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Analysis of Solar-Powered D.C Air Conditioning System

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Abstract- In this paper an attempt has been made to run a high capacity packaged type air-conditioner using solar energy. For this purpose the vapour compression cycle has been selected. In this the D.C powered compressor is used to save the losses of input energy. It is found that for cooling a given space 10TR capacity cooling unit is needed. As per market survey we found that package type vapour compression system can fulfil this requirement. To power this unit we need 12 photovoltaic modules of 345 W_p capacity connected in series. In this analysis the COP of system has been taken 2.52. Four quantities per panel of 24 volts battery are needed to give backup power for system.

Index Terms- PV modules, heat load, solar energy, package air-conditioner, package unit, D.C compressor, battery.

I. Introduction

Solar energy is one of the most available forms of energy on the earth's surface. The main purpose of using solar energy is to reduce the emissions of CO_2 and other harmful gases that are responsible for global warming and ozone layer depletion.

The air conditioning is an attractive field for the application of solar energy because of the availability of maximum solar radiation during summer season when we need cooling. This research program addresses the need for the development of new air conditioning. Now days we need such technologies that have lower operational cost and minimum impact on the environment.

Solar photovoltaic system and solar power is one of renewable energy system which uses PV modules to convert sunlight into electricity. The electricity generated can be stored or use directly, fed back into grid line or combined with one or more other electricity generator or more renewable energy sources. Solar PV system is very reliable and clean sources of electricity that can suit a wide range of application such as residential, industry, agriculture, livestock, etc.

Many studied have been done to develop efficient air conditioning system using solar energy. M. Okumiya et.al [1] had studied the performance of solar-thermal air conditioning system installed in an office building. X.Q. Zhai et. al [2] had designed and installed solar powered adsorption air conditioning system. N. Nakahara et. al [3] had discussed the roll of compound parabolic collector in this field. Z.F. Li and K. Sumathy [4] have been analysed the performance of solar absorption air conditioning system and found that generator inlet temperature of the chiller is the most important parameter in design and fabrication of solar powered air conditioning system. Kaled S. Al Qdah [5] has investigated the design and performance of air conditioning system using photovoltaic cell. Rachid C. et.al [6] have been optimize the photovoltaic system and calculated the solar radiation falling on the photovoltaic system.

In this present study our main goal is to cool a given space of a building using photovoltaic system. The solar energy is used to power the D.C. motor that run the vapors compression system.

II. METHADOLOGY

For the purpose of analysis we have chosen space that is a classroom inside JMI campus, New Delhi, having size 20.5 x 7.66 x 3 m. it is required to cool the specified space for 6 hour. The heat load calculation has been done on the basis of building structure, outside and inside temperature and relative humidity. The design maximum temperature is taken 43^o C during summer and the comfort temperature inside the room is taken 25^o C with relative humidity of 60%. The detail heat load calculation is given in Table 1.0 the selected specifications of air-conditioning unit are as following specification:

- Type of System - Packaged air-conditioning
- Unit capacity -10TR
- Input Power -14kW
- Input Voltage -220V

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2.1 Heat Load Calculation:

Table 1.0

	SOURCES	LOAD (Watts)
Sensible Heat	Heat gain from walls, roof, floor, door & window	6560.45
	Solar heat gain through glass	756
	Heat gain from 60 person	4500
	Heat gain due to ventilation	6608
	Heat gain due to lighting	1680
	Heat gain due to fans	800
	Heat gain due to fresh air	2280
	TOTAL SENSIBLE HEAT GAIN	1.065×23184.45 = **24.7 kW**
Latent Heat	Heat gain from 60 person	3300
	Heat gain due to ventilation	2700
	Heat gain due to fresh air	1176
	TOTAL LATENT HEAT GAIN	1.06x7176 = **7.6 kW**
TOTAL HEAT GAIN	**24.7+7.6 = 32.3 kW**	

Considering Factor of safety 15%, the Grand Total Heat load become 10 TR**.**

2.2 Sizing of Photovoltaic panel:

A Voltage regulator is designed to automatically maintain a constant voltage level

$$COP_{cooling} = \frac{\text{Desired output}}{\text{Input Power}}$$

$$W = \frac{35}{2.52} = 14\ kW$$

Where the acceptable COP system recommended should be 2.52.

So, we need 14000 W for 6 working hours per day

Input Power x Working hours in day= Work hours per day

14000×6 = 84000 W.hr/ day

Per day minimum hour sunlight is 6 hr/day

$$\text{Total load capactity} = \frac{\text{work per day}}{\text{min sunlight}/\text{hday}}$$

We need photovoltaic solar system with capacity 14kW. To fulfill the requirement of this load we need 12modules as given in Table 2.0.

Table 2.0

Total load (kW)	Energy lost	P.V panel energy needed	Panel generation factor	Total PV panel capacity	Powered (Wp)	No of PV panel
14	1.3	18200	4.32	4212.96	345	12

So, this system is powered by least 12 modules of 345 Wp PV modules.

Nominal battery Voltage = 24V and 48 V.

Battery loss 80% = 0.85

Depth of Discharge = 0.6

Table 3.0

Total load (kW)	Nominal battery Voltage – I (V)	Nominal battery Voltage- II (V)	Day of Autonomy (day)	Battery Capacity-I (Ah)	Battery Capacity-II (Ah)
14	48	24	6	3431.373	6862.745

Table 4.0

No of PV panel	Starting Current (I) when battery Voltage=48	Starting Current (II) when battery Voltage=24	No of battery needed - I	No of battery needed -II
12	48	24	2	4

III. RESULT

For a cooling space (20.5 ×7.66×3) m we have calculated cooling effect 10 TR. This capacity of cooling effect can be achieved by using Package type air-conditioning system. To fulfil the requirement of power we need 12 photovoltaic modules of 345 W_P. The arrangement of modules and cooling unit is given in Fig.1.0

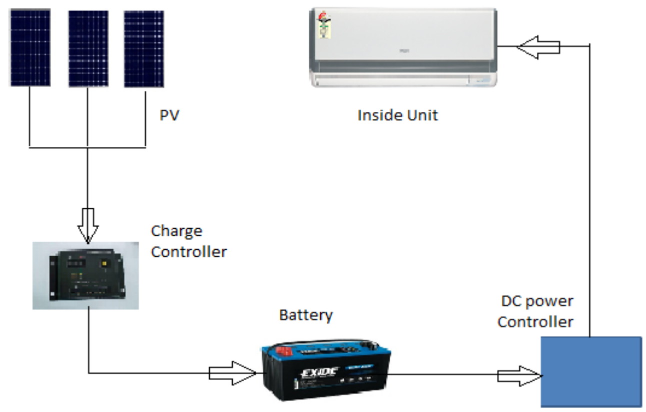

Figure 1.0 Final actual system cycle

IV. CONCLUSION

This work focuses on design, construction and testing to run a high capacity package type system air-conditioner using solar energy integrated with photovoltaic (PV) system and applying it under a classroom inside JMI campus, New Delhi climate conditions. The project comes as solution to reduce or save the losses of input energy by using D.C powered compression. For this purpose we need 12 PV modules of 345W_P. Two options have been adopted for selecting batteries. In one case we need 48 batteries of 24 Volts and 24 batteries of 48 volts to maintain the backup of the system.

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