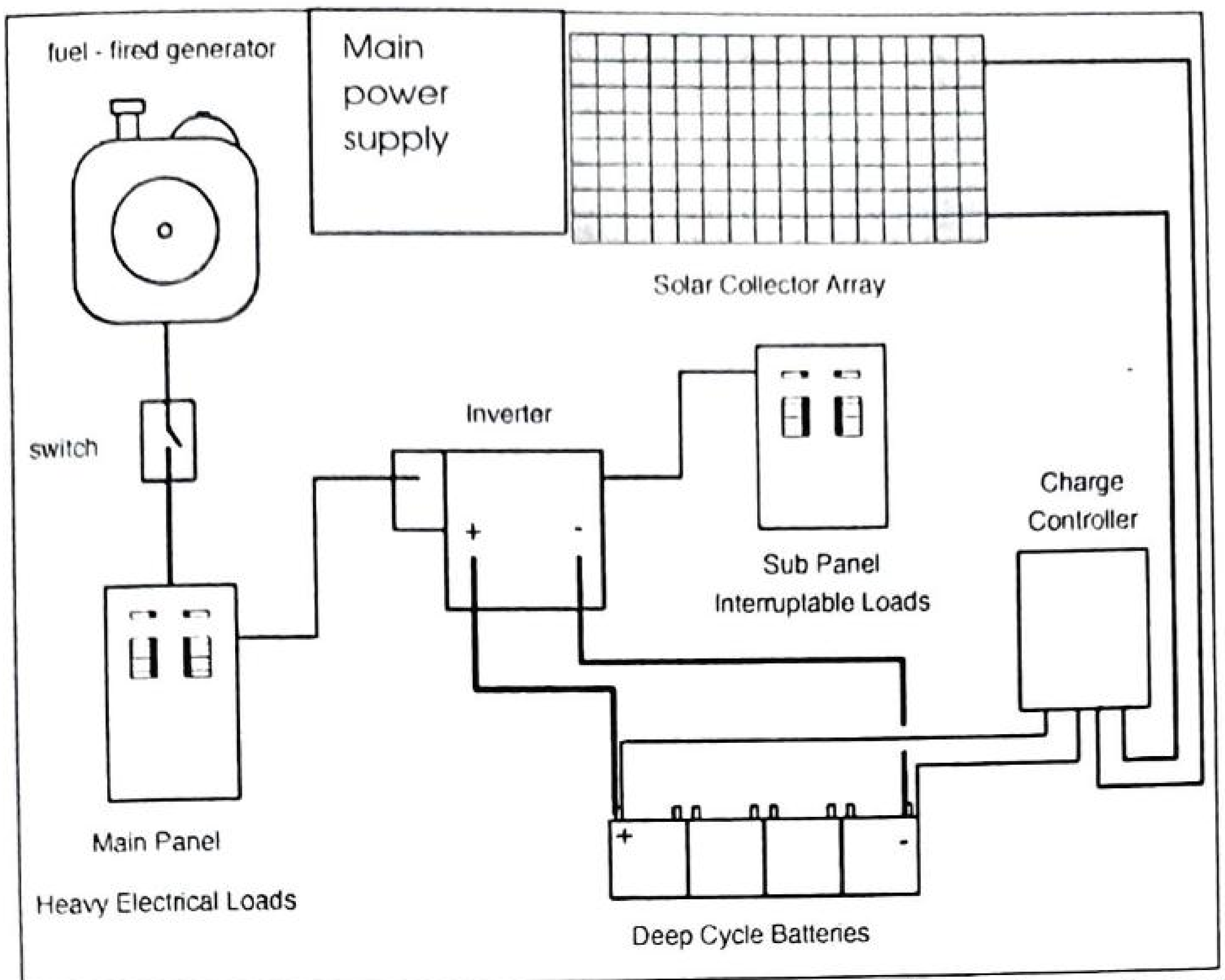


Fig. 2. Schematic diagram of solar electric system (culled from Time savers standard 1999)

