

LOW COST PORTABLE DUAL PURPOSE SOLAR POWERED REFRIGERATOR

Abstract

Solar energy is proved to be an ideal source for low temperature heating applications. Three known approaches that use solar energy to provide refrigeration at temperature below degrees include photovoltaic (PV) operated refrigeration, solar mechanical, and absorption refrigeration. Both PV operated and solar mechanical cycles rely on vapor compression refrigeration cycle whereas absorption refrigeration uses thermal energy as the primary input to the cycle. Among these three approaches, the photovoltaic system is the most viable and appropriate means for small capacity portable systems located in areas not near conventional energy resources.

Keywords: Solar Power, Refrigeration, Vapour Absorption, Peltier Effect, Solar Heating.

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I. INTRODUCTION

Due to its inherent accessibility and ability to be widely distributed among prospective beneficiaries, solar energy stands out as a ray of hope. Additionally, the decentralization inherent to solar power smoothly meshes with the features of local economies common in rural areas, fostering a symbiotic relationship that strengthens both access to energy and economic survival. Solar technology has developed into modular units in this complex tapestry, each one specifically designed to fit in with the small-scale economies that dot the world's economy.

This chapter's main goal is to show how solar energy is useful and affordable for the purposes for which it is intended. The second stage is to choose a particular field of solar energy that is pertinent to emerging countries in Asia. The next step is to choose a viable device for future research and development when the problem has been recognized. Solar energy has seen substantial growth in research and development over the last 20 years. The uses of solar energy have been the subject of several academic papers, symposia, and conferences. Among these, a notable recent contribution emerges: a comprehensive report issued by an impromptu Consultative Panel associated with the Board on Science and Technology for International Development. This report, titled "Solar Energy for Developing Nations: Viewpoints and Prospects," goes beyond the scope of prior analogous surveys. It succinctly summarizes the findings of the Panel, which hold more weight than those of previous surveys. The key takeaways from the Panel's insightful findings can be encapsulated as follows: Solar evaporation, a traditional technique with a history of extracting salt from seawater or brine, continues to retain significance on both small and large scales. This method persists as a cornerstone, seamlessly bridging the gap between modest localized operations and grand-scale endeavors.

The history of technology has produced water heating breakthroughs that span eras and attest to a progression of development principally positioned to complement the native resources and production capacities of each sovereign enclave. The scope of application resonates especially strongly in the confines of healthcare facilities, educational buildings, similar businesses, and domestic hearths since the potential refinement is expected to bring about greater accessibility to hot water reserves. The technology's adaptability demonstrates such broad variety that domestic manufacturing within the constraints of poor countries is made possible with ease. At first glance, it seems reasonably explicable that the technology would need to be calibrated to match their contextual settings. Solar distillation's hegemony continues to encircle the hazy world of exploration in simultaneous orchestration. Small-scale communal distilleries, however, are close to the edge of enormous commercialization as these experimental endeavors come to a head. A measure of assurance significant enough to inspire practical application has crystallized in the annals of the present day for effective solar distillation designs.

Research should focus carefully on the challenge of integrating the current technology with the unique requirements inherent to developing countries in order to further the development of this application. This will mean carefully orchestrating design changes, opening the door to the possibility of utilizing locally produced materials and components. In the field of desiccation, particularly as it relates to the world of agricultural produce, solar energy, with its long history, serves as a cornerstone. In this symphony of progress, a new path for investigation appears in the form of adjusting the solar stagecraft to accommodate

various dehydrated goods or particular cultivars. This area of research has the potential to open up practical paths and conceive of prospects of greater utility within poor countries, eventually sprouting into a more frugal exploitation of food reserves. The majority of research and technological advancement in the field of solar thermal forays has traditionally been focused on temperate regions that are unique to industrialized countries.

The expert panel's understanding of the true scope of developing countries' heating needs or the potential for solar energy to meet these needs is incomplete. The majority of the research on air conditioning has been conducted in the United States and Australia, and it is still in its early phases. The economic viability is now being investigated, despite the fact that the technical feasibility seems promising. The most efficient ways to use solar energy for cooling in underdeveloped nations are still to be determined, as are the urgency and size of the need for air conditioning. Different systems and processes can be modified to use solar-powered refrigeration. There is still no clear consensus on what size solar refrigerators should run at in developing nations. There are still many questions unsolved about refrigeration. However, this application offers a tantalizing chance to improve the efficient use of current food supplies, assuming that effective refrigeration systems can be devised.

