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FABRICATION OF SOLAR POWERED PORTABLE REFRIGERATOR AND A BATTERY CHARGING DEVICE

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ABSTRACT
The main goal of doing this project is to fabricate a portable solar refrigerator and also a battery charging device and also to seek solutions to the global warming problem, by coming up with a solutions to eliminate the emission of CFC's. Our project is to design a Mini Solar Based Refrigerator, which eliminates the emission of CFC's, is very eco-friendly and also cheaper when compared to the present day Refrigerators. The paper presents the fabrication of a portable refrigerator works on solar energy and thermoelectric effect. This portable solar powered refrigerator can be used in deserts, rural areas where electricity is not available throughout the day, and also be used in medical applications. This is also arranged with a charging device which can be used for lighting and to charge electronic devices like mobile phones.

INTRODUCTION
In today's climate of growing energy needs and increasing environmental concern, alternatives to the use of non-renewable energy sources and polluting fossil fuels have to be investigated.one such alternate is solar energy.Green energy also known as regeneration energy, has gained wide attention in today's world. Green energy can be recycled, much like solar energy, water power, wind power, biomass energy, and terrestrial heat, temperature difference of sea, sea waves, morning and evening tides. Among these various energies, solar energy is the most powerful resource that can be used to generate power. Solar-powered refrigerators are most commonly used in the developing world to help mitigate poverty and climate change. By harnessing solar energy,these refrigerators are able to keep perishable goods such as medicines 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 are already being employed in areas of Africa which 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, Either batteries (electric refrigerators) or phase-change material is added to provide constant refrigeration. The collector, generally PV modules collects the radiation that falls on it and converts it into energy. The generated energy will be stored in storage devices. Due to the advantage of solar energy, it can be used in producing refrigeration effect in refrigerators. Portable solar powered refrigerator can also be designed and fabricated to produce cooling and heating effect. This portable solar powered refrigerator can be used in deserts, rural areas where electricity is not available throughout the day, travelling, and also be used in medical applications. This is also arranged with a charging device which can be used for lighting and to charge electronic devices like mobile phones.

LITERATURE REVIEW
Solar refrigeration may be accomplished by using one of the following refrigeration systems: vapor compression, absorption or thermoelectric refrigeration systems. The first two systems need high and low pressure sides of a working fluid to complete the refrigeration cycle, and are somewhat difficult to be developed into a portable and light solar device used outside. [1] The thermoelectric refrigeration system, which has the merits of being light, reliable, noiseless, rugged, and low cost in mass production, uses electrons rather than refrigerant as a heat carrier, and is feasible for outdoor purposes in cooperation with solar cells, in spite of the fact that its coefficient

performance is not as high as fora vapor compression cycle. In past years, much work has been reported on thermoelectric cooling. The thermoelectric refrigeration system is having potential application of storage and transportation of life saving drugs and biological materials at remote areas of our country where grid power is unavailable. Mathur has compared the performance of vapor compression, thermoelectric and absorption refrigerators. [5] T. Hara investigated a solar cell driven, thermoelectric cooling prototype headgear for outside personal cooling. H. j Goldsmidstudied a solar assisted automobile thermoelectric air conditioner [2]. Researchers developed a prototype which consists of a thermoelectric module, array of solar cell, controller, storage battery and rectifier. The studied refrigerator can maintain the temperature in refrigerated space at 15oC, and has a COP about 0.4-0.7 under given conditions. In developed countries, plug-in refrigerators with backup generators store vaccines safely, but in developing countries, where electricity supplies can be unreliable, alternative refrigerationtechnologies are required. 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. 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. They can also be difficult to adjust which can result in the freezing of medicine. There are two main types of solar fridges that have been and are currently being used, one that uses a battery and more recently, one that does not.

Solar refrigerators today

Solar-powered refrigerators are most commonly used in the developing world to help mitigate poverty and climate change. By harnessing solar energy, these refrigerators are able to 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 which 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 batteries (electric refrigerators) or phase-change material is added to provide constant refrigeration.

