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Research on the Effcetive Usage of Solar Air-Conditioner Energy

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Abstract: *A cooling framework using sunlight based vitality would for the most part be progressively productive cost insightful, in the event that it was utilized to give cooling prerequisite in the business and residential just as modern structures. What's more, in twenty first century is quickly turning into the ideal vitality storm and the best test confronting humankind is vitality. The interest for vitality could twofold or significantly increase as worldwide populace develops and creating nations extend their economies. Thus the most plentiful vitality asset accessible to human culture is sun powered vitality the principle point of the venture is to lead tests and to dissect the presentation of sunlight based forced air system for Vijayawada climatic conditions. The exploratory arrangement was made by the ideal structure of PV Solar boards, battery-inverter framework, climate control system and the outside and indoor temperatures are noted hourly, day by day, for office working long periods of 9.00 am to 5.00 pm, during top summer a long time of March, Apr, and May' 2017 and COP is determined. COP is changed during the available time of working of the sunlight based forced air system with most extreme worth (3.4) toward the beginning of the day, evening times and least (1.4) toward the evening time. The venture cost of the sun based vitality arrangement for an office size of 4x3x3 m3 with 1 TR is evaluated as Rs. 97,100/ - and restitution period is determined as 57 months, with the present govt. sponsorships (30%), and power tax..*

I. Introduction

Day by day the energy consumption is increasing very rapidly. The rate of energy consumption is increasing. Supply is depleting resulting in inflation and energy shortage. Alternative or non-conventional or renewable energy resources are very essential to develop for future energy requirements. The energy demand increases day by day because of population increasing industrialization increases and transportation increases etc.

There are two main sources of energy. They are

- Conventional
- Non-conventional sources of energy

Historical Background

Recent years energy consumption for cooling has increased dramatically in India. The main reasons for this increasing energy demand for summer air-conditioning are the population growth, increased living standards and comfort demands as well as type of architecture; this increasing demand is one of the most significant costs to India households during summer. Vijayawada is one of the most holy places has a very sunny climate, with high demand for air conditioning on hot summer’s days; the electricity grid increasingly faces the danger of overload due to air conditioner use, which would cause essential service disruption and severe economic impact. Solar air conditioning is one of the few solutions provided to overcome the summer high demand and addresses peak loading, and does so with reduced environmental impact at Vijayawada.

Air conditioning systems in use are most often built around a vapor compression system driven by grid-electricity. In remote Saudi’s villages, far from the grids, electric energy is usually supplied by diesel generators. In most of these cases, the supply with diesel fuel becomes highly expensive. Solar air conditioning might be a way to reduce the demand for electricity. Therefore, this work focuses in the design and construction of solar-powered air conditioning system integrated with photovoltaic (PV) system According to the solar radiation map shown in Figure 1, it can be seen that solar energy is the best source to generate electricity in India, and specifically Vijayawada city where the annual intensity of solar radiation varies from 2200 to2400 kWh/m2, making it potential to consider the solar energy as the best option for power generation.It can be seen that many researchers conducted solar cooling and solar-powered air conditioning systems but none of these conducted the potential of solar power air conditioner in India especially Vijayawada region in spite of its climatic conditions, which is the motivation of this work. This project will focus on the design and construction of solar-powered air conditioning system integrated with photovoltaic (PV) system which is easy to use in Vijayawada and the non-electrified remote areas outside Vijayawada where the intensity of solar radiation reaches to 7.5 kWh/m2 a day.

