Midway Design Review

Solar Winds - Team 6
December 7th, 2018
Faculty Advisor: Stephen Frasier
Meet the Team

Ajey Pandey
EE

Richard Kornitsky
EE

Jason Sproviero
EE

Jayme Gordon
EE

Nicholas McCarthy
EE
Problem Statement

- Cooling draws a significant amount of power
- Cooling is a “peaky” load
  - Daily, cooling peaks around 3-4PM
  - Annually, cooling peaks in late summer
- Solar power makes peaky loads even peakier
  - Phenomenon known as the “duck curve”
- Grid-scale battery storage is in research phase
- Industry focus has been storing electrical (solar) power as electrical energy
Our Solution: Solar Winds

Store electrical power as thermal energy during non-peak load times

- Develop contained cooling system
- Store thermal energy in liquid solution
- Deliver cooling with stored energy
“Country Fair” Use Case

- Temperature is ~ 80°F
- User has a van or light-duty pickup truck
- Cooling system distributes air
- Noticeably cool small volume by ~ 3.5°F
Design Alternatives

- Compressor
  - Cons: Moving parts, Thermodynamics
  - Our design: Peltier cooler

- Ice Maker
  - Cons: Power demand, insulator
  - Our design: Brine

- Cold sink
  - This design: Attach heat sink to cold side of TEC and insert into tank
  - Cons: Difficulty interfacing, leakage, mounting, heat transfer
  - Our design: Water cooling block
Previous Specifications

1. Store 3000 BTU of energy as ice or liquid cooling solution

2. Cool a 1 ft x 2 ft x 5 ft area by 3.5°F for 1.5 hours

3. Store energy using photovoltaic input, with a DC power source as a backup

4. Fit a form factor such that two people can carry it into a van or light-duty pickup truck

5. Be constructed such that it can be disassembled with basic tools, like Phillips-Head screwdrivers or standard-size wrenches
Revised Specifications

- Energy storage scaled down by a factor of 5 to demonstrate critical functionality

- Previous BTU specification was calculated without thermodynamics knowledge

1. Cool 2 cubic foot area by 3.5º F for 1.5 hours

2. Store electrical power as thermal energy during non-peak load times

3. Fit a form factor such that two people can carry it into a van or light-duty pickup truck
Previous Block Diagram

Legend:
- Orange Arrow: Power
- Black Arrow: Data
- Grey Arrow: Ice Flow

Diagram:
- Management
  - User Input Temp
  - Processor
- Cooler
  - Temp Sensor (External)
  - PWM Generators
  - Fan
  - Ice
  - Temp Sensor (Ice)
  - Ice Maker
- Car Battery
  - Charge Controller
  - Solar
Redesigned Block Diagram
Changes in Implementation

Our solution: Store electrical power as thermal energy during non-peak load times

- Replace ice with brine

  *Brine demonstrates energy storage*

- Scale down thermal energy storage

  *Demonstrating functionality of solution does not rely on storage quantity*

- Change source of electrical power

  *Functionality of solution does not rely on power source*
Plans To Implement Each Block
Objective:

Circulate brine through pumping system to cooling block

Parts:

Thermoelectric Cooler: Laird HiTemp 387001828 (ET series)

Chosen operating conditions: 24V, 192W
Maximum operating conditions: 46V, 300W

Cooling block: DIYhz Aluminum Radiator (40mm x 40mm x12mm)

Liquid Cooler Heat Sink: CORSAIR Hydro Series H60 120mm
Control Block

Objective:
User control of cooling

Parts:
User Input: Control circuitry
Microcontroller: ATmega328
Feedback Block

Objective:
Report data from cooling system to microcontroller

Parts:

Tank temperature sensor: DS12B20 integrated circuit
  Selection criteria: Waterproof

Fan temperature sensor: LM35 integrated circuit
  Selection criteria: Readily available
Objective:
Develop array of sensors to track user

Parts:
Servomotor: Direct vents towards user
Interrupt: Allow user to manually interrupt
Sensors: Detect user motion
Power Block

**Objective:**
Provide power to each block

**Parts:**

*Power Supply:*

Chosen operating condition: 24V

Maximum operating conditions: 200V, 16.5A, 3300W
1. Store 3000 BTU of energy as ice or liquid cooling solution. This will be measured by measuring temperature of ice/cooling solution of a known specific heat, then calculating energy from the temperature differential.

2. Cool a 1 ft x 2 ft x 5 ft area by 3.5ºF for 1.5 hours. This will be measured with a thermometer outside the cooler. We project this will require 2000 BTU/hour to achieve.

