UMassAmherst

Final Project Review

Solid State Air Conditioning with Thermal Storage

Solar Winds - Team 6

April 23rd, 2019

Faculty Advisor: Stephen Frasier

SOLAR WINDS

Department of Electrical and Computer Engineering

Meet the Team

Ajey Pandey
EE

Richard Kornitsky
EE

Jayme Gordon
EE

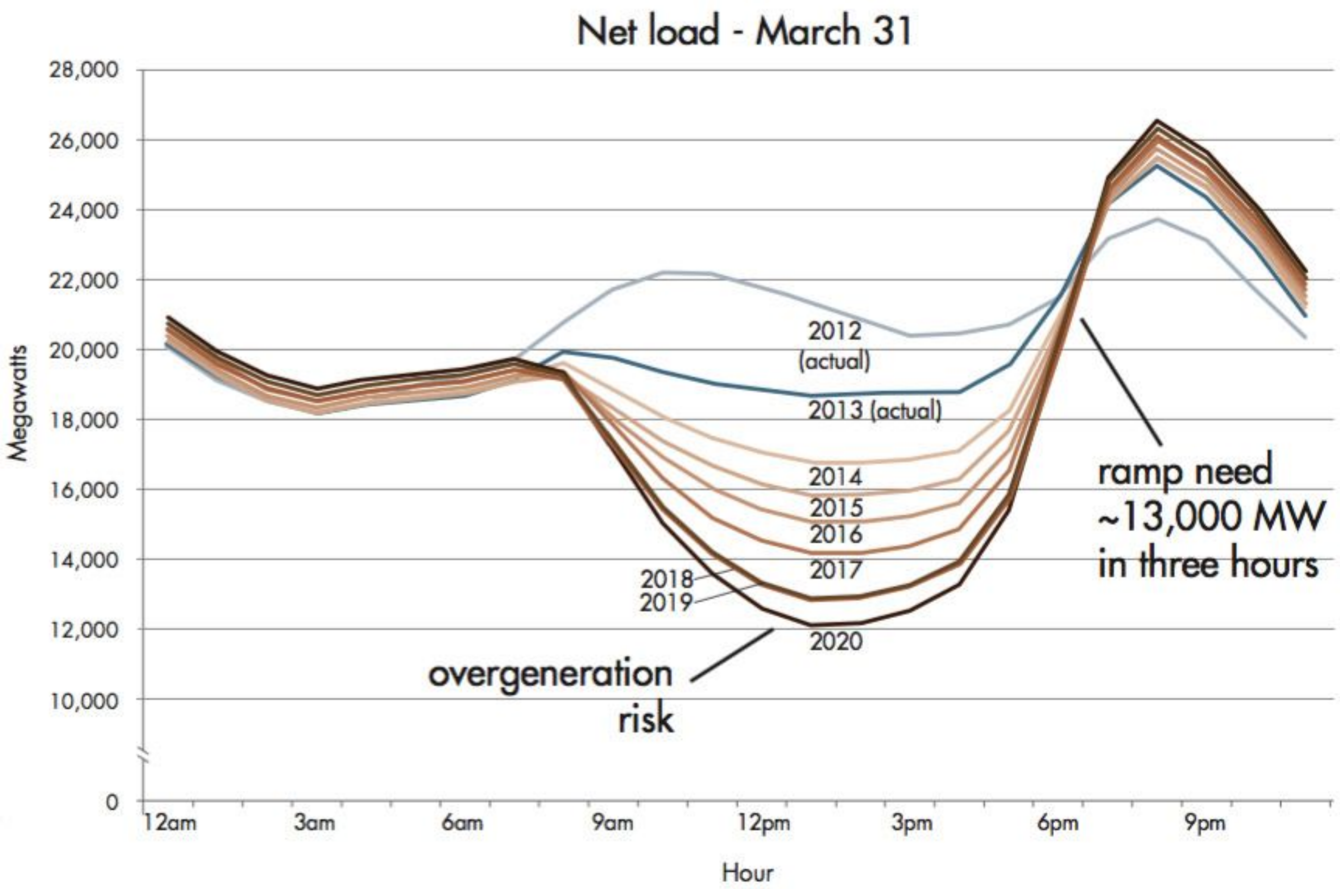
Jason Sproviero
EE

Nicholas McCarthy
EE

Problem Statement

- Cooling draws a significant amount of power
- Present cooling solutions require constant power supply
- Scheduled blackouts occur in developing countries
- Energy storage necessary for generation such as solar and wind
