Journal of Advances in Science and Technology

Vol. V, Issue No. IX, May-2013, ISSN 2230-9659

RELATIVE EVALUATION OF SOLAR THERMAL COOLING AND SOLAR PHOTOVOLTAIC COOLING TECHNIQUES

AN INTERNATIONALLY INDEXED PEER REVIEWED & REFEREED JOURNAL

www.ignited.in

Journal of Advances in Science and Technology
Vol. V, Issue No. IX, May-2013, ISSN 2230-9659

Relative Evaluation of Solar Thermal Cooling and Solar Photovoltaic Cooling Techniques

Mr. Powar Rajendra Sadashiv[1]* Dr. Brijesh Tripathi[2] Mr. Kulkarni Prasad Ramchandra[3]

[1] Research Scholar, Pacific University, Udaipur

[2] Assistant Professor, School of Engineering, Gautam Buddha University Noida (U. P.)

[3] Research Scholar, Pacific University, Udaipur

Abstract – The Energy Information Administration of the United States Department of Energy activities that more than 80% of the energy utilization of the U.S. by 2035 will originate from fossil powers. This projection ought to be the fuel to push activities identified with renewable energy keeping in mind the end goal to lessen energy utilization from fossil powers to keep away from their undesirable results, for example, carbon dioxide outflows.

Since sun oriented radiation match pretty well building cooling requests, sun oriented cooling frameworks will be an important element in the following decades to meet or surpass the green gases diminishment that will be requested by the social order and regulations to moderate environmental outcomes, for example, a dangerous atmospheric devation.

Sun oriented energy could be utilized as source of energy to process cooling through distinctive technologies. Sun based thermal energy applies to technology, for example, absorption chillers and desiccant cooling, while electricity from sun oriented photovoltaic could be utilized to drive vapor packing electric chillers. This study concentrates on the examination of a Solar Thermal Cooling System that uses an absorption chiller driven by sun based thermal energy, and a Solar Photovoltaic Cooling System that uses a vapor pressure framework (electric chiller) driven by sun based electricity (sun oriented photovoltaic framework). Both sun based cooling frameworks are looked at against a standard air cooled cooling framework that uses electricity from the lattice. The models utilized within the recreations to acquire the effects are portrayed in the paper on top of the parameters (inputs) utilized.

Effects are exhibited in two figures. Every figure has one bend for the Solar Thermal Cooling System and one for the Sun based Photovoltaic Cooling System. One figure allows estimation of investment funds computed based the net introduce esteem of energy utilization require. The other figure allows evaluating 1 For date of the meeting the creator is no longer associated to Mississippi State however University of Texas at Tyler.

Essential energy utilization lessening and outflows lessening. Both figures presents the effect for every ton of refrigeration and as a capacity of territory of sun based collectors or/and territory of photovoltaic modules. This approach to present the consequence of the reproductions of the frameworks makes these figures truly general. This implies that the effects could be utilized to think about both sun based cooling frameworks freely of the cooling request (capacity of the framework), and also allow the investigation for diverse sizes of the earth's planetary group used to reap the sunlight based energy (collectors or photovoltaic modules).

----------♦----------

INTRODUCTION

The Energy Information Administration of the United States Department of Energy, in the Annual Energy Outlook 2010 archive, ventures that the utilization of renewable energy in the United States will double by 2035. This expand is truly serious when contrasted and the expansion of the other sources of essential energy. Case in point, the second biggest expand of energy utilize compares to coal with just 20%.

In any case, regardless of this upturn in the utilization of renewable energy, more than 80% of the energy utilization of the U.s. by 2035 will originate

from fossil energizes. Subsequently, there is a need to lessen energy utilization from fossil energizes and their undesirable results, for example, carbon dioxide outflows.

In spite of the fact that energy utilization for space heating and space cooling in structures differs in size hinging upon the atmosphere zone, energy use for space cooling has an important commitment on the structures energy use profile. Energy to drive space cooling frameworks expends electricity that (1) it is more unreasonable at top times when the interest for cooling is more terrific, and (2) helps with the discharge of nursery gases concurring with the fuel blend of the electric district furnishing electricity to the building. Since the building request for space cooling builds and matches great the sun powered radiation accessibility, it appears that the utilization of sunlight based energy for space cooling has the possibility to dislodge electric power and energy from the framework.

