ISSN: 0974-5823 Vol. 7 No. 3 March, 2022
*International Journal of Mechanical Engineering*

# SOLAR BASED DOMESTIC REFRIGERATION SYSTEM USING PELTIER MODULE

**Sunil Bharti Harishankar[1], Hardik Bhupendrabhai Ramani[1], Ritesh Yadav[2] and Santosh Pawar[3]**
[1]Department of Mechanical Engineering, Dr. A.P. J. Abdul Kalam University, Indore
[2] Department of Physics, Dr. A. P. J. Abdul Kalam University, Indore
[3]Department of Electronics & Communication Engineering, Dr. A.P. J. Abdul Kalam University, Indore
Corresponding author Email: sunilbharti19@gmail.com

**ABSTRACT:**

Now a day, we have many problems such as numerous energy crisis and environment degradation owing to the increasing $CO_2$ emission and ozone layer depletion has become the main examine to both developed and developing nations. Our project takes advantage of the solar energy for its functioning. Solar refrigeration utilising thermoelectric module is likely to be one of the most cost effective, clean and environment friendly technology. This paper does not require any type of refrigerant and mechanical equipment like compressor, prime mover, etc for its functioning. The primary aim of this project is to offer refrigeration to the distant regions where electricity supply is not feasible.

**Keywords:** Refrigeration, Peltier effect, Thermo-electric module, solar energy.

## I. INTRODUCTION

Because they account for 91% of household usage, aqua ammonia systems need the attention of analysts despite their widespread use in homes powered by PV electricity aqua ammonia systems. Chillers remove heat from an area to decrease the temperature such that it is lower than the surrounding area's temperature (0-6). Electricity from the grid is used to power these systems. An aqua ammonia cooling system powered by solar energy has been studied for feasibility in this research proposal. It's been estimated how much power a 25W family refrigerator needs to operate for four hours a day. The goal of the project is to develop a gadget that does the same thing without harming the environment, while also cutting down on emissions of $CO_2$ and $SO_2$ — two pollutants that have a negative impact on our desire to live in harmony with nature.

Solar energy is the most cost-effective, non-competitive, and widely available energy source because of the availability of sunlight all year round. Photovoltaic technology can take this energy and turn it into something useful, like electrical energy for your home or business. Since its unique characteristics, such as vapour-compression and electric heating (or cooling) systems, have reignited interest in thermoelectric heating (or cooling) technology lately. The Peltier effect is used between the junctions of two semiconductors in thermoelectric (TE) modules, which are solid-state heat pumps (or refrigerators when cooling). Since heat transfers from one side to another in the TE module need a DC power source, there must be a hot and cold side on each of the devices that utilise these modules. To be appropriate for individuals who live in rural regions where loadshading is a significant issue, the heating and cooling system service has as its primary goal. Remote areas of the globe or extreme weather conditions may benefit from using the method. Since the turn of the century, refrigeration has played a critical role in our everyday lives.

Renewable energy resources are increasingly being seen as a viable energy source throughout the globe. This is due to two factors: first, the poorer quality of life caused by air pollution; and, second, the growing demand on our natural energy supplies as the global population grows. These two facts lead to the conclusion that the current supply of natural energy supplies will run out sooner rather than later. Photovoltaic driven refrigeration is the fundamental concept, and it uses a battery bank in conjunction with a direct current source or solar panel (if required). When German scientist Thomas Seebeck discovered in 1821 that an electric current would flow continuously in closed circuit made up of two dissimilar metals if the junctions of the

metals were kept at two different temperatures, this was a major step forward in the field of thermoelectricity.

Refrigeration has played a critical role in our daily lives since the turn of the century. Most of the developed world's attention these days is focused on renewable energy resources. This is due to two factors: first, the poorer quality of life caused by air pollution; and, second, the growing demand on our natural energy supplies as the global population grows. It's clear after looking at these two facts that natural energy supplies are limited. The fundamental concept is to use a battery bank in conjunction with a photovoltaic refrigeration system supplied by a direct current source or solar panel (as required).

