

A Solar Heater/Drier for Low Temperature Household Energy Needs

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- Some slides covering details will be skipped in the live presentation.
- These can be read later by a viewer with more time.

Why This Work? Household Energy Includes:

High temperature thermal, mostly cooking.

Electricity, for light, radio, cell phone charging.

Liquid fuel, for transportation, etc.

Low temperature thermal, heating water, drying, space heating, and others. Low temperature thermal is well suited to solar energy, with very inexpensive solar devices performing well.

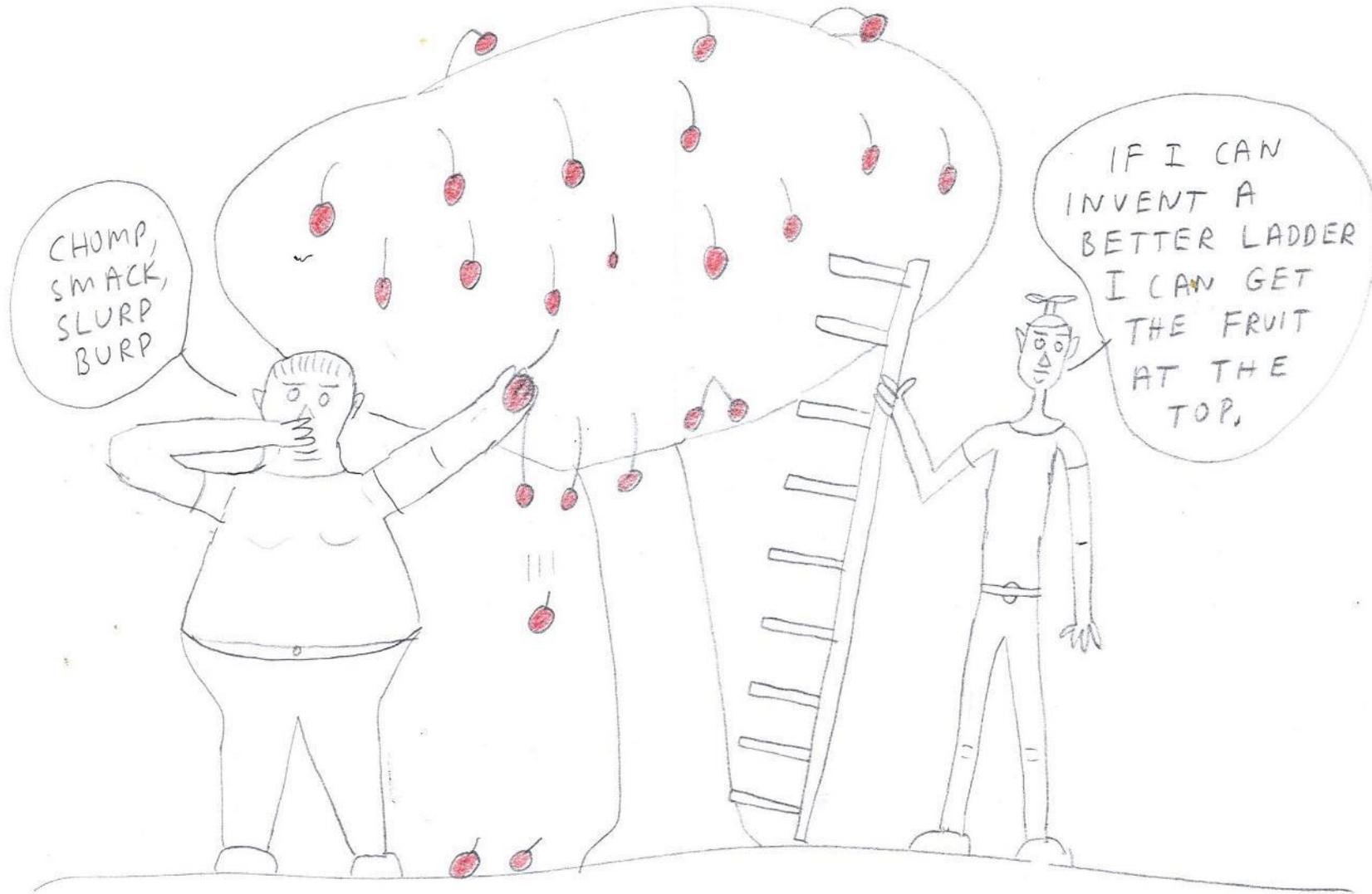
An axiom in solar energy is that it's way harder to heat something to a high temperature, partly because it takes more energy, but also because solar energy is not concentrated (the way fire is concentrated).

Johnson and Bryden studied fuel use in detail in a village in Mali

(Energy supply and use in a rural West African village, Nathan G. Johnson and Kenneth M. Bryden, Energy 43 (2012) pp. 283-292.)

- Water and space heating accounted for 22.2% and 19.1% of energy use, respectively.
- Nearly all respondents bathed in hot water once per day.
- 15-30 liter cooking pots were placed on outdoor 3-stone fires.
- Space heating is seasonal, but can account for 20+ kg of wood per day per family burned indoor fires.
- And further, I note that a lot of Africa is about a mile above sea level, and the nights are cool.

A kilogram of wood saved is a kilogram of wood saved.....



IT'S A
HEROIC
STRUGGLE

1/16/19 .D.C

The General Purpose Solar Heater/Drier

- A device that can heat water, dry wood, dry grain, pasteurize water, provide space heating, and others.
- User decides what to use it for.
- Cost is very low.
- A typical size is shown here, could be larger, smaller, or duplicated (that is, use two of them).

