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Solar Power Air Conditioner

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Abstract: In many parts of Texas, air conditioning can account for 25 to 40 percent of a household's annual energy costs (Green Living, 2003). Many low-income families cannot accommodate such an expense and are forced to live without air conditioning. By the time they have paid for rent, then food, there may not be enough money left for lighting and air conditioning. Unfortunately, there is a lack of adequate assistance for such people. Congressman Gene Green (D-TX, 29th District) states that while almost 60,000 Houston area families had their power cut off in 2001, only 14,443 people received cooling assistance in the entire state of Texas. This poses serious health risks for such households, particularly the elderly.

Keywords: Solar Energy, Air Conditioner, Photovoltaic Panel.

I. INTRODUCTION

In many parts of Texas, air conditioning can account for 25 to 40 percent of a household's annual energy costs (Green Living, 2003). Many low-income families cannot accommodate such an expense and are forced to live without air conditioning. By the time they have paid for rent, then food, there may not be enough money left for lighting and air conditioning. Unfortunately, there is a lack of adequate assistance for such people.

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According to the Houston Department of Health and Human Services, senior citizens accounted for 14 of the 20 heat-related deaths reported in Houston and Harris County during the summer of 2001 (HDHHS, 2003). The Center for Disease Control also reports that the average annual rate (per 1 million population) of heat-related deaths is greatest among the elderly, as shown in Figure 1. An even greater number suffer non-fatal illnesses and personal discomfort.

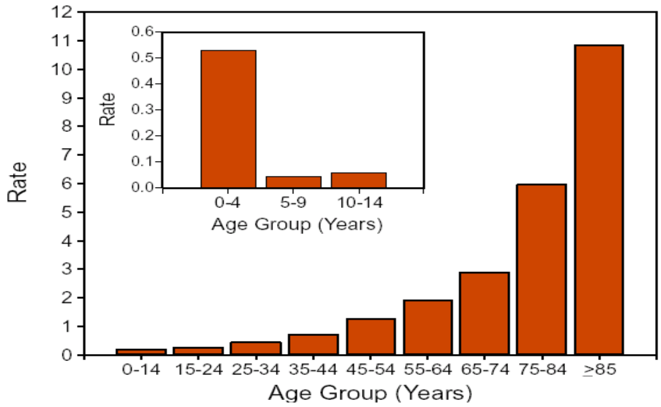

Fig 1 Average annual rate of heat-related deaths, by age group United States, 1979-1992 (CDC, 1995)

II. BRIEF SURVEY OF SOLAR ELECTRIC POWER

A solar power system is more than just a set of solar arrays. Several components are required for a properly functioning system. If the system is designed to provide power twenty-four hours a day, or any period where the sun is not shining, a battery bank or some secondary power source is required. If not, the system is much simpler. In both cases, any solar power system will include some form of photovoltaic panel, frame or structure, and power outlets. Generally, some form of inverter or power conditioner will be required. If a secondary power source is required, then a charge controller and battery (or other secondary power system) will also be included. General descriptions of each of these solar power subsystems will be provided:

A PHOTOVOLTAIC PANEL

There are three basic types of photovoltaic modules commercially available today: single crystal silicon, polycrystal silicon, and thin film/amorphous (Solar Panels, 2003). (For those familiar with spacecraft solar panels, all of these are essentially silicon solar arrays. The more efficient dual or triple junction, concentrator arrays, etc. have not moved into common terrestrial use as of yet.) While there are differences in efficiency and appearance, all of these silicon cells work essentially the same way, converting sunlight directly into electricity.

B INVERTER

An inverter is a device that converts direct current electricity to alternating current electricity. In a solar power system, it converts the DC energy from the photovoltaic panels or batteries into AC electricity to power appliances. (Schwartz, Home Power, 2003)

C BATTERY

Most batteries used in solar power systems are lead-acid types, as they tend to offer the best power to price ratio. The acid is typically 30% sulfuric acid and 70% water. They are deep cycle batteries, meaning they are designed to be discharged down as much as 80% time after time. These batteries come in three basic forms: flooded, sealed gel, and absorbed glass mat (AGM). The different forms have various advantages and disadvantages, but the AGM is often recommended as the battery of choice due to the fact that it cannot leak acid and requires no maintenance, though they are often 2-3 times more expensive than the flooded battery (Battery FAQ, 2003).

D CHARGE CONTROLLER

A charge controller is used in any solar power system that includes batteries. The charge controller blocks reverse current and prevents battery overcharge. Some controllers also prevent battery overdischarge, protect from electrical overload, and display battery status and the flow of power (Charge Controllers, 2003).

E POWER OUTLETS AND WIRING

While wiring may seem self-evident, it is important to consider wiring in the design of a solar power system. Choosing improper wiring may result in feeble performance of appliances and/or fire risks. Generally, power loss is the concern for low voltage systems and fire safety is the concern for high voltage systems (Wire Sizing, 2003). And of course, any solar power system must have receptacles for the loads to plug into. These receptacles may sometimes include some form of circuit protection.

F FRAME/STRUCTURE

Some kind of structure is necessary to hold the photovoltaic modules in place. Often, this will be a roof or pole mount, and in the case of the pole mount it may be fixed or sun tracking. It is necessary to ensure that the mounting chosen is compatible with the photovoltaic modules selected.