## II. LITERATURE REVIEW

New Jersey Medical Center Reddy, New Jersey Medical Center (2016), Despite massive efforts to slow global warming, it has only gotten worse. An eco-friendly and low-power refrigeration system using the thermoelectric effect is presented in this article. Compressor, condensers, expansion valves, the evaporator, the refrigerant, and so on all operate synchronously in traditional refrigerators, which utilise complicated systems. To eliminate the need of these complicated components, a thermoelectric refrigerator utilises the Peltier effect. Thus, hazardous chlorofluorocarbons (CFCs) released into the atmosphere may be reduced, which in turn serves to slow the rate of rise in global temperatures. A microcontroller also makes it possible to regulate and adjust the temperature precisely where you want it. As a result, this product may be utilised both at home and in the workplace. There are no hazardous gases emitted by the device. This gadget may be used in a variety of ways because of the heat it emits and the heat it can be used for. By not contributing, this idea seeks to reduce air pollution while simultaneously lowering electricity usage.

Hassan, M.T. and others; Abbas Z, Shah A.N. and Hassan et al (2020), One of the most efficient methods to conserve energy and achieve sustainability is to switch air conditioning and ventilation systems from conventional to renewable energy systems. A solar-powered home air cooler using Peltier plates has been designed, fabricated, and evaluated in this experimental research to satisfy the comfort requirements set by ASHRAE standards in terms of cooling performance. Additionally, it looks at the impact of Peltier modules on the efficiency of a standard room air cooler system. There were four Peltier modules running at different temperatures in a 1212 room throughout the tests. Three times, the tests were carried out under the same circumstances. In order to reduce the temperature of water, the Peltier effect was utilised, and then cooled water was used to reduce the temperature of the surrounding air. The comfort zone was created using the cooled air. As a consequence, the experimental zone's temperature was lowered by 5%, 13%, 19%, and 23% when utilising only one of the Peltier modules, respectively. At 27 °C, the experimental zone's temperature, the rise in relative humidity was 5%. Using this new Peltier-based home solar-powered cooling system may save as much as 200 MW of energy, according to the study's energy analysis findings, which indicated significant energy savings.

Y. Shin, J. Ham, and H. Cho (2019), It was discovered that changing the interior temperature of a car from an unpleasant level to a comfortable one altered the brain and pulse rhythms of test participants. Subjects were also given questionnaires to gauge their degree of thermal comfort, with the findings evaluated. When the cabin and vent exit temperatures were 30°C and 16.5°C, respectively, the stress index and low-to-high frequency ratio (LF/HF) did not clearly indicate an unpleasant situation. Due to the activation of high wave due to low air temperature from vent exit, test participants' thermal feeling temperature decreased. Long durations of driving also made the participants' eyes tired, which contributed to their discomfort. When tested in the heating setting, participants reported feeling quite comfortable due to the warm air coming from the vent outlet. Because of this, the participants were able to maintain an awake state even after reaching cabin temperatures of 17.5 degrees Celsius and 37.5 degrees Celsius, respectively.

Pushpendu Dwivedia K. Sudhakar Archana Sonia E Solominc I Kirpichnikova (2020), Photovoltaic (PV) panels, which generate electricity from the sun's energy, are notoriously inefficient. The increase in surface temperature has a negative impact on the P.V. module's output. This rise is due to the heat generated by the absorbed sunlight, which reduces the panel's output, efficiency, performance, and lifespan. Using cooling methods may be a viable option for reducing cell temperature and preventing overheating of PV panels. In this

article, several viable cooling techniques are presented in detail, including new and advanced P.V. panel solutions, and future research directions are indicated. Various characteristics and capabilities of each cooling method are given in order to give researchers who want to investigate, enhance, or optimise any cooling technique for P•V modules a better understanding and useful recommendations.