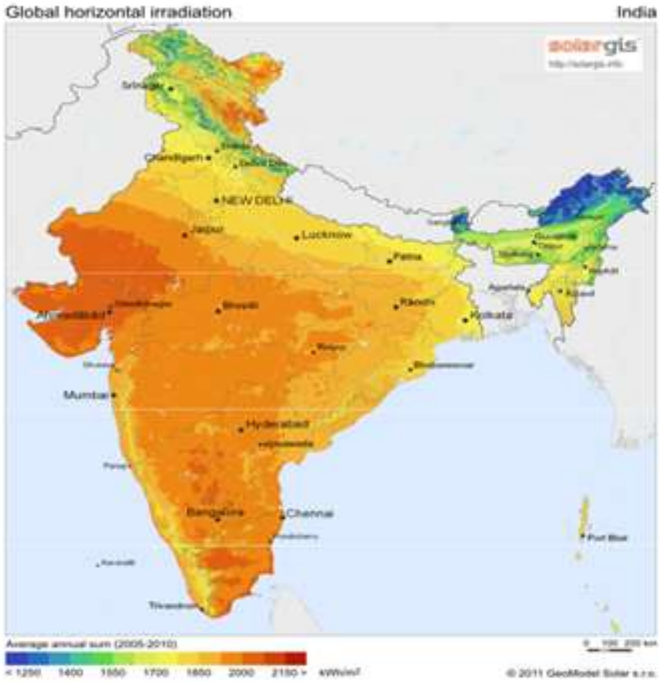


Figure 1 Annual solar radiation map for India.

In this work, the design of the solar-powered air conditioning system is described in detail and its performance over an entire cooling season is investigated by utilizing the PV panels to generate necessary power for small-scale air conditioning system about 1 TR and compare the system performance with the conventional system.

II. Literature Review

Salman Tamseel et al [2016]analyzed solar powered D.C air conditioning system which runs on vapour compressor cycle and D.C powered compressor is used to save the losses of input energy and found that C.O.P of the system is 2.52 and four quantities per panel of 24V battery are needed for their panel.

Khaled S. Al. Qdah [2015] designed and calculated the performance of solar air conditioning system at Al.Madimah Almunawwarah an important holy place in the world where the temperature is higher than 42˚c in summer and found the cooling load as 1 ten refrigeration (3.5 KW) and found that C.O.P of solar air conditioning system varies from 2.16 to 4.22 which are comparable with conventional system performance.

Shaik Gulam Abdul Hasan et al [2015] designed air conditioning system using variable refrigerant flow for commercial building Besant to conserve the energy compared with conventional chilleared found that the power saving is 6.6 times than the distal split air condition unit as the power compaction is almost same for 100% and 20%.

Xiafcng Li et al [2015] studied three types of cooling system water cooled, air cooled and a hybrid solar-based air conditioning system and found that hybrid solar based A/C system reduced power consumption for cooling and reduced 140 tons of greenhouse gases emission cacl year.

III. Working Methodology

The Working Methodology in this project is consists of two sections. They are

- Solar Energy Conversion
- Cool Air Generation by air conditioner

Solar Energy Conversion

Solar energy conversion is done by using battery, inverter and charge controller. As sun light falls on solar panel, which converts into electrical energy by photoelectric effect. This electrical energy stored in battery in the form of chemical energy. Charge controller is employed in between solar panel and battery which prevents overcharging and April protect against overvoltage, which can reduce battery performance or lifespan, and April pose a safety risk. The stored energy directly can use for DC loads or else need to be converted AC (alternate current) by the help of inverter. Below shown figure explains solar energy conversion.

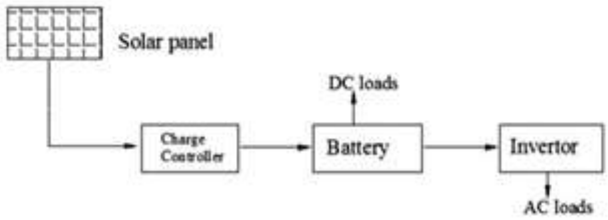


Figure 2 The Pictorial view of the Solar Energy Conversion Process

Cool Air Generation by air conditioner

Based on air conditioning unit capacity that has been selected under climatic conditions and the data collected, where the intensity of solar radiation about 7.5 kwh/m2, the PV solar-powered system specifications can be selected and design. A photovoltaic system is an array of components designed to supply usable electric power for a variety of purposes. The sun delvers its energy to us in two main forms, heat and light. There are two main types of solar power systems, namely, solar thermal systems that convert heat to electricity, and solar PV systems that convert sunlight directly into usable direct current (DC) electricity. One or more DC to alternating current (AC) power converters which called inverters. PV cells are made from layers of semi-conducting material, usually silicon.

