Residential Thermal Storage & Cooling

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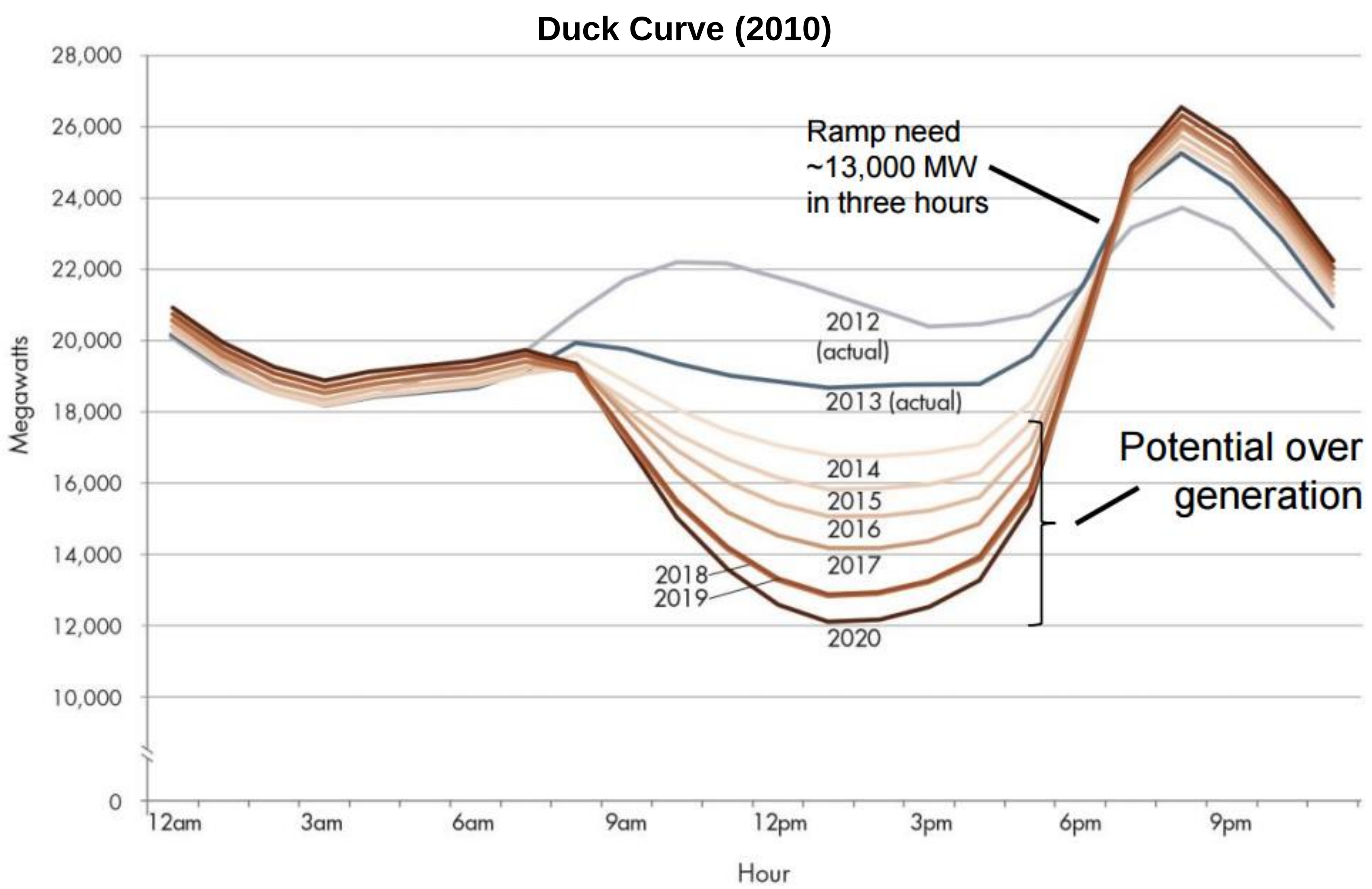
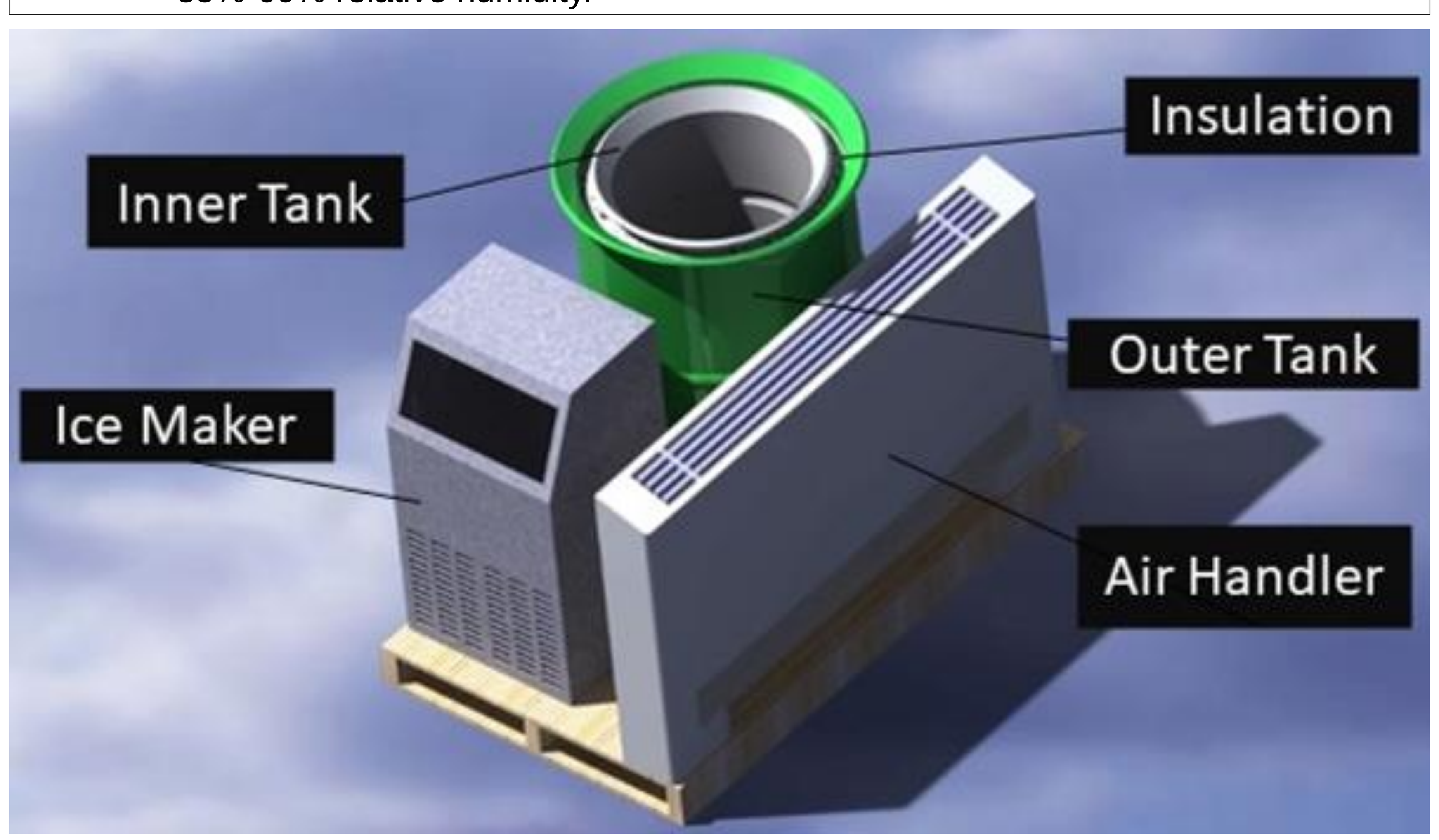
Introduction and Purpose