Construction-Pick a site



Put down 5 cm base of loose stuff



Add black plastic



Bucket supports



Stuff to be heated or dried



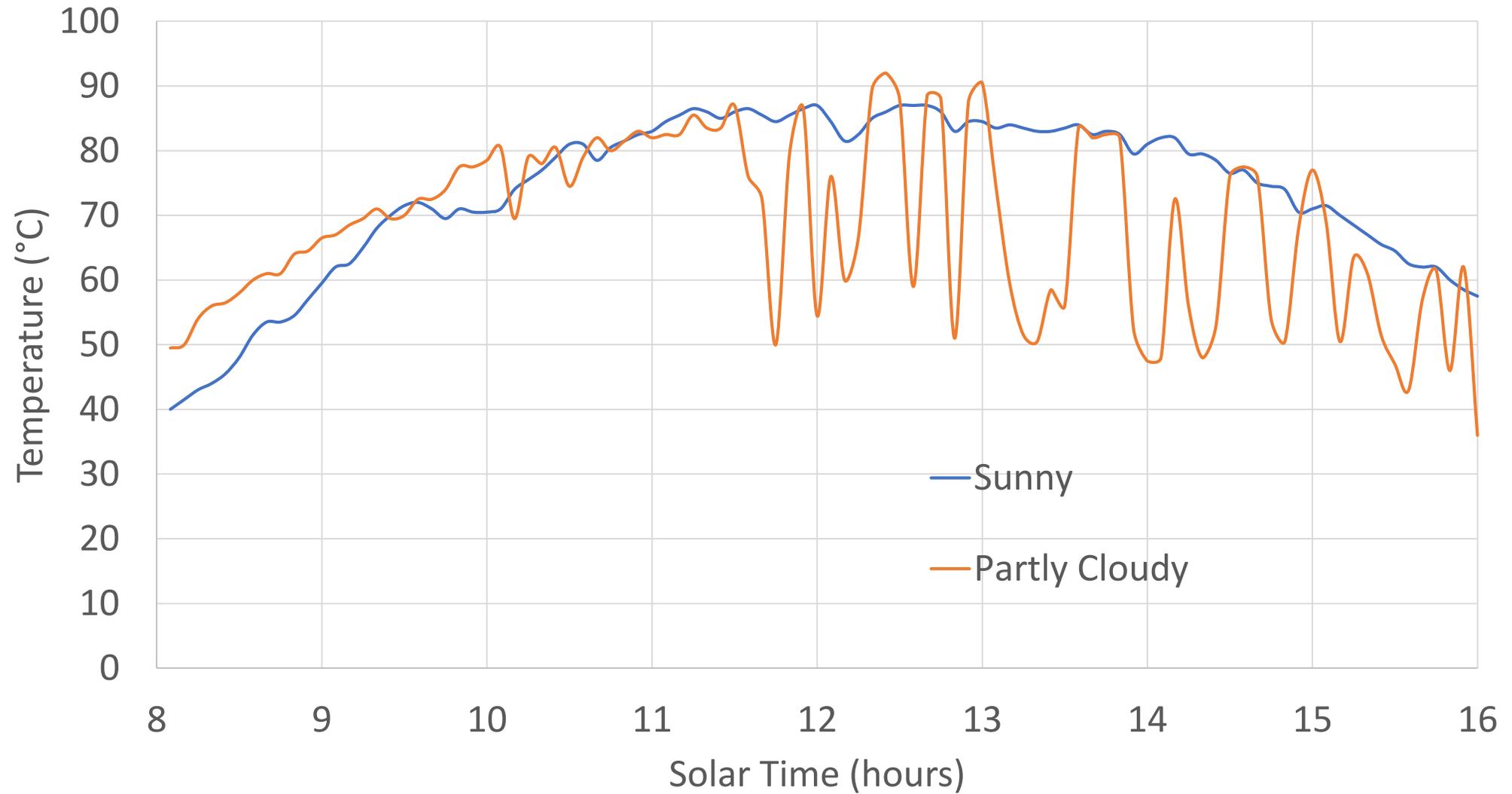
Put down cover layer



Cover layer (clear or whitish plastic)

