TESH

Thermal Energy Storage for Homes

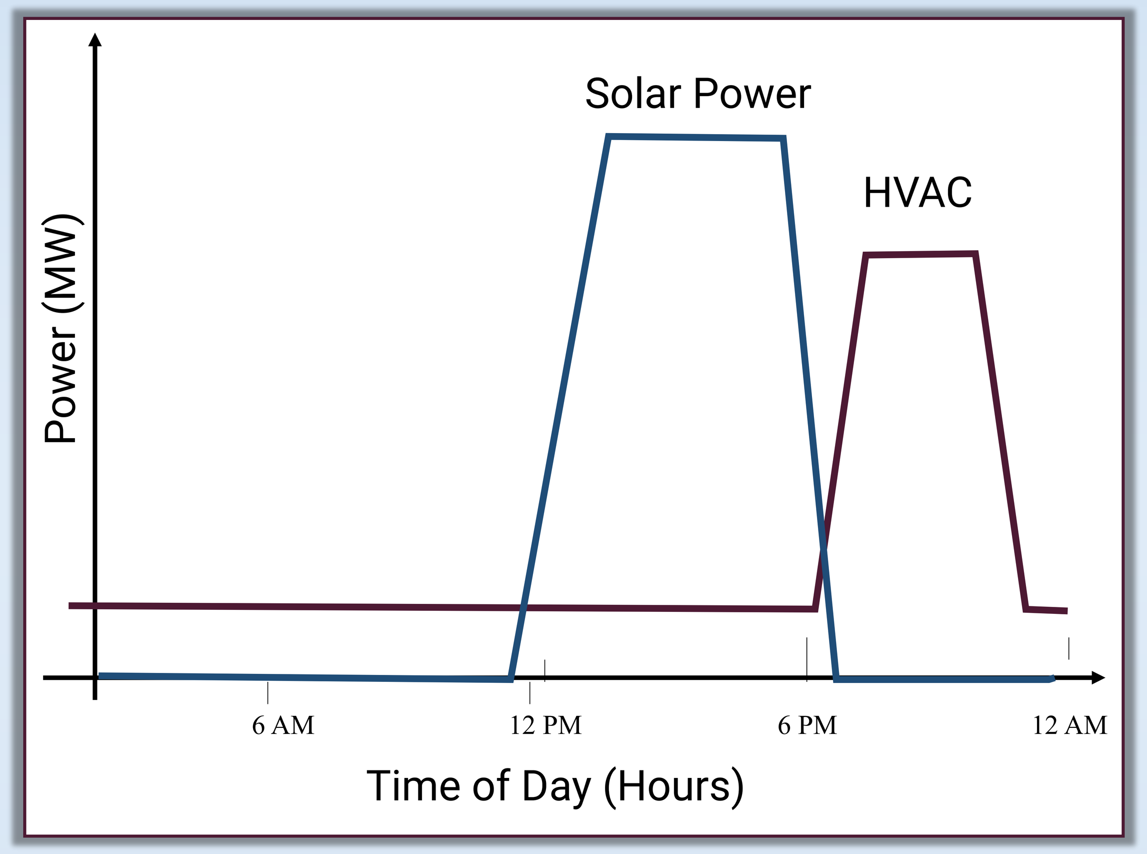
Balaji Venkatesh

Introduction

Solar energy is a type of renewable energy from sunlight . One way to collect this energy and make it useful are solar panels. These panels generate electricity whenever they receive light energy. Many homes are starting to install solar panels and generate their own electricity.