Components explanation

- **Solar panels** collect sunlight and convert it into an electrical current. Solar panels are supported by solar mounts (or racks).
- **An inverter** is an important part of many energy systems. It converts direct current (DC) energy into more widely usable alternating current (AC) energy.
- **Batteries** store energy for later use.
- **A system meter** measures how full the battery is, how much electricity the panels are producing and how much electricity is being used.
- A main DC disconnect is found in any battery-based system, between the battery and the inverter. This is a large breaker to allow easy shut off, for battery service.
- **Charge Controller** protects the battery (battery bank) from being overcharged.
- **Rectifier**. These could be considered the opposite of an inverter: they change AC to DC. If the solar PV array is getting lots of sunlight, a portion of its generated power can be used to charge the battery.
- The AC breaker panel is the same as what is found in any household.

Maintenance

Maintenance of equipment is an integral part of running them. Although the life expectancy of solar collectors is put at 25 years, it is most unlikely and unwise to leave them unattended for more than five years. Most solar systems installed initially fell into disuse because of poor applications and the insufficient knowledge on their maintenance. For the solar system to work efficiently, the end user has to be educated into the workings and maintenance of the system. This can only be achieved if the architect and other professionals have the technical knowledge themselves.

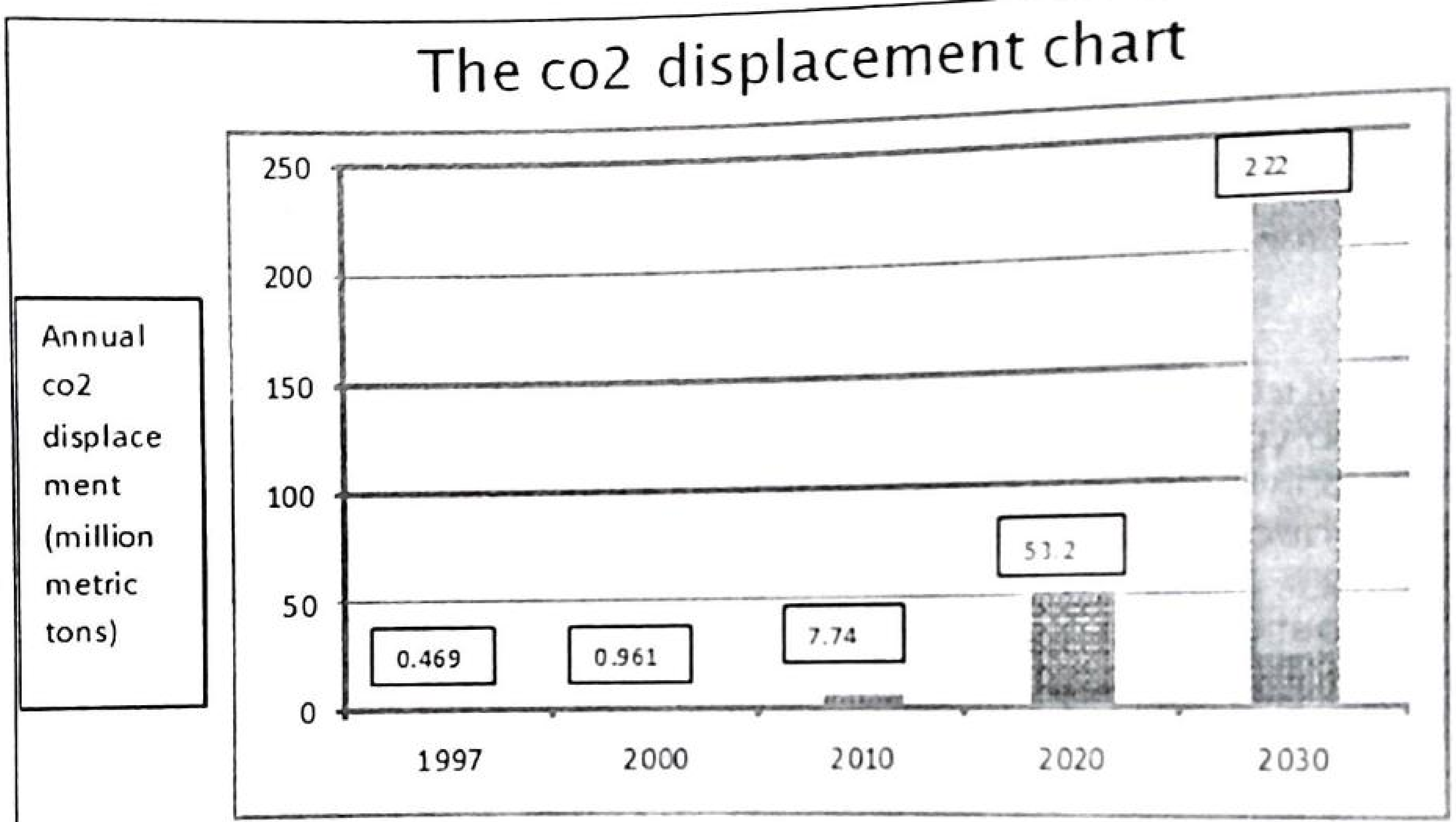
The following are the maintenance checklist of a solar collector.

