

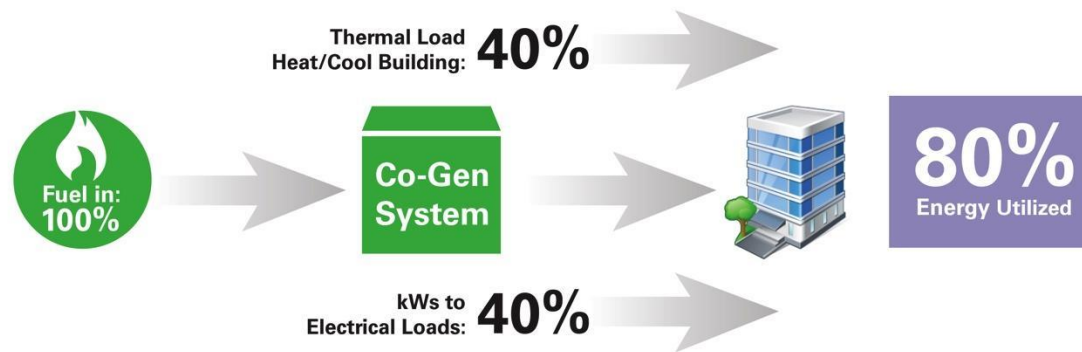
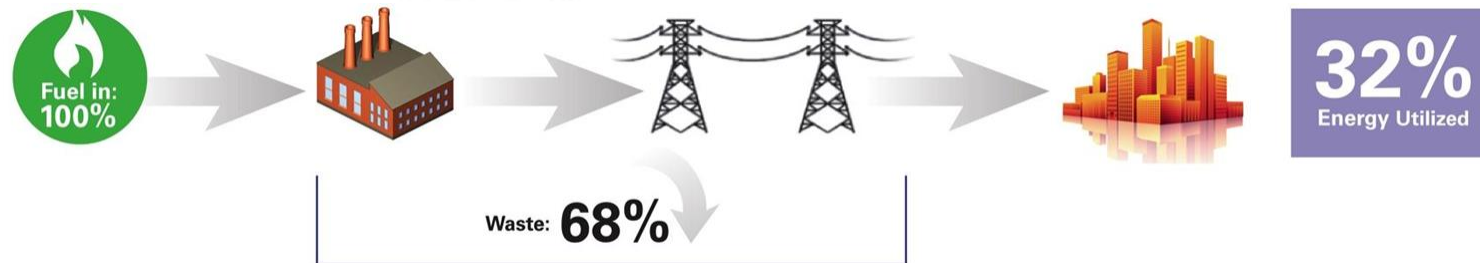


A Working Model to Demonstrate Combined Cooling, Heating, and Power

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Tim Mast



Technology Spotlight: Combined Cooling, Heating, and Power



Graphics from www.greencity-power.com/combined-heat-and-power/

Messiah College: Committed to Sustainability



“...Preparation for
lives of service,
leadership and
reconciliation...”

