

Design of Solar Powered Air Conditioner in Rwanda

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ABSTRACT

The development of renewable energy is one of the goals of our country, to reduce the environmental impacts caused by the increasing demand of energy in all sectors of modern life. , Air-conditioning is one of the major consumers of electrical energy in many parts of the world today. Air-conditioning systems in use are most often built around a vapor compression system driven by grid-electricity. However, most ways of generating the electricity today, as well as the refrigerants being used in traditional vapor compression systems, have negative impact on the environment. This project investigates the design of solar-powered air-conditioning system integrated with photovoltaic (PV) system which consists of PV panels, charge controller, inverter and batteries. This air conditioning system can be used in regions without access to the national grid like in the Eastern Province where temperatures are high. The first step in this project is the cooling load calculations for the selected space to be cooled. The second step considers the availability of solar radiation, temperature of the location, geographical conditions and arrangement of PV system. Therefore, it is required to design the solar powered air-conditioner as per above parameters.

Keywords: photovoltaic, Rwanda, Solar

1. BACKGROUND

Air-conditioning is one of the major consumers of electrical energy in many parts of the world today. The average temperature worldwide is also expected to rise because of the global warming and this might already have begun (Placeholder1). An environmental control system utilizing solar energy source would generally be more cost effective than others if it was used to provide both heating and cooling requirements in the building it serves.

Various solar powered heating and cooling systems have been tested widely, but solar powered air-conditioners have received little more than short-term demonstration attention. Solar cooling technologies collect the solar energy from the sun and use it to provide cold air for residential, commercial buildings and industries.

Nearly all air-conditioning systems in use are built around vapor compression systems driven by grid-electricity. But, most ways of generating electricity used today have some negative impacts on the environment, solar air-conditioning might be the best way to maintain the temperature in a given room cool and dry.

The construction of solar air-conditioning systems, the refrigerants are not used. Refrigerants being used in traditional vapor compression systems also have negative impact on the environment. Other options are to use waste heat from different processes such as industry, refineries, garbage

treatment facilities, ceremony house, meeting house etc. Even driving the air-conditioning systems directly with fossil fuels might in some cases be a more environmental friendly alter-native than using electricity. This technology can be used to reduce the energy consumption environmental impact of mechanical cooling system

2. METHODS

The researcher choose a survey research design because it best served to answer the questions and the purposes of the study. The survey research is one in which a group of people or items is studied by collecting and analyzing data from only a few people or items considered to be representative of the entire group.

3. RESULTS

The solar panel installation: step by step procedure

Before starting Solar panel installation and Photovoltaic Panel Selection for equipment selected after calculating the total heat gain.

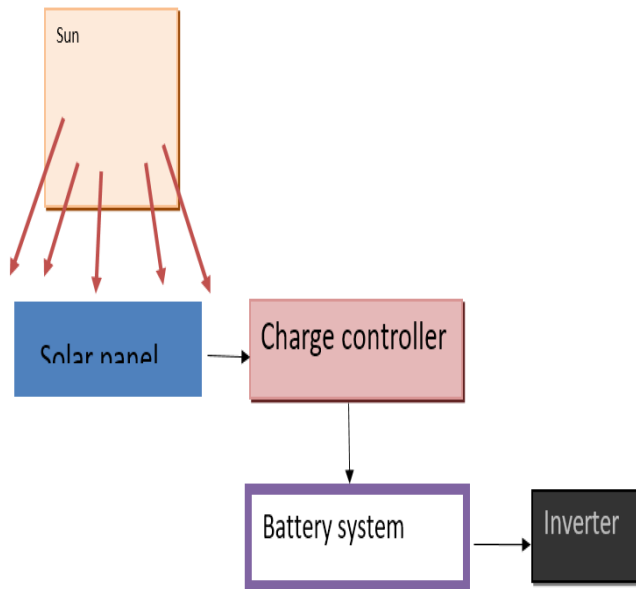


Figure 1. Solar panel installation (our design)

Figure shows how the solar powered air-conditioner system will be structured and the following are the explanations on this figure. The Sun will hit on the solar panel then the solar panel components do their role:

When sunlight strikes solar cell surface, the cell creates charge carrier as electrons and holes. The internal field produced by junction separates some of positive charges from negative charges. Holes are swept into positive layer and electrons are swept into negative layer. When a circuit is made, free electrons have to pass through the load to

recombine with positive holes; current can be produced from the cells under illumination.

The individual solar cells are connected together to make a module to increase current and the modules are connected in an array Depending on current or voltage requirements, solar arrays are connected in a variety of ways:

- If the solar arrays are connected in parallel, the output current will increase.
- If the solar arrays are connected in series, the output voltage will increase and the current is in the DC form.

After creating that electricity, it is transmitted to the air-condition and the cooling action is starting in room.

Coming to the working of solar powered air-conditioner, it has panels mounted in a particular arrangement at an angle of 15 degrees in such a way that it can receive solar radiation with high intensity easily from the sun.

- These solar panels convert solar energy into electrical energy as studied earlier. Now this electrical energy is stored in batteries by using a solar charger.
- The main function of the solar charger is to increase the current from the panels while batteries are charging, regulates the voltage and current coming from the PV panels

going to battery and prevents battery overcharging and maintain the battery life.

- The purpose of using inverter is to convert DC output of PV panels into a clean AC current for using our AC air-conditioner.

The Battery Size According to Alexander (1989); Khurmiand Gupta (2000);

- **Battery Capacity (Ah) = Total Watt-hours per day used by appliances x Days of autonomy**

(0.85 x 0.6 x nominal battery voltage)

The days of autonomy according to our design is 3 days

According to the market, 12 volts battery is preferable.

