**LOW COST PORTABLE DUAL PURPOSE SOLAR POWERED REFRIGERATOR**

Boddu Tejaswini1, E. Sheeba Percis2 , A. Nalini 3

1 Research Scholar, Department of EEE, Dr. M.G.R. E & RI, Maduravoyal, Chennai – 95, TN, India

2,3 Professor, Department of EEE, Dr. M.G.R. E & RI, Maduravoyal, Chennai – 95, TN, India

1. **INTRODUCTION**

The Basis for Considering Solar Energy There are several important reasons for considering solar energy as an energy resource to meet the needs of developing countries. First, most of the countries called developing are in or adjacent to the tropics and have good solar radiation available. Secondly, energy is a critical need of these countries but they do not have widely distributed, readily available supplies of conventional energy resources. Thirdly, most of the developing countries are characterized by aid climates, dispersed and inaccessible populations, and a lack of investment capital and are thus faced with practically insuperable obstacles to the provision of energy by conventional means, for example, by electrification. In contrast to this solar energy is readily available and is already distributed to potential users, Fourthly, because of the diffuse nature of solar energy the developments all over the world have been in smaller units which fit well into the pattern of rural economics. The present study is part of a project in solar energy utilization at AIT(Artificial Intelligence Technique), aimed at the development of one or more prototype units

Demonstrating the usefulness and economic viability of solar energy for the designed purposes, The specific objective of the argument in this chapter is to identify an area of solar energy utilization useful to the developing countries of Asia, and further, to select: a suitable device for development and a preliminary investigation. Possibilities for Research and Development Solar energy research seems to have gathered momentum during the last two decades. Over this period there have been many publications, seminars, and conferences dealing with solar energy. One of the most up-to-date and comprehensive surveys of solar energy applications is a report by an ad-hoc advisory panel of the Board on Science and Technology for International Development entitled Solar Energy for Developing Countries: Perspectives and Prospects. The conclusions of this report supersede those of earlier such surveys and are summarised below. The panel observes that solar evaporation has been a historical, traditional method of obtaining salt from seawater or brines; it remains important today on both a small and a large scale in many countries. There appears to be little research that cannot as well be done by the industries using this process. Water heating technology is well established and the needed development is largely to adapt the technology to use materials and manufacturing capabilities of the country in question. Hot water for hospitals, schools, and other such institutions and families could become more widely available with these developments. The nature of the equipment is such that it can be manufactured in developing countries, and adapting it to their conditions seems to be straightforward. Solar distillation must still be regarded as experimental but small-scale community stills are near to extensive commercial applications. Designs are now available for serviceable solar stills that can be used with a reasonable degree of confidence. Further research in this application would involve the adaptation of existing technology to the specific needs of developing countries through design modifications to allow the use of locally available materials and locally manufactured components. A traditional and widespread use of solar energy for drying, particularly, of agricultural products. The design and control of tiles for particular crops or other materials to be dried are areas of research that could lead to more practical applications in developing countries which could result in improved utilization of food supplies. Research and development in solar heating have been aimed almost entirely at applications in the temperate climates of Industrialized countries. The panel knows little of the real extent of the need for space heating in developing countries, or of the possible role of solar energy in meeting these needs. Studies in air conditioning aimed primarily at United States and Australian applications are still in the early stages. Technological feasibility appears to be assured; economic feasibility is now under study. The best methods of obtaining cooling with solar energy in developing countries are far from clear at this time and the immediacy and extent of needs for air conditioning are not known. There are many refrigeration cycles and systems that can be considered for solar refrigeration. It has yet to be established what may be the best scale on which to operate solar refrigerators in developing countries. There are many open questions regarding refrigeration, and the application has the attractive possibility of better utilization of available foodstuffs if refrigeration could be successfully provided.

The possible applications of the successful development of economic solar energy conversion to meet needs for mechanical or electrical energy are wide. This conversion remains an elusive yet intriguing problem. Solar cooking appears to be simple in its technology and significant in its advantages if it can be successfully applied, Solar cookers have been developed to a degree of satisfactory technical performance for providing at least part of the cooking. needs of families, However, extensive field trials in India, Mexico, and Morocco have so far not resulted in social acceptance of these devices. The conclusions at the Panel are summarized thus: the solar processes that are now useful or that could be brought to a stage of development in which they could produce useful results in the shortest time are evaporation, drying, distillation, and water heating. More extensive development in refrigeration, solar heating, cooling, and thermal design of buildings should make some of these uses practical within the decade. Applications of solar power will require the substantial development of new technology.