Messiah's CCHP Installation



Central Campus



Frey Hall
Hot water and chilled water

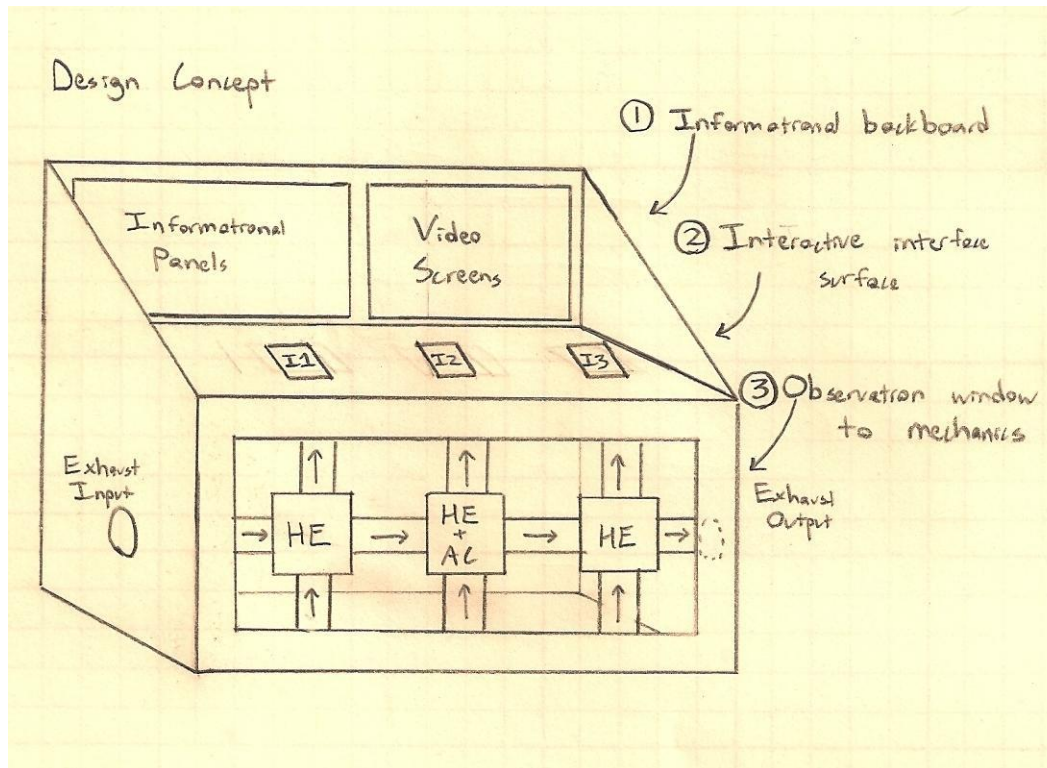


Eisenhower Campus Center &
Sollenberger Sports Center
Electricity, hot water, and chilled water



Kline Hall & Jordan Science Center
Hot water and chilled water

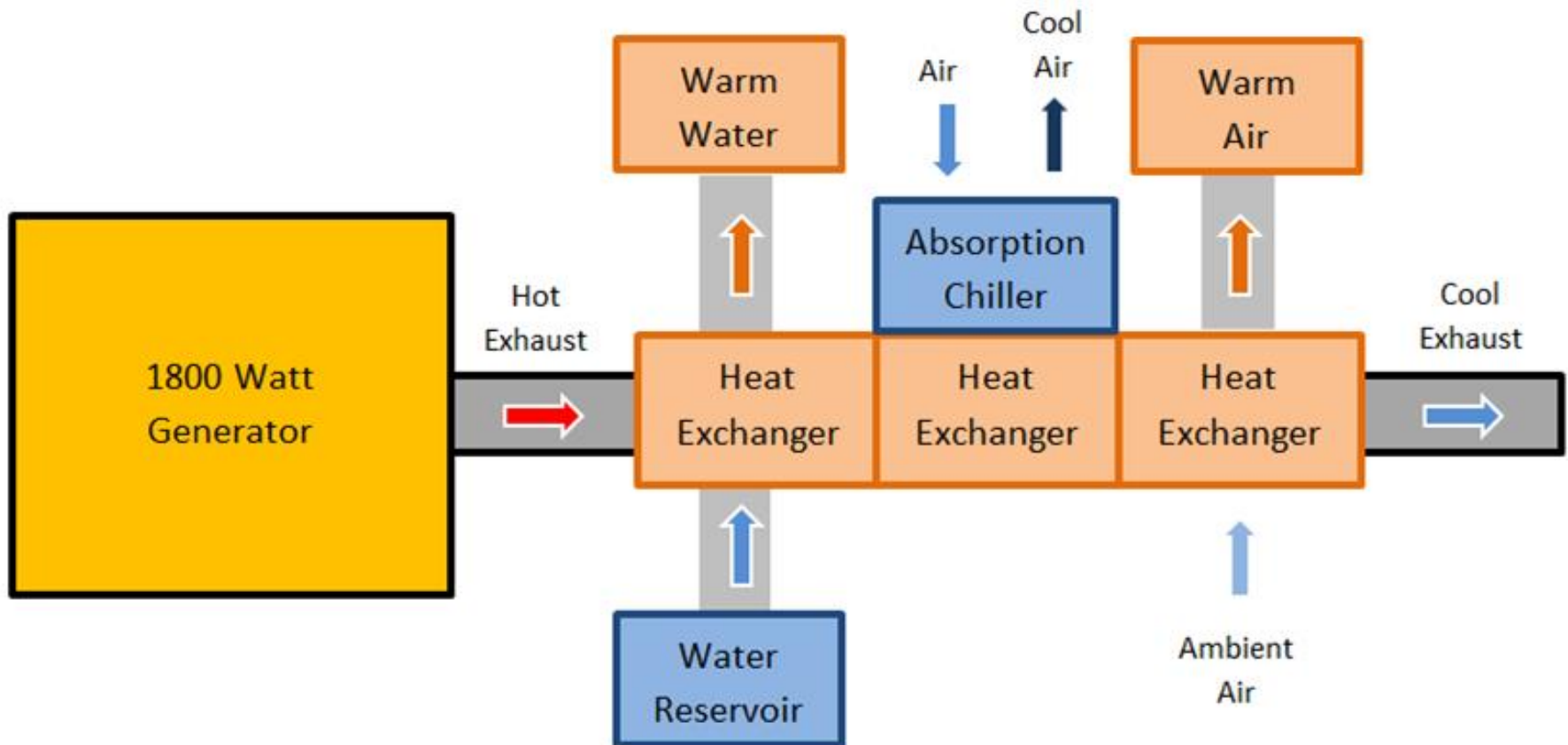
Designing the CCHP Educational Experience