In the United States, 92% of the electricity produced comes from non-renewable resources. Air conditioning represents 17% of electricity consumption for an average U.S. household. The Duck Curve illustrates how peak solar production is out of phase with peak energy demand. This causes overproduction of solar energy with no adequate means of storage during peak demand times. This thermal storage tank alleviates the large gap of energy needs seen in the Duck Curve and allocates sustainable energy usage to a large consumer of electricity. This system provides an environmentally friendly solution to solar energy storage and air cooling as it eliminates refrigerant use and the need for cycling toxic batteries by using water thermal storage.



Requirements

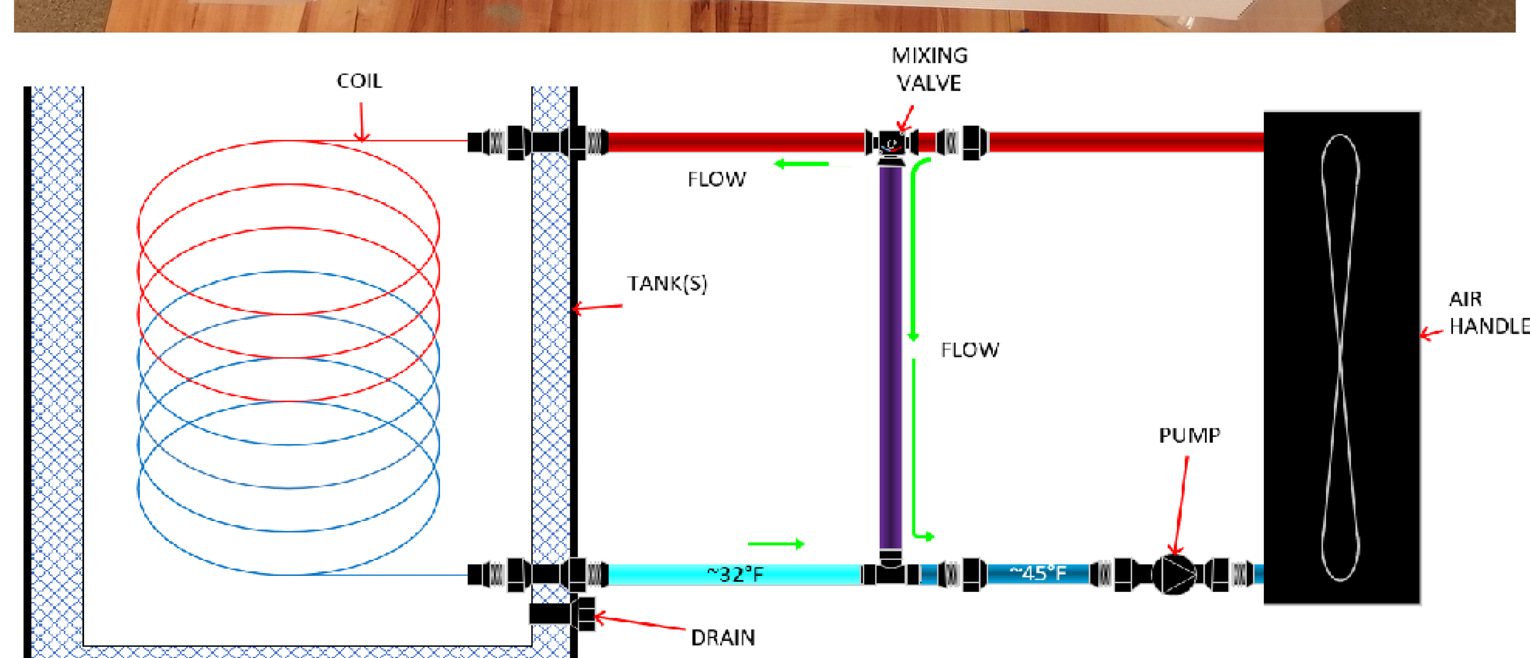
- Net-zero for a 24-hour operation cycle
- Assumed power supply from solar energy array
- Scope of focus: ASHRAE Zone 2A during summer conditions
- Maximum of 1 ton cooling capacity.
- Maintain human comfort (ANSI/ASHRAE Standard 55-2017: 68°F-80°F, and 35%-60% relative humidity.