1. **LITERATURE SURVEY**

The existing refrigerators utilized solely the heat in practice. Electrolux Inc. took up the responsibility of commercial production of it. Later on, further modifications were added and refrigerators were then assigned different names, “Triple Fluid Vapor Absorption Refrigerator”, “Absorption-Diffusion Refrigerator”, “Pumpless Continuous Action Absorption Refrigerator”, etc. Theoretical investigations on the gas circuit of TFVAR with ideal operating conditions. He ignored the propulsion force required for the circulation of the gas mixture and diffusion effects in the evaporator and absorber but clarified the influence of the circulation rate of the gas mixture and Gas Heat Exchanger (GHE) efficiency. A water cooling VAR system used R22-DMF as a working fluid built by Agarwal and Sabti (1982), capacity of 60 kg of water per day from 30°C to 15°C. A theoretical study of NH3 -H2O two-stage absorption system with high generator temperature range 100°C to 170°C by Johnston (2000). He suggested that the performance of the system improve than a steady state system by using evacuated tubular collectors. Keizer (2002) reported a theoretical and experimental analysis of single and two-stage ammonia-water absorption systems. He also made a detailed study about film and vertical tubular bubble absorbers and compared the obtained result.

1. **History of solar refrigeration**

"In developed countries, plug-in refrigerators with backup generators store vaccines safely, but in developing countries, where electricity supplies can be unreliable, alternative refrigeration technologies are required”[3]. Solar fridges were introduced in the developing world to cut down on the use of kerosene or gas-powered absorption refrigerated coolers which are the most common alternatives. They are used for both vaccine storage and household applications in areas without reliable electrical supply because they have poor or no grid electricity at all.[4] They burn a liter of kerosene per day, therefore, requiring a constant supply of fuel which is costly and smelly, and are responsible for the production of large amounts of carbon dioxide.[5] They can also be difficult to adjust which can result in the freezing of medicine.[6] Two main types of solar fridges have been and are currently being used, one that uses a battery and more recently, one that does not.

1. **Existing methods**
2. **Refrigeration using solar energy**

Refrigeration is one application of solar energy where the demand matches the availability of solar radiation. Because of this advantage and the increasing cost and uncertainty of conventional fuels, serious efforts are underway all over the world to develop technically and economically viable solar cooling systems. Air conditioning for achieving comfortable conditions for living, refrigeration for storage of perishable food products, essential drugs, and vaccines are the main areas in which solar energy can be employed. Refrigeration using solar energy can be achieved through the following means.

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

Solar-powered refrigerators are most commonly used in the developing world to help mitigate [poverty](http://en.wikipedia.org/wiki/Poverty) and [climate change](http://en.wikipedia.org/wiki/Climate_change). By harnessing [solar energy](http://en.wikipedia.org/wiki/Solar_energy), these [refrigerators](http://en.wikipedia.org/wiki/Refrigerator) can keep perishable goods such as meat and dairy cool in hot climates and are used to keep much-needed vaccines at their appropriate temperature to avoid spoilage. The portable devices can be constructed with simple components and are perfect for areas of the developing world where electricity is unreliable or non-existent. Other solar-powered refrigerators were already being employed in areas of [Africa](http://en.wikipedia.org/wiki/Africa) that vary in size and technology, as well as their impacts on the environment. The biggest design challenge is the intermittency of sunshine (only several hours per day) and the unreliability (sometimes cloudy for days). Either battery (electric refrigerators) or phase-change material is added to provide constant refrigeration.

1. **Proposed method**
2. **Passive solar cooling**

In this type of cooling solar thermal energy is not used directly to create a cold environment or drive any direct cooling processes. Instead, solar building design aims at slowing the rate of heat transfer into a building in the summer and improving the removal of unwanted heat. It involves a good understanding of the mechanisms of heat transfer: heat conduction, convective heat transfer, and thermal radiation, the latter primarily from the sun. For example, a sign of poor thermal design is an attic that gets hotter in summer than the peak outside air temperature. This can be significantly reduced or eliminated with a cool roof or a green roof, which can reduce the roof surface temperature by 70 °F (40 °C) in summer. A radiant barrier and an air gap below the roof will block about 97% of downward radiation from roof cladding heated by the sun. Passive solar cooling is much easier to achieve in new construction than by adapting existing buildings. There are many design specifics involved in passive solar cooling. It is a primary element of designing a zero-energy building in a hot climate.

