Solar Water Heater Project

Prepared For:
Environmental Science Lab 102
Tuesdays 12:45 to 3:40 PM
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Proposal

Our Objective:

Our group is going to design four separate collectors. Each will be 18 inches x 32 inches. Inside each collector there will be different amounts of copper-serpentine tubing. In the first collector we will use 4ft, the second one will be 6ft, the third one will have 8ft, and the fourth and final collector will have 10ft of copper tubing. We are hoping that the variations of length of copper tubing will account for the change of season and the temperature of the best collector will remain at about 105°F.

Variables:

Controlled Variable – Area of Collector and Diameter or tubing
Independent Variable – Length of Tubing
Dependent Variable – Change of Season/Temp and Cost Effectiveness

Hypothesis:

We will show that the collector with the longest pipe will have the largest change in temperature, but that one of the collectors will be close to a comfortable temperature along with being the best length of tubing for the area of the collector box. Even through the seasons, one of the collectors will be acceptable for the change in seasons and be the most cost effective.

Materials/Cost:

- 4 pieces Plexi-glass- $40.00
- 28 ft of copper- $2.11/ft
- Wood- $0.48/ft
- 3 cans of Black Spray paint -- $2.91
- Screws - $4.98
Design:

Schedule:

March 17 – Start building collectors (have them running by the end of class)

March 24 – Collect Data and Design Graphs for Evaluation

March 31 – Collect Data and Design Graphs for Evaluation

April 14 – Collect Data and Design Graphs for Evaluation

April 21 – Collect Data and Design Graphs for Evaluation. Also, start designing final graphs for final Presentation

April 28 – Collect Data and Design Graphs for Evaluation

May 4 – Evaluate Data and continue work for Final Presentation

May 12 – Final Presentation
Results:

During this data collection we collected two weeks of data due to the spring break.

Throughout the two weeks for the four foot collector got up to a high of sixty nine degrees Celsius which is one hundred and fifty two degrees Fahrenheit. The four foot collector has shown no big difference in the increase of heat compared to the other collectors.
During this data collection we collected two weeks of data due to the spring break.

Throughout the two weeks of data collection of the six foot collector we ran into a serious problem. The tubing at the base of the collector had pinched and caused a leak. Causing the water flow to slow up tremendously and even completely stop, causing the water in the beaker to dry up quickly. The six foot collector has shown no big difference in the increase of heat compared to the other collectors.
During this data collection we collected two weeks of data due to the spring break. Throughout the two weeks for the eight foot collector got up to a high of sixty eight degrees Celsius which is one hundred and fifty four degrees Fahrenheit and thirty eight degrees Celsius in the beaker which is one hundred degrees Fahrenheit. The eight foot collector has not proven to get higher temperatures than the six foot collector, surprisingly enough.
During the two weeks of data collection for the ten foot collector we experienced yet another dramatic issue that threw off our results. The plexi-glass on the collector fell down, causing our results to suffer. Even though the plexi-glass had fallen down we were still able to raise the temperature in the beaker. The water in the beaker got up to forty degrees Celsius which is one hundred and four degrees Fahrenheit. The ten foot sadly is not showing a difference in heat increase compared to the other collectors although our hypothesis is that the ten foot collector is the more dominant choice.
During this week of testing we had a successful week. We added 325ml to the beaker of the four foot collector. We did not run into any problems as far as any leaks in this collector. Although we are coming to find out that there is not much difference in the temperature increase throughout the other longer lengths compared to the four foot collector. This week the water in the beaker got up to thirty six degrees Celsius, which is ninety six degrees Fahrenheit.
This week the six foot collector had a small leak but we fixed it. We added 225ml of water to the beaker this week our six foot heat collector box is showing a tremendous amount of heat in the box getting up to almost eighty five degrees Celsius which is one hundred and eighty five degrees Fahrenheit. The water in the beaker also got up to a high temperature of forty four degrees Celsius which is one hundred and eleven degrees Fahrenheit.
This week the eight foot collector did not suffer any sort of problems. We added 300ml of water to the beaker this week our eight foot heat collector box is showing no tremendous amount of heat increase, the box getting up to almost seventy one degrees Celsius which is one hundred and fifty nine degrees Fahrenheit. The water in the beaker also got up to a high temperature of forty one degrees Celsius which is one hundred and four degrees Fahrenheit.
This week the ten foot collector did not suffer any sort of problems. We added 400ml of water to the beaker this week our ten foot heat collector box is showing no tremendous amount of heat increase, the box getting up to almost sixty four degrees Celsius which is one hundred and forty seven degrees Fahrenheit. The water in the beaker also got up to a high temperature of forty three degrees Celsius which is one hundred and nine degrees Fahrenheit.
During this week of data collection we did not really experience any problems with the four foot and six foot collectors. We added 450ml of water to the beaker this week because we had a hot week of data collection causing the water to evaporate faster. Although the hotter more sunny days we are not seeing a big difference in the temperature increase between the four foot collector compared to the other collectors.
During this week of data collection for the six foot collector the temperature in the box got up to seventy four degrees Celsius which is one hundred and sixty five degrees Fahrenheit. The temperature in the beaker got up to forty six degrees Celsius which is one hundred and fourteen degrees Fahrenheit.
During this week of data collection for the eight foot collector we ran into a big problem with our data collector. The computer shut down causing our data to be cut short as seen on the graph. We only got about 128 hours of data yet it is still enough to compare to the other collectors. The eight foot collector although showing progress failed to have a higher temperature of water in the beaker than the six foot collector only getting up to seventy one degrees Celsius in the box which is one hundred and fifty nine degrees Fahrenheit. Also the beaker only got up to forty three degrees Celsius in the water which is one hundred and nine degrees Fahrenheit.
During this week of data collection for the ten foot collector the computer shut down causing our data collection to be cut short. Although we are still able to compare results with other collectors the ten foot shows progress yet almost struggled to reach higher temperatures than the six foot collector only getting up to sixty seven degrees Celsius in the box which is one hundred and fifty two degrees and forty eight degrees Celsius in the beaker which is one hundred and eighteen degrees Fahrenheit.
Discussion

