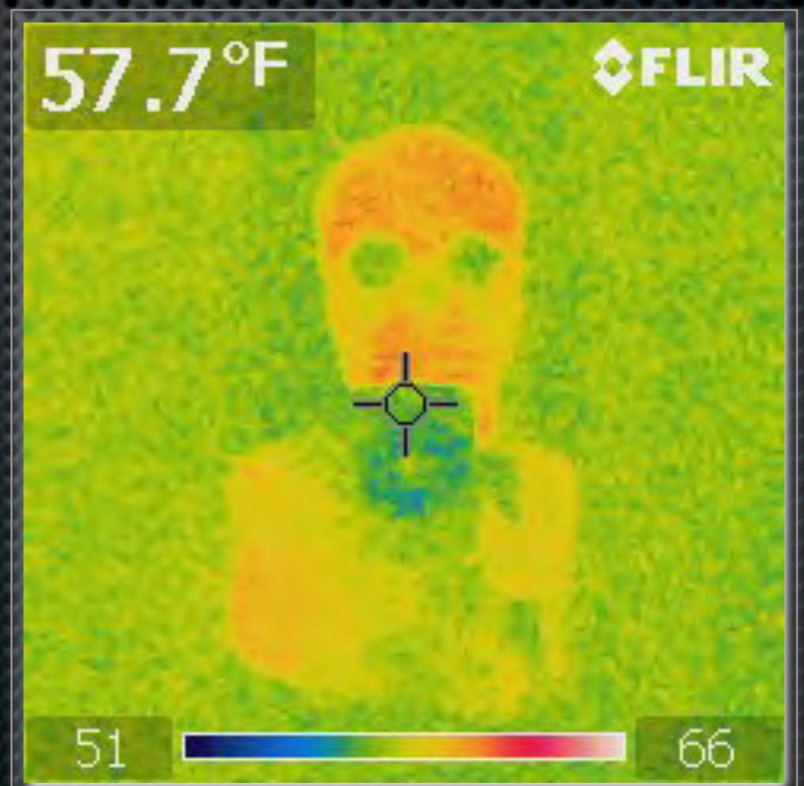
Solar cookers for teaching physics

Shawn Reeves

EnergyTeachers.org

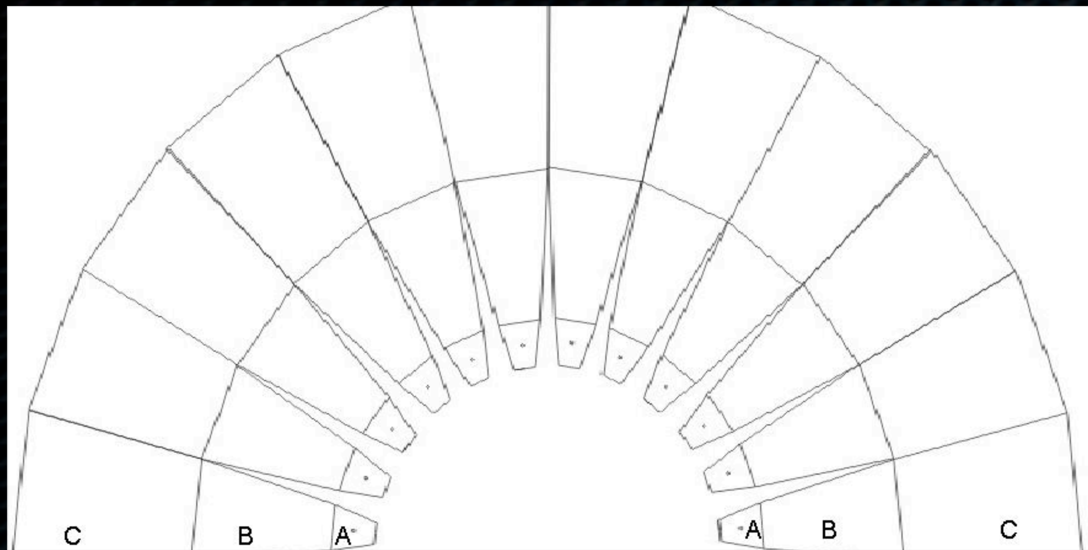


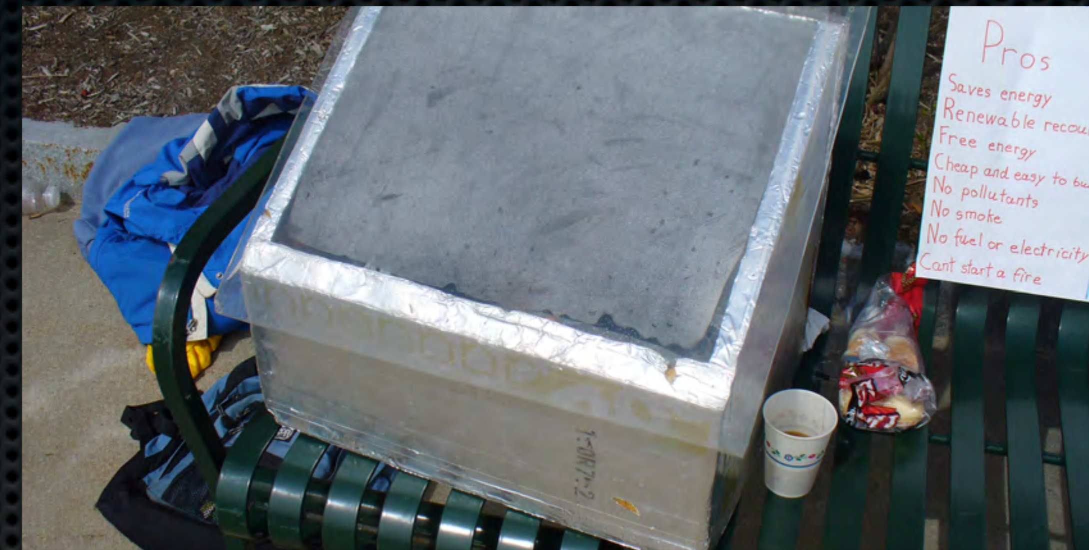
[AS PRESENTED TO AMERICAN ASSOCIATION OF PHYSICS TEACHERS, JANUARY 2014]
It's obvious to students that some lessons clearly address socially important issues. In these cases, it is not necessary to bludgeon them with that connection.
What scientific questions can we explore with solar cookers? How about pedagogical goals, from defining temperature to gaining facility with modeling interactions with energy?

Scientific questions

What scientific questions can we explore with a solar cooker?

Solicit questions from the audience. My favorite is “When is radiation more important than convection for heat loss in a cooker or other situations?” seen later in this presentation. What are scientific questions, what are engineering questions? What are social questions? What’s the overlap?