Battery capacity = 3372.5 Ahr

So, the battery should be rated 12 V, 3372.5 Ahr, for 3 days autonomy.

Now that the daily energy consumption is known, we can determine the battery required. A deep cycle, sealed lead acid battery is typical for this type of application since it operates over a wide temperature range, is usable in any orientation and, unlike a flooded lead acid battery, it requires no maintenance.

The battery of the chloride Exide that will be used for storing energy. Batteries are available in various volts and ampere hour range. To determine the one to use, consideration was given to the voltage and the ampere hour rating. The 12V battery was selected. The ampere hour measures the length of time the battery will discharge while in use and is not charging. A 3372.5 ampere hour battery will give 3372.5 amperes of current for one hour and the current required by the compressor is less than that.

4. DISCUSSION

The purpose of solar powered air-conditioner is to consider both air conditioner and PV system in order to achieve the space cooling and desired temperature of the room. As one of the sources of renewable energy, solar energy is likely the most suitable system and our country focus on that. The air-conditioner powered by solar energy can achieve the purpose of cooling the room as the one of electrical powered do. This system has simpler capacity control, mechanism, easier to install, high reliability, silent operation, long life and low maintenance cost, and friendly source of energy to environment for cooling applications. The figure shown below is giving the whole systems will be looked and its connection.

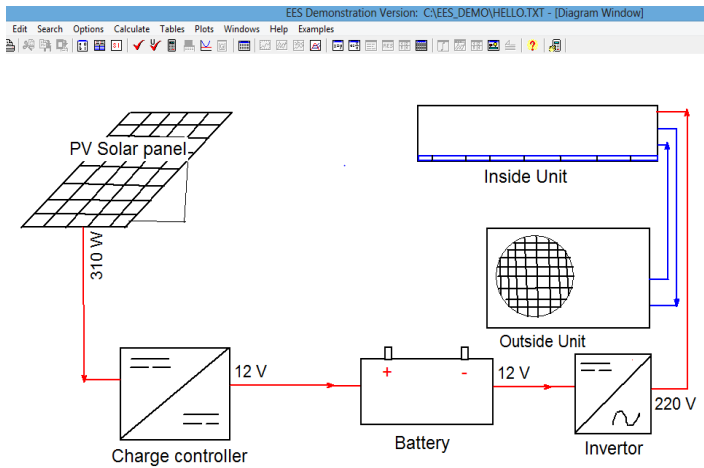


Figure 2. solar powered air conditioner (our design)

The most common type of air conditioning finding in our country is technically referred to the vapor-compression refrigeration system. The operation of the air conditioning system starts at the time the refrigerant flows across the evaporator inside the space to absorb heat. The refrigerant that went into the evaporator leaves as vapor. Then, the low pressure and cool vapor is taken outside and compressed by the compressor to become a hot, high pressure gas.

Compressor is operated by electrical generated by solar panel. The compressor can be described as the heart of air conditioning system as it pumps refrigerant throughout the system. The main function of a compressor is to compress refrigerant vapor to a high pressure, making it hot for the circulation process, and the hot vapor pass through the condenser and gives off some of its heat as outdoor air is blown across the condenser coil.

Some of the important points discussed on comparing the solar and electrical powered air-conditioner are summarized as follows:

- ✓ Solar powered air-conditioner causes no pollution when compared to its counterpart using hydroelectricity and it does not affect the environment.
- ✓ It can be used for at least 3 days when there is no sunlight. This means that the air-conditioner powered by solar store the usable energy without other cost.
- ✓ Maximum amount of current can be drawn without increasing voltage across the terminal by arranging group of cells in parallel connection.
- ✓ The amount of charging during operation varies as per different direction of sunlight which reaches the solar panel and the solar panel should be perpendicular to the sun ray to obtain maximum output.
- ✓ The sun shines everywhere in the country but at different power, so this air-conditioner can operate on in regions with high temperatures and which have no access to electrical grid.

5. CONCLUSION

This project work has given me opportunity for find out my technical knowledge in our domain of engineering and get the time of testing the level of

our design and how to build our confidence to develop ourselves as a professional engineers.

This work focuses on design, construction and testing the performance of solar-powered air conditioning system integrated with photovoltaic (PV) system and applying it in Nyagatare, RWANDA climatic conditions. The project comes as a solution to reduce the demand of electricity especially during the summer, reduce the harmful effect caused by the production of electricity where used fuel and reduce the cost used in cooling the room in many areas of our country. This project has greater efficiency where the electricity is not available. Solar energy as a power source can reduce peak energy demand used in cooling system and increase the rate of air-conditioned demand in many people need it but the problem be the high cost and consumption of energy of air conditioner. This air-conditioner reduces the cost of air conditioning compare to normal air-conditioner. The objective of the project was to design a solar powered air-conditioner, this was achieved by converting a solar energy as source of power into electricity and operates the compressor of air-conditioner, which was successfully achieved.

6. LIST OF ABBREVIATIONS

A: Area of cross-section of the pipe

AC: Alternative current

DC: Direct current

E pan: pan evaporation

g: Acceleration of gravity

I: Intensity

Kg/cm²: Kilogram per centimeter square

Km²: Kilometer square

kW/m²: kilowatts per square meter

kW: kilo Watt

Kwh: kilowatt hour

Kwh/m²: kilowatts hour per square meter

L/h: Liter per second

L/s: Liter per second

M: Meter

m²/s: meter Square per second

mm: millimeter

MW: Mega watt

N/m²: Newton per square meter

P: Power

Pa: Pascal

PV: Photovoltaic

T: Temperature

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ND, conceptualize the idea and both others contributed equally thereafter.

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Both authors are affiliated to Distance production House University/ IST Burkina Faso.

Conflict of interest

We declare not conflict of interest

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