In this Project

Here in this project we have tried to amalgamate two concepts which have taken the energy sector by storm over the last couple of years. We have worked on presenting a working model of a solar powered refrigerator/heater using the unconventional technique of thermoelectric Peltier effect. This will probably revolutionize the concept of refrigeration because of the simple fact that it is eco-friendly and the ease of fabrication that goes in making it. Though it hasn't found wide spread applications in the industry yet, it is sure to take some big leaps in times to come.

THE MAIN COMPONENTS OF PORTABLE SOLAR REFRIGERATOR

Solar panel

Solar power is the conversion of sunlight into electricity, directly using photovoltaic (PV).A solar panel is a packaged interconnected assembly of solar cells, also known as photovoltaic cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Because a single solar panel can only produce a limited amount of power, many installations contain several panels. This is known as a photovoltaic array.

Fig 1.Solar panel

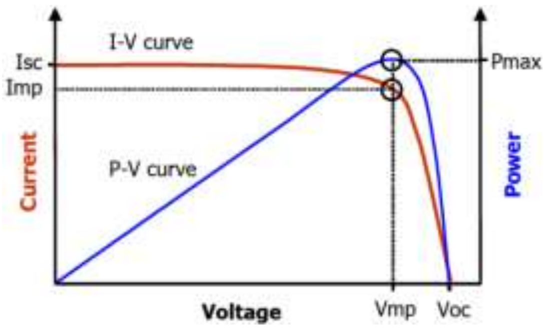
Photon-to-Electric Energy Conversion

Photovoltaic devices allow the direct production of electricity from light absorption. The active material in a photovoltaic system is a semiconductor capable of absorbing photons with energies equal to or greater than its bandgap. Upon photon absorption, an electron of the valence band is promoted to the conduction band and is free to move through the bulk of the semiconductor. In order for this free charge to be captured for current generation, decay to the lower energy state, i.e. recombination with the hole in the valence band, has to be prevented through charge separation.

Solar panel specifications

PV module performance parameters PV module performance is given by the following parameters:

1. Short Circuit Current (ISC) – 1.40A
2. Open Circuit Voltage (VOC) – 21.60V
3. Maximum Power (PMAX) – 20W
4. Current at PMAX (IMP) – 1.18A
5. Voltage at PMAX (VMP) – 17V
6. Fill Factor (FF) – 0.85



Graph 1.Illuminated I-V Sweep Curve

Lead acid battery

Lead-acid batteries are the most common in PV systems because their initial cost is lower and also because they are readily available anywhere in the world. There are many different sizes and designs of lead-acid batteries, but the most important characteristic is that they are deep cycle batteries. Lead-acid batteries are available in both wet-cell (requires maintenance) and sealed no-maintenance versions.12v, 7Ah battery is used in this portable solar refrigerator.

Lead acid batteries are reliable and cost effective with an exceptionally long life. They have high reliability because of their abilityto withstand overcharge, over discharge vibration and shock. The use of special sealing techniques ensures that the batteries are leak proof and non-spill-able. Other critical features include the ability to withstand relatively deeper discharge, faster recovery and more chances of survival if subjected to overcharge. The batteries have exceptional charge acceptance, large electrolyte volume and low self-discharge, which make them ideal as zero-maintenance batteries.

Power Supply Design

For AC input

The input to the circuit is applied from the regulated power supply. The a.c. input i.e., 230V from the mains supply is step down by the transformer to 12V and is fed to a rectifier. The output obtained from the rectifier is a pulsating d.c voltage. So in order to get a pure d.c voltage, the output voltage from the rectifier is fed to a filter to remove any a.c components present even after rectification. Now, this voltage is given to a voltage regulator to obtain a pure constant dc voltage.

*For DC input:*The power will be supplied to the refrigerator by a 12v, 7Ah lead-acid battery through the voltage regulator.

Refrigerator

The refrigerator in the portable solar refrigerator works on thermoelectric effect. The thermoelectric effectis the direct conversion of temperature differences to electric voltage and vice-versa. A thermoelectric device creates a voltage when there is a different temperature on each side. Conversely, when a voltage is applied to it, it creates a temperature difference. At the atomic scale, an applied temperature gradient causes charge carriers in the material to diffuse from the hot side to the cold side, similar to a classical gas that expands when heated; hence inducing a thermal current Controllers.