1) The surface of the collector should be checked and freed from foreign matter such as insects and bird droppings.
2) Period check on the coating of the metal parts and repainting with matching colour of corroded surfaces.
3) Roof and fixings may suffer some movement due to settlement or climatic conditions which may lead to gaps in the roof structure, these gaps will need to be mended.
4) After a period of severe weather, the installation will require to be checked and repair damages if noticed.

5) Solar panels may be damaged by other trades working on the roof, such as television cable installation or the repair of the roof itself. Care should therefore be taken when such activity takes place.

THE BENEFITS OF PHOTOVOLTAIC CELL TECHNOLOGY

1. The PV system can be constructed to any size in response to the energy needs at hand and can be enlarged or moved according to the energy demand.
2. It operates reliably for a long period of time and needs virtually no maintenance.
3. It can be used by architects as aesthetic elements built into roofs, skylight awnings entry ways and facades.
4. It is not affected by fluctuations in fuel prices as it is a fuel free technology
5. It is green and therefore does not pollute the environment. The NREL chart below shows the contribution of PV technology towards reduction of Co2 into the atmosphere.



Under the present growth trends, by 2030 installed pvc system will offset 222 million tons of co2 yearly, equivalent to that generated by 50million cars

Culled from NREL report 2001

It is not expensive: According to NREL report (2001) The cost of producing PV modules, in constant dollars, has fallen from as much as $50 per peak watt in 1980 to as little as $3 per peak watt today, dropping PV electricity to 15¢–25¢ per kilowatt-hour—which is competitive in many applications. When this is compared with what is obtainable in Nigeria, the PVC cannot be said to be the most expensive. The table below compares three sources of energy supply.

TABLE 1 field study 2008 and NREL report 2001

SN/ SOURCE OF ENERGY	RATE/KWT/HOUR	GREEN RATIING
PHCN	N6	-Water Pollution -Noise Pollution -Not Reliable
Personal Generators	N36	-Pollutes The Environment, -Noise, And Air Pollution - Not Reliable Break Down
PVC	N18	-Noise Free -And Air Pollution Free

The analysis of the table shows that even though the PV source of power supply is still not the cheapest, it is still the most reliable and most eco-friendly. As the technology improves it is expected that the cost will come down.

Conclusion

The use of solar energy as an alternative source of power is not as complex as it seems. What needs to be done is for the professionals especially the architect to have the knowledge of the principles and workings of the solar energy technology. The factors that the architect needs to consider when designing are: the knowledge of how the system works, sizing of the panels, installation and maintenance. The building should also be designed in such a way that there will be as much as possible natural lighting and cross ventilation of the spaces. This will reduce the dependence on electricity for cooling and ventilation. It is expected that by the time each architect start to recommend the free and Eco- Friendly Technology, a lot of money which is being used to power generators will be saved and pollution to the environment would be reduced by 38%.

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