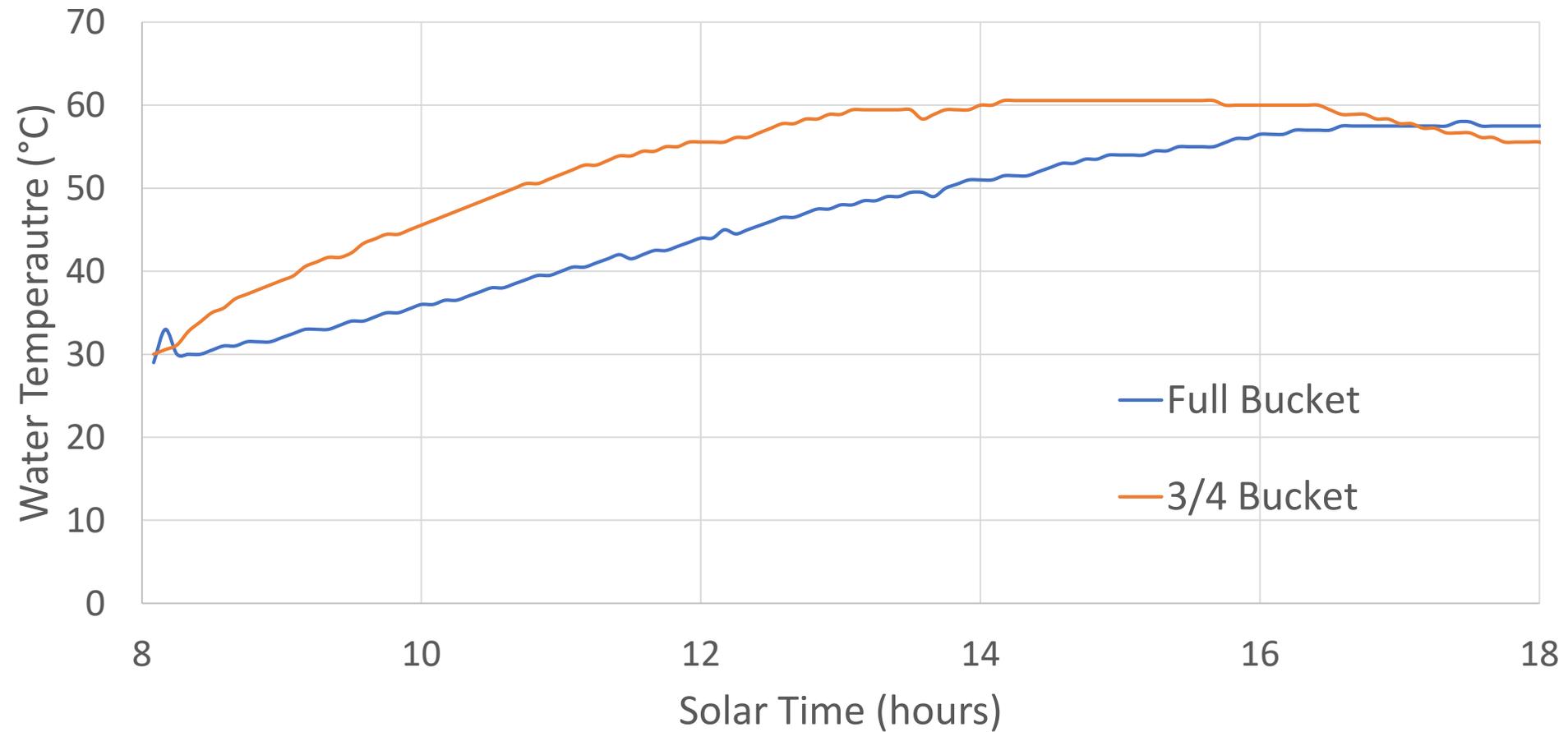


Black Plastic Temperatures



Water Temperatures

June 30, Sunny



Heat going into water comes from:

- About 1/3 direct sunlight hitting the buckets
- About 1/3 hot air rising off the hot black plastic
- About 1/3 radiation from the hot black plastic to the cooler buckets
- To my knowledge, no other solar collector works on this principle
- It is an “energy harvester” that works by harvesting energy from a large area and transferring some of it to the target.
- The advantage is a lot of energy at low cost. The disadvantage is that you can never get all that hot.

Space heating requires a lot of energy

- Use 1 or 2 solar heaters, with 4-8 buckets total.
- Bring buckets inside at night. Possibly use as hot water bottles.
- This is 9 to 18 Mjoules of energy, at 50 degrees C.
- Equal to 2.5 to 5 kW-hr of electricity.
- Equal to 8.5 to 17 cubic feet of natural gas.
- Equal to 1.9 to 3.8 kg of wood in a 30% efficient heating stove.
- Hot buckets radiate heat to the room, even if the room is cool.

Fuel wood is usually large and potentially wet



Wood Drier



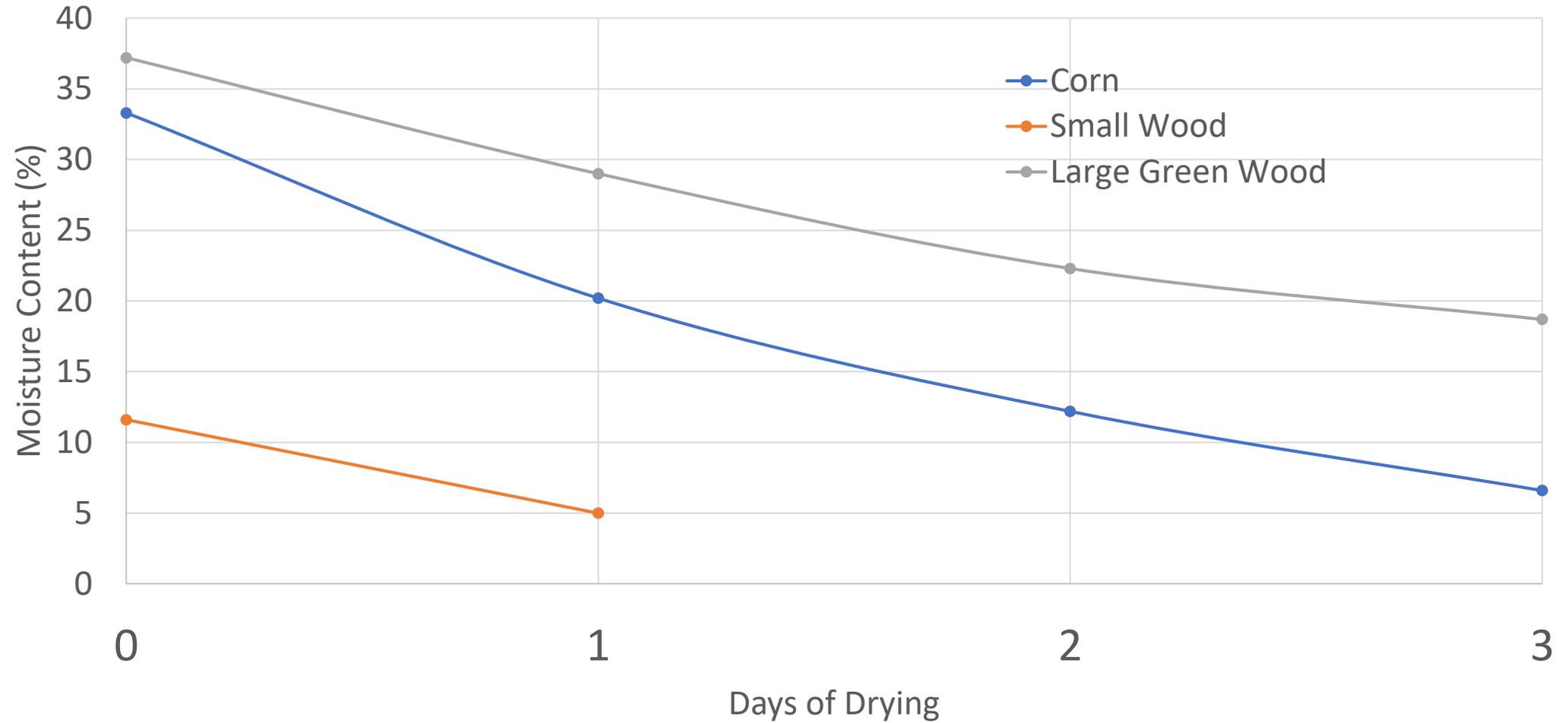
Split log, about 7 cm diameter, fresh from tree