The term "thermoelectric effect" encompasses three separately identified effects: the Seebeck effect, Peltier effect and Thomson effect.

Thermoelectric refrigerator works on Peltier effect.A Peltier cooler, heater, or thermoelectric heat pump is a solid-state active heat pump which transfers heat from one side of the device to the other side against the temperature gradient (from cold to hot), with consumption of electrical energy. Such an instrument is also called a Peltier device, Peltier heat pump, solid state refrigerator, or thermoelectric cooler (TEC). The Peltier device is a heat pump: when direct current runs through it, heat is moved from one side to the other. Therefore it can be used either for heating or for cooling (refrigeration), although in practice the main application is cooling. It can also be used as a temperature controller that either heats or cools. The inside dimensions of the refrigerator is 140mm(w) x 140mm(D) x 208mm(H)

Thermoelectric Module

A thermoelectric (TE) module, also called a thermoelectric cooler or Peltier cooler, is a semiconductor-based electronic component that functions as a small heat pump. A Peltier cooler, heater, or thermoelectric heat pump is a solid-state active heat pump which transfers heat from one side of the device to the other side against the temperature gradient, with consumption of electrical energy. Such an instrument is also called a Peltier device, Peltier heat pump, solid state refrigerator, or thermoelectric cooler (TEC). The Peltier device is a heat pump: when direct current runs through it, heat is moved from one side to the other. Therefore it can be used either for heating or for cooling (refrigeration), although in practice the main application is cooling. It can also be used as a temperature controller that either heats or cools.When a voltage or DC current is applied to two dissimilar conductors, a circuit can be created that allows for continuous heat transport between the conductor's junctions. The Seebeck Effect- is the reverse of the Peltier Effect. By applying heat to two different conductors a current can be generated.

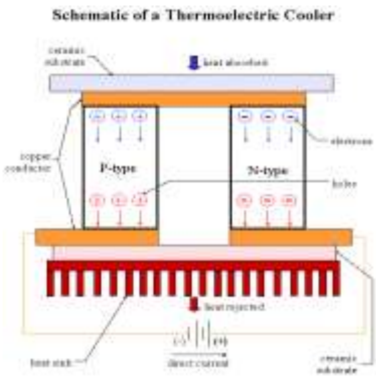


Fig 2.Schematic of a thermoelectric cooler

Heat sink

A heat sink is designed to increase the surface area in contact with the cooling fluid surrounding it, such as the air. Approach air velocity, choice of material, fin (or other protrusion) design and surface treatment are some of the factors which affect the thermal performance of a heat sink. Heat sinks are used to cool computer central processing units or graphics processors. Heat sink attachment methods and thermal interface materials also affect the eventual die temperature of the integrated circuit. Thermal adhesive or thermal grease fills the air gap between the heat sink and device to improve its thermal performance.

Fig 3.Heat sink

Cooling fan:
The axial-flow fans have blades that force air to move parallel to the shaft about which the blades rotate. Axial fans blow air along the axis of the fan, linearly; this type of fan is used in a wide variety of applications, ranging from small cooling fans for electronics to the giant fans used in wind tunnels.

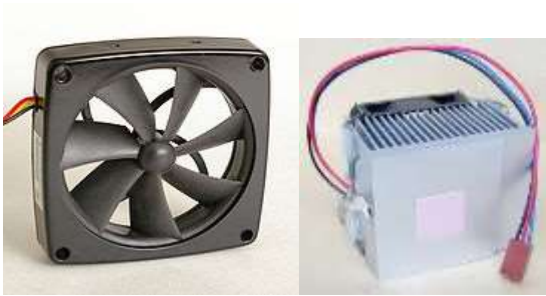


Fig 4.Axial flow cooling fan

Voltage regulator
As the name itself implies, it regulates the input applied to it. A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. In this project, power supply of 5V and 12V are required. In order to obtain these voltage levels, 7805 and 7812 voltage regulators are to be used. The first number 78 represents positive supply and the numbers 05, 12 represent the required output voltage levels. These regulators can provide local on-card regulation, eliminating theDistribution problems associated with single point regulation. Each type employs internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1 A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltage and currents.