- Industry focus has been storing electric (solar) power as electrical energy

Duck Curve


Net load - March 31
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
0
Megawatts
12am
3am
6am
9am
12pm
3pm
6pm
9pm
Hour
2012
(actual)
2013 (actual)
2014
2015
2016
2017
2018
2019
2020
ramp need
~13,000 MW
in three hours
overgeneration
risk

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

Use Case: County Fair

- 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

Table of Requirements & Specifications

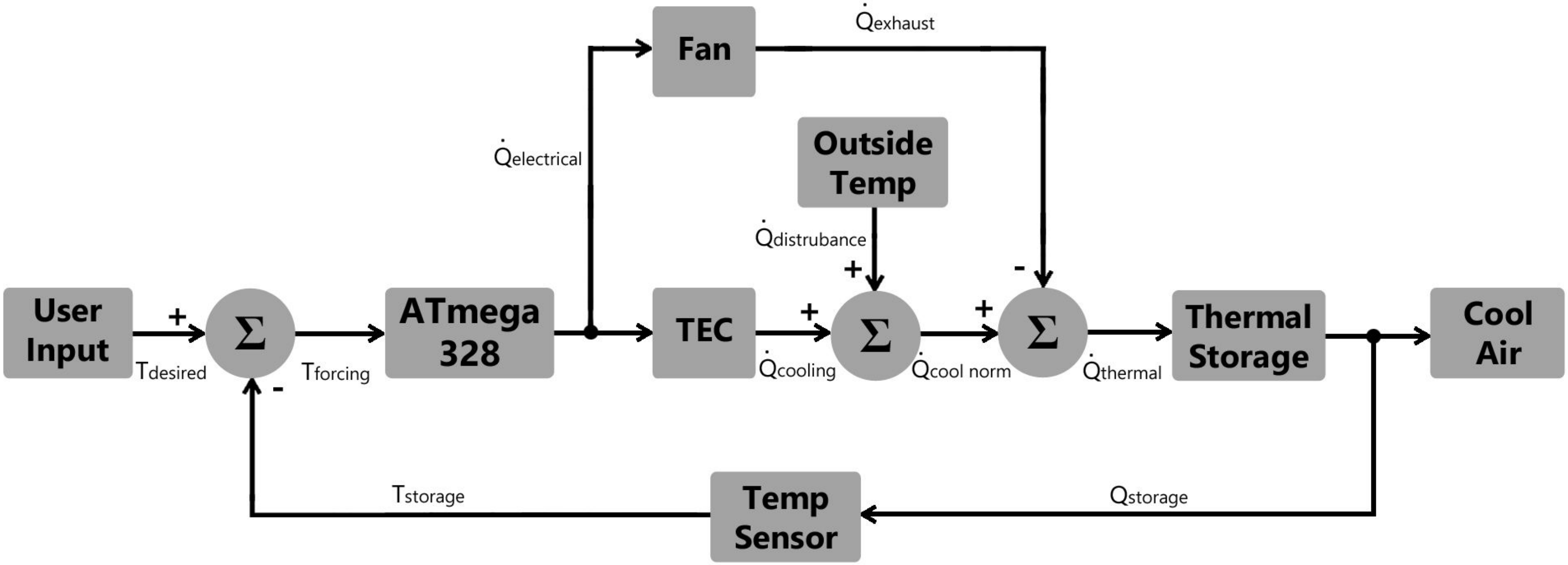
Requirement	Specifications	Value
portable	dry weight	< 150 lb
	size	< 20 cuft
cooling	air cooling	3.5° F
responsive	water cooling	< 6 hours

