ECE 413: Senior Project Development

Final Project Report

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1 Method

1.1 Virtual Water Heater Research

The main equations for the code are the only research that was necessary for the emulation portion of the project.

Thermal Energy Transfer

$$Q = m * c * \Delta T$$

This is the main equation behind this code. There are some conversion factors necessary to get the energy, Q, to be measured in [Wh]. This equation is used to derive the water temperature and timed energy transfer equations.

Current Water Temperature

$$T = \frac{TotalMass * TempSetPoint * .001163\frac{Wh}{calorie} - Q}{TotalMass * TempSetPoint * .001163\frac{Wh}{calorie}}$$

This equation from [3] is important in order to check the results of the water heater against the physical water heater. The current water energy can be extrapolated from this equation too. This is used every iteration of the water heater main loop.

Timed Energy Transfer

$$Time = \frac{\frac{c * LitersOfWater * \Delta T}{60}}{ElementPowerRating}$$

In this equation, c is rounded to 4.2. This equation controls how many times the main loop is iterated through. The information was found from citation [2].

Standby Energy Losses

$$StandbyLosses = \frac{.541511 * \Delta T * 5min}{60}$$

The standby loss equation was found from an online study of a 52 gallon water heater [1]. The value found from the study, 1.3868 $\frac{W}{^{\circ}F}$, was interpolated to fit the water heater being emulated through the ratio of water heater surface areas. Thus equation is used once the water is brought back to temp and there is time left in the hour before the next draw.

1.2 Flow Chart Diagram

The main design for the virtual water heater is a large loop controlling the output of the water heater and which data to output to the terminal and to a CSV file for further manipulation.

1.3 Future Work

The shed capability has not been implemented in any way into this program. My thoughts of how to enter it are place a while loop just above where the code is placed in the emulator.py code that has an if statement inside of it. The while loop will allow one iteration of the CommandFlow code for each time a shed command is not sent. Once a shed command is seen, current values are passed through to the outputs, and the only manipulation that comes is when water is drawn. Once an "End Shed" command is seen, the water heater will return to normal operation.

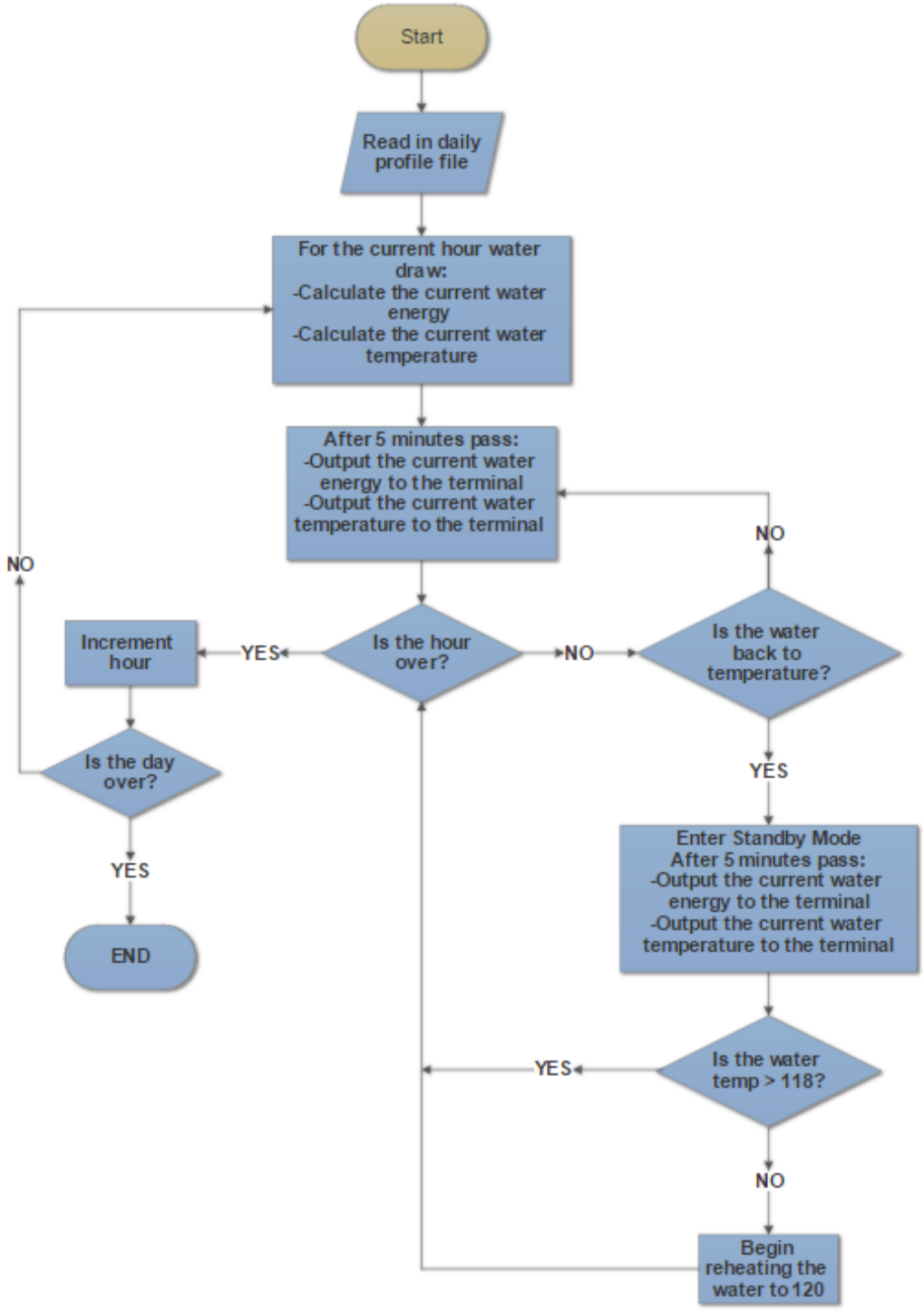

Figure 1: Emulation flow chart

2 Bibliography

[1] Ek, C. W., P.E., & Auburg, C., P.E., CEM. (n.d.). Electric Water Heater Standby Losses: Comparison of Conservation Strategies and Their Energy Savings. Retrieved June 15, 2017, from http://aceee.org/files/proceedings/1984/data/papers/$SS84_{P}anel5_{P}aper_{0}6$.pdf

[2] James, E. (2017, April 24). How to Calculate Time to Heat Water. Retrieved June 16, 2017, from http://sciencing.com/calculate-time-heat-water-8028611.html

[3] When Two Samples of Water are Mixed, what Final Temperature Results? (n.d.). Retrieved June 16, 2017, from http://www.chemteam.info/Thermochem/MixingWater.html