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A review on various type of solar based cooling system

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ABSTRACT

In this paper, a review has been carried out on a variety of kinds of techniques which are accessible for using solar electricity for cooling purposes. Solar cooling methods such as Solar Electric Method, Solar Mechanical Method and Solar Thermal Methods have been discussed. In solar thermal methods, a number of techniques like Desiccant cooling, Absorption cooling and Adsorption cooling has been discussed. All the techniques have been assesed economically and environmentally and their running traits have been in contrast to establish the great viable technique for photo voltaic refrigeration. Also, the a variety of available technologies for Cooling Thermal Energy Storage (CTES) have been mentioned in this paper.

Keywords: Solar photovoltaic cooling, Solar Electric Method, Solaar Mechanical, Solar Thermal,Chilled Water Storage (CWS) system, etc.

I.INTRODUCTION

A solar-powered cooling is a technique which runs on electrical energy furnished by way of solar energy. Solar-powered coling are capable to keep perishable goods such as meat and dairy cool in hot climates, and are used to maintain plenty wished vaccines at their fabulous temperature to avoid spoilage. Solar-powered refrigerators can also be most many times used in the developing world to help mitigate poverty and climate change. In developed countries, plug-in refrigerators with backup mills shop vaccines safely, however in developing countries, the place electricity elements can be unreliable, choice refrigeration cooling are required. Solar fridges were introduced in the growing world to cut down on the use of kerosene or gas-powered absorption refrigerated coolers which are the most frequent alternatives. They are used for each vaccine storage and family applications in areas without dependable electrical supply because they have terrible or no grid electricity at all. They burn a liter of kerosene per day consequently requiring a regular supply of gas which is high-priced and smelly, and are responsible for the manufacturing of large quantities of carbon dioxide. They can additionally be challenging to adjust which can end result in the freezing of medicine. The use of Kerosene as a fuel is now extensively discouraged for three reasons: Recurrent cost of fuel, subject of maintaining correct temperature and risk of inflicting fires.

II.LITERATURE SURVEY

1	M.M. Hussain, et al.	The simulation of thermal energy storage (TES) system for HVAC system has been dealt within this paper. To store cooling capacity, HVAC system.	The results of various studies and analyses conducted on TES systems revealed that the storage temperature decreases linearly with time when there is no load and follows the load profile during daytime and decreases linearly with time at the end. Also, it was found out that the storage temperature decreases slightly with increase in ambient temperature when there is no load.
2.	Fakeha Sehar, et al.	In this paper, the impact of ice storage systems on the chiller energy consumption for large and medium-sized office buildings in diverse climate zones has been investigated.	By discharging ice storage during the peak hours, the ITS were able to achieve peak energy savings by reducing or even by completely eliminating the chiller operation during the daytime. It was also noticed that climatic zones with summers having high temperatures and relative humidity (RH) increase not only the building cooling load but also the chiller energy consumption by decreasing the cooling intensity of the condenser water
3.	Mehmet Azmi Aktacir	In this study, a PV-powered multi-purpose refrigerator system has been erected to investigate experimentally its daily and seasonal operating performances based on semi-arid climatic conditions of Sanliurfa province in Turkey	On observation, the following results were observed- Low temperature of 10.6°C was reached in the refrigerator, the highest energy amount produced by PV panels was recorded between 11:00 am and 14:00 pm, amount energy consumed by the refrigerator was determined to be 347.7 Wh/day, the amount of energy stored in the battery bank was 78.2 Wh/day while the amount of electric energy produced by photovoltaic panel was 425.9 Wh/day.
4.	Sanford A. Klein and Douglas T. Reindl.	In this paper, it was stated that the energy use associated with refrigeration system operation and the environmental impacts associated with its generation and distribution often outweigh the choice of environmental friendly refrigerants	The COP of all the three refrigeration cycles- Solar Electric, Solar Mechanical and Absorption cycles were compared and found to be low due to various barriers like firstly, the solar refrigeration systems are complicated, costly and bulky because of the necessity to locally produce the power required for operation and