Requirements:

- Heat source:
 - Gas-electric generator
- User interfaces:
 - Hot water
 - Hot air
 - Refrigeration

Thermodynamics



Generator Analysis



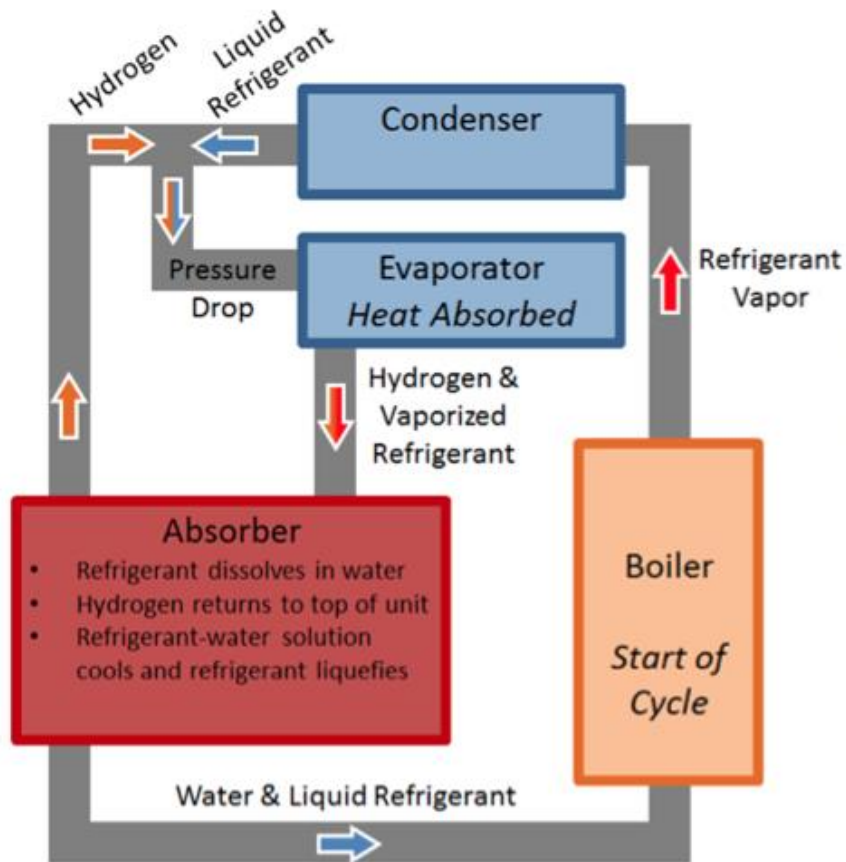
- Known:
 - 1800 Watt
- Assumptions:
 - Generators are approximately 35 percent efficient
 - 30 percent of total power is exhaust heat
 - Output temperature of generator is 1200 degrees F
 - Pressure drop through system is small

Heat Exchanger - Heating Water Analysis

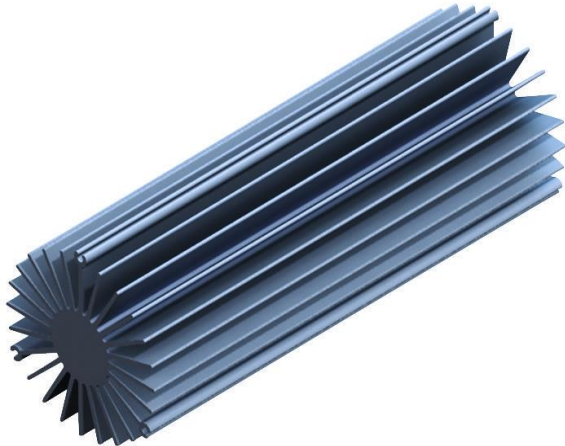
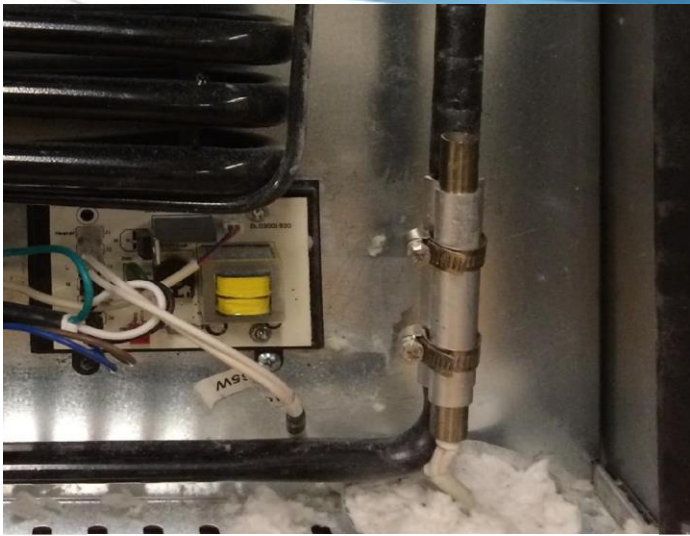
- Known:
 - Entering exhaust temperature
 - Flow rate of exhaust
- Assumptions:
 - Water starts at room temperature
 - Leaving exhaust temperature
 - Water flow rate
- Estimate:
 - 113°F water output