The author is S.M.A. Rahmana Ahmed Amine, and the author's last name is ChaoukiGhenaia (2020), Here, a brand-new solar thermoelectric refrigerator concept is presented. Cooling is provided in the refrigerator via the thermoelectric module's cooling action. A low-temperature heating application utilises the thermoelectric module's (TEM) rejected heat to its full capacity. A well-insulated rectangular aluminium container serves as the cooling chamber. The cold chamber of the system was intended to have a temperature of 10 degrees Celsius so that it may serve as a refrigerator. Experiments showed that in the cold chamber, the system could achieve a temperature of approximately 10°C, while in the hot chamber, a temperature of about 40°C was achieved. Temperature effects had a lower coefficient of performance (COP) than cooling effects, with COPs of approximately 0.61. The thermoelectric refrigerator's electro-thermal dynamic behaviour was also simulated using TRNSYS software, which was created a computational model. The simulation's outcomes matched up well with the experiments'. Eco Audit CES Edu pack software was used to do life cycle studies to determine the feasibility of the new design. Based on the findings, it seems that the innovative system is both economically and ecologically feasible.

## III. METHODOLOGY

Here's a schematic of an experimental solar-powered peltier refrigerator, which serves several purposes similar to a standard refrigerator.

**Peltier Module**

This research revolves on Peltier's impact. There is a direct relationship between temperature and electric voltage in the thermoelectric effect. When the temperature changes on either side, a thermoelectric device generates a voltage. After an electrical current is conducted across the intersection of two different metals, heat will be removed from one alloy and transferred to the other. The Peltier effect powers thermoelectric refrigerants. The gadget, on the other hand, has two faces. In the presence of a direct current (DC) electric current, heat is generated from both sides, with one becoming colder and the other getting hotter. The heatsink is located on the hot side of the motherboard. However, the freezing point is lower than the ambient temperature.

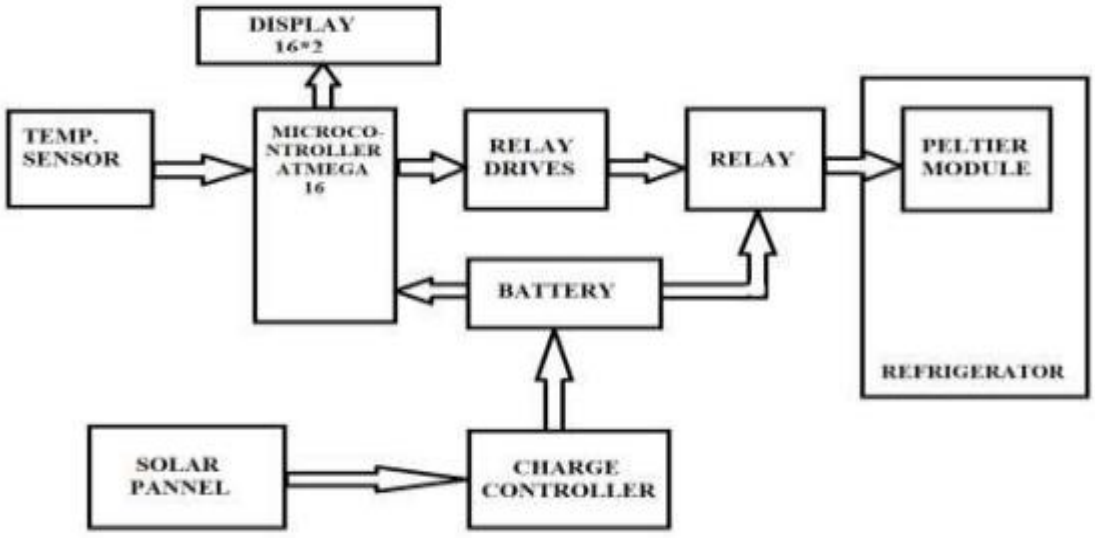


**Figure 1: Block diagram solar based refrigeration system**

**Temperature controller and solar panel**

It is an analytic temperature controller that receives input from a temperature sensor and outputs a control signal to something like a heater or a blower. A photovoltaic cell in a solar panel converts light energy into usable electrical energy. During this study, the output voltage of the solar panel was utilised as an analytical