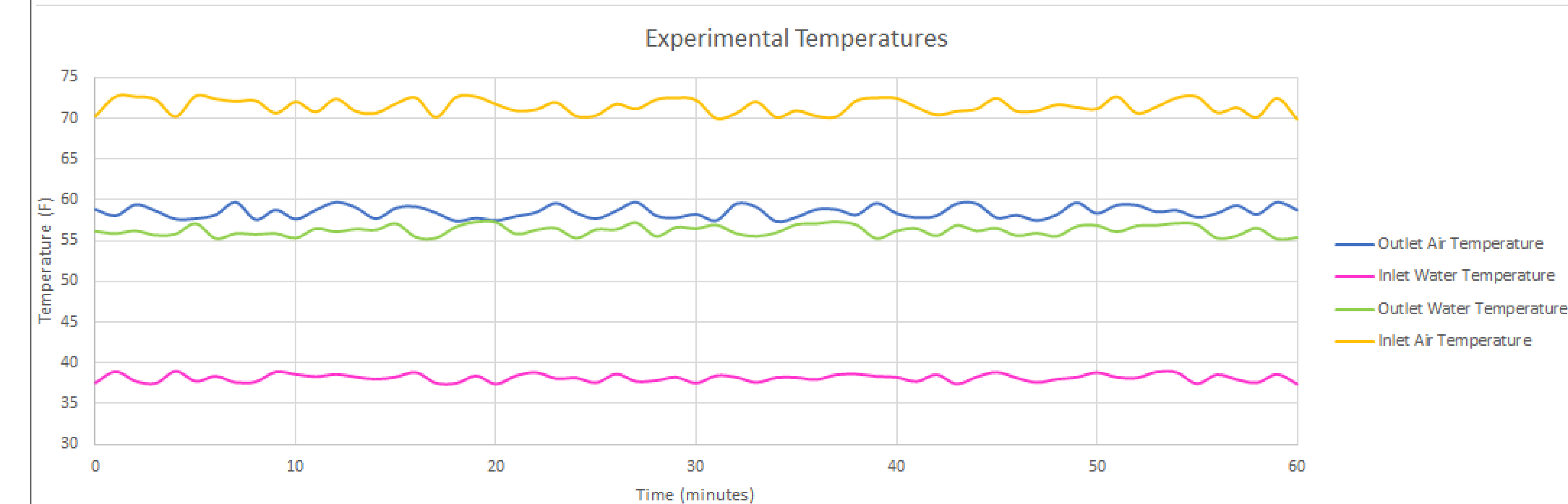
Abstract

A lab scale thermal storage and cooling system was designed to test system and scale feasibility. The major components of the system are an ice maker, insulated storage tank, water pump, hydronic air handler, and instrumentation. Ice and water are loaded into the storage tank and the chilled water is pumped through the air handler coil. The energy dense latent heat of the ice provides the system with the temperature difference used to produce the cooling and dehumidification. Final testing proved an air temperature and relative humidity change from 72°F with 40% to 59°F with 57%, respectfully.