Sunlight based energy might be utilized as source of energy to process cooling through diverse technologies. Sun powered thermal energy applies to technology, for example, absorption chillers and desiccant cooling, while electricity from sunlight based photovoltaic could be utilized to drive vapor packing electric chillers.

In this study a steady cooling load presumption was utilized to streamline the reenactments. The steady load is defended following it could be recognized as a base stack for structures, for example, information focuses. Nonetheless, for variable load, since the effects are exhibited as examination against a reference standard framework with an air cooled electric chiller, operation at halfway load might as well have the same decision however with an alternate extent. Tampa was picked as a site for reenactment since it could be recognized as a normal sunlight based radiation for examination in different areas. That is, if the area has pretty much sunlight based radiation force, the outcomes from the study could be extrapolated. To record for the variety in surrounding temperature and sun based radiation accessibility, the recreations performed in a hour timestep with climate conditions acquired from climate documents from Energyplus. Keeping in mind the end goal to think about the budgetary practicality of both sun based cooling frameworks, the monetary dissection is displayed dependent upon net present worth of the expense to work every framework. The data displayed in this paper could be utilized to confirm the preparatory funds at different areas with diverse conditions or parameters. This data is certain to frameworks that as of now utilize air cooled electrical chillers. This thusly implies that the extent of the framework is small to medium estimate range. For bigger water cooled chiller arranges different chances ought to be assessed incorporating the utilization of twofold stage absorption chiller that has better coefficient of performance, and the utilization of the thermal sun powered framework to generate heat for different utilizes when cooling load are most certainly not consistent throughout the year.

Sun powered thermal technology essentially changes over sunlight specifically into heat and makes this heat accessible for diverse requisitions. The essential sun powered thermal requisition is domestic hot water heating (DHW) for private homes, since the temperature level required is direct (45°c to 60°c) and DHW is required throughout all around the year. Sun powered aided space heating frameworks and process heat requisitions for low temperature up to 95°c, and for medium temperatures up to 250°c or high temperature up to 400°c are later developments. Also, sun oriented thermal heat could be utilized to drive a thermal cooling machine and can, in this way, be utilized as energy source for cooling.

Sun powered thermal frameworks fluctuate consistent with collector sort and mounting, storage volume, control method and framework design to furnish the heat needed with the right temperature and the right volume at the lowest venture costs. Since sun oriented radiation is an energy source shifting day by day and occasionally, the storage volume must be acclimates in like manner; normally a go down heater is incorporated to furnish the client with a protected heat supply. Along these lines, sunlight based thermal frameworks must be versatile to suit distinctive sorts of provision, considering an extraordinary number of variables.

The most well-known sorts of collectors are even plate and cleared tube collectors, As they are no concentrating collectors; they are typically utilized for DHW and space heating, and in addition process heat requisitions with temperature levels up to 95°c; to furnish higher temperatures generally thinking collectors are utilized. For exceptionally low-temperature provisions like swimming-pool heating, unglazed plastic collectors are sufficient.

THERMALLY DRIVEN COOLING SYSTEMS

Thermally driven cooling frameworks can utilize any sort of heat source that gives satisfactory temperatures. They are particularly suitable for utilization with solar thermal energy in light of the connection between the level of solar illumination and the cooling administrations needed. As of now, the air-conditioning planet business is ruled by decentralized room air conditioners, e.g. part and multi-part frameworks. Also, these frameworks are routinely less proficient than bigger centralized technologies; they make a colossal effect on the electricity prerequisites as far as energy and power. This underlines the need for the development of small-scale solar thermal driven cooling machines in the extent of 2-5 kw units.

Solar cooling and air-conditioning is still in the early phases of development and along these lines offers impressive potential for advancement. Consequently, there is a necessity of far reaching research into making strides storage materials and heat transfer media and additionally the further development of frameworks, to turn them into exceptionally minimal, effective units.