Absorption Refrigeration



Absorption Chiller Heat Exchanger Analysis

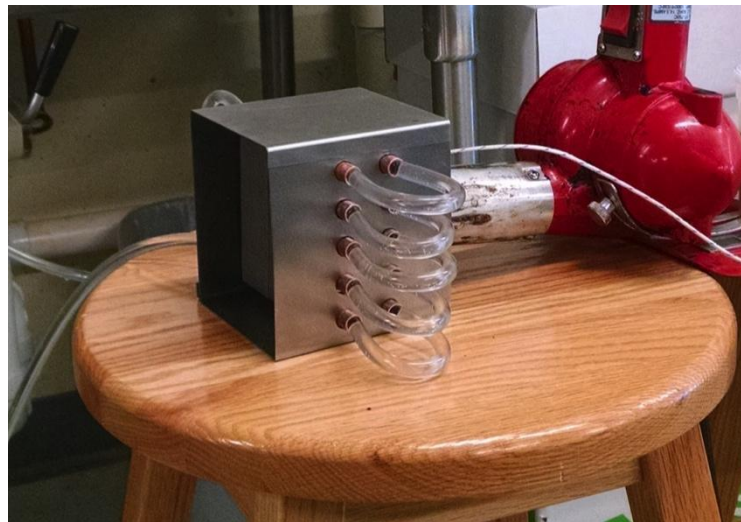
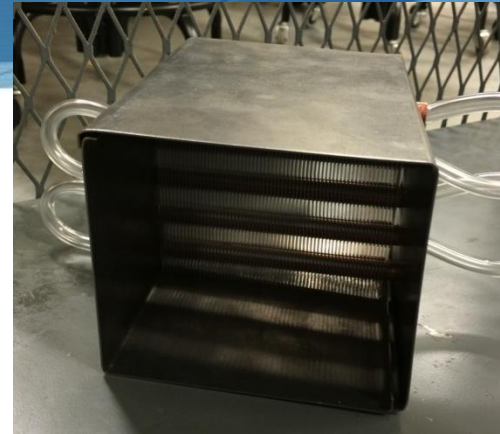
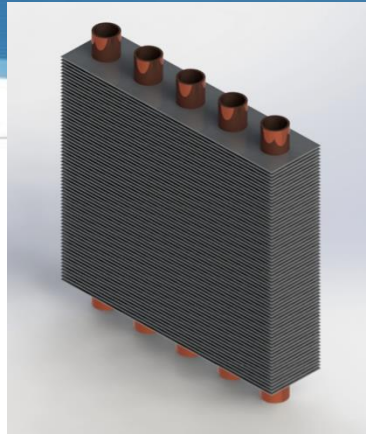


- Known:
 - Surface temperature: 620°F
 - Power rating: 65W
- Assumptions:
 - Uniform gas stream temperature
- Estimate:
 - 450°F required exhaust temperature

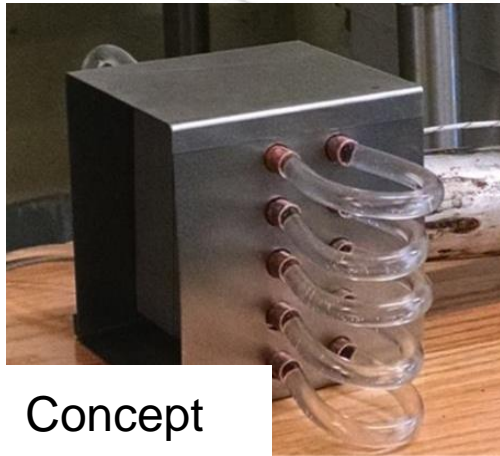
Heat Exchanger- Heating Air Analysis

- Known:
 - Entering exhaust temperature
 - Mass flow rate of exhaust
- Assumptions:
 - Air has ideal gas properties
 - Air starts at room temperature
 - Mass flow rate of air
 - Leaving exhaust temperature
- Estimate:
 - 200°F air output