Active solar cooling uses solar thermal collectors to provide thermal energy to drive thermally driven chillers (usually adsorption or absorption chillers). The Sopogy concentrating solar thermal collector, for example, provides solar thermal heat by concentrating the sun’s energy on a collection tube and heating the recirculated heat transfer fluid within the system. The generated heat is then used in conjunction with absorption chillers to provide a renewable source of industrial cooling. The solar thermal energy system can be also used to produce hot water. There are multiple alternatives to compressor-based chillers that can reduce energy consumption, with less noise and vibration. Solar thermal energy can be used to efficiently cool in the summer, and also heat domestic hot water and buildings in the winter. Single, double, or triple iterative absorption cooling cycles are used in different solar-thermal-cooling system designs. The more cycles, the more efficient they are. Efficient absorption chillers require water of at least 190 °F (88 °C). Common, inexpensive flat-plate solar thermal collectors only produce about 160 °F (71 °C) of water. In large-scale installations, there are several projects successful both technical and economically in operation worldwide including e.g. on the headquarters of Caixa Goral de Depósitos in Lisbon with 1579m² solar collectors and 545 kW cooling power or on the Olympic Sailing Village in Qingdao/China.

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Figure 1: Passive solar thermal cooling

1. **Solar thermal cooling**

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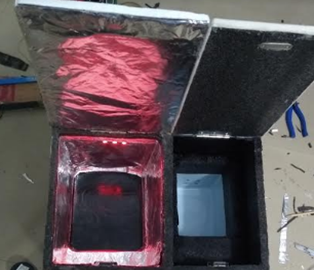


Figure 2: Photovoltaic solar cooling

The Audubon Environmental Center in Los Angeles has an example of solar air conditioning installation. The Southern California Gas Co. (The Gas Company), and its sister utility, San Diego Gas & Electric (SDG&E), are also testing the practicality of solar thermal cooling systems at their Energy Resource Center (ERC) in Downey, California. Solar Collectors from Sopogy and Heli Dynamics were installed on the rooftop at the ERC and are producing cooling for the building’s air conditioning system. In the late 19th century, the most common phase change refrigerant material for absorption cooling was a solution of ammonia and water. Today, the combination of lithium and bromide is also in common use. One end of the system of expansion/condensation pipes is heated, and the other end gets cold enough to make ice. Originally, natural gas was used as a heat source in the late 19th century. Today, propane is used in recreational vehicle absorption chiller refrigerators. Innovative hot water solar thermal energy collectors can also be used as the modern "free energy" heat source. For 150 years, absorption chillers have been used to make ice (before the electric light bulb was invented). This ice can be stored and used as an "ice battery" for cooling when the sun is not shining, as it was in the 1995 Hotel New Otani in Tokyo Japan. Mathematical models are available in the public domain for ice-based thermal energy storage performance calculations. The ISAAC Solar Icemaker is intermittent solar ammonia-water abs.

