Theoretical and Practical Applications of thermal solar panels
The penultimate student-produced document from FALL 2019 Cor100.16

Reviewed by John Pruden

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Power/Solar-Panel Experiment

Cole Anderson and Logan Gould

The solar-panel system holds 6 gallons of water. The mass is thus:
m = 6 gallons x 3.785 kg/gallon H_2O=22.71Kg

The specific heat of water is:
C = 4186 J/kgC

We will take the average temperature between the top and bottom to get the change in temperature. From the graph: T-average=½ (47.5+40.5)=44C

The initial temperature was 25C

Change in T=44C-25=19C

The amount of heat collected is then: Q=22.71x4186x19=1806217 joules

This energy was collected over 95 min = 5700 seconds

We can calculate the average power of collection:
power=energy/time=18
We can calculate the average power of collection:
Power=energy/time=1806217/5700=317Watts
On colder days about ½ of the absorbed energy is re-radiated. Under more normal temperature conditions, this re-radiation would be less of a factor. However, since the solar panel is about 1 square meter, we collect a net intensity of about 317 watts/meter^2

These are the calculations we got during the experiment. In the experiment we had a makeshift solar-panel water heater outside where the temperatures were below freezing. The starting temp of the water was 25C Over a period of 100 min the temperature increased by about 8C on average every 10min. At the end of the experiment the temperature was 47.5C, an increase of 22.5C in 100min. Solar-panels can even be useful in cold weather.

Solar Constant

Haley Wesley and Sarah White

Energy can be found in two forms: potential energy and kinetic energy. Potential energy is the energy by virtue of an objects position. It can also be defined as stored energy. Kinetic energy is the energy by virtue of the motion of an object. These forms of energy can be calculated through different equations. Power is the rate of doing work and can be calculated as Watts. The solar constant tells us how much power per unit the Earth receives from the sun. By the time it takes power to reach the earth it is reduced by ½. The solar constant is usually taken to be about 1,388 watts per square meter. In the upper atmosphere of the solar constant the value is about 1400 W/m^2. As for the collection of array of 8 panels you would have to calculate the unit of energy British thermal unit (BTU), which is equivalent to 1055 J, for one solar panel and multiply that by 8.

https://www.pveducation.org/pvcdrom/properties-of-sunlight/solar-radiation-in-space#:~:targetText=However%2C%20at%20some%20distance%20from,further%20away%20from%20the%20sun.

Alignment and measurement of the angle of the sun

Kyriece Lake and Blaze Nelson

To get the most from solar panels, you need to point them in the direction that captures the most sun. But there are a number of variables in figuring out the best direction. This page is designed to help you find the best placement for your solar panels in your situation. In the northern hemisphere, the general rule for solar panel placement is, solar panels should face true south. Usually this is the best direction because solar panels will receive direct light throughout the day. You need to capture the most sun possible so that your solar panel is running the most efficient it can.

There are many ways to measure the angle of the sun. One way is by sticking a pencil through the hole of a CD or DVD and finding the right angle where there is no shadow casting over the disc from the pencil. Another way is to pick a vertical object that is easy for you to measure and that is relatively permanent, like a sign or a fence post. Measure its height and write it down. Then right at noon on a bright sunny day measure the length of its shadow on the ground. Last, take the vertical measurement and divide it by the shadow measurement. (b/a) The result is the TANGENT of the angle.

Insulation & Thermal Siphon

Alexis Lyons, Savanna Thomas, & Sarah Darnell

Insulation is a very viable component to solar panels. To keep heat from escaping to the surroundings, both the tank and the tubes need to be insulated for maximum efficiency. This is also useful for saving money, seeing as without insulation, more heat would escape, causing the efficiency to decrease. Some examples of insulation consists of a car sunshade reflector around the hot water tank and a foam pool noodle around the tubes that will be transferring the water to and from the solar panel. Wrapping plastic around the solar panel, paired with the reflective boards on the back traps heat and increases efficiency by 60%.

Also, in terms of design, the top output of water needs to be more insulated, because the hot water is less dense than cold water, causing it to rise to the pipe on top. This effect creates a method of heat exchange called thermosiphoning. Thermal siphon is a natural pump that is doing work from the heat engine of the solar panel.

Water vs. Other Substances

Wyatt Frerichs and Jacob Wolfrom

Solar panels gather energy from the sun, but after the energy is collected it needs to be transported elsewhere to be useful. For most solar panels, this medium is water. Water is an ideal substance for solar panels because solar panels transfer energy through heat and water has an unusually high heat capacity of 4186 J/(kg*K). For comparison, this means that to heat 1kg of water by 1K takes the same amount of energy as it does to lift a 1kg mass almost a quarter mile, 418.6 meters. The formula for heat transfer is Q= (mass)**x**(heat capacity)**x**(change in temperature), or $\mathbf{Q=mc\Delta T}$. As a result, water changes temperature much slower than fluids such as air that only have a heat capacity of around 1000 J/(kg*K). This means that water can store large amount of thermal energy without reaching temperatures that become difficult to deal with, making it an ideal medium for energy transfer. In addition to the efficiency, water is extremely common and easy to acquire, making it a very cheap and effective component.

Energy required to raise each 6 gallons (23kg) of fluid by 1K

Water	Air
Q= mcΔT **Q**= 23kg x 4186J/(kg*K) x 1K **Q**= 96278J	**Q**= mcΔT **Q**= 23kg x 1000J/(kg*K) x 1K **Q**= 23000J

Thus, water can store roughly 4 times as much energy as air.

During the class we compared the heat capacities of aluminum and water.