III OVERVIEW OF MARS TESTBED SOLAR RECHARGE STATION

There is some NASA-JSC in-house experience with constructing solar power systems.

Fig 2 Solar Recharge Station

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The Environmental Office of the Center Operations Directorate and the Advanced Extravehicular Activity Group recently joined forces to build a solar recharge station (shown in Figure 2) to recharge electric tools and other equipment during on-site field tests at JSC's EVA Remote Field Demonstration Test Site, which simulates the surface of Mars.

The solar recharge station was constructed using commercially available components from Solar craft, Inc., located in Stafford, Texas. The purpose of this recharge station is twofold: one, to provide a power source more representative of what will be used on Mars and two, to demonstrate how state-of-the-art technology can be applied to improve life on Earth as well as explore space (Solar Recharge Station, 2003).

NSBE-HSC can tap into the expertise of the Environmental Office as well as organizations within Engineering and Mission Operations that regularly utilize solar power systems.

IV OVERVIEW OF SOLAR POWERED AIR CONDITIONER SYSTEM

Two options exist for this system: a continuously powered system requiring batteries or a non-battery system powered only during daylight hours. The continuously powered system has the advantage of providing a constant temperature, but comes at the cost of increased system complexity and expense.

The daylight system has the advantage of simplicity and reduced expense, but provides no cooling between sunset and dawn. This may be acceptable since the most severe thermal environment occurs during daylight. Overnight temperatures will generally be low enough to use conventionally powered fans, especially considering that the room will have been cooled considerably by the air conditioner.

The daylight system may be easier for elderly persons to operate, while the continuous system will be more comfortable. This paper will examine both options and will not recommend one system over the other, deferring that decision for later in the chapter's implementation of this project. Figures 3 and 4 graphically illustrate the components required for the daylight and continuous systems respectively.

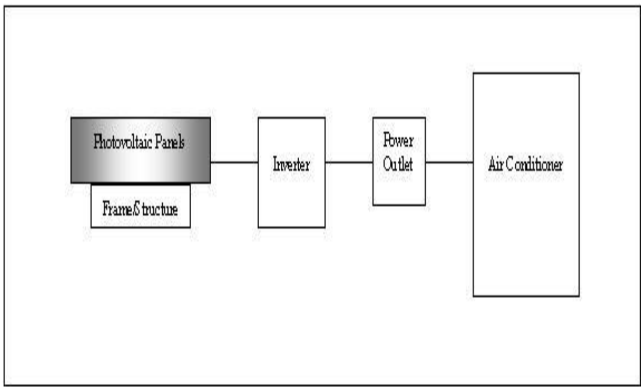

Fig 3 Daylight Solar Power Schematic

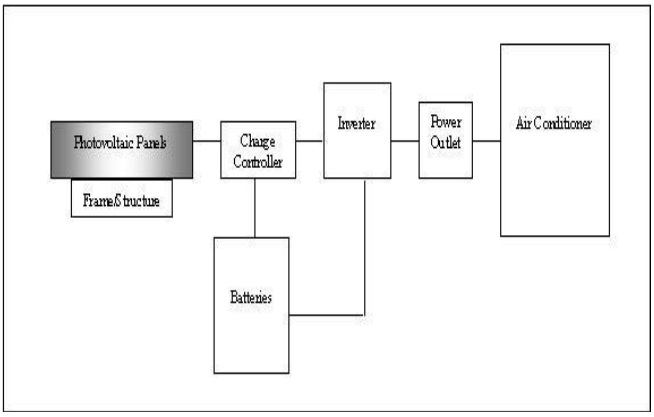

Fig 4 Continuous Solar Power Schematic

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V PRELIMINARY SYSTEM SIZING

Because this project only involves a solar powered air conditioner, the load analysis is particularly simple. Two options are initially being investigated for possible development by the chapter: a daytime-only system and a 24-hour system. The daytime-only system will only operate when the solar panels can provide power, while the 24-hour system must operate continuously. Both options will be sized below, based on today's vendor prices for commercially available equipment. Given that prices will fluctuate and various pieces of equipment may go in and out of production, this analysis should not be construed as an exact specification of what the system will look like and cost, but should be viewed more as a ballpark figure that the eventual system will approximate.

For option 1, the load analysis is simply the power required to supply the air conditioner. For option 2, the analysis is more complex. In addition to the air conditioner power, power is also required for battery charging and system losses. Charge power is impacted by the amount of time available for charging. For simplicity, the 24-hour system load analysis will assume twelve hours of charge time and ten hours of battery operation. Overcast conditions are not modeled in this initial analysis.

For both options, the air conditioner will be sized to accommodate a 300 to 350 square foot living area that includes a kitchen. A general rule of thumb suggests an 8,000 BTU unit for this size, with another 4,000 BTU recommended for the presence of a kitchen. Based on the data in Table 7, the Kenmore Multi-Room air conditioner with a 12,300 BTU cooling capacity is an appropriate unit. This air conditioner has a list price of $399.99 from Sears and requires 1140 W in power. Beyond this point, the data is different for each version.

VI CONCLUSION

We will not be able to help everyone, but we will make a difference. And in so doing, we will pioneer a roadmap that other organizations can adopt and join us in helping to make things better for the elderly in Houston. In so doing, we will enhance the images of NSBE, NASA, our contractors and our partners, while also gaining a sense of satisfaction from knowing we improved the world in a way that uniquely tapped into our specific abilities.

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