PERFORMANCE ENHANCEMENT OF PV COOLING SYSTEM – USING MODIFYING AIR CONDITIONING SYSTEM SIZING APPROACH

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Abstract: In this paper performance of PV cooling system is presented using modifying sizing approach. In this technology fan air speed is used to increase the set temperature of air conditioners. Elevated air speed may be used to offset an increase in their temperature and the mean radiant temperature, but not by more than 3.0°C (5.4°F) above the values for the comfort zone without elevated air speed. The required air speed may not be higher than 0.8 m/s (160 fpm). Annual load curves shows that for more than 90% of time load on air conditioner is nearly 75% of his full capacity. Result shows that in this approach enhances upto 20-25 % in the solar fraction.

Keywords: Solar Fraction, PV System, modifying size.

1. Introduction

The annual power consumption of photovoltaic operated air conditioner may be decrease by change in control strategy i.e operation of photovoltaic air conditioners. PV based air conditioning cooling system works during the office hours i.e. 09:00 -18:00. In the event that the building is unoccupied during the evening hours, like office buildings, it is possible to relax the restrictions on indoor thermal comfort. In any event, outdoor conditions are more favourable for passive cooling techniques, like natural, hybrid or indirect ventilation, which can be used to remove portions of the load [Singh A.P 2012]. The cooling system may be switched off for 1 or 2 hours before the closing of office and in that time the thermal comfort may be achieved by natural ventilation and ceiling fans. In the evening hours when the cooling system is off than the PV generated power supplied to cooling system is also zero, and this power is either feed to the grid or dumped. Thus this operation may decrease the annual power consumption but it will not increase the solar fraction.

The other way to increase the annual solar fraction is by reducing the size of the air conditioner. Marc 2010 reported that in the case where the air conditioner is undersized and runs in nominal conditions with good performances, thermal comfort inside the building will not be achieved in some critical periods of the year. In this case thermal comfort can be achieved with ceiling fans [O Marc2010]. Before applying this option cooling load analysis and thermal comfort condition must be analyzed.

2. Analysis of Peak Cooling Load Hours

Fig.1 shows the annual load duration curve for four climates. It has been observed from the curve that the peak cooling load greater than 9 TR (31.5kW) in year in the composite climate is one hour only. The peak cooling load greater than 8 TR (28 kW) is only 24 hours in hot and dry climate (Ahmedabad), 1 hours in warm and humid climate (Chennai) and 24 hours in composite climate (Delhi). Similarly the peak cooling load greater than 7 TR (24.5kW) is also less than 300 Hours in any climate. In the moderate climate the peak cooling load greater than 5 TR (17.5kW) is only 44 hours. Hence in this condition the sizing of air conditioner may modified and fix 7 TR (24.5kW) for the hot and dry, warm and humid and composite climate and 5 TR for the moderate climate.

3. Utilizing high air velocity

The decrease in the size of air conditioner reduces the thermal comfort inside the building. In this case the thermal comfort in the building can be achieved by air movement. However the precise relationships between increased air speed and improved comfort have not been established. ASHRAE 55-2004 standard allows elevated air speed to be used to increase the maximum temperature for acceptability if the affected occupants are able to control the airspeed. The amount that the temperature may be increased is shown in Fig.2. The combination of air speed and temperature defined by the lines in this figure results in the same heat loss from the skin. The reference point for these curves is the upper temperature limit of the comfort zone (PMV = +0.5) and 0.20 m/s (40 fpm) of air speed [ASHRAE 55-2004].