Corn Drier- 3 kg of corn, in a layer 1 cm thick



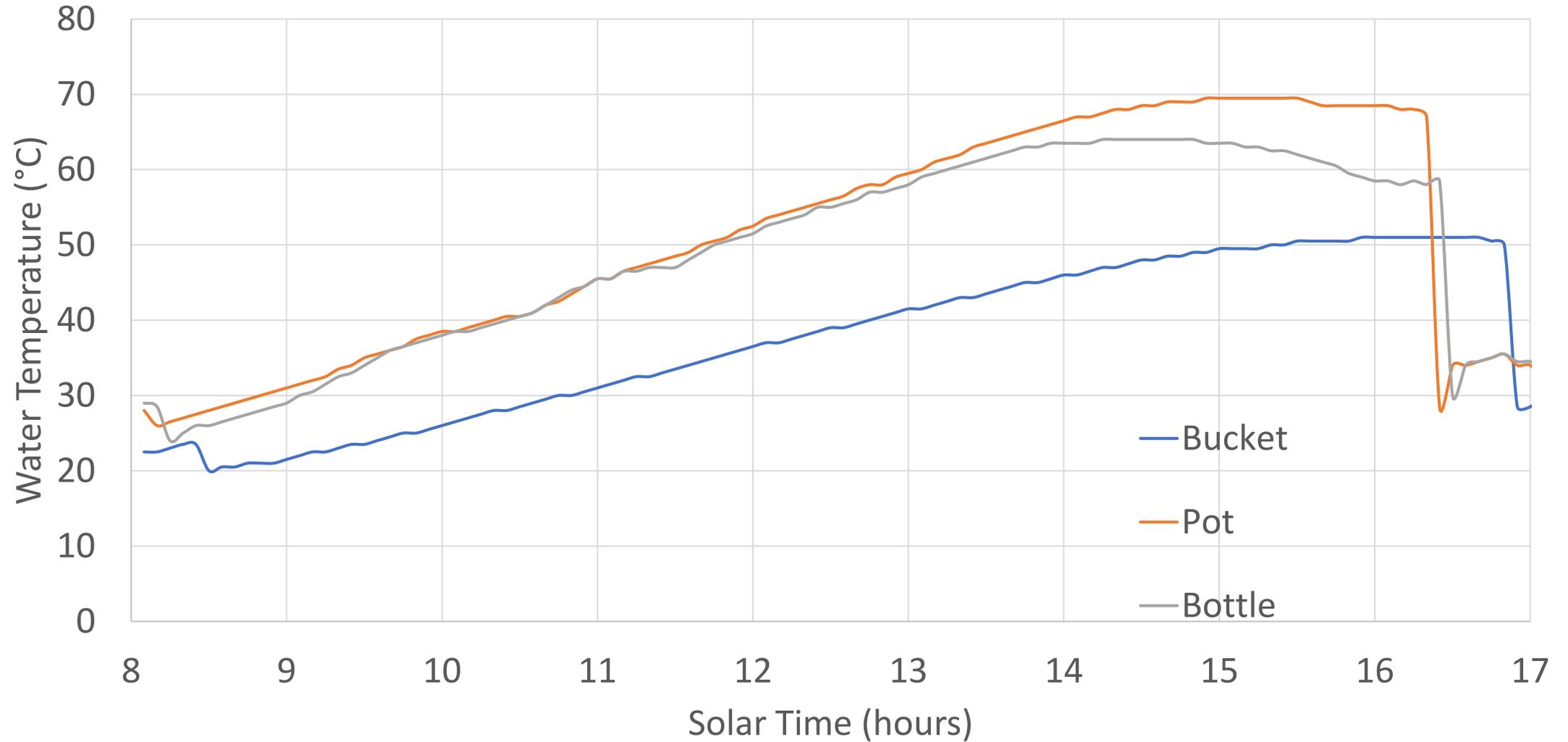
Drying Results



Preheat Water for Cooking



Water Temperatures



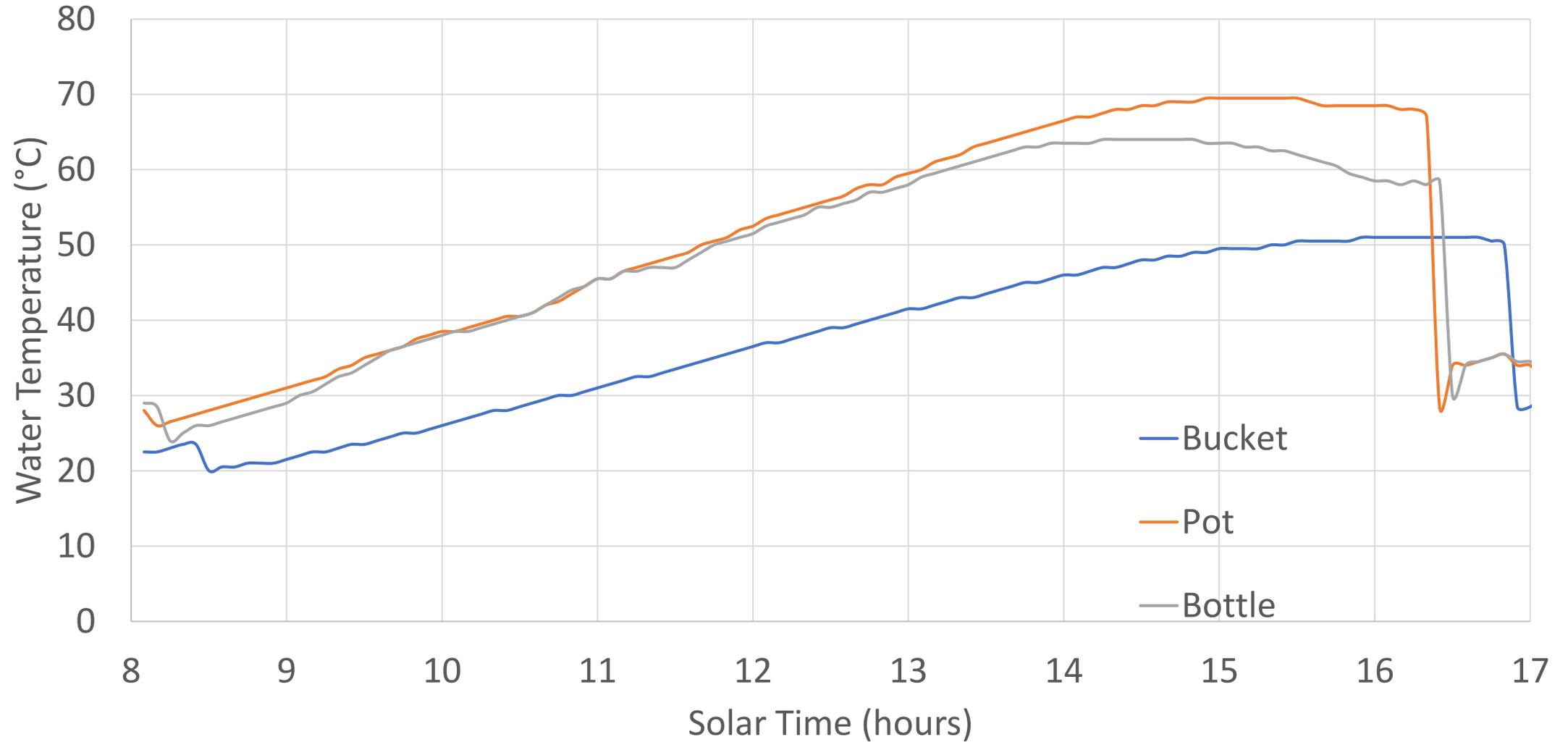
Pasteurize Water

- Heat water to a temperature that kills the pathogens.
 - Not necessary to boil water, as many believe.
 - About 65 C for a few minutes is good.
- Use pasteurization indicator to confirm that temperature was achieved.