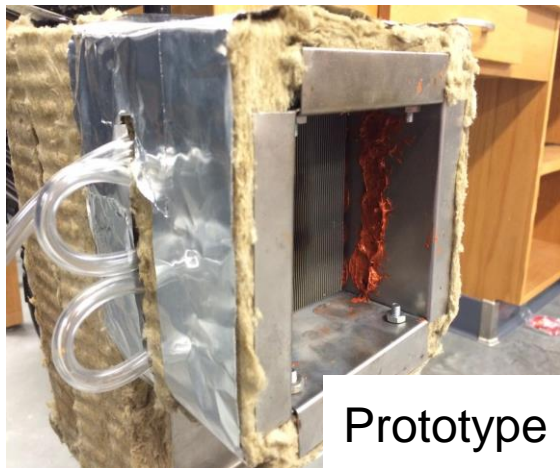
Heat Exchanger Fabrication



Heating Water



Concept



Prototype



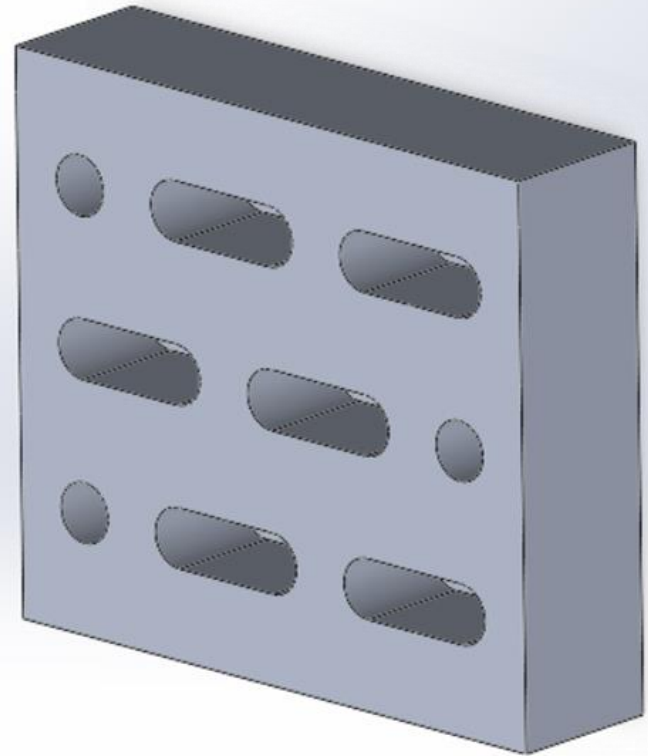
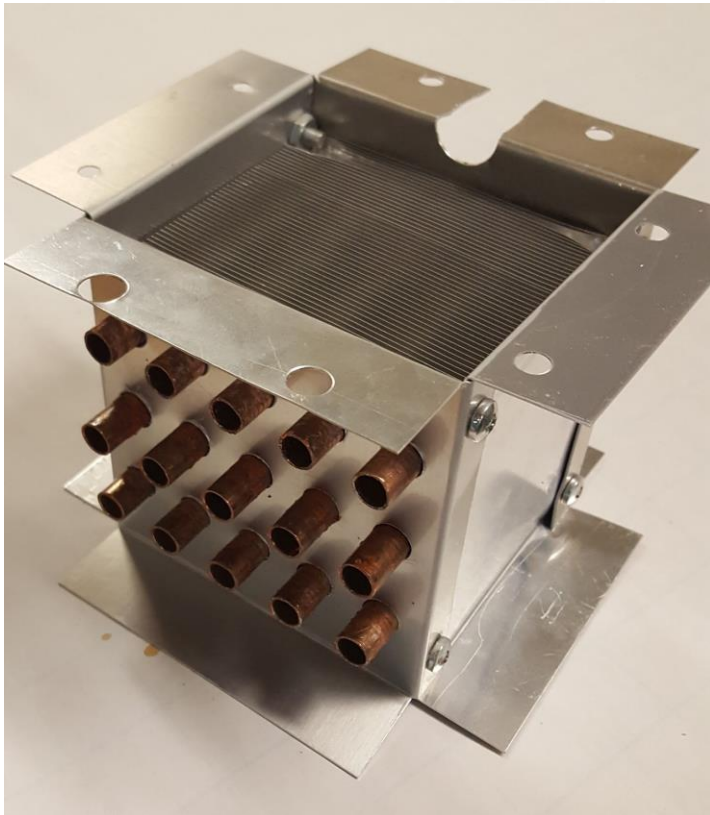
Final Version