When light shines on the cell it creates an electric field across the layers. The stronger the sunshine, the more electricity is produced. Groups of cells are mounted together in panels or modules that can be mounted on your roof . The peak sun hour is essential in order to know the number of PV modules to be installed. Before doing so, the power that can be assumed generated by the PV modules must be determined based on solar irradiance of the location . The function of charger is to regulate the voltage and current coming from the solar panel going to the battery. The battery is the key components in PV-SA systems as it act as energy back-up for the renewable energy systems. It also functions as storage devices for storing PV generated electricity during cloudy days and at night.

Figure 3 The Pictorial view of the Cool Air Generation by air conditioner

In order to apply this system in AC load, the inverter is needed to convert the DC electricity generated by the PV panel into AC. The AC load is a common type of load and easily available with cheaper in price As we mentioned previously, the purpose of charge controller is to regulate the current from the PV module to prevent the batteries from overcharging. A charge controller is used to sense when the batteries are fully charged and to stop, or decrease, the amount of current flowing to the battery. The solar energy is received by the PV module and transform into electrical energy. The electrical energy is then being regulated by charge controller either by supplies it directly into the load or charges the batteries. As the electrical energy coming from the PV module is in DC, inverter will convert it into AC as the compressor needs AC to operate. The electricity provided by the panel array and battery is DC at a fixed voltage. The voltage provided might not match what is required by the load. A direct/alternating (DC/AC) converter, known as inverter, converts the DC current from batteries into AC .

Collection of the Required Methodological Data

Various design parameters of solar air conditioner such as wind temperatures, humidity, daily and annual values of solar radiation for the site and tilt angle of the solar plate and the number of working hours are noted. The space chosen for the investigation is an office room with 4 × 3× 3 m dimensions. The office is situated in Ram Tech Pvt ltd, at Auto Nagar, Vijayawada.