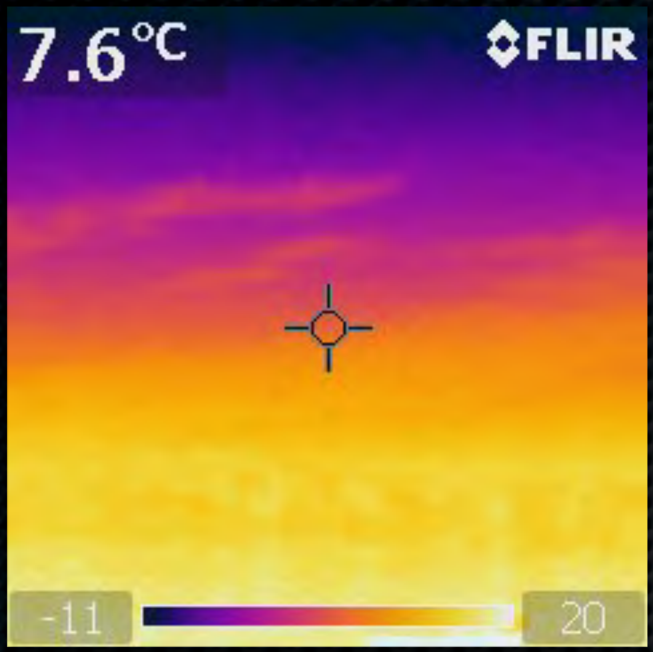
Cookers

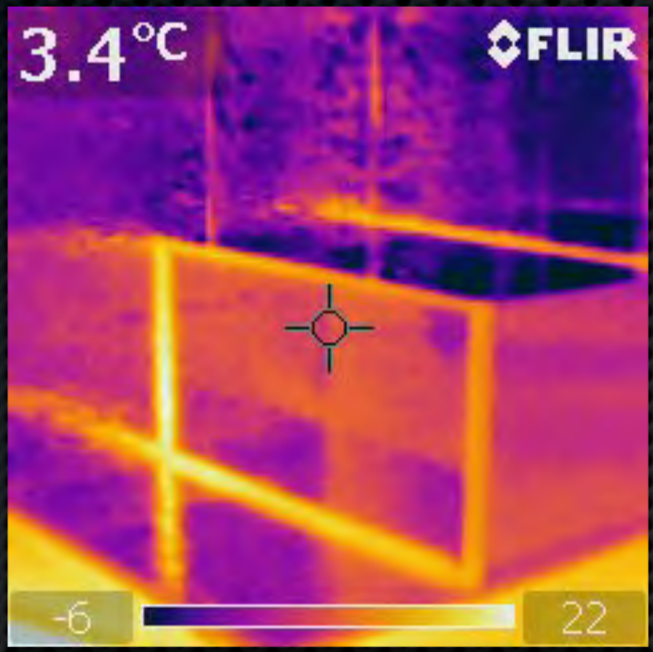
Some a sealed container with a window, some a concentrator of light, most both.

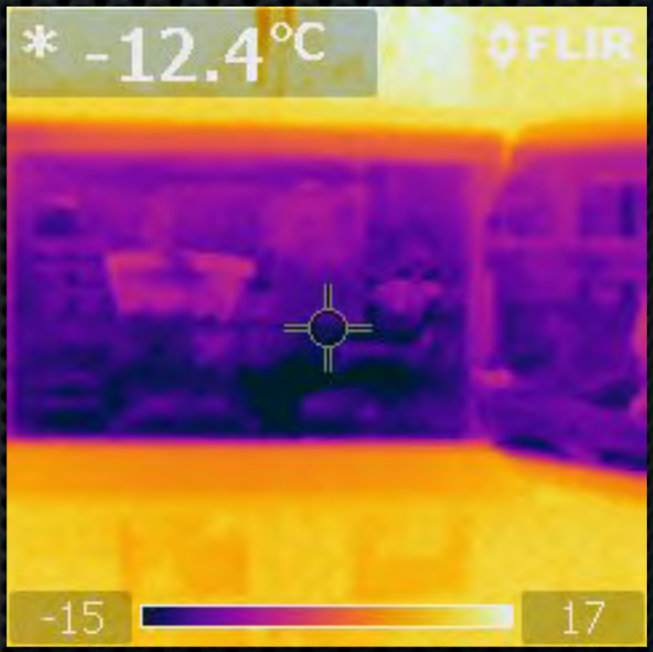
The design is often not a scientific question, but a valuable engineering one.

Supporting Apparatus

Explore selective materials like glass, aluminum, using a hot plate.
Collect data on light and heat with a datalogging sensor.



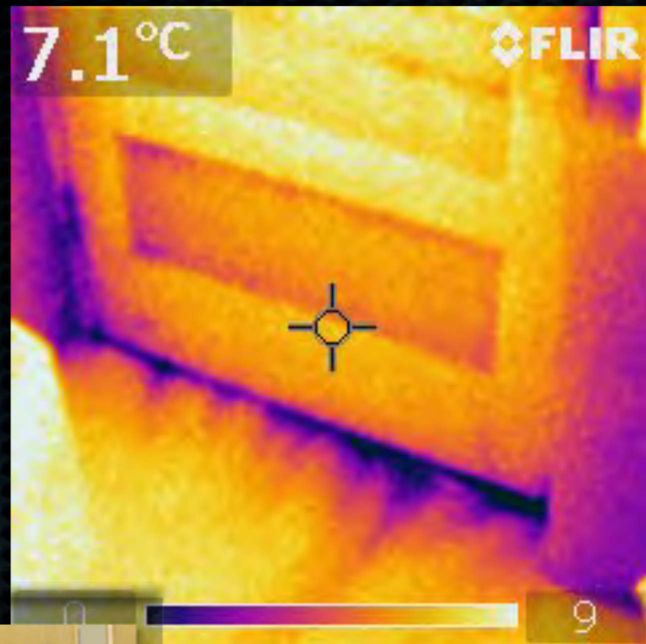




Thermal imagery

You can take the temperature of the sky but not the inside of a solar cooker. Take a picture of a freezer to show that power of radiation is not an on/off thing, but a continuous function of temperature.