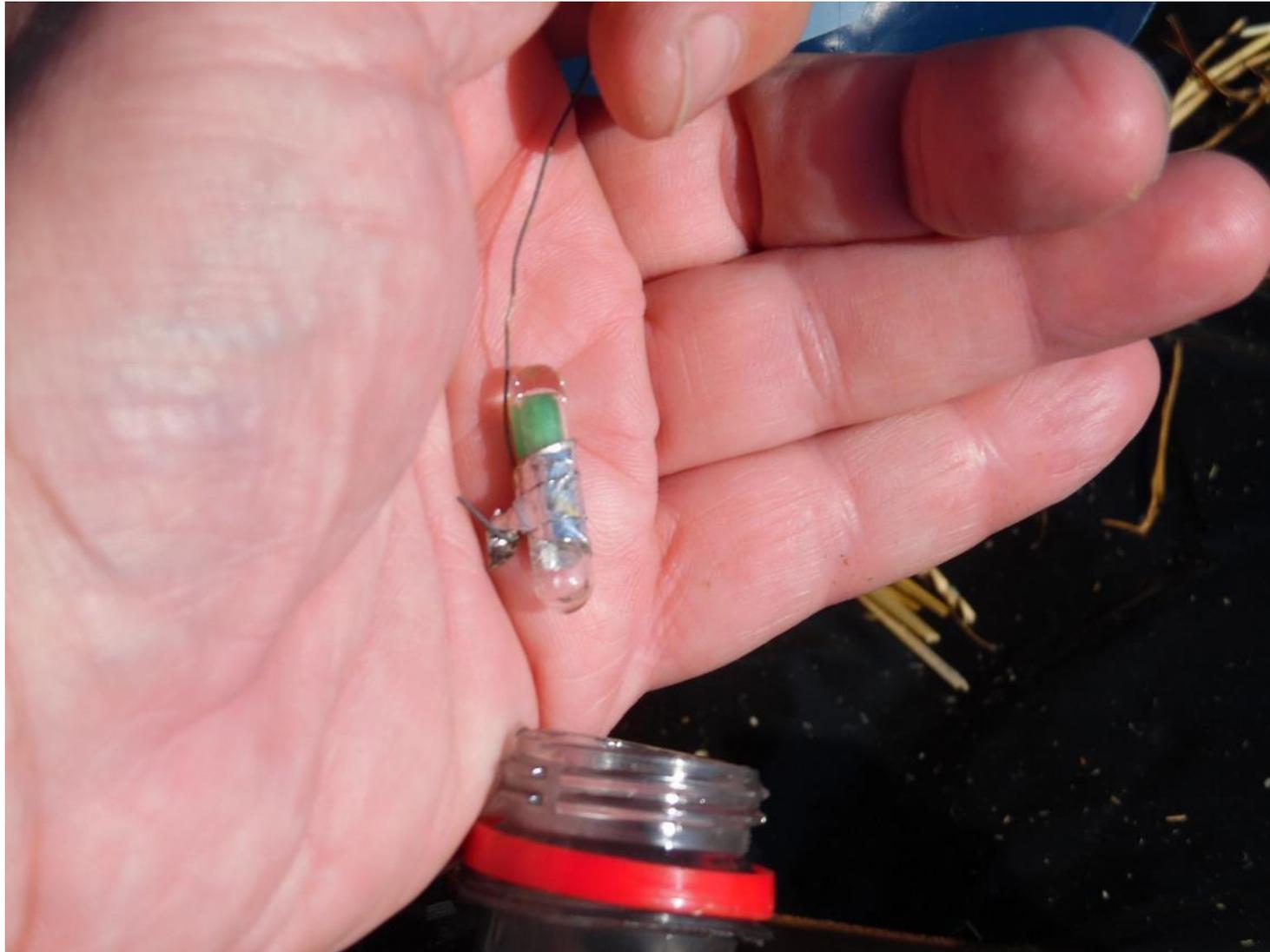
Pasteurize Water



Water Temperatures



Use Water Pasteurization Indicator (WAPI)



WAPI Basics

- Green wax in a sealed tube that melts at the pasteurization temperature.
- Wax starts solid in the high end of the tube.
- If wax is found in low end of the tube later, it melted and therefore the pasteurization temperature was achieved.
- Glass tube held on a wire, bend the wire 180 degrees to reuse the WAPI.

Global impact of boiling water

- About a billion people get their water boiled.
- If 2 liter/person/day, over a wood stove with an efficiency of 15%,
- This consumes 100,000,000 tonnes of wood per year