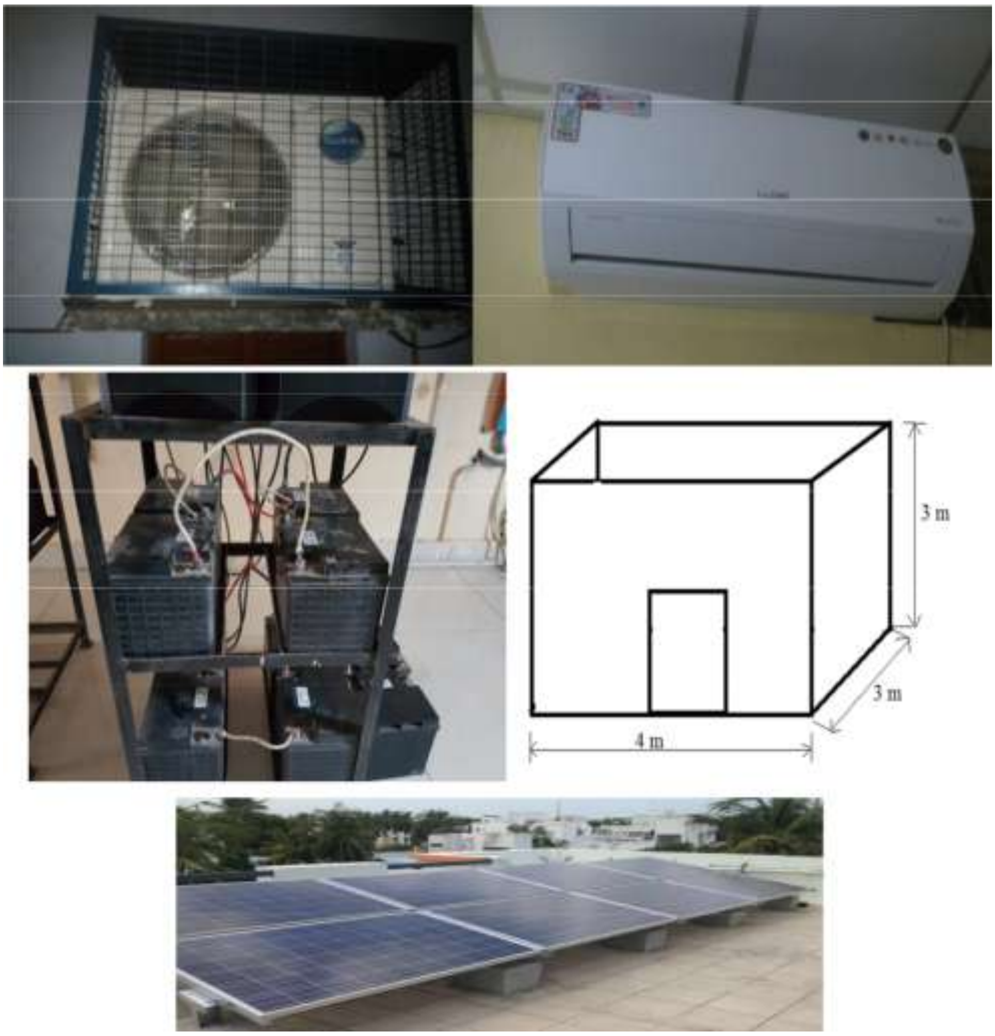


Figure 4 The Schematic diagrams of an investigated office situated in Ram Tech Pvt ltd, at Auto Nagar, Vijayawada

Design and Sizing of the Air Conditioning System

The ton of ac required to selected space based upon the length, breadth and height of the room. Multiply all of the three to get a total volume of the room.

Total volume of the space = Length x Breadth x Height in (feet)

[Note: 1 meter = 3.2 feet]

Total volume of the space =(4x.3.2)*(3x3.2)*(3x3.2)

=13.1*9.8* 9.8

1258.12 ~ 1259 feet

Total volume of the space =1259 Feet 3

Now compare the total volume of the space, selected Air-conditioner according to this tabular form

Table 1 Ton of refrigeration taken by using in total volume of the room in feet's. (ASHRAE date book)

Volume of space (in feet^3)	Ton Of Refrigeration Required
Less than 729	0.75
Between 729 – 810	0.75
900	0.75 – 1
1000	1
1089	1
1210	1 - 1.5
1296	1 - 1.5
1440	1.5
1690	1.5
1960	1.5-2
2250	2

From the table1, the required ton of refrigeration for the space considered is 1 TR (Volume is 1296 feet3).
For 1 Ton of Split Air-Conditioner
Energy Efficiency Ratio (EER) =
Power consumption =
=1*3516/3.1

=1134.19W.

=1.134 KW hr
The 1 Ton 3 Star Split Ac Power Consumption

Per hour of running = 1.134*0.6 Kw Hr
=0.680 unit
For Office working 8 Hour Energy consumption = 0.678*8
=5.4432 Kw Hr

= 5.443 Units

So Far a Month (30 Days) it will be Consume =5.443*30 =163.29 units(30 Days)

At current Rate of around 7.83 /- Rs Per unit Energy in Andhra Pradesh Current bill paying for 30 Days =163.29*7.83

=1278.56 /-Rupees.

Calculation of Battery Size and Number of Batters Required
In this project, the power of 1 ton split ac (watts per Hour) is 1134 and the voltage 24v. The calculation of the current load is Power (in watts) =Voltage x Current
1134 (watts) = 24V x current
1134 / 24 = 47.25 amps ~ 48 amps
Now the solar system needs to generate at least 50 amps of current to power the connected electrical load.

Calculation of the Battery Backup Required
The solar PCU/inverter will directly power to electrical load through solar. However, when solar is not available, the solar energy stored in batteries can be used to power load. The battery backup required minimum of 5 hours. So calculation the size of battery based on the total load and backup time required.