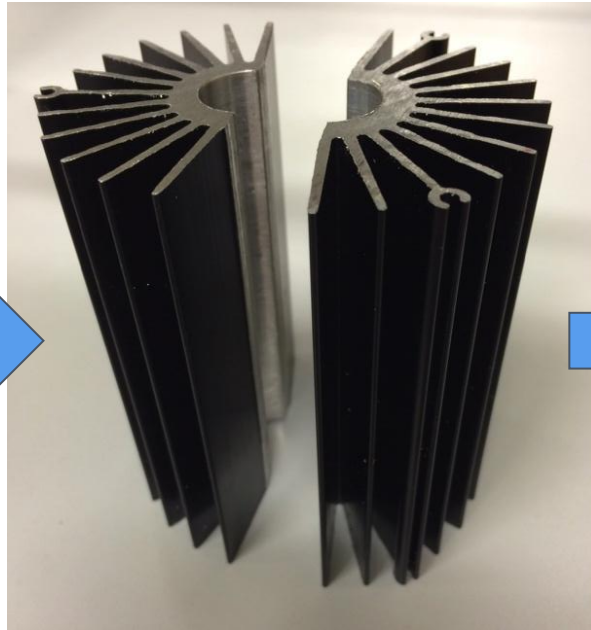
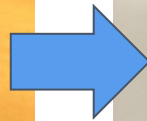
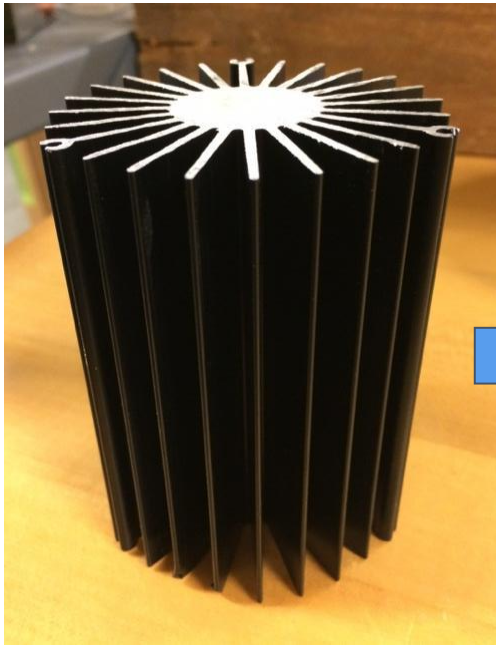
Heating Air



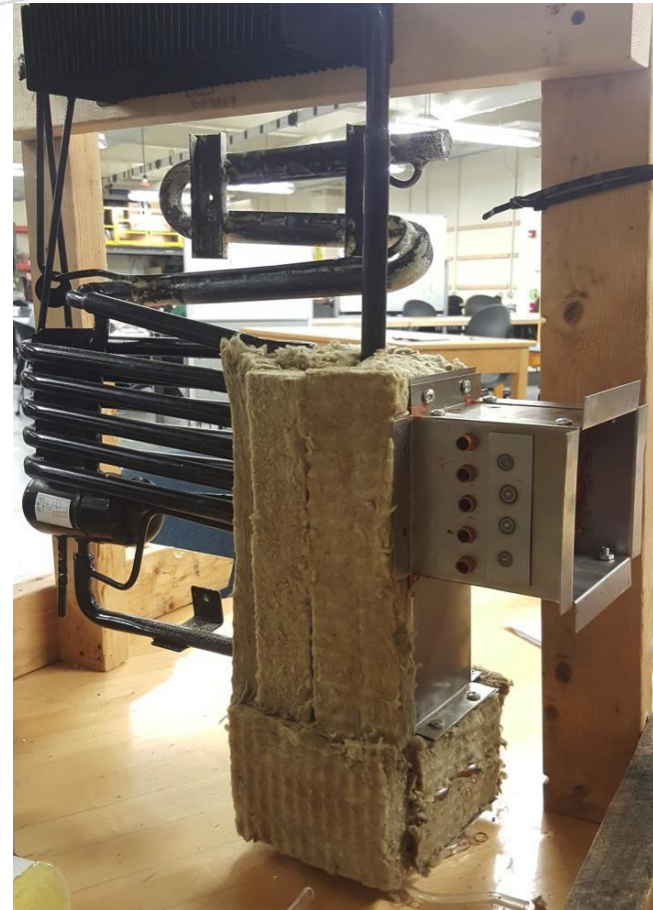
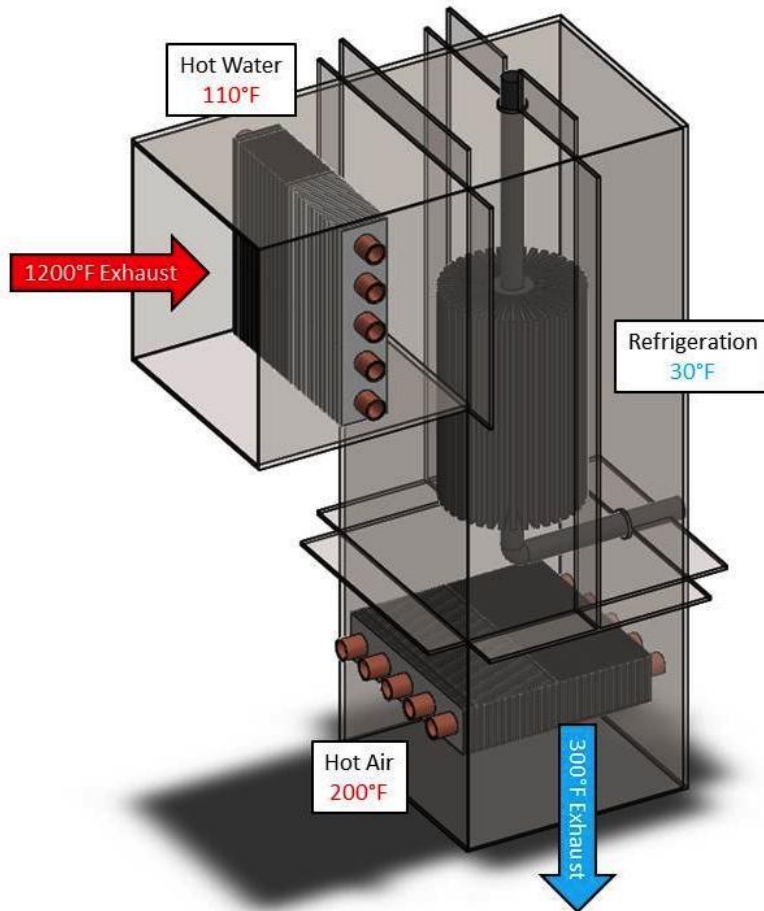
Heating Air