- Producing 150,000,000 tonnes of CO₂ (and other stuff)
- About 0.5% of the 30,000,000,000 tonnes of CO₂ from burning fossil fuels.
- Use of the WAPI reduces energy and fuel use by 50%
- Use of solar reduces energy and fuel use by 100%.

Maintenance/Longevity

- Insulation work well even when damp or tamped down.
- Plastic lasts many months, UV stabilized plastic would last at least a year.
- WAPI is reusable indefinitely.

Future Work-Summer 2019

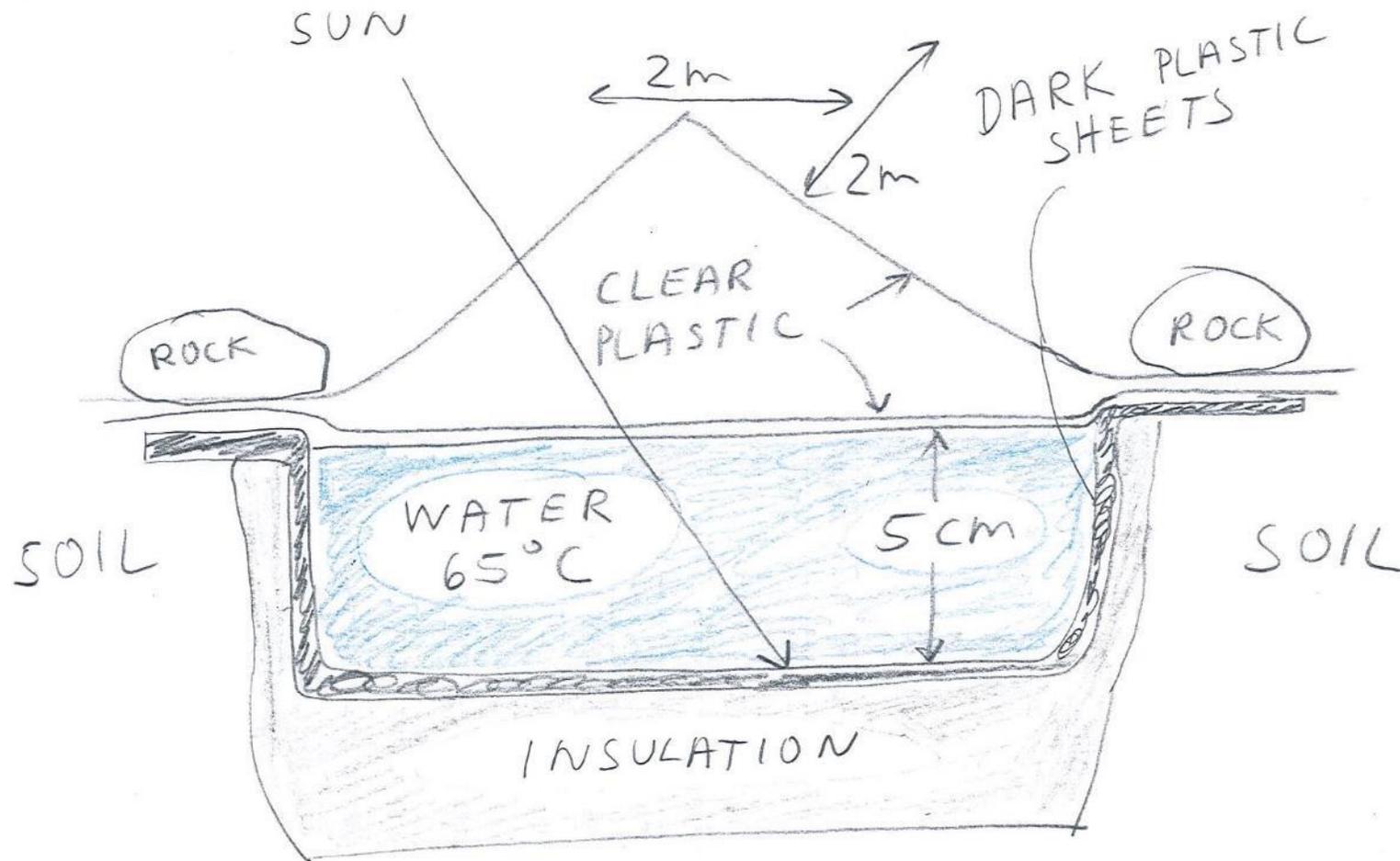
- In 2018 it took most of the summer to work out the optimum (simplest) design.
- In 2019, do more detailed studies with the optimum design.
- Take drawing lessons.

