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Design and New Development of Solar Air Conditioner

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Abstract— The application of Air-Conditioner increases day to day as home appliances and in industry from the last decade. In recent years, progress on solar-powered air conditioning has increased; nowadays air conditioning system is almost a must in every building if we want to have a good indoor comfort inside the building. This paper focuses to the design and construction of a direct current (DC) air conditioning system integrated with photovoltaic (PV) system which consists of PV panels, solar charger, inverter and batteries which can be operated on solar power and can be used in non-electrified areas as we all know, solar energy is cost effective, renewable and environmentally.

Keywords— *Evaporator; Condenser; Expansion valve; Compressor*.

I. INTRODUCTION

Generally in steady rise in temp., living standards around the hot and humid region prefer to use Air conditioner due to maximum availability of sun radiation. This system also uses as heating system in winter season as room heater. Air Conditioners (ACs) thus, work on the basic principle of reducing ambient air temperature. The major components of air conditioners are:

a. Evaporator;
b. Condenser;
c. Expansion valve;
d. Compressor
e.

However, refrigerant gas is commonly used for cooling, whereas a thermostat is employed to monitor and regulate the temp. Atmospheric air is passed over evaporator coil containing the refrigerant, which help in absorbing the heat from the air and cools it. The compressor pressurizes the refrigerant and also leads to phase transition along with the condenser. This cycle continues till the indoor is cooled[1]. While air conditioners offer us an ideal indoor climate, they have a major drawback. Due to the enormous energy consumption, they are highly expensive to operate and are not eco-friendly, since they emit greenhouse gases. Already we have pointed out about the quality of life index however air conditioning is the prime need of extreme hot climate and congested indoors. Fortunately, solar powered air conditioning offers an innovative solution to this problem.

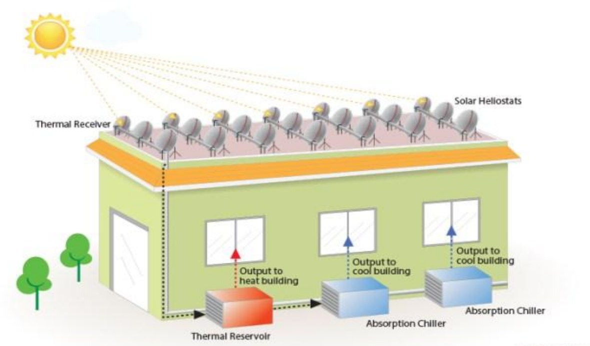


Fig.1: Desiccant offers AC Cooling

II. OBJECTIVES

a) To develop a model for green energy application solar air conditioning system may opt whole year;

b) Approach for cooling and heating by the same indoor unit through valve operation;

c) To record data-base of solar air-conditioning system for annual financial cost benefit analysis (CBA) w. r. t. conventional electric power consumption based on said system over a period of 20 years.

d) To compare power consumption rated with conventional electric power supply operated air conditioner unit with that of solar-base power from this project;

e) To analyze data and evaluate the performance of different refrigerant in respect of *Hybrid solar powered A.C. instead of solar powered A.C.* for making the best performance.

A solar powered AC can work as five different principles based on location and usages, we can opt for appropriate technology.

III. SYSTEM DESIGN

The proposed concept of the system consists of air conditioner and PV system indicates in block diagram shown (Figure 1). In order to determine characteristics and properties of all the components used to operate in stable condition, and if possible achieving efficiency as conventional air conditioning system. For example, for cooling purpose, performance of DC air conditioning should be the same as normal AC air conditioner.

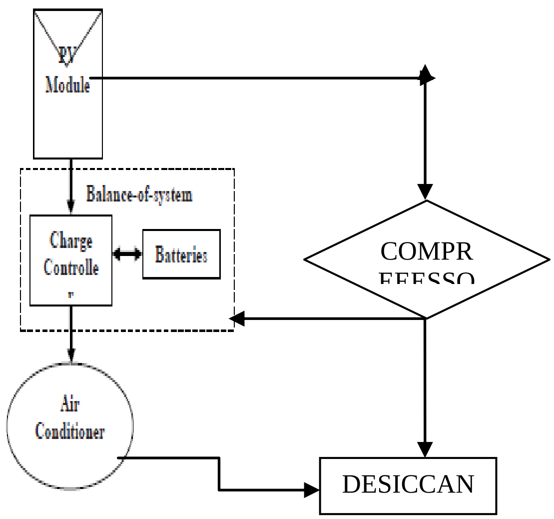


Fig 2: Block diagram of Solar AC design

STEP-WISE DISCUSSIONS:

- At normal temperature Refrigerant liquid (desiccant) enters into evaporator tube from Compressor. Then warm indoor air is removed to produce dry air. As this warm air flows across evaporator tube, the refrigerant liquid absorbs heat from the air due to very low pressure develops in evaporated tube. However, the air cools rapidly, its moisture contents condense on the very cold surface of evaporator coil. The resulting condensate drains off into a drip pan. The air flows back to the house through ducts.
- After absorbing heat from the indoor air the temperature of the refrigerant increases, causing it to boil and change into a gas, its temperature becomes about 50°F.
- The only difference in the solar based system is that refrigerant leaves evaporator tube; it takes a detour through a solar evacuated tube collector. The solar collector "pre-heats" the refrigerant before it enters the Pump which behaves as a compressor.
- The refrigerant enters the dc operated electric pump that increases refrigerant's pressure by forcing it into a chamber. Increasing the gradual pressure of a gas also increases its temperature. The compressor's job is to heat up the refrigerant to about 170°F so that the refrigerant can dump its energy into the outside air even on a hot summer day.

The vapor compressor system thus, reduces demand for electricity. Moreover, traditional vapor compression systems process negative impact on environment. Instead of CFC, glycol solution if used pollution will minimize as well as immerse new economic viewpoint.

IV. METHODOLOGY

The law of conservation of energy illustrates, indoor cooling temp. is not equivalent to the outdoor heating temp. Thus, impact of heat island effect (HIE) due to condensation of heat in outdoor atmosphere will be developed [8]. The absorption of solar thermal energy in refrigerant is mechanized and utilizes the said energy as a latent heat for cooling purpose then the sign of heat island effect does not develop.

.i) ***SOLAR THERMAL COOLING****:* This system uses Heliostats which are highly curved mirrors lined up to attract the sun light. These mirrors will reflect the sun light to the pipe containing water. Due to heat water turns to steam, which will turn the turbine to generate electricity and in turn drive air conditioner.

ii**) PHOTO-VOLTAIC CONVERSION*:*** In this method, photovoltaic cells help in converting Sunlight to electricity which will directly power up the air conditioner.

iii) ***ABSORPTION AND ABSORPTION SYSTEM:*** This part indicates on the basis of vaporizing water at a low pressure (say,10 m bar). With such cool water production the incoming air will be cooled and expelled. This device is powered up by thermo- chemical process of absorption. During winter, this absorption machine can act as a heat pump. This is an eco-friendly AC which can be used in both commercial and non-commercial purposes.

iv ***COOLING WITH DESICCANTS:*** Here, desiccants such as Sodium chloride, Lithium chloride, are used (hydroscopic materials that attracts water) .This process combines dehumidification and evaporative cooling. Subject to the atmospheric condition, different solutions containing other than solid and liquid desiccants like the mixture of lithium chloride and tri-ethylene glycol (Goswami, 1999) takes place in the chamber of cooling.

v) ***PERFORMANCE EVALUATION AND ECONOMIC ANALYSIS****:* The quantity of solar resource and economical effectiveness of the system if evaluate. The life cycle costs for solar cooling system thus is calculated competitiveness with regards to price and thermal efficiency for domestic applications will determine, step-wise.

vi) ***RESULT ANALYSIS AND RECOMMENDATIONS***: The results were analyzed and necessary improvements recommended. Options for improving technical effectiveness, development efforts and economic competitiveness were suggested.

Such a new methodology by which Solar AC rating can be calculated from small to large unit represent in terms of KW instead of TON.

In short, such air conditioner has a solar panel, convert the sun light to electricity. This power enables the equipments to run the compressor. The heat generates through the solar panels can also heat up the water which reduces cost of heating water. The new solar panel is erected to heat up water and a fraction of its heat exchanger to heat the air. The second compartment will also draw in the air and through an attached desiccant wheel; the moisture will certainly be removed outside environment that further heat up and impact on increase of g.h.g. effect thus develop as a result.

- Fan pulls outdoor air into the condenser unit and across the condenser coil.
- As the refrigerant cools down, it starts to return (condense) back into liquid form, and enters the expansion valve. This valve restricts the flow of fluid, and lowers its pressure as it leaves the expansion valve. The rapid drop in pressure caused refrigerant liquid to become very cold again, and the cycle repeat.