Table of Requirements & Specifications

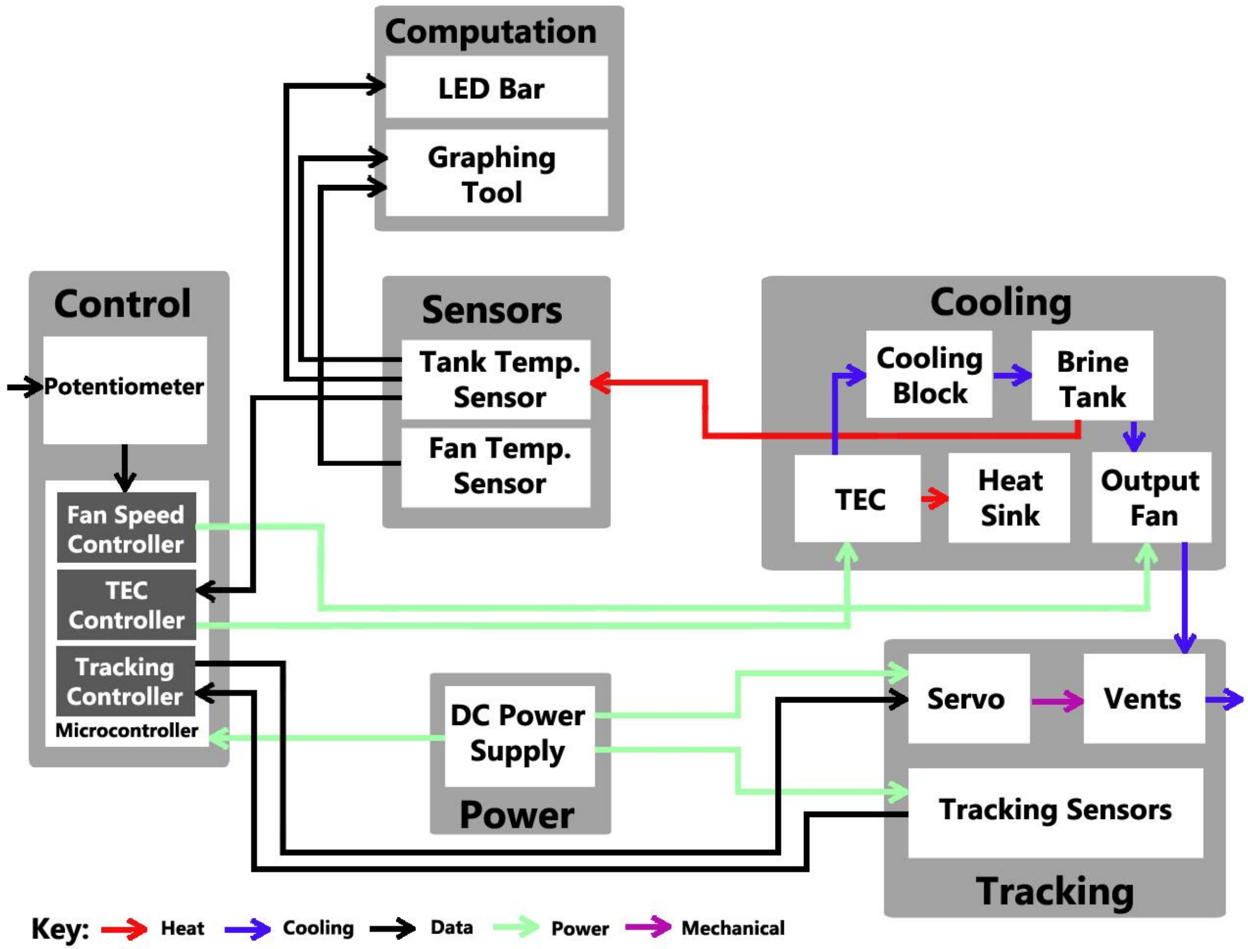
Requirement	Specifications	Value	Actual
portable	dry weight	< 150 lb	60 lb ✓
	size	< 20 cuft	20.8 cuft ✓
cooling	air cooling	3.5° F	3.9°F ✓
responsive	water cooling	< 6 hours	3 hours ✓