New Ideas-2019

- The solar puddle was developed by me in 1990's, and recently reinvented by Pete Schwartz, which he calls a covered solar pond.
- Like the solar heater/drier seen in this presentation, the solar puddle is a good way to pull in a lot of heat energy for very little cost.
- How can you apply this to domestic water heating without hauling buckets?
- Several ways to achieve this, giving a very cheap solar water heater for tropical locations.

Solar Puddle Cross Section

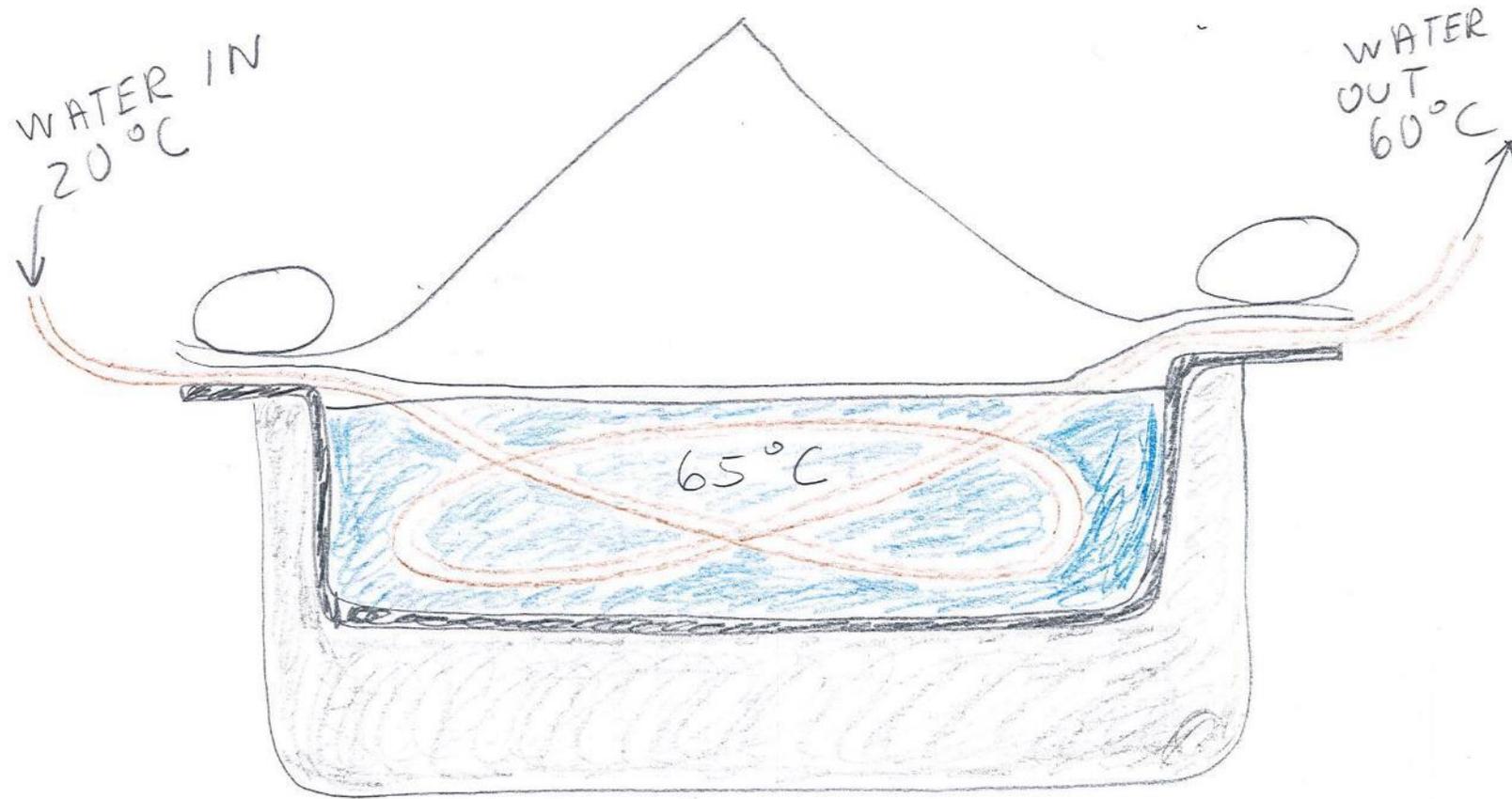
(horizontal dimensions severely compressed)