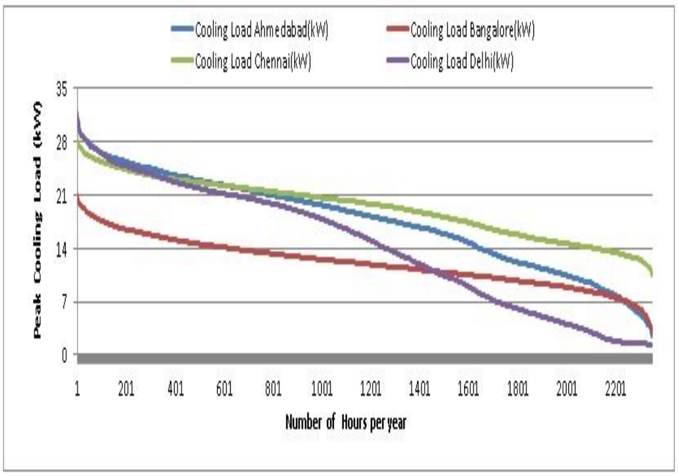

Fig. 1 Annual Load Duration Curve

Elevated air speed may be used to offset an increase in their temperature and the mean radiant temperature, but not by more than 3.0°C (5.4°F) above the values for the comfort zone without elevated air speed. The required air speed may not be higher than 0.8 m/s (160 fpm). Large individual differences exist between people with regard to the preferred air speed. Therefore, the elevated air speed must be under the direct control of the affected occupants and adjustable in steps no greater than 0.15 m/s (30 fpm). The benefits that can be gained by increasing air speed depend on clothing and activity [ASHRAE 55-2004].

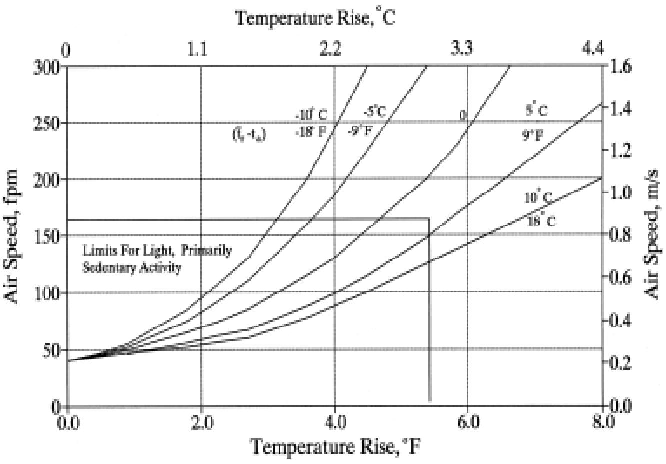

Fig 2 Air speed required offset increased temperature [ASHRAE 55-2004]

4. Performance analysis of PV cooling system with modified size

In this section performance analysis of PV cooling system using modified size are presented and discussed.

Solar Fraction

Fig.3 shows the variation of annual solar fraction with the PV area for the four different climates. It has been observed from the graph that the solar fraction is highest for the moderate climate (Bangalore) and lowest for the warm and humid climate (Chennai). Fig.3 shows the comparison of solar fraction using 10 TR (Moderate climate -7TR) and 7TR (Moderate climate -5 TR) air conditioner. It has been observed from the graph that the solar fraction is very high when we are using the small size of air conditioner. This is due to fact that the small size air conditioners consume less power than the bigger one resulting in the good matching with the power generation by the photovoltaic panels. The solar fraction reaches as high as 0.79 for hot and dry climate (Ahmedabad), 0.89 for moderate climate (Bangalore), 0.77 for warm and humid climate (Chennai), and 0.77 for composite climate (Delhi) when 110 m² PV area was used.

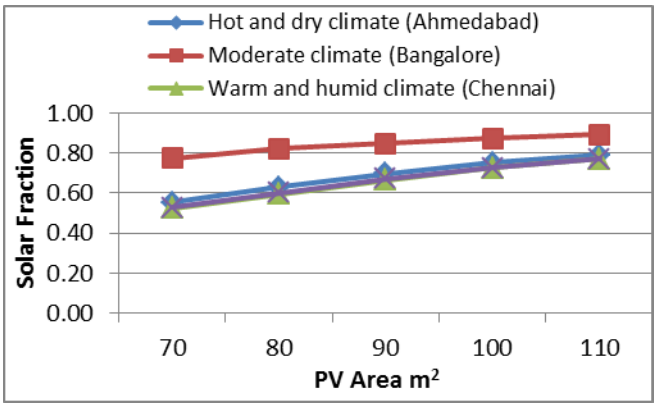

Fig. 3 Variation of Solar Fraction with PV area

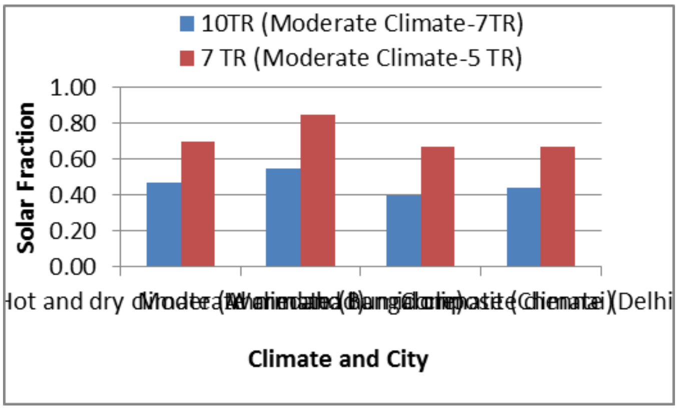

Fig 4 Comparison of Solar Fraction (PVArea-90 m²)