Problem

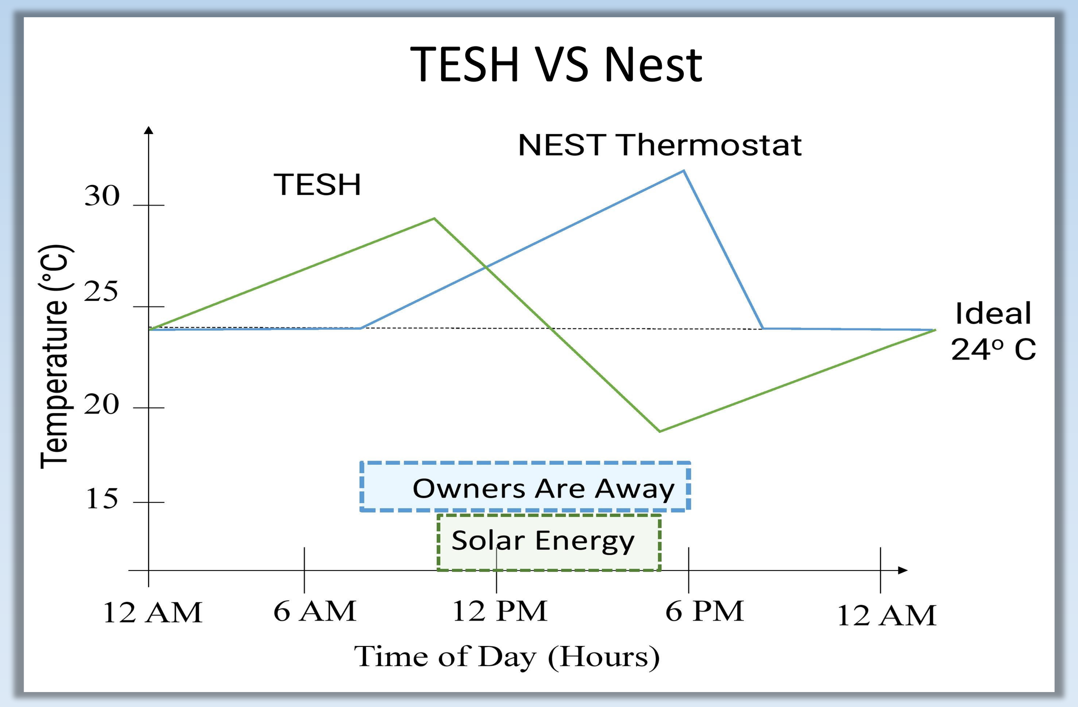
A problem has arisen with the matching of the solar energy coming in and the home loads that use it. One of the main electric loads in a house is the HVAC system. Most families will leave the house for the day, from for example at 7 am. When they return at 6 pm, they want to turn on the AC to make the house more comfortable. However, at this time, the sun starts to go down, and soon, the AC must run completely off non-solar energy. This is a problem.



There is a mainstream solution to this problem: batteries. The batteries store the energy during hours in which there is sun, and while the AC is needed, the batteries output the power back into the house. However simple and easy this seems, batteries have a very adverse effect on the environment. Batteries contain chemicals that are very harmful to the environment. Methods to obtain materials for and manufacture batteries cause environmental damage, and recycling them requires special equipment.

Solutions

The new solution is TESH. TESH uses thermal energy storage to move the HVAC load to when we can use solar to fuel it. How exactly? While there is solar energy coming in, the HVAC system 'supercools' the home, bringing the temperature to above/below the required temperature,. Once the energy is gone, the system allows the temperature to rise/lower through the rest of the day and night. This means that the HVAC only runs through the day, while there is solar energy, and doesn't use utility power through the night.



Design and Calculation

To determine the energy needed, we need to find out how much energy is required to change the temperature of the air in the house. Let's take an example: 2500 square foot house with 9 foot ceilings. The objective is to lower the temperature from 30°C to 15°C.

Energy to be removed to cool air:

$E = M \cdot SPH \cdot (T_2 - T_1)$

E: Energy

M:Mass

SPH: Specific Heat of Air (40%)

T: Temperature

$T_1 = 15°C$

$T_2 = 30°C$

SPH = 1.0 kJ/kg

$M = V \cdot D$

V: Volume in m^3

D: Density

D = 1.2754 kg/m^3

$V = 2{,}500 \cdot 9 / [3.2808^3] = 637.1290\ m^3$

$M = V \cdot D = 6.37.1290\ m^3 \cdot 1.2754\ kg/m^3 = 812.5944\ kg$

$E = M \cdot SPH \cdot (T_2 - T_1) = 812.5944\ kg \cdot 1.0 \cdot (30°C - 15°C)$

$= 12\ 188.9158$ *joules*

A refrigerator typically consumes 30% electrical energy to transport one unit of heat energy.

$0.3 \cdot E = 3{,}656.6747$ joules

Total Electric Energy required

On average modern photovoltaics (PV) solar panels will produce 8 - 10 watts per square foot of solar panel area. Assuming a 20% efficiency in operation, total Power produced by PV panels on 100 square feet PV panel:

= 100 square feet · [10 W/square feet] · 0.2 = 0.2 kW

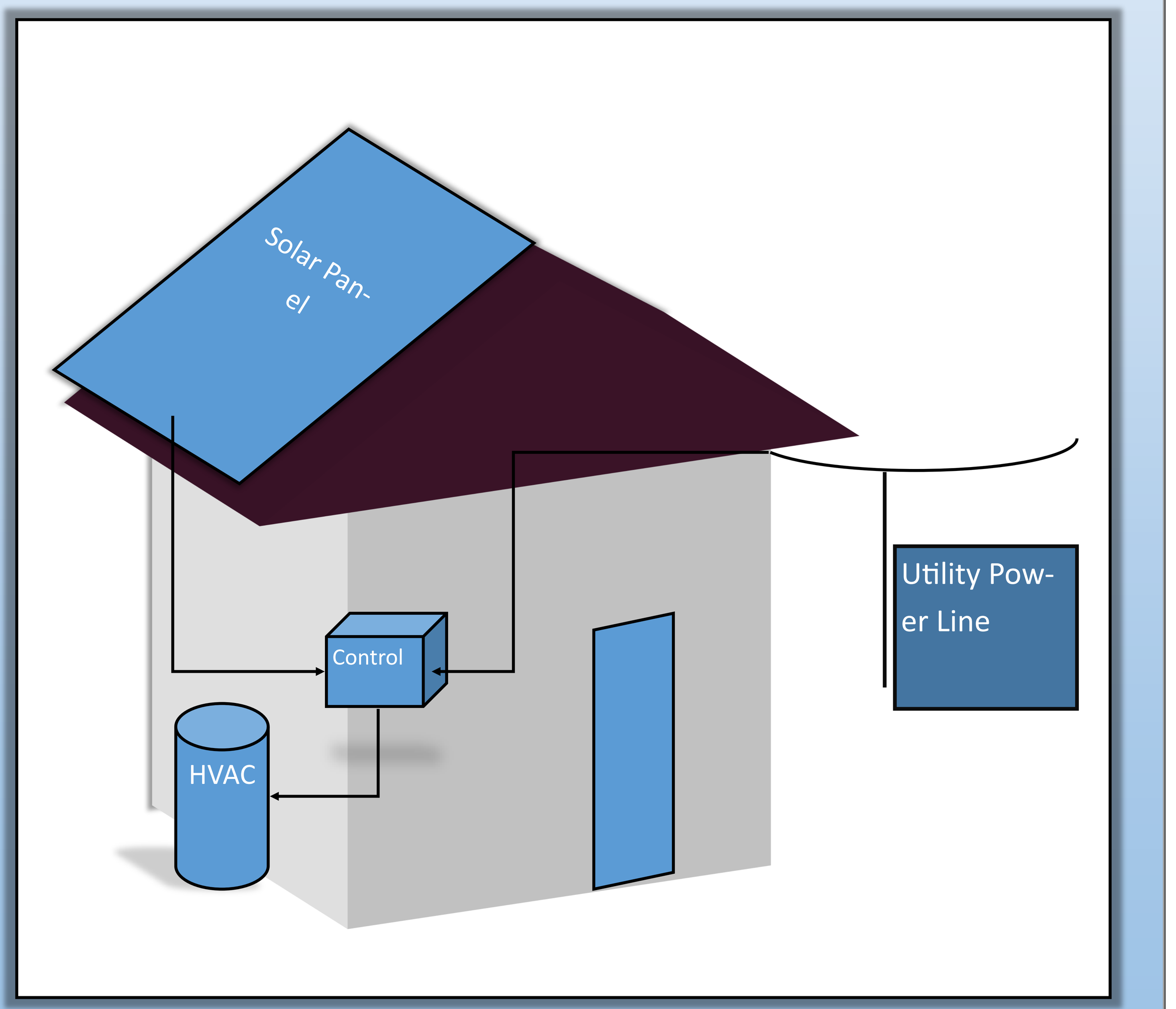
Considering PV panels work from 11 am to 4 pm, i.e.5 hours, total energy produced equals:

= 5 · 0.2 = 1 kWh = 3,600 joules

Hence, this with PV arrangement, enough energy can be taken from PV panels and cool the home.