The use of solar energy to drive cooling cycles [12] for space conditioning of most buildings constitutes an attractive concept, since the cooling load coincides generally with solar energy availability and therefore cooling requirements of a building are roughly in phase with solar incidence. Solar cooling systems have the advantage of using harmless working fluids such as water, or solutions of certain salts. They are energy efficient and environmentally safe. They can be used, either as stand-alone systems or with conventional air conditioning, to improve the indoor air –quality of all types of buildings. The main goal is to utilize "zero emission" technologies to reduce energy consumption and CO_2 emissions.

Such a scenario does not represent an ultimate limit for concentrating solar power technologies [3] (CSP) technologies. According to the IEA (2003), before 2030 some 4,700 GW of total power capacity is expected to be built worldwide, either as additional capacity or in replacement of existing capacity. The Greenpeace-ESTIA scenario [8] considers that in 2040, CSP plants could total 630 GW. This would probably represent a significant market share of power investments in sunny regions,

Apart from producing electricity, concentrating solar technologies have a broad range of other current or potential uses, either to provide direct heating or cooling.

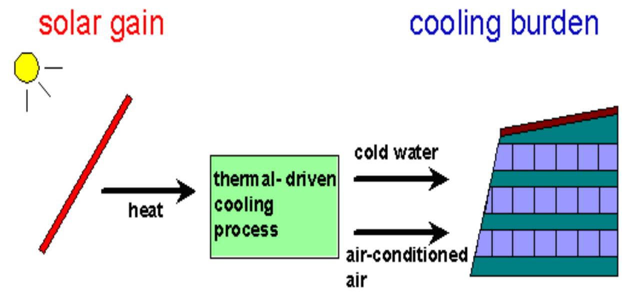


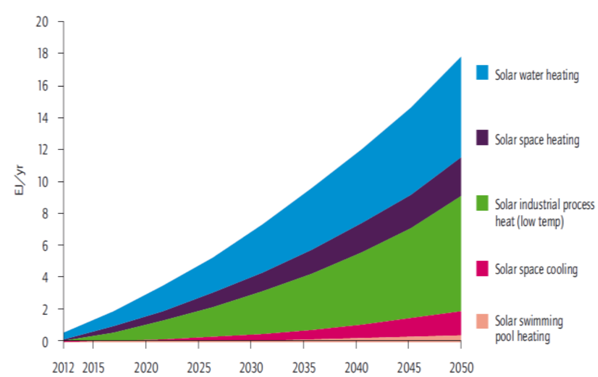
Fig. 3: Basic structure of solar cooling system [13].

Present scenario of solar air conditioner in India:

With steady urbanization, this kind will help of solar heat utilization in building space cooling due to the convenient coincidence between the availability of maximum solar irradiance and the peak demand for cooling, particularly in commercial buildings. Solar cooling such as desiccant cooling can extend comfort also humidity levels. Industrial Refrigeration, in the food processing sector, is an attractive option for solar thermal air conditioning technology.

This roadmap envisages development and deployment of solar heating and cooling by 2050 to produce 16.5 EJ (4 583 TWh; 394 Mtoe) solar heating annually, more than 16% of total l energy use for low temperature heat, and 1.5 EJ solar cooling, nearly 17% of total energy use for cooling [12] by that time. It would include the following contributions.

Fig.4 Roadmap vision for solar heating and cooling (Exajoule/yr)



Since PV cooling's cost effectiveness depends largely on the cooling equipment and given poor efficiencies in electrical cooling methods until recently it has not been cost effective without subsidies. Using most efficient electrical cooling methods and allowing longer payback schedules is changing that scenario.

Now, new non-compressor based electrical air conditioning systems are coming on the market. Indirect evaporative

coolers use nothing but a fan and supply of water to cool high-rise buildings without adding extra interior humidity.
Now a day, manufacturers are used one kind of another absorption heat pump for solar thermal closed loop air conditioning.

- ✓ Absorption ammonia/water;
- ✓ Absorption water/ Lithium Bromide;
- ✓ Absorption water / Lithium Chloride;
- ✓ Absorption water / Silica Gel or water / Zeolite;
- ✓ Absorption Methanol / Activated Carbon

Thus, solar energy heats any of a fluid that provides heat to the generator and is re-circulated back to the collectors. Such heat will provide to the generator drives a cooling cycle that produces chilled water.