3. Fit a form factor such that two people can carry it into a van or light-duty pickup truck.

4. Provide a paper design on sensors to enable directionality and prediction.
MDR Deliverables (Updated)

- Energy storage scaled down by a factor of 5 to demonstrate critical functionality
- Previous BTU specification was calculated without thermodynamics knowledge

1. Cool 2 cubic foot area by 3.5º F for 1.5 hours
2. Fit a form factor such that two people can carry it into a van or light-duty pickup truck
3. Provide a paper design on sensors to enable directionality and prediction
MDR Deliverables (Updated)

- Energy storage scaled down by a factor of 5 to demonstrate critical functionality
- Previous BTU specification was calculated without thermodynamics knowledge

1. ✔ Cool 2 cubic foot area by 3.5º F for 1.5 hours
2. ✔ Fit a form factor such that two people can carry it into a van or light-duty pickup truck
3. ✔ Provide a paper design on sensors to enable directionality and prediction
Demo of MDR Deliverables
Prototype MK-I
Prototype MK-II
Prototype MK-II
Testing Water Cooling

Parameters: 24 Volts to TEC, Output Fan off, 1 gallon water, 60 grams salt
Testing Air Cooling

Parameters: 24 Volts to TEC, Output Fan on, 1 gallon water, 60 grams salt
Initial/Ambient Temperature: 72.4°F, Target Output Temperature: 68.9°F,
Average Output Temperature: 68.5°F
Testing Air Cooling

Parameters: 24 Volts to TEC, Output Fan on, 1 gallon water, 60 grams salt
Initial/Ambient Temperature: 72.4°F, Target Output Temperature: 68.9°F,
Average Output Temperature: 68.5°F
Proposed CDR Deliverables

- Demonstration of Complete System Functionality
  - Build custom cooler box - Jayme & Richard
  - Data collection tool - Jayme & Nick
  - Feedback loop & temperature control - Nick & Ajey
  - Printed circuit board (PCB) - Jason
  - Sensors for directionality & prediction - Ajey & Richard
Leaking Foam Cooler
Solution: Custom Built Cooler
# Gantt Chart

<table>
<thead>
<tr>
<th>Activity</th>
<th>Dates</th>
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</thead>
<tbody>
<tr>
<td>Sensors for directionality &amp; Prediction (Richard + Ajey)</td>
<td>Jan 22</td>
</tr>
<tr>
<td>Refinement of Sensors for directionality &amp; Prediction (Richard + Ajey)</td>
<td>Jan 29</td>
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<tr>
<td>Custom Cooler Box built (Jayme + Richard)</td>
<td>Feb 5</td>
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<tr>
<td>Prototype for Microcontroller (Jason)</td>
<td>Feb 12</td>
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<tr>
<td>PCB for Microcontroller (Jason)</td>
<td>Feb 19</td>
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<tr>
<td>Program Feedback Loop (Nick + Ajay)</td>
<td>Feb 26</td>
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<tr>
<td>Normalizing Temperature Sensors (Nick + Ajay)</td>
<td>Mar 5</td>
</tr>
<tr>
<td>Add User Input (Ajey + Nick)</td>
<td>Mar 12</td>
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<tr>
<td>Data Collection Tool (Jayme + Nick)</td>
<td>Mar 19</td>
</tr>
<tr>
<td>Refinement of Data Collection Tool (Jayme + Nick)</td>
<td>Mar 26</td>
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<tr>
<td>Heat Transfer Analysis (Ajey + Richard)</td>
<td>Apr 2</td>
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<tr>
<td>Heat Transfer Testing (Ajey + Richard)</td>
<td>Apr 9</td>
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<tr>
<td>Measure Cooling Performance (Nick)</td>
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<tr>
<td>CDR Documentation (All)</td>
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<tr>
<td>CDR Preparation</td>
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<tr>
<td>CDR Presentation</td>
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<tr>
<td>Project Refinement</td>
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Individual Responsibilities

**Ajey** - Sensors for directionality & prediction, program feedback loop, normalize temperature sensors, add user input, heat transfer analysis & testing

**Jason** - Protoboard & PCB for microcontroller

**Jayme** - Custom cooler box built, data collection tool

**Nick** - Program feedback loop, normalize temperature sensors, add user input, data collection tool

**Richard** - Sensors for directionality & prediction, custom cooler box built, heat transfer analysis & testing
THANK YOU