Battery charging device
A USB battery charging device is also coupled to the equipment to recharge batteries of different electronic equipment like mobile phones, MP3 players, digital cameras etc. Input voltage- 12V to 20V, Output voltage-5v DC and 2.5A .

DESIGN AND CONSTRUCTION OF THE PORTABLE SOLAR REFRIGERATOR
The major components of the thermoelectric refrigerator include: thermoelectric module (Peltier element), finned surface (or heat sink), solar panel,battery,digital thermometer, cooling box and cooling fan. The components are assembled, in this study; single thermoelectric module was used in the design of the refrigerator.

Following are the specifications of the thermoelectric module used in this study. Maximum current (A) =3.3A, Maximum voltage (V) =12, Maximum power (W) =39.6W,

On the heat sink a cooling fan is attached to it. This is axially blowing the air in to the heat sink. So that heat will dissipate in to surroundings.

On the other side of the heat sink the module is fixed at the center to release heat more efficiently out into the atmosphere. So that hot side is in contact with heat sink. . Between the heat sink and module surfaces thermal grease is applied in order to eliminate the air gap and to increase the thermal conductivity. And then attach the spacer block on the cold side of the module by applying thin layer of thermal grease. . Thus the assembly of the heat sink, cooling fan, module and spacer block is finished.

A thermocouple sensor is also used in cooling box for measuring the temperature. Then the assembled box is fabricated as for our requirement. Thus the design of cooling box is completed.

Fig 5.Construction of a portable solar refrigerator

Experimental calculations
Mass of water =0.2kg
Specific gravity of water = 1
Type of supply = DC
Voltage = 12V
Current = 3.3A
Work input = 39.6W
Specific heat of water(C) =4180J/kg
Temperature difference (dt) = 28.5-18 = 10.5 C

TABLE I

S.no	**Time**	**Temperature of water in C**	**Temperature difference in 5 min**
1	2 PM	30	
2	2.05	25	5
3	2.10	23	2
4	2.15	20	3
5	2.25	18	2

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TABLE 2
Refrigeration and COP

S.no	Mass of water	Time taken to cool	COP	Refrigeration effect
1	0.2kg	10 min	0.422	16.72W
2	0.4kg	10 min	1.05	41.8W

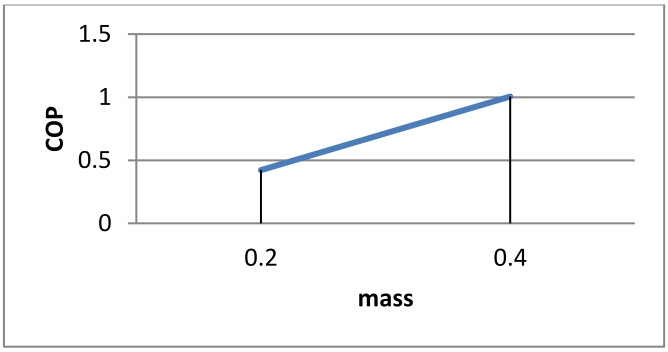

Fig 6. Graph between mass and cop

CONCLUSION

By using this system we can reduce electricity bill up to 20% because it can be works on dc power directly which is recharged by solar power. Solar power is always available in nature, but initially it takes more cost of installation of solar panel and the main drawback of the system is low C.O.P. Thermoelectric junctions are generally only around 5–10% as efficient as the ideal refrigerator (Carnot cycle), compared with 40–60% achieved by conventional compression cycle systems. Due to the relatively low efficiency, thermoelectric cooling is generally only used in environments where the solid state nature (no moving parts, maintenance-free, compact size) outweighs pure efficiency. This project uses a solar inverter system by using charging battery through which we can drive different kinds of applications like refrigeration, charging and lighting. The charged battery is used to store the energy as a backup source and drive the devices.

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