One significant field of exploration exercises must be the development of smallscale frameworks that can blanket synchronously heating and cooling, alleged "solar-combi-plus frameworks". The point is to accomplish business smaller items that might be advertised to customers as options to the small-scale conventional chillers.

Moreover, huge development work is needed in their incorporation into general building technology. In the short term, the principle errands for research and development are: state of- the-craftsmanship framework technology and plan, operation and framework following and in addition the development of "best practice" guidelines and general standardization. In the medium term, conservative consolidated frameworks for heating, cooling and process water heating (solar-combi-plus) in private and small office structures must be produced and the skill must be transferred to the organizers furthermore installation engineers. These frameworks must be as bundles including at least development exertion in the building in request to realize most extreme dependability solace. In the long haul, units must be produced that are essentially more conservative, particularly in the regions of lower power frameworks and for decentralized use in single rooms or combination into a veneer. Facade integrated modules will give heating, ventilation, cooling and dehumidification as needed.

R&d exertion is required for frameworks with sorption processes on the low driving temperatures advertise, between 85 and 110°c. Further development is important to lower driving temperatures without efficiency misfortunes so as to raise the heat handling efficiency of solar thermal collectors, particularly even plate collectors. In existing edifices and dispersion frameworks, cooling frameworks with high driving temperatures are typically fundamental since the commissioned frameworks require low delta temperatures.

In this manner it comes to be important to utilize profoundly proficient solar collectors. For multi-arrange processes with most extreme efficiency, solar collectors for high temperatures between 140 also 180°c must be produced. Guaranteeing conceivable outcomes are likewise advertised by frameworks that work as singlestage frameworks under low levels of solar illumination and afterward switch to a two-stage framework when the solar illumination is higher, or when a reinforcement heat source, for example a biomass burner is utilized.

The achievement of solar thermal supported cooling frameworks hinges on upon the accessibility of quite effective frameworks which have the ability to displace the electrically driven part frameworks presently being utilized. Noteworthy R&d work is needed so as to significantly enhance efficiency in the heat and mass transfer of the reactor, and in the inner interconnection for maximisation of heat recuperation.

PHOTOVOLTAIC PERFORMANCE

The performance of the PV system is influenced by a few parameters incorporating temperature. The part of assimilated sun based radiation that is not changed over into the electricity changes over into thermal energy and causes a decline in electrical efficiency. This undesirable impact which accelerates an increment in the PV unit's working temperature and thus bringing about a drop of change efficiency could be mostly escaped by a fitting strategy for heat extraction. PV/T galaxies comprising of photovoltaic modules and thermal collectors are connected to cool photovoltaic board and utilize the heat created by the board and increment add up to energy yield of the system. By legitimate dissemination of a fluid with low delta temperature, heat is concentrated from the PV modules keeping the electrical efficiency at tasteful qualities. The concentrated thermal energy might be utilized as a part of some ways, expanding sum energy yield of the system. Numerous specialists have explored and proposed distinctive techniques for outline and enhancement of the PV/T systems to enhance the system efficiency by cooling PV module and gathering more energy. The primary notions of mixture PV/T systems have been introduced by some analysts since 1978. Tripanagnostopoulos mulled over half breed PV/T universes tentatively and utilized water and air to concentrate heat from the PV module extraordinary surface. He utilized a half and half system with air channel under the PV module for heat extraction with air course and an alternate crossover system with thermal unit of water flow through a heat exchanger. In the system he tried, water was circled in funnels with the even surface of a copper sheet put at the back surface of the PV module and in thermal contact with it. Kalogirou and Tripanagnostopoulos demonstrated diagnostically the potential profits of PV/T systems contrasted with normal PV modules and introduced legitimization of energy and cost outcomes in regards to system requisition. Their system could be acknowledged as an estimation of the expense adequacy of new sun oriented energy systems in practice.