			secondly, the energy source for these systems i.e. solar energy is variable which requires energy storage system that further adds to the system size and cost
5.	S.M. Hasnain, et al.	In this paper, the incorporation of ice thermal storage with conventional air conditioning systems in Saudi office was studied	It was estimated that in Saudi Arabia, the use of ice storage systems with gas turbines for inlet air cooling will increase the turbine's output by 30% and reduce its heat rate by 10% at a mere fraction of the cost of installing the additional capacity for power generation in order to meet the summer peak demand
6.	Todd Otanicar, et al.	In this paper, a variety of solar cooling schemes have been economically and environmentally analyzed to reveal some key details regarding system choice.	The paper reveals that the costs for solar thermal cooling are not projected to decrease as much as PV cooling over the next 20 years due to the relatively stable cost of collection and storage. Solar electric cooling, even with the associated impact of refrigerants with global warming impact, have a lower projected emission value of carbon dioxide per kWhr of cooling than any of the thermal technologies due to the much larger COP values associated with solar electric cooling
7.	David MacPhee, et al.	In this paper, the solidification process for an encapsulated ice TES is investigated.	Results indicate that considerable cost and energy savings could be realized by utilizing a higher HTF temperature, perhaps a few degrees below the solidification temperature of the PCM. It is possible for the designers to increase flow rate to make up for the increase in charging time associated with this increase in HTF inlet temperature since, the losses associated with viscous dissipation and hence, pressure drop have been shown to be inconsequential compared to other modes of losses
8.	B. Rismanchia, et al.	In this paper, a performance assessment of four main types of ice storage techniques for space cooling purposes,	In the case of full storage, the energy efficiencies associated with the charging and discharging processes are well over 98% in all cases, while the exergy

		namely ice slurry systems, ice-on-coil systems (both internal and external melt), and encapsulated ice systems is conducted.	efficiencies ranged from 46% to 76% for the charging cycle and 18% to 24% for the discharging cycle. For the partial storage systems, all energy and exergy efficiencies were slightly less than that for full storage, due to the increasing effect wall heat leakage has on the decreased storage volume and load. The results show that energy analyses alone do not provide much useful insight into system behavior, since the vast majority of losses in all processes area result of entropy generation which results from system irreversibilities

There are three methods by which solar power can be utilized for cooling purposes. They are as follows-

Solar photovoltics powered cooling.

Solar radiation based Mechanical cooling.

Solar Thermal cooling.

Solar photovoltaic powered cooling:

In Solar photovoltaic cooling, the solar power is at once transformed to DC cutting-edge by means of an array of photo voltaic cells recognized as Photovoltaic (PV) panel. Photovoltaic Cells are nothing however semiconductors which allow direct conversion of solar power to direct current. A phase of this modern is saved through lead acid battery whilst the rest is utilized in driving the compressor of the refrigerator. This DC modern can be both used to run a DC motor coupled to compressor or an inverter can be used to convert this DC cutting-edge to AC modern-day for running the compressor. A photo voltaic charge controller consisting of capacitor, sensors etc. can also be required to stabilize and smoothen the current.

A regular Solar PV system includes different aspects that must be chosen according to the system type, site location and applications. The major factors for photo voltaic PV device are photo voltaic charge controller, inverter, battery bank, auxiliary energy sources and loads (appliances).

• PV module – converts sunlight into DC electricity.

• Solar charge controller – regulates the voltage and current coming from the PV panels going to battery and prevents battery overcharging and prolongs the battery life.

• Inverter – converts DC output of PV panels or wind turbine into a smooth AC current for AC home equipment or fed returned into grid line.

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• Battery – stores energy for offering to electrical appliances when there is a demand.

• Load – is electrical home equipment that linked to photo voltaic PV system such as lights, radio, TV, computer, refrigerator, etc.