There are several possible applications for commercially feasible solar energy conversion to meet mechanical and electrical needs. But this subject continues to be complicated and fascinating. Contrarily, solar cooking shows promise because of its straightforward technique and possible advantages if adopted. With the goal of meeting at least a portion of a family's cooking needs, solar cookers have been developed to a certain level of technical efficiency. Large-scale field tests have not, however, led to the widespread acceptance of these devices throughout society in the situations of India, Mexico, and Morocco. The following are the main conclusions given by the expert panel: Evaporation, drying, distillation, and water heating are examples of solar processes that are currently beneficial or have the potential to be improved to a useful level in the near future. Some of these uses might be possible over the next ten years with more thorough improvements in solar heating, cooling, and building architecture. It's crucial to keep in mind though that considerable new technological breakthroughs are necessary for the efficient use of solar energy.

II. LITERATURE SURVEY

In actual use, traditional refrigeration systems only used heat as a source of energy. The refrigeration industry's commercialization was led by Electrolux. Following the introduction of iterative modifications, these refrigerators were given new names, including "triple fluid vapor absorption refrigerator," "absorption-diffusion refrigerator," and "pumpless continuous action absorption refrigerator," among others. The triple fluid vapor absorption refrigerator (TFVAR)'s gas circuit functioning was optimized theoretically, with an emphasis on the best working conditions. The complexity of diffusion effects during evaporation and absorption, as well as the energy needed for gas mixture flow propulsion, were not taken into account in this work. The focus was instead on clarifying the effect of the gas mixture flow rate and the effectiveness of the gas heat exchanger. One particular example is the use of a water-cooled VAR system with the R22-DMF pair as the working medium. In 1982, it was discovered that this device was capable of converting 60 kilogram of water per day from 30°C to 15°C. A hybrid NH₃-H₂O 2-stage absorption system was another breakthrough, as described by Johnston in 2000. This system is differentiated by its elevated generating

temperatures, which range from 100°C to 170°C. An evacuated tubular collector enabled a claimed improvement in system performance when compared to a stationary system. Similar to this, Keizer in 2002 carried out a comprehensive analysis of both single and dual-stage ammonia-water absorption systems. Notably, Keizer examined in-depth the examination of film and vertical tube bubble absorbers, making meaningful comparisons from the data acquired.

III. HISTORY OF SOLAR REFRIGERATION

Plug-in coolers powered by generators provide secure vaccine storage in developed countries. Solar refrigeration, however, is crucial in developing nations that struggle with intermittent electricity. Due to a lack of power, these areas frequently use gas and kerosene for cooling. In places with little or no electricity, solar fridges fill the needs for both residential cooling and vaccine preservation, reducing this dependence. These refrigerators, which use about one liter of fuel each day, release a lot of carbon dioxide and require a steady supply of expensive fuel. Additionally, due to their operational sensitivity, medical supplies may accidentally freeze. There are primarily two different types of solar refrigerators: one that runs on batteries and one that doesn't.

IV. EXISTING METHODS

Refrigeration using Solar Energy: In refrigeration, solar energy plays a key role, especially when energy requirements coincide with solar radiation availability. This balance, together with the rising costs and unpredictability associated with traditional cooling techniques, have sparked international initiatives aiming at developing effective and affordable solar-powered cooling systems. Refrigeration plays important functions in maintaining vaccination potency, keeping perishable foods, protecting essential drugs, and creating comfortable indoor conditions through air conditioning. The following techniques can be used to harness solar power for refrigeration:

- Vapor Absorption Systems (VAS)
- Vapor Jet Systems (VJS)
- Thermo-electric cooling systems
- Adsorption refrigeration systems

By reducing poverty and mitigating climate change, solar-powered freezers, especially in developing countries, serve a crucial role. In warmer areas, they efficiently cool perishable foods like meat and dairy, and by preserving the proper temperature, they help maintain vaccination efficacy. These portable refrigerators may be put together from simple parts and are ideal for places without access to electricity or where solar refrigerators are already in use. These refrigerators, which differ in size, technology, and environmental impact, have already been installed in a variety of African locales. Due to the intermittent nature of sunlight (limited hours and sporadic cloudy days), phase change materials or batteries must be incorporated into designs in order to maintain consistent cooling.