Absorption Chiller Fabrication



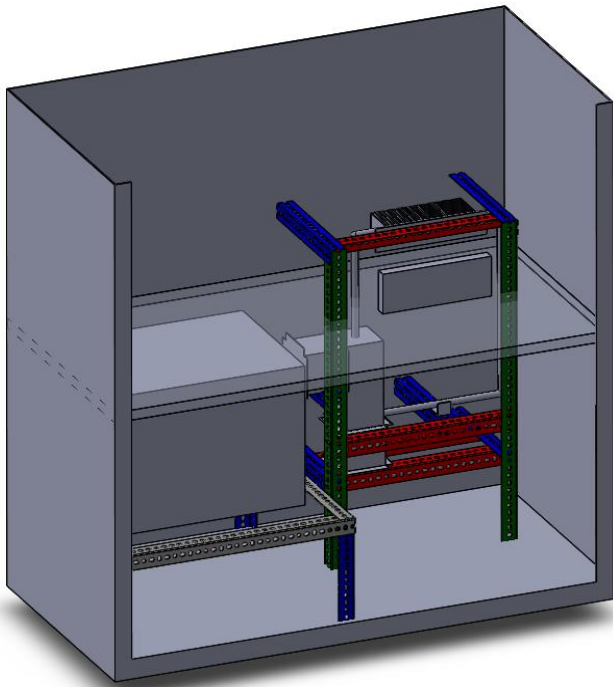
Interconnections



Validation



Integration



Interfaces



Final Insulation



Thermocouples and Displays



Type K Thermocouple Range: -454 to 2300F (-270 to 1260C)

Results

Each part of our design functioned properly

- Water went from 69°F to 110°F at a flow rate of 10 mL/s
- Absorption chiller reached 40°F
- Air temperature reached 220°F