energy source and was dependent on the amount of light falling on the panel. There is a 25 W solar panel with a DC output voltage of 12 volts and a current output of 12 amps. A photovoltaic cell is a specific kind of solar cell that uses solar panels to convert photons to electrons to create a current. Solar-powered photovoltaic cells are made of semiconductive materials like silicon and use light from the sun to power their operations. As the sun's photons strike the photovoltaic cells' electrons, they create an electrical current that powers the devices. Each cell has its own electric pasture for directing the flow of electrons in the right way. When these electrons enter the PV cell, they pass via an alloy contact, which may be utilised as a power device.

**Integrated battery and inverter/cooler for the CPU**

The voltage and current of the battery with built-in inverter utilised in this study are 12 V and 12 A. With the 14 V Converter, the output voltage for all four ports is 12V DC. Power conversion from DC to AC is adequate with new battery-based inverters. Using an AC power supply to connect the inverter/charger opens up a whole new world of possibilities. Generators have been the most popular off-grid backup power source since they increased the system's pliability and flexibility, and they were also utilised for high-power, irregular demands. It can power loads while also assisting in battery recharging during a period of overcast weather. As an alternative to short winter daylight hours, the generator may decrease the cost of a PV-based system by sizing it for average yearly insolation. In the event of an inverter or battery failure, a generator may serve as a stand-alone backup.

By bringing in colder air ahead of time, the CPU cooler actively cools the processor and analytically ventilates the heat from the components. In terms of cost and practicality, it's the best method to prevent the Peltier from overheating. When the CPU fan runs, the Peltier is kept cold by drawing in more cooling air before it becomes too hot and damages the Peltier. Cooling the Peltier fans come in various sizes and are typically supplied with an aluminium or copper heatsink fan. The Peltier is cooled by using CPU cooling fans and an aluminium heatsink fan. Both are attached directly to the Peltier. Using a fan connected to a fin-like structure, hot air is sucked from the element and pushed into a cavity between the fins, where it is cooled. This process is known as cooling the processor.

## IV. CONCEPT OF DESIGN

Refrigeration is the process of lowering the temperature in order to chill a product or an area to a desired temperature below the ambient temperature. There's a relationship between electric field strength and temperature gradient known as the Seebeck coefficient; it's also known as the voltage-to-temperature ratio. The junction's Peltier coefficient is a material-dependent characteristic that measures the power generated at the junction as a percentage of the current passing through it. When a current or temperature gradient is applied to a sample, the Thomson coefficient measures the power evolution per unit volume.

**Construction of Refrigeration System**

The construction setup of the refrigerator is as follows,

a) Thermo-electric module
b) Refrigeration chamber
c) Battery
d) Solar cell
e) Charge controller

**A. Thermo-electric module (Model no. – TEC1- 12706)**

When electricity is supplied to a thermo-electric module (TEM), it acts as a heat exchanger by moving heat from the cold to the hot side. If the current is reversed, the heat will flow in the other way. Cooling units - Peltier modules of reasonably high power may be created by combining several pairs of p and n semiconductors [5]. There are 127 p–n couplings, as indicated in the model no.

1) Material used- Silicon - Bismuth
2) A = 0.04 x 0.04 = 0.0016 $m^2$

**B. Refrigeration chamber**

Conventional refrigeration chambers are utilised for comparison. There are no restrictions on the design of the chamber. We utilised a cooler box with a capacity of 7.8 litres. The chambers' capacity is maintained to a minimum during testing. Polystyrene is used to insulate the chamber. In addition, the inside side of the insulation has an aluminium shell for improved cooling.