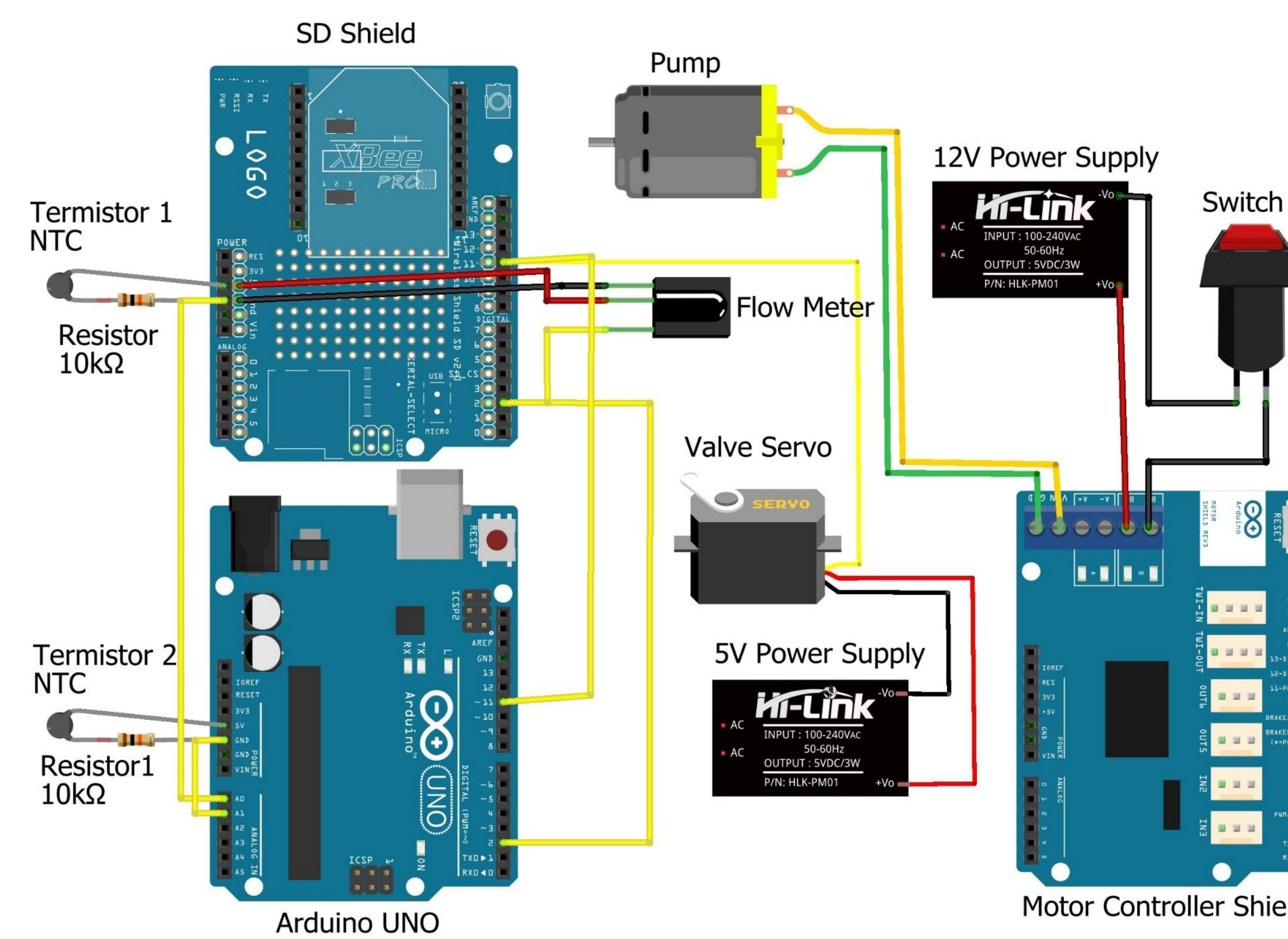
The system achieved the desired inlet water temperature and flow rate specified for the air handler and closely modeled it's cooling capacity for the room conditions of the test space.
The original system was built with a copper coil as the heat exchanger in the storage tank. Results of testing prompted the removal of the coil and using the meltwater directly as the working fluid. To improve the design, a more direct and automated method of loading the tank with ice would remove the need to manually "charge" the tank.



Results



Using a thermistor, the air handler inlet and outlet water temperature, and dry bulb air temperature were measured over a 60 minute period. The trend lines show the predicted measurements associated with the slightly deviated data points around a constant temperature for each respective variable. The working fluid achieved a temperature difference of about 18°F (38°F to 56°F). As a result, the air temperature changed by about 12°F from the return air (71°F) to the supply air (59°F).



Conclusions

The System achieved ANSI/ASHRAE human comfort standards with return air temperature of 75°F with 40% relative humidity. At steady state with a room condition of 71ºF and 40% relative humidity, the system is capable of approximately 1/2 ton of cooling capacity. This system has proven that a small scale concept relieves the "Duck Curve"; however, it is not cost effective for personal residential use. Universities such as Embry-Riddle and other large commercial campuses utilize thermal storage systems for cooling to take advantage of varying daily utility rates and the return on investment from large scale designs. If thermal storage systems such as this were integrated on a large scale within residential communities the system may become cost effective, especially with the associated solar array powering the system.

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