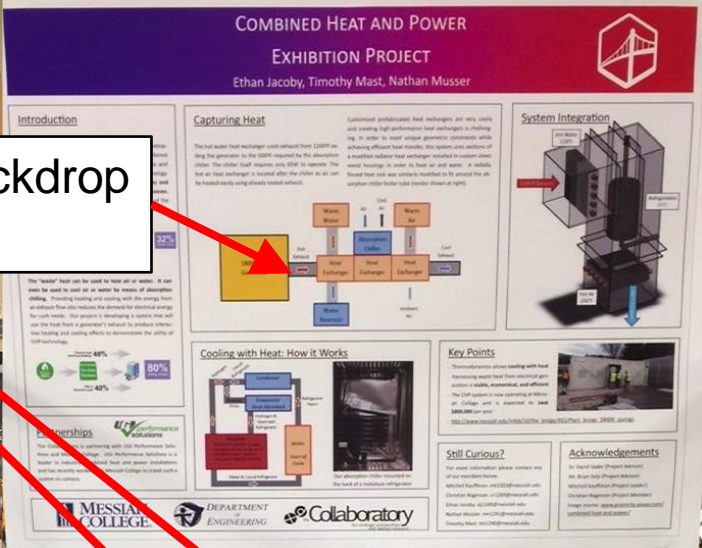
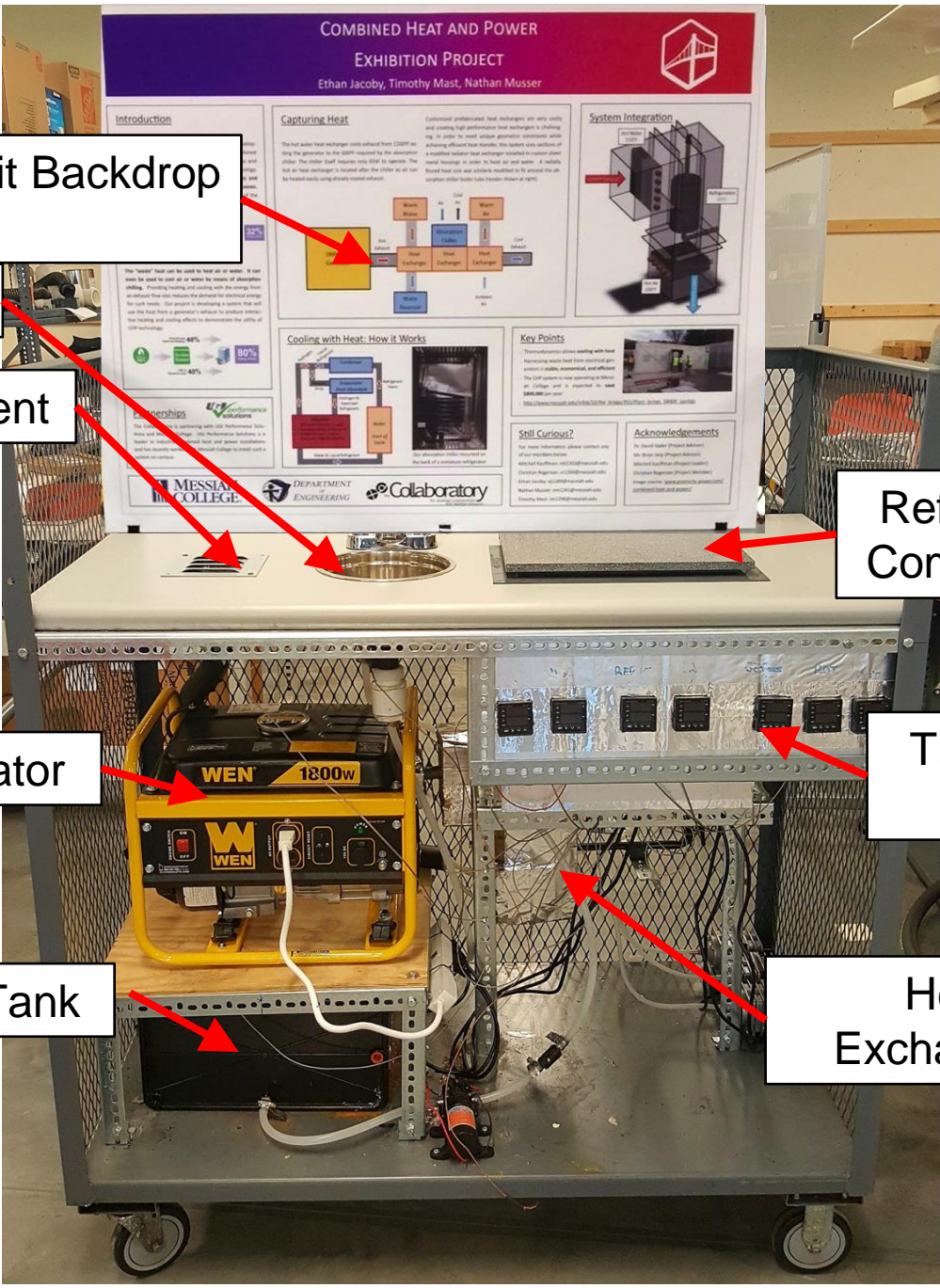


Exhibit Backdrop

Sink

Air Vent

Refrigerated Compartment

Generator

Thermocouple Readouts

Water Tank

Heat Exchangers

Outcome

Acknowledgements

Dr. David Vader – for his help as a faculty advisor

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