V. PROPOSED METHOD

1. Passive Solar Cooling: To rapidly produce a chilly environment or start chilling operations, this cooling technique does not directly harness solar thermal energy. Instead,

solar building design emphasizes improving heat removal from buildings and reducing the amount of heat that enters them during the summer. This necessitates a thorough understanding of the sun's primary source of thermal radiation, heat conduction, convective heat transfer, and heat conduction, among others. An attic, for instance, could become hotter than the surrounding air during the summer due to poor thermal design. The surface temperature of the roof can be reduced by as much as 70°F (40°C) in summer using strategies like cool roofs or green roofs to combat this. Additionally, 97% of the sun's downward radiation can be stopped by adding an air gap and radiant barrier beneath the roof. Compared to retrofitting existing structures, achieving passive solar cooling is typically simpler with new construction. It involves a variety of design components and is essential for producing energy-efficient buildings, especially in warm areas.

The process of active solar cooling uses solar thermal collectors to produce thermal energy, which powers thermally driven chillers, also referred to as adsorption chillers. These chillers function by concentrating solar thermal heat, such as through the Sopogy system, in which collection tubes are heated and the fluid used for heat transmission is circulated. This generated heat is used to power absorption chillers, providing a sustainable energy source for commercial cooling. Hot water is also produced using solar thermal systems. There are quieter and less vibration-prone alternatives to compressor-based chillers, which can nevertheless save energy. Solar thermal collectors are used in a variety of situations, such as chilling household hot water in the summer and heating buildings in the winter. They have one, two, and three iterative cooling cycles; the higher the cycle number, the more effective the device. Minimum water temperature requirements for efficient absorption chillers are 190°F (88°C). There have been several large-scale initiatives all across the world that have been both technically and financially successful. Examples include the Lisbon offices of the Portuguese bank Caixa, which have solar collectors that cover 1579 m² and have a 545 kW cooling capacity. A Chinese village for Olympic sailing is another illustration.



Figure 1: Passive Solar Thermal Cooling

- 2. Solar Thermal Cooling:** In order to power thermally powered chillers, often referred to as adsorption chillers, active solar cooling uses solar thermal collectors to generate thermal energy. For instance, Sopogy solar thermal collectors concentrate solar heat by heating

collection tubes and recirculating heat transfer fluid inside the device. As a sustainable energy source for industrial cooling, the generated heat then powers absorption chillers. Hot water can be produced by solar thermal devices as well. Although compressor-based chillers can save energy, there are alternatives that are less jarring and vibrational. Solar thermal collectors can be used for a variety of purposes, such as chilling household hot water in the summer and heating buildings in the winter. These collectors are available in iterative cooling cycles of one, two, and three, with more cycles suggesting greater efficiency. Absorption chillers need water that is at least 190°F (88°C) to function properly. Numerous projects around the world have shown technical proficiency and cost-effectiveness in large-scale installations. A prime example is the Caixa Geral de Depósitos building in Lisbon, Portugal, which has 1579 m² of solar collectors and 545 kW of cooling capacity. The Olympic Sailing Village in Qingdao, China, is another illustration. Notably, the United World College in Singapore was planning to commission the planet's most potent plant (1500 kW) in 2011. Flat plate solar collectors, which are made specifically for temperatures above 200°F, can be effective and affordable thanks to features like double glazing and enhanced backside insulation. Solar panels made of evacuated tubes are another alternative.



Figure 2: Photovoltaic Solar Cooling

Systems for cooling using solar thermal energy are not new. In the latter half of the nineteenth century, gas was frequently employed as a heat source, and today, propane is the preferred coolant for recreational vehicles. At that time, ammonia and water were the most often used phase change refrigerants for absorption cooling; today, lithium-bromide is in that position. Solar thermal energy can now be used as a "free" heat source thanks to advancements in hot water solar collectors. An illustration is a solar air conditioning system that The Gas Company and SDG&E are testing at the Downey Energy Resource Center. The rooftop of the center has solar collectors from Heli Dynamics that generate coolant for the air conditioning system. The expansion/condensation pipes in this system produce ice by heating one end and cooling the other. Even before the development of the electric light bulb, ice has been made using absorption chillers for more than 150 years. This ice can be kept and used as a "ice battery" to keep things cool when the sun isn't out. The New Otani Hotel in Tokyo employed stored ice for cooling in 1995, serving as an illustration of this. The public

domain contains mathematical models for evaluating the efficiency of thermal energy storage based on ice. An ammonia-water absorption cooler makes up the sporadic solar icemaker, or ISAAC.

In addition to the more traditional compressor-based electric cooling systems, photovoltaic (PV) power can also power adsorption- or absorption-based systems. Even though they are the least efficient cooling solution, compressors are frequently utilized for this purpose. For small-scale (less than 5MWh/yr) household and commercial cooling applications, PV technology is commonly used. The justification for this preference is frequently contested, but typical explanations include incentive systems, the small residential spaces that other solar cooling technologies can cool, the development of more effective electric coolers, and the relative simplicity of PV installation in comparison to other solar cooling technologies like radiant cooling.