Solar Puddles Being Tested, early 2000's (with bubble wrap tops)



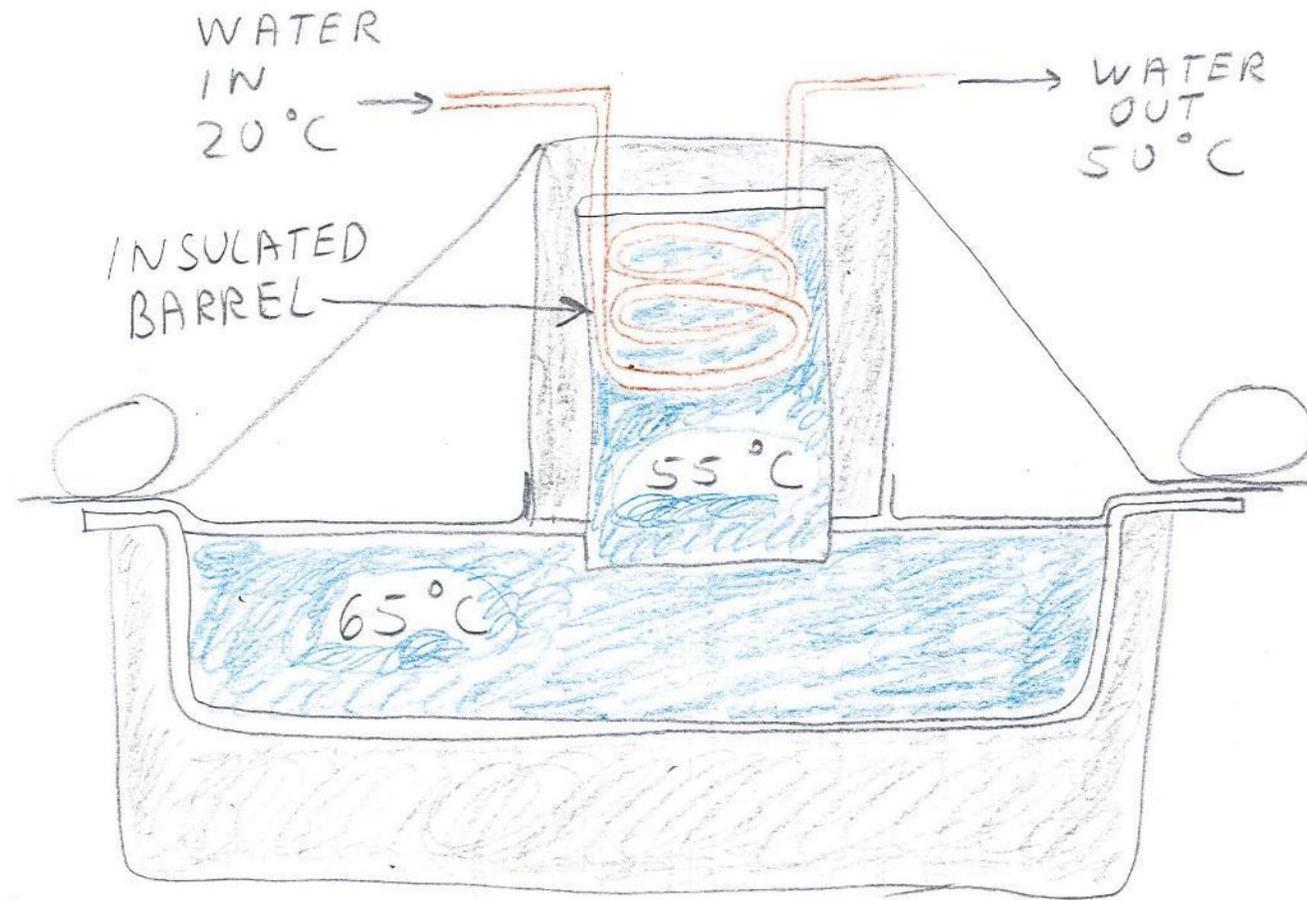
Solar Puddle with Tube



Solar Puddle with Tube

- Run a metal tube with piped water through the puddle.
- Heat transfer is very good.
- Piped water comes out hot.
- Voila, you have piped hot water! (At least in the afternoon and early evening.)
- If you have an electric water heater (small hotels) use this to preheat the water to save electricity.

Solar Puddle with Barrel and Tube



Solar Puddle with Barrel

- The puddle cools down at night, for something like a small hotel you might want hot water at night.
- Add an insulated barrel to capture and hold the heat.
- Voila, you have piped hot water at night!

Contact information and further details

- Dale Andreatta, Ph.D., P.E.
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- See a short video about the system at: <https://youtu.be/PlXmttxNeNs> where the character between the P and the X is a lower case ell.
- A detailed report is also available on request.