Photovoltaics can provide the power for any type of electrically powered cooling be it conventional compressor-based or adsorption/absorption-based, though the most common implementation is with compressors which is the least efficient form of electrical cooling methods. For small residential and small commercial cooling (less than 5 MWh/yr.) PV-powered cooling has been the most frequently implemented solar cooling technology. The reason for this is debated, but commonly suggested reasons include incentive structuring, lack of residential-sized equipment for other solar-cooling technologies, the advent of more efficient electrical coolers, or ease of installation compared to other solar-cooling technologies (like radiant cooling). Since PV cooling's cost-effectiveness depends largely on the cooling equipment and given the poor efficiencies in electrical cooling methods until recently it has not been cost-effective without subsidies. Pairing PV with 14 SEERS and fewer coolers is the least efficient of all solar cooling methods. Using more efficient electrical cooling methods and allowing longer payback schedules is changing that scenario. For example, a 100,000 BTU U.S. Energy Star-rated air conditioner with a high seasonal energy efficiency ratio (SEER) of 14 requires around 7 kW of electric power for full cooling output on a hot day. This would require over a 7-kW solar photovoltaic electricity generation system (with morning-to-evening, and seasonal solar tracker capability to handle the 47-degree[vague] summer-to-winter difference in solar altitude). The photovoltaics would only produce full output during the sunny part of clear days. A more efficient air conditioning system would require a smaller, less-expensive photovoltaic system. A high-quality geothermal heat pump installation can have a SEER in the range of 20 (+/-). A 100,000 BTU SEER 20 air conditioner would require less than 5 kW while operating. Newer and lower power technology including reverse inverter DC heat pumps can achieve SEER ratings up to 26, the Fujitsu Halcyon line being one notable example, but its requirements of 200-250v AC input makes its use in the USA in smaller grids newer Their are new non-compressor-based electrical air conditioning systems with a SEER above 20 coming on the market. New versions of phase-change indirect evaporative coolers use nothing but a fan and a supply of water to cool buildings without adding extra interior humidity (such as at McCarran Airport Las Vegas Nevada). In dry arid climates with relative humidity below 45% (about 40% of the continental U.S.) indirect evaporative coolers can achieve a SEER above 20, and up to SEER 40. A 100,000 BTU indirect evaporative cooler would only need enough photovoltaic power for the circulation fan (plus a water supply) A less-expensive partial-power photovoltaic system can reduce (but not eliminate) the monthly amount of electricity purchased from the power grid for air conditioning and other uses.

1. **Geothermal cooling**

Earth sheltering or Earth cooling tubes can take advantage of the ambient temperature of the Earth to reduce or eliminate conventional air conditioning requirements. In many climates where the majority of humans live, they can greatly reduce the buildup of undesirable summer heat, and also help remove heat from the interior of the building. They increase construction costs but reduce or eliminate the cost of conventional air conditioning equipment. Earth cooling tubes are not cost-effective in hot humid tropical environments where the ambient Earth temperature approaches the human temperature comfort zone. A solar chimney or photovoltaic-powered fan can be used to exhaust undesired heat and draw in cooler, dehumidified air that has passed by ambient Earth temperature surfaces. Control of humidity and condensation are important design issues.

1. **Advantages of solar refrigeration**

* Cost effective
* Live wherever you want
* Reduce your carbon footprint
* Low on maintenance

1. **Conclusions**

An overall system coefficient of performance (COPsys) can be deﬁned as the ratio of refrigeration capacity to input solar energy. The COP sys is low for all three types of solar refrigeration systems. However, this dentition of efficiency may not be the most relevant metric for a solar refrigeration system because the fuel that drives the system during operation, solar energy, is free. Other more important system metrics are the specialized, weight, and, of course, the cost. Several barriers have prevented more widespread use of solar refrigeration systems. First, solar refrigeration systems necessarily are more complicated, costly, and bulky than conventional vapor compression systems because of the necessity to locally generate the power needed to operate the refrigeration cycle. Second, the ability of a solar refrigeration system to function is driven by the availability of solar radiation. Because this energy resource is variable, some form of redundancy or energy storage (electrical or thermal) is required for most applications, which further adds to the system's size and cost. The advantage of solar refrigeration systems is that they displace some or all of the conventional fuel use. The operating costs of a solar refrigeration system should be lower than that of conventional systems, but at current and projected fuel costs, these operating cost savings would not likely compensate for their additional capital costs, even in a long-term life-cycle analysis. The major advantage of solar refrigeration is that it can be designed to operate independently of a utility grid. Applications exist in which this capability is essential, such as storing medicines in remote areas. Of the three solar refrigeration concepts presented here, the photovoltaic system is most appropriate for small-capacity portable systems located in areas, not near conventional energy sources (electricity or gas). Absorption and solar mechanical systems are necessarily larger and bulkier and require extensive plumbing as well as electrical connections. In situations where the cost of thermal energy is high, absorption systems may be viable for larger stationary refrigeration systems. The solar mechanical refrigeration systems would require tracking solar collectors to produce high temperatures at which the heat power cycle efficiency becomes competitive. If the capital cost and efﬁciency of tracking solar collectors can be signiﬁcantly reduced, this refrigeration system option could be effective in larger-scale refrigeration applications.

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