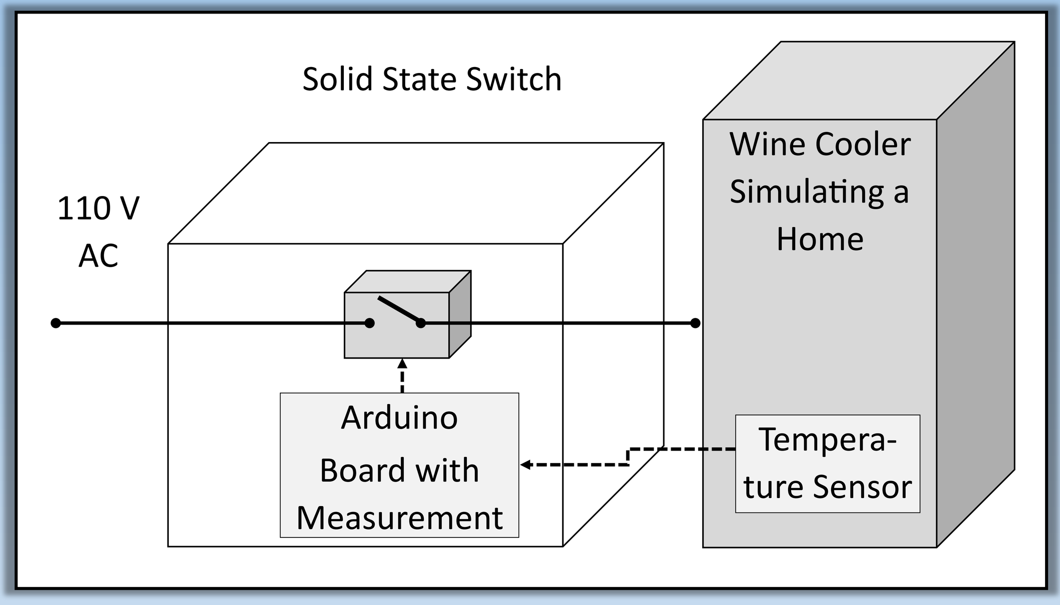
Integration

The TESH system works very much like the thermostats we currently use in our homes. In fact, the only difference is the times that the it turns the HVAC on and off. This means that the TESH system can be integrated into the existing thermostat interface in our homes.

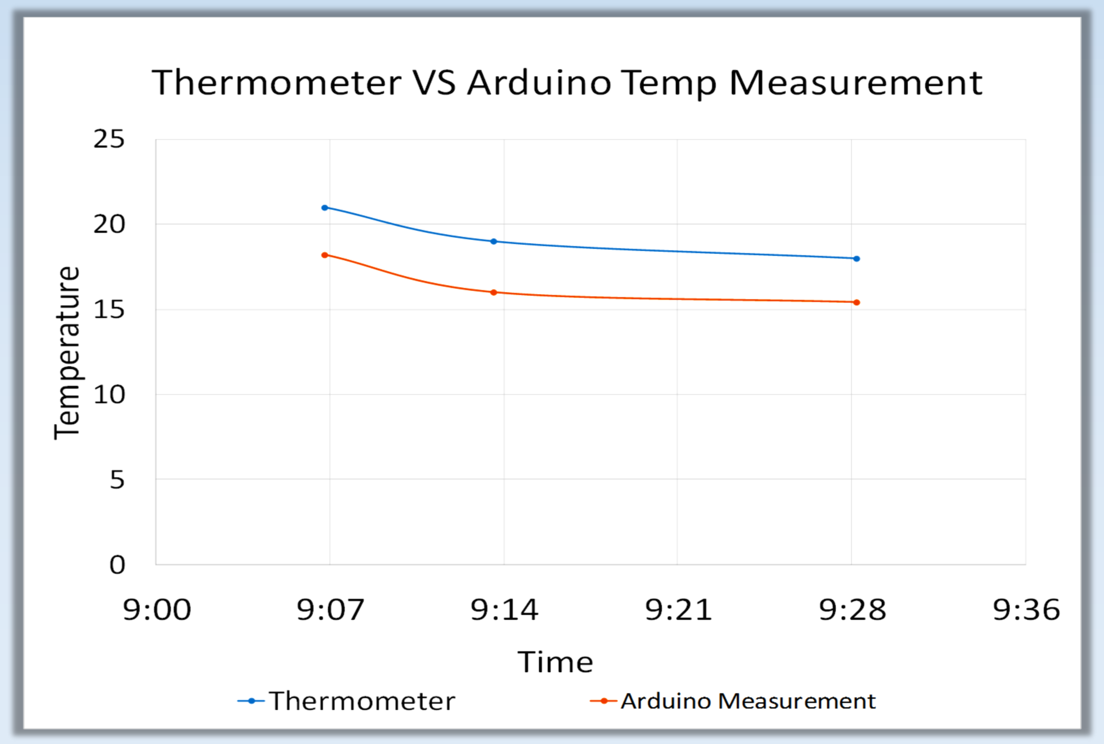


Testing and Calibration

The experiments were conducted using an Arduino-based beta TESH system. The experiment used a model of a home made from a wine cooler.



The above diagram shows the layout and schematic of the experiment.



The above diagram shows the error in the Arduino temperature measurement. This marginal error was corrected to provide accurate results.

Benefit

With TESH, the renewable solar energy can be used without another medium of storage, like batteries. This means there are two major benefits to using the TESH system. The first is a reduced effect on the environment. Since no batteries are used, there is no need for poisonous chemicals to be made and thrown away, The second benefit is that the price. Batteries cost a lot of money to make and maintain, and TESH gets rid of the need for them.

The TESH system is inexpensive to make; the model version cost only $100. A commercialized system based on a normal thermostat would cost even less, perhaps only requiring a single board similar to a $15 Arduino. This will make sure that the system is easily available to the average homeowner, and that cost will not be a preventing factor.

Commercialization

The commercialization of the TESH system is quite simple. In fact, the commercialized, thermostat-like system would be simpler than the model that we constructed. All it would need is a Arduino type board costing about $15, a small LCD screen costing about $10, a Wi-Fi chip costing about $5, and a plastic enclosure costing about $2. In total, the system would cost about $32, and would be a replacement for the current thermostat we already use in our homes.