One strategy for cooling photovoltaic module is to flow a film of water over the PV module to diminishing its temperature. By utilizing this technique reflection might likewise be diminished and hence the electrical efficiency will move forward. Krauter considered the

impacts of cooling photovoltaic cluster surface with film of water on the power created by the show. Abdolzadeh and Ameri enhanced the operation of a photovoltaic water pumping system by spreading water over the front of the photovoltaic cells. Kordzadeh examined the impacts of ostensible power exhibit of 90 and 135 W on 16 m head of water pumping system on board efficiency and also the board efficiency for 135w ostensible power yield on distinctive heads of pumping system. A dainty proceeds film of water was running on the highest point of the PV board without water being recirculated. The focal point of the later system (slim water running on top of the photovoltaic show) is acquiring better electrical efficiency in light of diminishing the reflection misfortune, notwithstanding diminishing temperature of the cluster. The impediment of this system is that the heat picked up by the water running on top of the photovoltaic exhibit is squandered.

For every singular PV system, engineers should use particular supplies, for example, inverters, to guarantee that the system runs at greatest efficiency. Diverse inverters are appraised for distinctive greatest voltages and have higher efficiencies between distinctive voltage ranges. Engineers should precisely measure the PV system in diverse temperature environments to guarantee that the yield voltage is not too high, which could harm the gear. A PV system in Arizona will have a greatest system voltage that is lower than the same system in North Dakota (with the same materials) due to the higher temperatures in Arizona. Since PV boards are more productive at lower temperatures, engineers additionally outline systems with dynamic and aloof cooling. Cooling the PV boards allows them to capacity at a higher efficiency and prepare more power.

Boards might be cooled energetically or latently. A dynamic system obliges some outer power source to run. A latent system is obliges no included power. An illustration aloof system could be a show of boards that are situated off the top 2 feet (61 cm), to allow air to commonly flow behind the boards and pull away some heat, or a white-hued top that anticipates the surfaces around the boards from heating up and bringing about extra heat pick up. An animated system may have fans to blow air over the boards, or pump water behind the boards to force away heat. An animated cooling system may be utilized within certain circumstances in which the added efficiency to the boards is more amazing than the energy required to run the system, for example, with a sun based power plant in a desert. They likewise may be utilized within circumstances in which some extra reason could be attained, for example, domestic water heating.

SIMULATIONS

This paper exhibits the greatness of the parameters utilized in the simulations, and in addition illustration on how the models were actualized for the Pc simulations. For the budgetary investigation the following supposition were made:

- Project life: 25 years
- Discount rate: 6.1%
- Inflation: 2%
- Electricity heightening rate: 1.09%
- Electric rate: $0.1 consistent

(1) Reference System-Since the cooling load for this dissection was set to be consistent, the electricity expended by the electric chiller is the same for all hours and registered. The coefficient of performance for electric chillers in this study is acknowledged to be 3.5 or regular energy efficiency proportion (Diviner) of in the ballpark of 12.

(2) Solar Thermal Cooling System - The absorption chiller is situated to work just when the solar energy is sufficient to drive the chiller without the necessity of operation of the electric chiller. As it were, stand out chiller (electric or absorption) works at a particular time. In this way, the point when the absorption chiller does not work, this system is equal to the reference system. The data about the emptied tubes solar collector utilized within the simulations is identified with collectors Seido1-16 of Beijing Sunda Solar Energy Technology. The parameters utilized within the simulation are given in Table 1.

Fluids properties	c	4115	J/kg/°C
	ρ	1000	kg/m^3
Chiller inlet temperature	T_1	88	°C
Chiller mass flow rate	$\dot{m}$	0.244	kg/s/Ton
Absorption chiller COP	$COP_{a,ch}$	0.7	
Collectors azimuth angle	γ	0	degree
Solar collectors tilt	β	28	degree
Collectors	SEIDO1-16		
(Evacuated-tubes)	C_1	0.537	
Coefficients Eq. (10)	C_2	1.70	W/°C-m^2
	b	0.08	
Collector gross area	A_{sc}	4	m^2
Collector mass flow rate	$\dot{m}_{sc}$	0.036	kg/s

Table 1 Parameter for the Solar Cooling System

(3) Solar Photovoltaic Cooling System - For the simulations, the Sanyo Hit-H250e01 parameters have been chosen, acknowledging the most extreme power focus operation, the efficiency parameters are incorporated and introduced on Table 2 and the module operation temperature and temperature amendment figure have been

computed for each hour to figure the immediate energy era over the year.