Show camera. EnergyTeachers.org offers to lend it or train how to use it.




Energy audits: A high-tech way to stay warm this winter

Inspectors turn to infrared cameras to spot air leaks that the eye cannot.

By Mark Clayton| Staff Writer for The Christian Science Monitor/ November 11, 2008 edition

Ann Hermes/The Christian Science Monitor

Leak Seeker: Home inspector David Valley uses a thermal camera to spot where heat has escaped from Meghan Kaiserman's home. Dark colors indicate where cold areas are.

Middleton, Mass.

After home heating oil prices surged last winter, Meghan Kaiserman decided this fall to get ahead of any price spike and go thermal – that is, she chose to get a thermal-imaging home-energy audit.

Convection isn't everything

Does more energy leave the cooker via radiation, convection, or conduction?

(see next slide...)

Stefan-Boltzmann law: $P=e\alpha A(T_1^4-T_2^4)$

Convection isn't everything

...continued

Stefan-Boltzmann law, with emissivity:

$$P=e\alpha A(T_1^4-T_2^4)$$

P is power; e is emissivity;

α is Stefan-Boltzmann constant, 5.7×10^{-8} W/m^2K^4

T_x are temperatures of two interacting surfaces

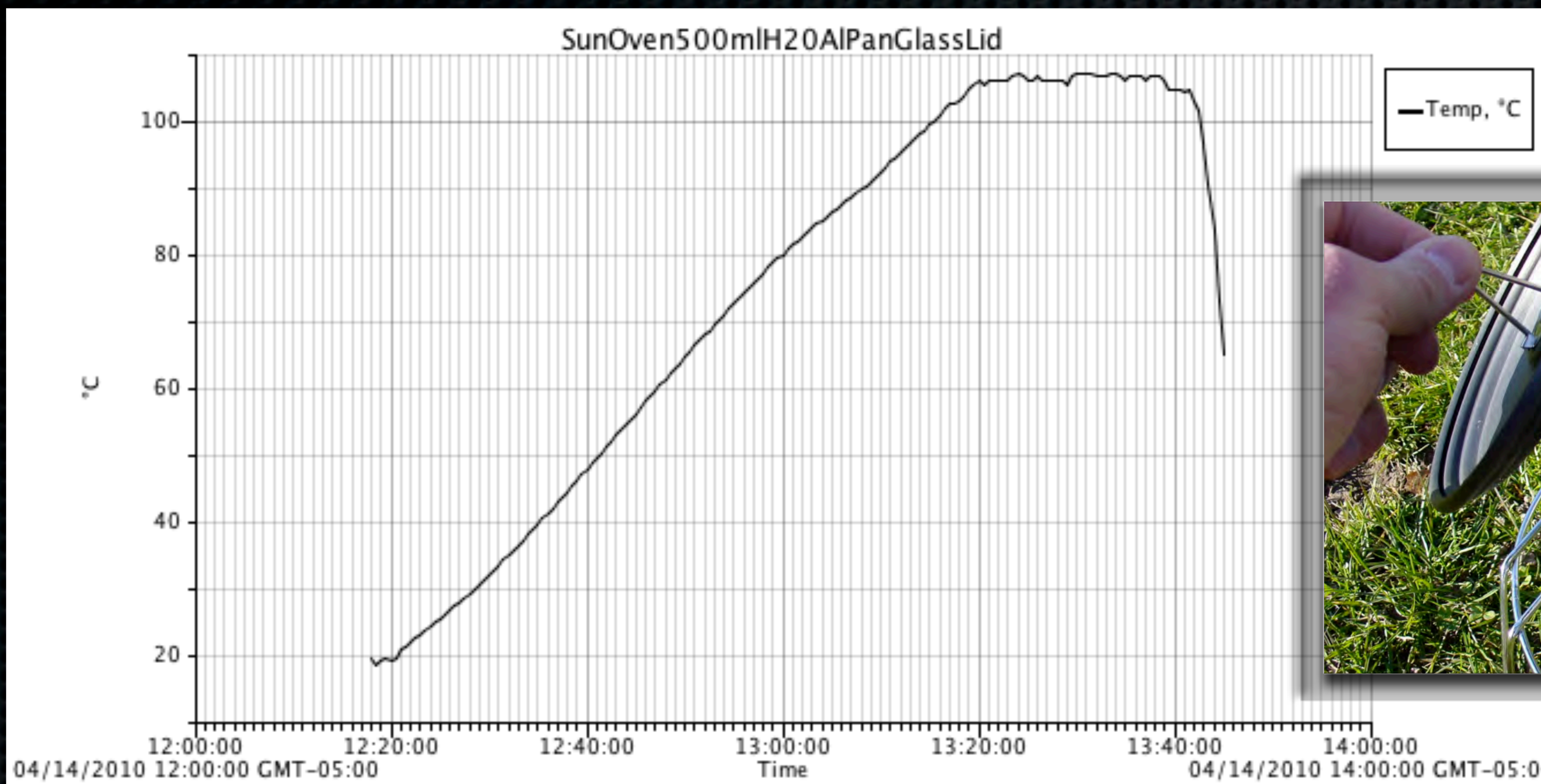
Compare to power seen in temperatu

$$P=m^*c(T_2-T_1)/(t_2-t_1)$$