As stated in the introduction our hypothesis was to show that the collector with the longest pipe, which is 10 feet, will have the largest change in temperature. We hypothesized that one of the collectors was going to be close to a comfortable temperature along with being the best length of tubing for the area of the collector box. We were also hoping that the variations of length of copper tubing will account for the change of season and be most cost effective. However, our results disagreed with our hypothesis.

Before we starting collecting data we had to complete the most difficult task of all, build four, functioning collectors. We all contributed by collecting and purchasing the materials we needed, we even took time to travel to home depot as a group. After successfully designing the collectors we began taking data as soon as possible. We basically took data for 5 weeks, each week topping of our beakers with 1 liter of water. In the first week of data taking (March 24-31) we ran into an issue with the computers. The data for the 4 foot and 6 foot collector was lost. After we took our first weeks data we added 400 ml to each beaker and began taking data for another week. Our second and third week of data was put together because of spring break. When we returned to collect our data we noticed a few more issues. The plexi-glass covering the 10 foot collector slid off and there was a kink in the tubing in the 6 foot collector causing the water to evaporate. We fixed those problems and refreshed all four beakers with new water, topping them off with 1 liter. We finally came back to the green house to take our fourth week of data and had no problems, which was a big relief. We added 400 ml of water to the 10 foot collect, 300 ml to the 8 foot collector, 225 ml to the 6 foot collector, and 400 ml to the 4 foot collector so each would be topped off at 1 liter. Our fifth and final week of taking data we
ran into another issue with the computer but still came together as a group and stayed positive.

We added 500 ml of water to the 10 foot and the 8 foot collectors, 700 ml to the 6 foot collector, and 450 ml to the 4 foot collector. We combined all of our data to come up with the maximum temperature. (The graph below shows the results)

![Graph showing maximum temperature](image)

(As you can see there was an error in the collector with the 6 foot tubing during Mar. 31-Apr. 14 and also the data from Mar. 24- Mar. 31 was lost for the 4 and 6 foot collectors due to technical difficulties.)

We also created a graph to check our hypothesis about the change of season.
A tip for the future researchers to attempt a project like this one, would be for them to be fully aware of “what it’s like in the real world.” –James Floyd
Conclusions and Recommendations

Our hypothesis predicted that the collector with the most piping (10ft) will have the largest change in temperature, while one of the collectors will be close to a comfortable temperature (105° F, +/- 5° F or 40.5° C) along with being the most cost effective. There will also be one collector that will be the most acceptable throughout the changing temperature and sunlight during the different seasons.

Our research mostly supported our hypothesis. The 10ft collector did in fact have the largest change in temperature, as supported by our data. As the graph *Change in Temperature Max* shows, during the week of March 24-31, the 10ft collector had a 24.69° C change in temperature, compared with the 8ft collector with a 22.91° C change. That week we were not able to get data for the 4 and 6 ft collectors because the computer had shut down. The next week, March 31 to April 14, the 6 ft collector actually had the greatest change in temperature max of 29.44°, while the 10ft’s change was only 27.43°. We believe this data, while correct, does not show the whole story- the 6ft collector had sprung a leak during this particular week, therefore lowering the volume of water which in turn heats up faster than the higher volume of water in the other 3 collectors. Our last 2 weeks of data also show that the 10ft collector had the greatest change in temperature max, with a change of 28.73° during April 14-21 and 26.36° during April 21-28.

The second two parts of our hypothesis are a bit harder to prove with our data, but our group believes that the 4ft collector not only is the most cost effective, but also will be the most acceptable throughout the ever changing seasons, especially during the summer months. As
the Max Temperature graph shows, the 4 ft collector reached a high of 39.72° C during the week of April 21-28. That is only .78° away from our temperature goal of 40.5° C. The other 3 collector’s temperatures are a lot farther away from our goal, especially during that week. The 6 ft collector’s max temperature was 6.61° away, the 8ft’s 3.71°, and the 10ft’s 6.02°. Looking at the Cost Effectiveness graph, it is easy to see that, based on the calories, assumed $ per year, the cost of each collector, and net cost, the 4ft collector is the most cost efficient water heater and will continue to be for years to come.

If we could try and test our solar powered hot water heaters again, it would benefit us greatly to keep collecting data over the course of each season, to better dictate which collector would be more efficient for winter months, as opposed to only spring, because our answer of which collector is most acceptable would presumably change. Also, we had some trouble with leaks and computers, which did interfere with our data. Without these certain obstacles, it would have been easier to control our experiments and correctly collect our data.

Overall, our experience of building these solar hot water heaters has been very interesting, and beneficial in allowing each of us to better understand how data and research can be understood and evaluated.
Cost Over 5 Year Intervals

![Graph showing cost over 5 year intervals for different lengths (4ft, 6ft, 8ft, 10ft) and cost intervals.]
Bibliography