Parameter	Value
PV panel denomination	Sanyo HIT-H250E01
η_{cell}	18%
η_{inv}	90%
η_{STC}	95%
η_{loss}	95%
η_{dirt}	93%
τ	$0.004\ K^{-1}$
PV modules orientation	
γ	0
β	28

Table 2 PV Module Parameters

The PV system is associated with the electric matrix. Assuming that the PV is not fit to fulfill the power request from the electric chiller, power is depleted from the lattice. Conflictingly, if overabundance of power is prepared by the PV system, the surplus energy is accounted energetic about the solar photovoltaic system since this energy removes energy from the electric framework. With respect to the solar thermal system, when there is no accessibility of solar energy, this system is identical to the reference system.

RESULTS AND DISCUSSION

To make the outcomes from this study as general as could reasonably be expected, the outcomes are displayed for every ton (3.517 kw) of refrigeration and for every region of solar collector or photovoltaic module (PV). Figure 1 outlines the investment funds in many dollars for every ton of refrigeration as a capacity of region of collector/PV. Investment funds were registered as the distinction between the net present quality (Npv) of the reference system and the solar system. It is important to demonstrate that the investment funds were figured with a consistent electricity rate of $0.1/kwh. Hence, to figure the real investment funds for an alternate cost of electricity, the data given by Figure 4 must be increased by the new take in $/kwh.

This will allow the spectator to gauge the real reserve funds for any cost of electricity. In this sense, to record for the expense of the request a mixed rate might be utilized. As a case on how Figure 4 might be utilized, if the expense of the PV system is thought to be $480/m2 ($5/w), the aggregate cost of a PV system of 15 m2 is evaluated at $7,200/ton. This system, in light of Figure 1, offers funds in the request of $8,000/ton throughout the 25 years venture life. Accepting a straight esteem of cash in time, it might be said that the payback of the extend at an electricity rate of $0.1/kwh is 22.5 years for a cooling system at consistent load. It ought to be recognized that the real payback is longer if variable cooling load is recognized.

Assuming that the expense of the electricity if not quite the same as the $0.1/kwh utilized to advance Figure 1, the investment funds of $8,000/ton must be reproduced by the new cost. For instance, if the expense is $0.08/kwh, the reserve funds will be $6,400 throughout the 25 years venture life. This will intimate that the investment funds will be insufficient to pay for the system. In any case, profits, for example, emanation diminishment ought to be mulled over to assess the engagingness of the task.

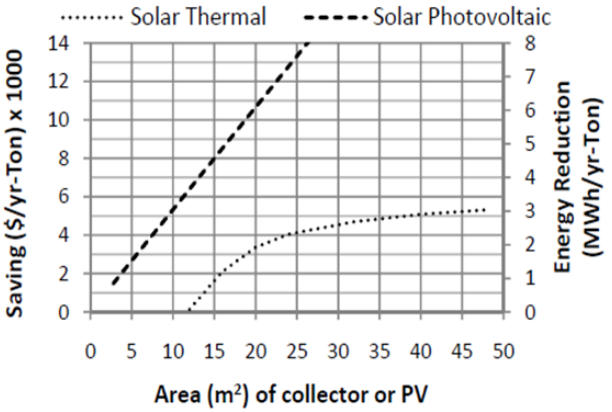

Figure 1 Savings Based on NPV and Energy Reduction

Figure 1 likewise shows the energy utilization lessening. Energy is giving in a large number of watts-hour for every ton of refrigeration and outflows in kilograms for every ton of refrigeration, both as a capacity of range of collector/PV. Energy utilization diminishments were processed as the distinction between the energy utilization of the reference system and the solar system. In the event that essential energy utilization diminishment needs to be figured, values from Figure 4 must be reproduced by the electricity site-to-source energy transformation calculate ECF relating to the electric area of the site. For instance, if ECF is 3 for the electric locale of the site for which the task is constantly assessed, a 15 m2 PV system will decrease essential energy utilization in the measure of 13.5 MWH for every year for every ton of refrigeration. This measure is gotten by increasing the ECF of 3 by the 4.5 MWH/yr-Ton acquired from Figure 1.