m is mass of water; c is 4.2J/gK; t is time

If pot (0.1 sq. m)temp is 373K and surroundings are 300K, then radiative power loss is about 50W.

Here's where our HOBO comes in handy. We drop it in known mass of water in pot, get temperatures over time. See next slide.



Convection isn't everything

...continued.

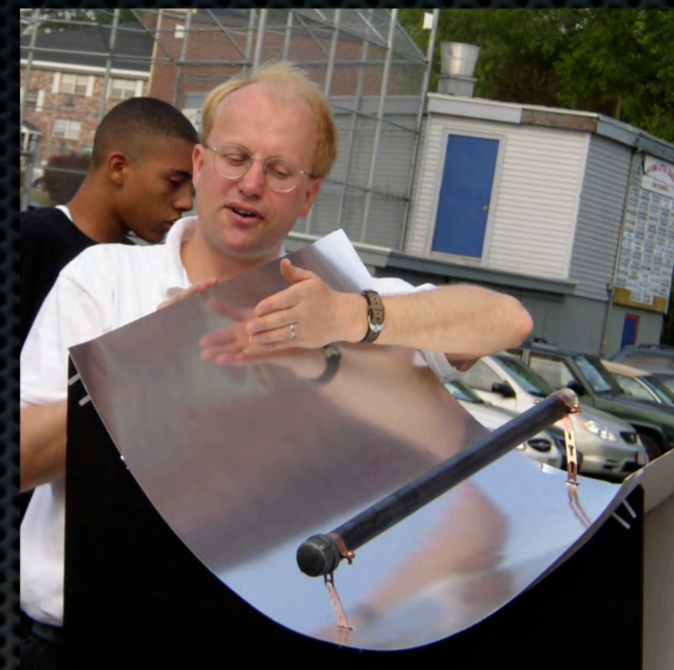
$P=m*c(T_2-T_1)/(t_2-t_1)$

Most existing solar cooker labs are about building, not measuring.

Variations

- Design challenges—Maximize temperature, speed; minimize budget; local materials; limit materials, build time...
- Proofing box—Keep food warm without sun.
- Characterize materials—How do combinations of transparent material and absorbing material perform.
- Heat capacities of different contents.
- Vary liquid level, see if 'full' most efficient or not.

Here we are back to various scientific and engineering questions, based on goals.
Solicit more variations.



A relaxing laboratory

The slow pace of the energy transfer will have a mellifluous effect on your sanity. There’s plenty of time to enjoy discussing energy transfer, or just soaking in sunlight. Importantly, you get to eat your results.

Show camera. EnergyTeachers.org offers to lend it or train how to use it.