**C. Battery**

Batteries transform chemical energy into electrical energy via an electrochemical reaction. The battery's primary function is to produce electricity to power the cranking motor and other electrical components of the engine.

Specification,

1) Voltage 12 V
2) Current 7.2Ah

**D. Solar cell**

The direct conversion of solar energy is carried out into electrical energy by conversion of light or other electromagnetic radiation into electricity.

1) Voltage – 17 V dc
2) Current – 1.16amp
3) Power - 10 W
4) Solar irradiation – 1000 W/m2
5) No. of subcells – 72

**E. Charge controller**

When using solar refrigeration, it's critical to have a charge controller. Long-term safety and appropriate feeding are the goals of this device. A controller's primary functions are straightforward. When sunlight strikes a solar panel, the intensity of the sun's beams changes. In a solar refrigeration system, we utilize a charge controller to regulate the amount of power going to the solar panel. Battery overcharging and electrical overload are both prevented by a charge controller. A MPPT (Maximum Power Point Tracking) base solar charger powers our solar-powered refrigeration unit.

## V. WORKING OF THERMOELECTRIC COOLER

Equipment that converts solar energy into electrical energy is known as photovoltaic (PV) equipment. A solar cell generates a DC supply of 17 volts, 1.16 amps, and 10 watts using sun energy. This electrical energy is stored in a 12 volt DC battery, which powers transformers with the help of inverters. The transformer controls three fans, two of which are exhaust fans that remove heat from a heat sink plate when they are turned on. The third fan on the side serves as a heat extractor, drawing heat away from the system and transferring it to a sink for disposal. Heat is transmitted from one side to the other of the TEC while the device is operating, producing a cold and hot side. There is a difference in the heating and cooling COP due to the various types of heat reservoirs. The coefficient of performance (COP) measures how much heat is extracted from a cold reservoir compared to the amount of effort that is put in. When it comes to heating, however, the COP measures how much energy is wasted due to the heat being taken from the cold reservoir and the input labour.

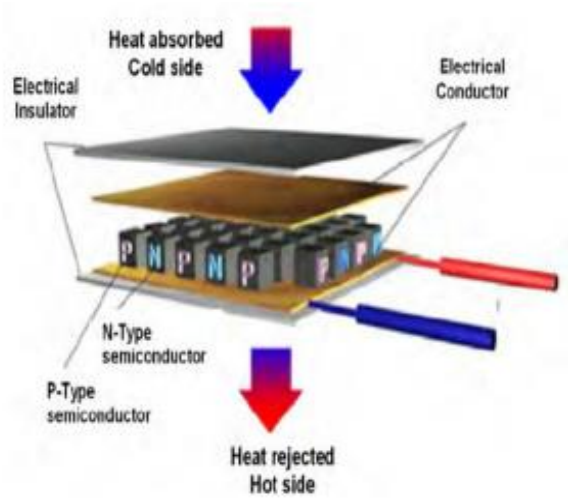


**Figure 2: Working of Peltier module as refrigerator**

**Working Design**

For a Peltier effect project, one of our initial steps is to choose an appropriate Peltier module (or modules). The following criteria, derived from prior research, should be taken into account while making module selections. 1) The temperature at which it operates must not exceed the set limits. Modules with hot sides should reject less heat than modules with cold sides. 3) A suitable heat sink should be supplied on the hotter side to provide the required cooling. In selecting a Peltier module, consider the volume that has to be cooled.