Total load (in watts) x hours of backup needed/24
=
=
=236.25 ~ 237 Ah

=237 AH

The size of battery based on the total load and backup time required is 237 Ah, this value round it off 250 Ah because 237 Ah batteries is not designed.

Calculation of Size of Solar Panels Based On Battery Size and Current of Electrical Load
The validation of the battery size and back up is an important stage in the project process. The sizing of solar panels comes at the last because panels are either going to feed the battery or run electrical load. They need to produce enough voltage and current to charge the battery properly and to run electrical load.

Charging Current of Battery= ¬ =25 Amp

The solar panels need to make 25 amps of current feed to battery bank. The electrical load to need 48 amps to run the ac. Need to add this to the amps that the battery bank is going to take (25+48) 73 amps. Solar panels make 73 amps.
Fact: On an average, 250 watts solar panels have a voltage of 30v.
Power = Volts x Amps

Calculation the electrical load in (section 4.4.3) that needs 73amps (25 amps to feed the battery bank and 48 amps to run the electrical load directly through solar) to run the air conditioner.
Power =25 x 73 amps
= 1825 watts. ~ 2000Watts
Install the panels of 2000 watts to feed the battery bank and run electrical load. Go for 8 panels of 250 watts The outdoor and indoor temperatures are noted hourly, daily, for office working hours of 9.00 am to 5.00 pm, during peak summer months of March, Apr, and May' 2017 and COP is calculated.

Table 2 The variation of Average temperatures with time during the month of Mar – 2017

S.NO	DATE	Recorded Values of Outdoor, Hour Temperature in (^{o} C)								
		9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM
Mar' 2017	1-5 Avg	27	29	32	33	35	34	32	30	28
	6-10 Avg	28	30	32	33	35	34	32	30	28
	11-15 Avg	26	28	31	34	36	33	31	28	26
	16-20 Avg	28	30	33	34	36	34	32	29	28
	21-25 Avg	28	30	33	34	36	35	33	30	28
	26-30 Avg	29	30	33	35	37	35	32	30	29
	Month Avg.	28	30	32	33	36	34	32	29	28

Table 3 The variation of Average temperatures with time during the month of April – 2017

S.NO	DATE	Recorded Values of Outdoor, Hour Temperature in (^{o} C)								
		9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM
Apr' 2017	1-5 Avg	28	30	32	35	36	34	32	29	28
	6-10 Avg	27	30	32	33	35	34	32	30	28
	11-15 Avg	29	31	33	35	36	34	32	30	29
	16-20 Avg	31	34	38	40	44	41	37	34	31
	21-25 Avg	30	31	33	36	37	34	32	30	28
	26-30 Avg	28	30	33	35	37	34	32	29	28
	Month Avg.	29	31	33	36	37	35	33	30	29

Table 4 The variation of Average temperatures with time during the month of May – 2017

S.NO	DATE	Recorded Values of Outdoor, Hour Temperature in (^{o} C)								
		9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM
May' 2017	1-5 Avg	30	32	36	38	40	37	34	31	29
	6-10 Avg	26	29	31	33	34	32	30	28	26
	11-15 Avg	27	30	32	34	37	34	31	29	27
	16-20 Avg	27	29	31	34	35	33	30	28	26
	21-25 Avg	26	29	31	33	35	33	30	28	27
	26-30 Avg	26	28	31	32	33	31	29	27	26
	Month Avg.	27	30	32	34	36	33	31	29	27

The Average C.O.P noted hourly, daily, for office working hours of 9.00 am to 5.00 pm, during peak summer months of March, Apr, and May' 2017 and COP is calculated.