Current trends in energy supply and use are patently unsustainable – economically, environmentally and socially. Without decisive action, energy-related emissions of carbon dioxide (CO2) will more than double by 2050 and increased oil demand will heighten concerns over the security of supplies. It is desirable to change current path, but this will take an energy revolution and low-carbon energy technologies will have a crucial role to play. Energy efficiency, many types of renewable energy, carbon capture and storage (CCS), nuclear power and new transport technologies will all require widespread deployment if we are to reach greenhouse gas (GHG) emission goals. The task is also urgent if investment decisions taken now do not saddle us with sub-optimal technologies in the long term. This roadmap envisages that by 2050, solar energy could annually produce 16.5 EJ of solar heating, more than 16% of total final energy use for low temperature heat, and 1.5 EJ solar cooling, nearly 17% of total energy use for cooling. Solar heating and cooling are to play its full role in the coming energy revolution [4]. There are four cooling systems, viz., Solar PV cooling technology, solar thermo-electrical cooling, solar thermo-mechanical cooling, and solar thermal cooling. The first is a PV based solar energy system, where solar energy is converted into electrical energy and used for refrigeration much like conventional methods [5].

The second one produce cool by thermoelectric processes. The third one converts the thermal energy to mechanical energy, which is utilized to produce the refrigeration effect. The fourth method utilizes a solar thermal refrigeration system [9, 10].

Table 1: COST EFFECTIVENESS

Sorbent	Solid	Liquid	Solid	Liquid
Typical material systems	water-silica gel ammonia-salt	water-water-lithium bromide, ammonia-water	water-silica gel water-lithium chloride-cellulose	water-calcium chloride, water-lithium chloride
Marketable technology	adsorption refrigeration machine	absorption refrigeration machine	absorption assisted air conditioning	-
Marketable output [kW cooling]	adsorption refrigeration machine [50 - 430 kW]	absorption refrigeration machine: 35 kW - 5 MW	20 kW - 350 kW (per module)	-
Coefficient of Performance (COP)	0.3 - 0.7	0.6 - 0.75 (one step) <1.2 (two step)	0.5 - >1	>1
Typical operating temp.	60- 95°C	80-110°C (one step) 130-160°C (two step)	45 - 95°C	45 - 95°C
Solar technology	vacuum tube collector, flat plate collector	vacuum tube collector	flat plate collector, solar air collector	flat plate collector, solar air collector

Life-cycle cost of electricity (LCCE) $= P_C + M_C + L_C + C_{EV} + C_{E/}$/ Total electricity generation throughout its life-time;
Where P_C = Plant Capital Cost,
L_C = Land cost,
C_{EV} = Cost of evacuation of generation,
C_E = Cost of electricity

V. ENVIRONMENTAL IMPACTS OF AIR CONDITIONING

Commercial buildings are well known one of the largest consumers of electricity. The domestic and commercial sector in India accounts for about 30% of its electricity use. A typically air condition building uses about 50 to 60% of the total energy for this purpose. Developed countries spend about more than 50% of the total energy consumption goes for Buildings heating and cooling.

Fig. 5: Roof-top solar pv air conditioner

In Europe the final energy demand for heating and cooling (49%) is higher than the electricity (20%) or transport (31%) EREC 2006. **[6]** In U.S alone air conditioning is about $ 10Bn industry that uses over 4.3quads (4.54 billion GJ) of primary energy, it was envisaged almost all built-in environment which comes from non renewable sources **[7].**

VI. EXPECTED OUTCOME

The project has immense potential in terms of commercial as well as domestic application and patentability. The major outcome of the proposed work is:

Major solar projects that connect to grid often face challenge of land acquisition and transmission connectivity, environment, and importantly, ongoing improvements to solar cell efficiency at the start of 2018 and battery technology targets will only get more attractive in future.
This paper may lead to the application of solar air-conditioner as a stand-alone system. This will also lead to modernization on utilization of solar air-conditioner. Several published articles give differing estimates of energy return on energy investment (EROI) that quantifies the benefit the user gets out of exploiting an energy source. Such divergence reflects the varied assumptions about parameters like system design, solar irradiation, and performance ratio and life time.

VII. CONCLUSION

This paper concludes that the system design needs to consider both air conditioner and PV system in order to achieve the space cooling. There are several characteristics that are needed to know either on the PV system or air conditioning system. Electrical equivalent, I-V characteristic curve and factors affect the output of PV cell is an important characteristic in photovoltaic. As for the air conditioning, cooling capacity must be determined first as it will give a rough idea on how to design and construct the system with enough electrical energy supplied to it. With considering of these several factors, it will help to improve the stability and efficiency of the system for greener solutions to the world's energy needs.
Moreover, goals of zero-energy buildings include sustainable , green buildings technology, that can significantly reduce or eliminate net annual energy bills. The supreme achievement is totally off-the-grid autonomous building that does not have to be connected to utility companies In hot climates particularly with significant degree days of cooling requirements, leading edge solar air conditioning will be an increasingly important critical success factor.

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