• Auxiliary energy sources - is diesel generator or different renewable strength sources

Solar radiation based Mechanical cooling

In Solar radiations based mechanical cooling, the mechanical power required to drive the compressor is generated by using solar driven heat power cycle. Rankine cycle is the heat power cycle considered for this process. In Rankin cycle, fluid is vaporized at an improved stress by heat exchange with a fluid heated by way of solar collectors. A storage tank can be covered in this technique to supply some high temperature thermal storage. The vapor flows thru a turbine or piston expander to produce mechanical power. The fluid exiting the expander is condensed and pumped back to the boiler stress where it is once more vaporized. The efficiency of the Rankine cycle will increase with increasing temperature of the vaporized fluid entering the expander. Whereas, the efficiency of a solar collector decreases with growing temperature of the delivered energy. High temperatures can be received through using concentrating photo voltaic collectors that track the sun's role in one or two dimensions.

Solar Thermal cooling.

The fundamental benefit of the usage of Solar Thermal cooling is that they can utilize more of the incoming daylight than photovoltaic systems. In a traditional PV collector, 65% of the incident photo voltaic radiation is lost as heat whereas in solar collectors over 95% of the incoming solar radiation is absorbed. But all of this is absorbed energy is now not transformed to beneficial power due to inefficiencies and losses. Collection efficiencies for commercial solar thermal collectors are generally greater than double that of crystalline photovoltaic photo voltaic collectors. A usual photo voltaic thermal refrigeration system consists of four simple elements - a photo voltaic collector array, a thermal storage tank, a thermal refrigeration unit and a heat change device to switch power between factors and the refrigerated space. Selection of the solar array depends upon the temperature wanted for refrigeration system. Generally for temperature vary 60-100C, flat plate collectors, evacuated tube collectors and concentrating collectors of low concentration can be used. Concentrating collectors are avoided for residential purposes due to excessive cost of solar trackers. Selection of the thermal storage tank depends upon the kind of storage medium and the temperatures desired. Water is on the whole selected for its low environmental affect and excessive particular heat.

III.DESICCANT

A desiccant device is typically an open cycle where two wheels turn in tandem – a desiccant wheel containing a material which can effectively take in water, and a thermal wheel which heats and cools inward and outward flows. Warm, humid, outdoor air enters the desiccant wheel the place it is dried by way of the desiccant material. Next, it goes to the thermal wheel which pre-cools this dry, heat air. Next, the air is cooled similarly by being re-humidified. When leaving, cool, conditioned air is humidified to saturation and is used to cool off the thermal wheel. After the thermal wheel, the now warm humid air is heated further by way of photo voltaic warmth in the regenerator. Lastly, this warm air passes through the desiccant wheel so that it can dry the desiccant material on its way out of the cycle. Pre-packaged desiccant is most commonly used to remove excessive humidity that would generally degrade or even smash merchandise sensitive to moisture. Some frequently used desiccants are silica gel, activated charcoal, calcium sulfate, calcium chloride, montmorillonite clay, and molecular sieves.

Absorption

An absorption cooling is a cooling that uses a heat source (e.g., solar, kerosene-fueled flame, waste warmness from factories or district heating systems) to supply the energy wished to pressure the cooling system. Absorption refrigerators are a famous alternative to normal compressor fridges the place electricity is unreliable, costly, or unavailable. In absorption, two in general used cycles are- LiBr (Lithium Bromide) and NH3 (Ammonia Hydrogen). The principal distinction between them is which resources are used as the refrigerant and absorbent. In a LiBr system, LiBr is the absorbent and water is the refrigerant. In an NH3 absorption system, water is now the absorbent and NH3 is the refrigerant. In each cases, the job of the compressor (in a traditional vapour compression system) is changed through an absorber and a generator. Concentrated absorbent enters the absorber, which is linked to the evaporator. When refrigerant is boiled off in the evaporator (removing heat from the refrigerated space), vapour (of pretty high pressure) then moves to the LiBr/water absorber where it is absorbed. Next, the combination strikes to the generator where photo voltaic warmth is furnished to boil off the refrigerant. High-pressure refrigerant vapour then travels to the condenser where warmness is rejected to the environment to condense the refrigerant again to liquid. Liquid refrigerant goes returned into the evaporator, where it can be used again to take in warmth from the refrigerated space, which completes the loop.

