Environment > Solar Water Heater Experiment

Recommended year level: 9 – 10 (7 – 12 including options)

Time taken: 90 minutes

Subject: Physics, Environment

Intro:

- This project uses an array of sensors to monitor the water temperature inside a functioning solar water heater.

Learning Outcomes:

- Students will understand how a solar hot water system works, and how such a system can be monitored for the existence of legionella bacteria.
- These outcomes will be achieved through a remote experiment which monitors the temperature of the water inside a solar water heater located in Melbourne, Australia.

Experiment Summary:

- Students will remotely access temperature data from a solar water heater located in Melbourne, Australia.
- Students will use the online plotting tool to visualise the temperature data recorded by 18 sensors inside the storage tank as a function of time. They will then use the temperature data to determine whether or not the water may harbour dangerous levels of legionella bacteria.

Answers to Evaluate Questions:

1. The water is being heated by the sun so the temperature of the water (and the outside) rises after sunrise, decreases again in the afternoon and continues to decrease throughout the night.
2. Warm water rises and cold water sinks in the tank. Also, warm water enters the tank from the right. So it is hottest at the top and to the right.
3. The water flows because warm water rises and cold water sinks. As the water in the tank cools down it sinks to the bottom and can leave the tank through the outlet at the bottom left. It then flows into the solar collector at the bottom. Water in the solar collector heats up and rises and forces its way back into the tank at the top right.
4. The tank needs to be *above* the collector for the water movement to work.

5. Black absorbs the most solar energy. Dark coloured things get much hotter in the sun than bright coloured things.
6. Legionella is killed by heat, and it needs to be killed *everywhere* in the tank. If it is killed in the least hot part of the tank then we know it is killed everywhere.
7. Close to 100°C water evaporates and turns into steam. Steam can cause lots of pressure which could mean the pipes will burst unless you release the steam into the air, losing valuable water.
8. In cooler areas you have to use an external heater to heat up the water regularly to 70°C or more.

Expected Results:

- The water temperature reaches a maximum in the early afternoon and a minimum overnight.
- Water near the top of the storage tank is warmer than water near the bottom of the tank.
- For a fixed height within the tank, water on the left and right sides of the tank may be at different temperatures. The coldest part of the tank is most likely to be near either sensor T1 or sensor T13, however results will vary.
- During the summer it is likely that the water temperature will be high enough to kill the legionella bacteria. During the winter it is very likely that legionella bacteria will be able to survive inside the tank.

Detailed Explanation:

- Hot water has a lower density than cold water. Therefore cold water is less buoyant and tends to sink to the bottom of the tank.
- The difference in density between cold water and hot water allows water to flow between the storage tank and the collector without the need for a mechanical pump. Cold water falls through the outlet at the bottom left of the storage tank and into the collector. At the other end of the collector, heated water rises upwards and re-enters the storage tank through the inlet located on the top right of the tank. This process is called *thermo-syphoning*.
- The solar water heater used in this experiment was designed specifically for used in the hot, dry climate of outback Australia. In such a climate it is expected that the temperature will be high enough to kill legionella bacteria most of the time.

Technical notes on the experiment:

- The temperature data are sampled approximately every 5 seconds. The data can be reduced to improve the page response time and to remove any spikes in the data. By default the data are reduced by a factor of 10.

- Sometimes the temperature sensors fail. This may lead to gaps in the data, or nonsensical temperature values. The temperature sensors do not perform well at temperatures below about 30°C.
- The minimum exposure periods to inhibit the growth of the legionella bacterium are defined in Australian Standard AS 3498, *Authorization requirements for plumbing products---Water heaters and hot-water storage tanks*. The standard contains two other conditions which have not been explored in this experiment. Only one of the three conditions needs to be satisfied for the water to be considered safe.