Table 5 The variation of Average C.O.P with time during the month of Mar – 2017

S.NO	MONTH	TIME	C.O.P						
			1-5 DAYS	6-10 DAYS	11-15 DAYS	16-20 DAYS	21-25 DAYS	26-30 DAYS	Month Avg.
1	MAR' 2017	09-00AM	4.4	3.6	5.5	3.6	3.6	3.1	3.6
2		10-00AM	3.1	2.7	3.6	2.7	2.7	2.7	2.7
3		11-00AM	2.2	2.2	2.4	2.0	2.0	2.0	2.2
4		12-00PM	2.0	2.0	1.8	1.8	1.8	1.6	2.0
5		01-00PM	1.6	1.6	1.5	1.5	1.5	1.4	1.5
6		02-00PM	1.8	1.8	2	1.8	1.6	1.6	1.8
7		03-00PM	2.2	2.2.	2.4	2.2	2	2.2	2.2
8		04-00AM	2.7	2.7	3.6	3.1	2.7	2.7	3.1
9		05-00PM	3.6	3.6	5.5	3.6	3.6	3.1	3.6

Table 6 The variation of Average C.O.P with time during the month of April – 2017

S.NO	MONTH	TIME	C.O.P						
			1-5 DAYS	**6-10 DAYS**	**11-15 DAYS**	**16-20 DAYS**	**21-25 DAYS**	**26-31 DAYS**	**Month Avg.**
1	APR' 2017	09-00 AM	3.6	4.4	3.1	2.4	2.7	3.6	3.1
2		10-00AM	2.7	2.7	2.4	1.8	2.4	2.7	2.4
3		11-00AM	2.2	2.2	2	1.3	2.0	2.0	2.0
4		12-00PM	1.6	2.0	1.6	1.2	1.5	1.6	1.5
5		01-00PM	1.5	1.6	1.5	1	1.4	1.4	1.4
6		02-00PM	1.8	1.8	1.8	1.1	1.8	1.8	1.6
7		03-00PM	2.2	2.2	2.2	1.4	2.2	2.2	2.0
8		04-00AM	3.1	2.7	2.7	1.8	2.7	3.1	2.7
9		05-00PM	3.6	3.6	3.1	2.4	3.6	3.6	3.1

Table 7 The variation of Average C.O.P with time during the month of May – 2017

S.NO	MONTH	TIME	C.O.P						
			1-5 DAYS	**6-10 DAYS**	**11-15 DAYS**	**16-20 DAYS**	**21-25 DAYS**	**26-31 DAYS**	**Month Avg.**
1	MAY' 2017	09-00 AM	2.7	5.5	4.4	4.4	5.5	5.5	3.6
2		10-00AM	2.2	3.1	2.7	3.1	3.1	3.6	2.7
3		11-00AM	1.5	2.4	2.2	2.4	2.4	2.4	2.2
4		12-00PM	1.3	2.0	1.8	1.8	2.0	2.2	1.8
5		01-00PM	1.2	1.8	1.4	1.6	1.6	2.0	1.5
6		02-00PM	1.4	2.2	1.8	2.0	2.0	2.4	2.0
7		03-00PM	1.8	2.7	2.4	2.7	2.7	3.1	2.4
8		04-00AM	2.4	3.6	2.1	3.6	3.6	4.4	3.1
9		05-00PM	3.1	5.5	4.4	5.5	4.4	5.5	3.6