The effectiveness of the cooling system itself has a direct impact on how cost-effective PV-based cooling is. PV cooling hasn't historically been a viable option without subsidies because of the inefficiency of electrical cooling. PV systems operate less than optimally when coupled with less effective air conditioners that have a Seasonal Energy Efficiency Ratio (SEER) of 14. This environment is changing as more effective electric cooling strategies are deployed and payback dates lengthen.

For instance, on a hot day, a 100,000 BTU U.S. Energy Star-rated air conditioner with a high SEER of 14 requires about 7 kW of electrical power to operate at full cooling capability. Due to the shifting solar angles during the day and across the seasons, this would require a PV power generation system with a capacity greater than 7 kW (with solar tracking). However, PV systems only generate at their highest output during periods of sunshine. Smaller and more cost-effective PV systems are needed for more energy-efficient air conditioners, such as those with SEER ratings of 20 or higher. Reverse inverter (DC) heat pumps are one example of a cutting-edge technology that can achieve SEER ratings as high as 26. In the USA, new non-compressor (DC) electrical AC systems with SEER over 20 are becoming available, and usage of 200–250v AC input is rising.

The use of indirect evaporative coolers at McCarran Airport in Las Vegas, Nevada, which uses just a fan and water to cool buildings without increasing interior humidity, is an example of more recent variations of these devices. In arid areas with relative humidity below 45%, which makes up about 40% of the continental U.S., indirect evaporative coolers can achieve excellent SEER ratings above 20, sometimes even reaching SEER 40. Only the circulation fan and a water supply would need to be powered by solar energy for a 100,000 BTU indirect evaporative cooler. Although it cannot be completely eliminated, using a partially powered PV system can lower the monthly grid electricity use for air conditioning and other demands.

- 3. Geothermal Cooling:** Earth sheltering or earth cooling tubes use the planet's inherent temperature to reduce or do away with the need for conventional air conditioning systems. This strategy works especially well in most areas where people live since these tubes may greatly reduce the buildup of unwelcome summer heat and help to evacuate heat from a building. They may result in higher building costs, but they also result in lower or even zero expenditures for traditional air conditioning equipment. However, in

hot and humid tropical areas where the Earth's temperature roughly resembles that of human comfort, these tubes are not economically viable. Options like photovoltaic-powered fans or solar chimneys can be installed to reduce unwelcome heat. A solar chimney has the ability to both release extra heat and pull in colder, dehumidified air that the Earth's temperature has forced out. A crucial part of the design process is the efficient management of humidity and condensation.

4. Advantages of Solar Refrigeration

- Cost effective
- Flexibility
- Reduce your carbon footprint
- Low on maintenance

VI. CONCLUSIONS

A system's Coefficient of Performance (COP) is a metric indicating the proportion of solar energy input to refrigeration capacity. But when assessing a solar cooling system, COP isn't necessarily the most important factor. Size, weight, and cost are all important metrics as well. The limited wide-scale use of solar cooling systems is attributed to a number of problems. First of all, compared to conventional vapor compression arrangements, these systems are more complicated, expensive, and space-intensive. This results from the need for local power generation to support the cooling cycle. A solar cooling system's efficiency is also dependent on how much solar radiation it can absorb. Given that this energy source is unpredictable, most applications frequently require redundancy or storage (either electrical or thermal). The system's size and cost are increased by this addition. The main benefit of solar cooling systems is their ability to partially or completely replace the need for conventional fuel.

A solar system's operating costs should ideally be lower than those of a traditional system. However, given current and projected fuel prices, even over the long term, the ongoing cost reductions provided by a solar system could not be sufficient to offset the higher initial costs of a conventional system. The capacity of solar cooling systems to operate independently from the electric grid is their main advantage. In some circumstances, such as the storage of drugs in remote areas, this is essential. The photovoltaic (PV) system is the most appropriate of the three solar cooling approaches for small-scale, mobile installations in places where traditional energy sources like electricity or gas are not easily accessible. However, both absorption and solar mechanical cooling systems are often more substantial, requiring complex electrical and plumbing connections, and are better suited for big stationary cooling arrangements. To obtain high temperatures for competitive thermal power cycle efficiency, the solar mechanical cooling systems would require tracking of the solar collector. This strategy, however, would be practical for bigger refrigeration applications provided the system's initial costs and the tracking effectiveness of solar collectors could be sharply decreased.

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