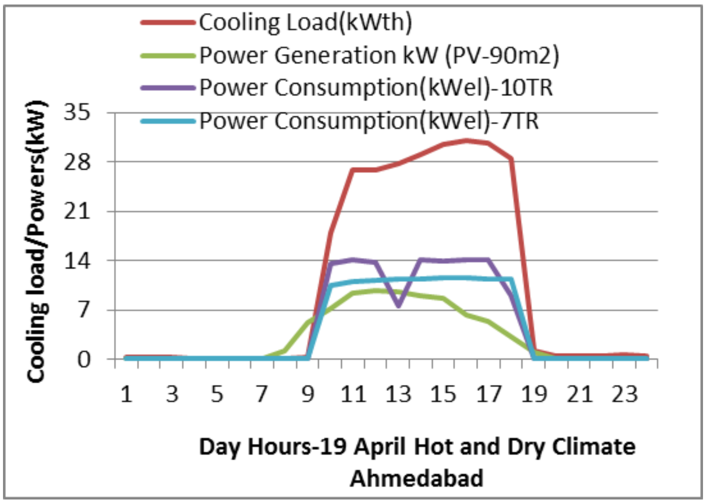

Fig: 5 Day Night profile of Cooling Load, Power Generation, and Consumption

Fig.5 shows the day night profile of cooling load, power generation, power consumption (10 TR) and power consumption (7TR) for the 19 April, Hot and dry climate Ahmedabad. On 19th April peak cooling load was reached. It has been observed from the graph that the power consumption by the bigger size air conditioner is high in comparison to the smaller one but it will off by thermostat when the temperature of building is reach the predefined temperature for comfort. While in the smaller size the compressor of the air conditioner is continuously running consuming the power but less than previous one. So in the latter case (smaller size air conditioner) there is very good matching between the power generation by the photovoltaic and power consumption resulting in the very high solar fraction.

Payback Time:

Fig.6 shows the comparison of Payback time for the 10TR and 7TR air conditioner. It has been observed from the graph that the payback time is very low in the 7 TR (Moderate 5 TR) because in this the solar fraction is very high resulting in the less grid power consumption and more amount of annual savings. The payback comes down from 18 year to 11 year for the hot and dry climate (Ahmedabad), for moderate climate (Bangalore) its changes from 26 to 13 year, for moderate climate (Bangalore) its changes from 18 to 10 yearfor moderate climate (Bangalore) its changes from 26 to 16 year.

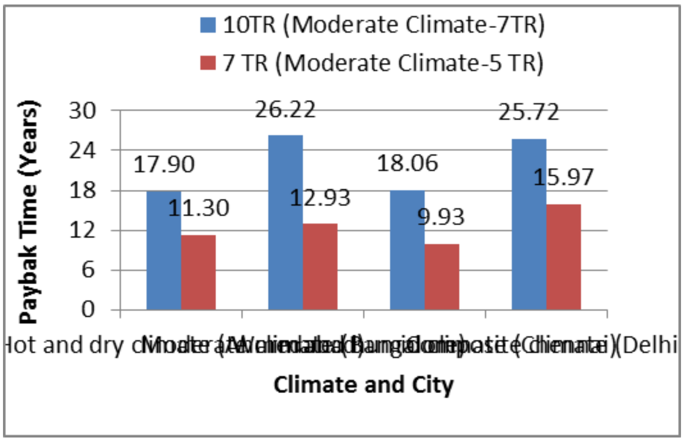

Fig 6 Payback Time (PV area -90m^2)

Conclusion:

It has been observed that in modifying sizing approach we use less capacity for air conditioner and set temperature is slightly high. Comfort can be achieved using air velocity. Solar fraction increases 20-30 % and payback time comes down .

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