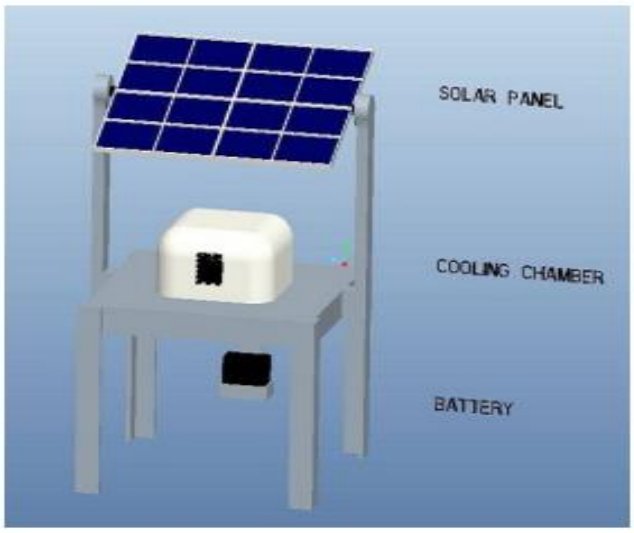


**Fig 3. Design structure of solar refrigerator using Peltier module**

**Observation table**

Module used: TEC1-12709
Compartment dimensions (mm): 260 i.e., (Volume of 6825000mm3).
Temperature 300°C

| Sr.no. | Time | | Temperature | |
|---|---|---|---|---|
| | Sec. | Min. | °C | °F |
| 1. | 0 | 0 | 30 | 86 |
| 2. | 32 | 0:32 | 29 | 84.2 |
| 3. | 49 | 0:49 | 28 | 82.4 |
| 4. | 62 | 1:02 | 27 | 80.6 |
| 5. | 76 | 1:16 | 26 | 78.8 |
| 6. | 88 | 1:28 | 25 | 77 |
| 7. | 100 | 1:40 | 24 | 75.2 |
| 8. | 120 | 2:00 | 23 | 73.4 |
| 9. | 135 | 2:15 | 22 | 71.6 |
| 10. | 152 | 2:32 | 21 | 69.8 |
| 11. | 168 | 2:48 | 20 | 68 |
| 12. | 196 | 3:16 | 19 | 66.2 |
| 13. | 216 | 3:36 | 18 | 64.4 |
| 14. | 244 | 4:04 | 17 | 62.6 |
| 15. | 292 | 4:52 | 16 | 60.8 |
| 16. | 332 | 5:32 | 15 | 59 |
| 17. | 416 | 6:56 | 14 | 57.2 |
| 18. | 524 | 8:44 | 13 | 55.4 |
| 19. | 780 | 13:00 | 12 | 53.6 |

**Applications of Systems**

1. Can be uses for remote place where electric supply is not available,
2. Medical and pharmaceutical equipment,
3. Military applications,
4. Laboratory, scientific instruments, computers and video cameras.
5. In restaurants /hotels

## VI. CONCLUSIONS

Based on the results of the experiment shown below, the following conclusions have been drawn: As a result of the cooling, the lowest temperature was 10°C, while the maximum temperature was 60°C. For many

reasons, switching to a solar-powered refrigerator instead of one powered by a compressor is a good idea. Thermal energy monitors, heat pumps, and coolers all utilise the thermoelectric effect. Thermoelectric cooling has a significant difficulty due to the reduced coefficient of performance, which occurs only in large-scale systems. To improve the thermoelectric cooler's performance, it's critical to examine several thermoelectric substances.

To keep things cold, refrigeration systems are often used, but they require a lot of energy and emit hazardous gases like CO2, CO, which contribute to global warming and climate change. A solar-powered refrigeration system utilising a peltier device is discussed in detail in this article. Solar energy is a never-ending, renewable energy source. The current system was built with nonrenewable resources and emits enormous amounts of hazardous gases, causing an energy shortage as well as the thinning of the ozone layer.

In the future, refrigeration systems will have to be designed utilising renewable energy resources like solar energy and the peltier effect to save on the cost of electricity. Thermoelectric module and electric control unit were used to construct and test a portable Heating and Cooling system. In distant and isolated areas of the nation, where load-shading is a significant issue, the system may be self-powered and utilised. It's essential to keep in mind that this is a one-time purchase that requires no ongoing upkeep.Improved module contact resistance and thermal interfaces may be able to further enhancesystem efficiency in the future. It is possible to increase the surface area covered by the system by adding additional modules.

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