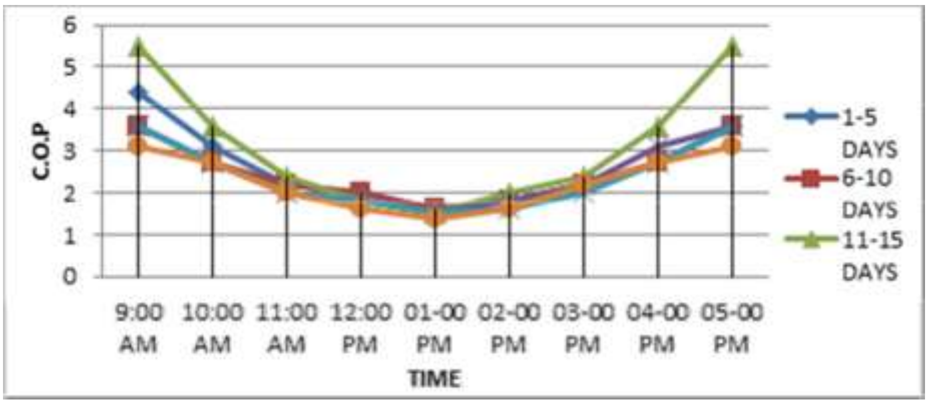


Figure 1 The variation of COP with time during the month of Mar – 2017

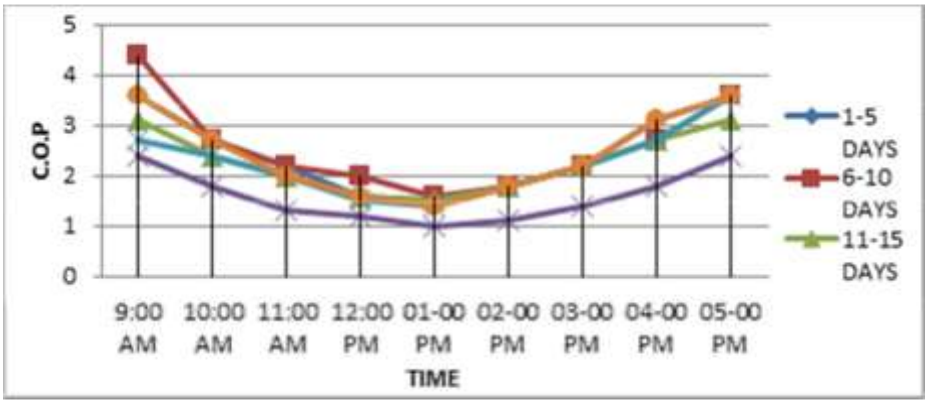


Figure 2 The variation of COP with time during the month of April – 17

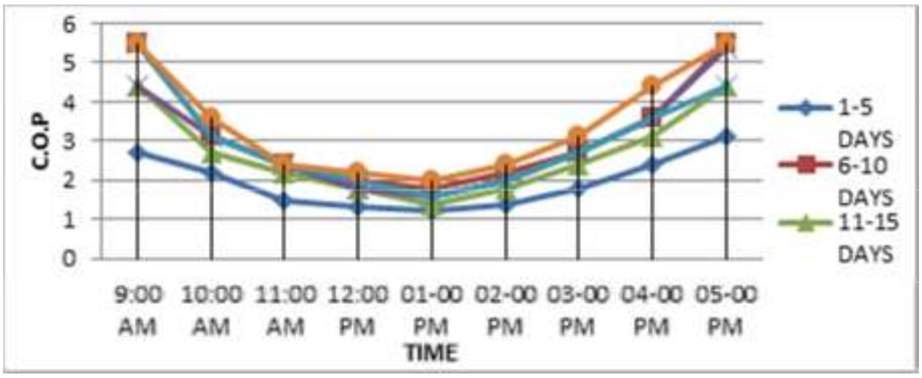
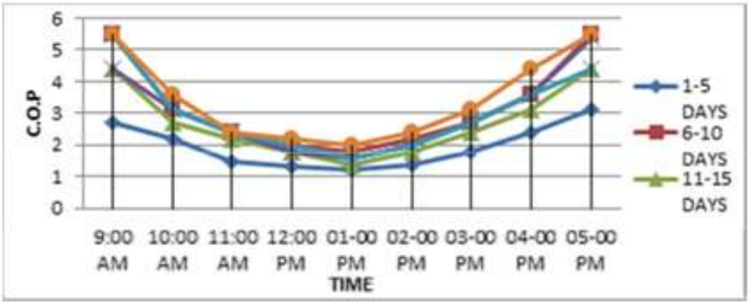
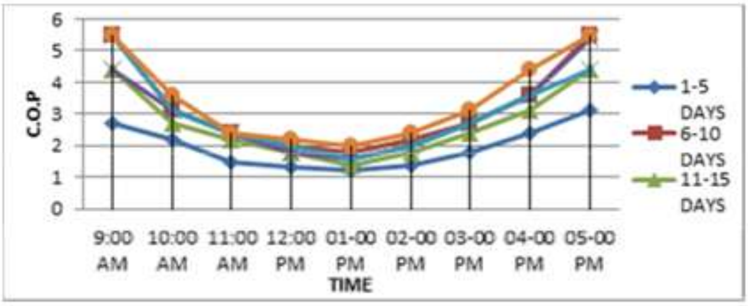