CONCLUSIONS

This paper introduces comes about because of the correlation of solar thermal cooling systems and solar photovoltaic cooling systems. To get the outcomes, both solar systems are assessed against a reference standard air cooled vapor clamping system (electric chiller) which devours electricity from the electric matrix. Shows for every system were actualized to

perform simulations to acquire comes about that allowed the development of general bends that could be utilized for distinctive ventures. Since the effects are given as a capacity or collector or PV module territories offer flexibility regarding the span of the system. Comes about for the investment assessment are dependent upon the net display esteem of the putting something aside for the 25 year life of the undertaking processed for an electricity cost of $0.1/kwh. In this manner, the effects might be extrapolated to whatever possible energy require by just reproducing the outcomes by whatever possible expense. Comes about for essential energy utilization diminishment and discharges decrease could be considered by simply reproducing the effects by the individual electricity site-to-source energy change component and electricity emanation calculate. Since numerous variables impact the design/performance of solar thermal cooling systems and solar photovoltaic cooling systems, from the outcomes it appears to be indiscreet to make a general decision about what system is superior to the next. Nonetheless, the methodology displayed in this paper will disentangle the side-by-side examination keeping in mind the end goal to settle on an improved choice when solar cooling will be instated.

REFERENCES

Henning, Hans-Martin. (2007). Solar assisted air conditioning of buildings – an overview. Applied Thermal Engineering, Vol. 27, pp. 1734-1749.

Sparber, W, Napolitano, A and Melograno, P. (2007). Overview on World Wide Installed Solar Cooling Systems. 2nd International Conference Solar Air Conditioning, Tarragona – Spain, 2007.

Kristian Fredslund, Fridrik Rafn Isleifsson, Julie Juel Andersen, Martina Zamboni, and Oxana Pantchenko (2009). Green Data Center Cooling. Local Renewable Energy Summer.

Fumo, N, Bortone, V and Zambrano, J C. Solar Thermal Driven Cooling System for a Data Center in Albuquerque New Mexico. Proceedings of ASME 4th

International Conference on Energy Sustainability ES2010, Phoenix, Arizona, USA, May 17-22, 2010.

U.S. Department of Energy, Energy Efficiency and Renewable Energy (EERE), Building Technology Program, Energy Plus Energy Simulation Software.

US Department of Energy, Energy Efficiency and Renewable Energy (EERE), Building Technology Program, Energy Plus Energy Simulation Software, Engineering Reference, 2010, pp. 1030-1040.

California Energy Commission (2001). A guide to photovoltaic system design and installation. Sacramento, CA.

Skoplaki, E. and Palyvos, J.A. (2009). On the temperature dependence of photovoltaic module electrical performance: A review of efficiency/power correlations. Solar Energy, Vol. 83, pp. 614-624.

E.C. Kern and M.C. Russel, Combined photovoltaic and thermal hybrid collector systems, Proceedings of the 13th IEEE Photovoltaic Specialists, 1978, pp. 1153–1157.

S.D. Hendrie (1979). Evaluation of combined photovoltaic/thermal collectors, Proceedings of international ISES Conference, pp. 1865–1869.

L.W. Florschuetz, Extension of the Hottel-Whillier model to the analysis of combined photovoltaic/thermal flat plate collectors, Journal of Solar Energy 22, 1979, pp. 361–366.

P. Raghuraman (1981). Analytical predictions of liquid and air photovoltaic/thermal, flat-plate collector performance, Journal of Solar Energy Engineering 103, pp. 291–298.

C. H. Cox and P. Raghuraman, Design considerations for flat-plate photovoltaic/thermal collectors, Journal of Solar Energy 35, 1985, pp. 227– 241.

S. Krauter (2004). Increased electrical yield via water flow over the front of photovoltaic panels, Journal of Solar Energy Materials & Solar Cells 82, pp. 131–137.

Corresponding Author

Mr. Powar Rajendra Sadashiv*

Research Scholar, Pacific University, Udaipur