Adsorption

In this cycle, solar heat is directed to a sealed container containing strong adsorbent saturated with refrigerant. Once this reaches the appropriate temperature/pressure the refrigerant desorbs and leaves this container as pressurized vapour. That is, the vapour has been compressed with thermal energy. This vapour then travels to a condenser where it turns to liquid with the aid of rejecting heat to the surroundings. Expanded, low-pressure liquid refrigerant then flows over the evaporator which pulls heat from the conditioned space to boil off the refrigerant. The refrigerant vapour can then be adsorbed once more with the aid of the cool adsorbent material easily at night. Although there are similarities between absorption and adsorption refrigeration, the latter is based totally on the interaction between gases and solids. The adsorption chamber of the chiller is stuffed with a strong cloth (for instance zeolite, silica gel, alumina, lively carbon and certain types of steel salts), which in its neutral state has adsorbed the refrigerant.

IV.RESULT

The results of the review shows Solar photovoltic Electric cooling as the most promising method for solar refrigeration over the other methods. As far as absoption systems are concerned, ITS has advantage over other methods based on storage volume capability, but it has a comparatively lower COP than other available techniques.

REFERENCES

[1] M. M. Hussain, I. Dincer and S. M. Zubair "A feasibility study of using thermal energy storage in a conventional air-conditioning system" International Journal of Energy Research, Int. J. Energy Res. 2004; 28:955–967 (DOI: 10.1002/er.1006).

2] Fakeha Sehar, Saifur Rahman, Manisa Pipattanasomporn "Impacts of ice storage on electrical energy consumptions in office buildings" Energy and Buildings 51 (2012) 255–262, journal homepage: www.elsevier.com/locate/enbuild , Received 23 October 2011, Accepted 8 May 2012.

[3] Mehmet Azmi Aktacir "Experimental study of a multi-purpose PV-refrigerator system" International Journal of Physical Sciences Vol. 6(4), pp. 746-757, 18 February, 2011 , DOI:10.5897/IJPS11.152 , ISSN 1992-1950 ©2011 Academic Journals, Accepted 15 February, 2011.

[4] Sanford A. Klein and Douglas T. Reindl "Solar Refrigeration" American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (www.ashrae.org). Reprinted by permission from ASHRAE Journal, (Vol. 47, No. 9, September 2005).

[5] S.M. Hasnain, S.H. Alawaji, A.M. Al-Ibrahim, M.S. Smiai "Prospects of cool thermal storage utilization in Saudi Arabia" Pergamon, Energy Conversion & Management 41 (2000) 1829-1839 , www.elsevier.com/locate/enconman , Received 18 August 1999; Accepted 7 February 2000.

[6] Todd Otanicar, Robert A. Taylor, Patrick E. Phelan "Prospects for solar cooling – An economic and environmental assessment" Elsevier, Solar Energy 86 (2012) 1287–1299, www.elsevier.com/locate/solener , Received 25 August 2011; received in revised form 16 November 2011; accepted 21 January 2012, Available online 17 February 2012.

[7] David MacPhee, Ibrahim Dincer, Asfaw Beyene "Numerical simulation and exergetic performance assessment of charging process in encapsulated ice thermal energy storage system" Elsevier, Energy 41 (2012) 491-498, Received 3 November 2011, Accepted 18 February 2012, Available online 27 March 2012, journal homepage: www.elsevier.com/locate/energy .

[8] B. Rismanchia, R. Saidur, H.H. Masjuki, T.M.I. Mahlia "Energetic, economic and environmental benefits of utilizing the ice thermal storage systems for office building applications" Elsevier, Energy and Buildings 50 (2012) 347–354, journal home page: www.elsevier.com/locate/enbuild, Received 29 September 2011, Accepted 2 April 2012.

[9] David MacPhee, Ibrahim Dincer "Performance assessment of some ice TES systems" Elsevier, International Journal of Thermal Sciences 48 (2009) 2288–2299, Received 20 September 2008, Accepted 7 March 2009, Available online 3 June 2009, journal homepage: www.elsevier.com/locate/ijts .