Figure 3 The variation of COP with time during the month of May – 2017





IV. Results And Discussions

The most common type of air conditioning is technically referred to the vapor-compression refrigeration system. The operation of the air conditioning system starts when 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 electrically operated can be described as the heart of air conditioning system as it pump 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. Next, the hot vapor pass through the condenser and gives off some of its heat as outdoor air is blown across the condenser coil. The warm liquid is carried back to the evaporator to repeat the cycle again. The experimental setup was made by the optimum design of PV Solar panels, battery- inverter system, air-conditioner and the outdoor and indoor temperatures are noted hourly, daily, for office working hours of 9.00 am to 5.00 pm, during peak summer months of March, Apr, and May' 2017 and COP is calculated. With the experimentation, analysis for Vijayawada climate, various results can be summarized as follows.

- From the climatic analysis of local climate, 'the Climate of Vijayawada' has been observed as hot and humid, with high relative humidity's and considerable wind speeds during summer. The thermal comfort of occupants requires use of air-conditioners to beat summer temperatures. The comfort indoor temperature is fixed as 220C.
- For the month of March' 2017, the outdoor temperatures are recorded for all the days of month and the average values are calculated at 6 intervals for every 5 days. It is observed that during 6th interval days, outdoor temperatures are high compared to other interval days and COP has varied accordingly (Table 3.5).
- For the month of April' 2017, the outdoor temperatures are recorded for all the days of month and the average values are calculated at 6 intervals for every 5 days. It is observed that during 4th interval days, outdoor temperatures are high compared to other interval days and COP has varied accordingly (Table 3.6).
- For the month of May' 2017, the outdoor temperatures are recorded for all the days of month and the average values are calculated at 6 intervals for every 5 days. It is observed that during 1st interval days, outdoor temperatures are high compared to other interval days and COP has varied accordingly (Table 3.7).
- The dependence of COP as a function of outdoor temperatures for different times, days for summer months are shown through graphs (Graph 3.1,3.2,3.3).
- It has been observed that for all days, months; there is a general trend of gradual decreasing of COP with wind outdoor temperatures, maximum at 9.00 am viz. 4.4, 3.6, 2.7 respectively for Mar, Apr, May' 2017 & 5.00 pm viz. 3.6, 3.1, 3.6 respectively for Mar, Apr, May' 2017, reaching minimum at 1.00 pm viz. 1.5, 1.2, 1.4 respectively for Mar, Apr, May' 2017 as outdoor temperature is high at that time.
- The analysis is made with hourly wind data during March, April, May' 2017 (peak summer) for Vijayawada, and from the results it is inferred that the use of solar air-conditioner for human comfort is feasible and cost incurred for solar energy setup will be saved within 57 months, if AC runs for 8 hrs./ day. If the analysis is extended for the whole day, all the time including nights also, there will be much more energy saving and payback period will be less.

V. Conclusions

From the design, investigation and calculation of solar energy for an air conditioner operation is feasible. The capital invested for solar panels and fittings for operation of 1 Ton of air conditioner is reasonable and payback period is within 57 months for 3 months summer usage, and will be lesser months for annual usage. With solar energy uses fissile fuel demand will be reduced and pollution will be controlled. Solar energy is an inexhaustible source of energy with the most potential as it will continue to produce solar power as long as the sun is there. Solar energy is totally free, widely available, produces no pollution, no emission and no noise which means generating solar power produces no carbon footprint. Among all the renewable energy sources available on Earth, solar energy is one of the most widely used renewable source of energy.

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