System Overview: Implementation of each Block

System Feedback



System Overview: Block Diagram



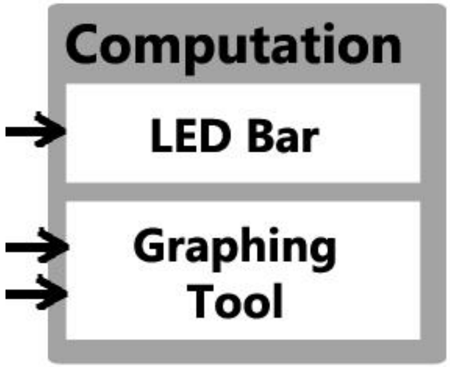
Computational Block

Objective:

Data collection and graphing

Parts:

Single-board Computer: Raspberry Pi 3 Model B+



System Overview: Individual Responsibilities

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

Jason - Protoboard & PCB for microcontroller, *user interface/ switching, cable management system (CMS), feedback hardware*

Jayme - Custom cooler box built, data collection tool, Graphical data presentation tool, *user interface/ switching, cable management system (CMS)*

Nick - Program feedback loop, normalize temperature sensors, add user input, *user interface/ switching, cable management system (CMS)*

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

Note: Italicization marks added responsibility

FPR Deliverables

Refine Complete System Functionality

- Refine data collection tool - Jayme
- Test & optimize feedback controllers - Nick & Ajey
- Refine printed circuit board (PCB) - Jason
- Refine directionality - Ajey & Richard

Added Goals

- Graphical data presentation tool - Jayme
- Power flow analysis efficiency report - Ajey
- Battery gauge - Ajey & Jason

FPR Deliverables

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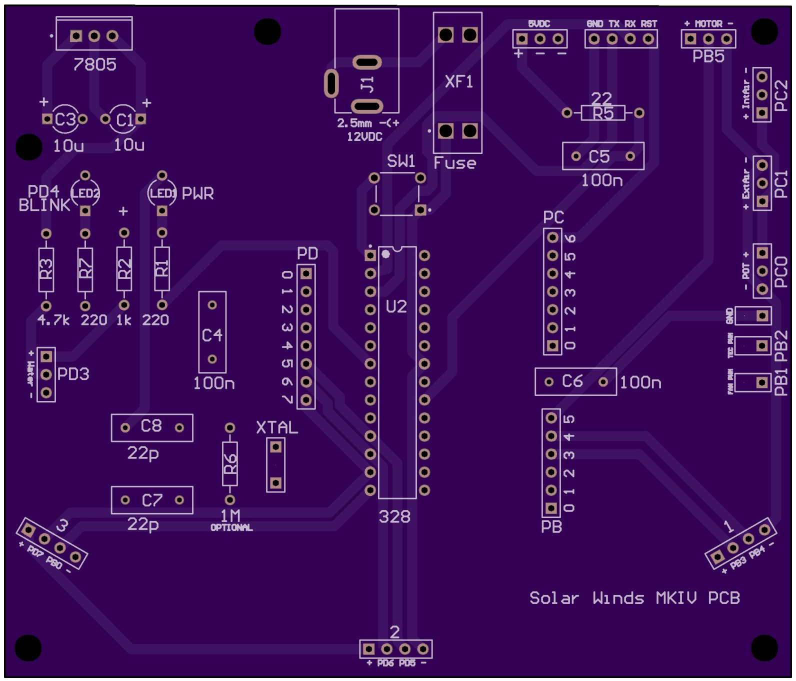
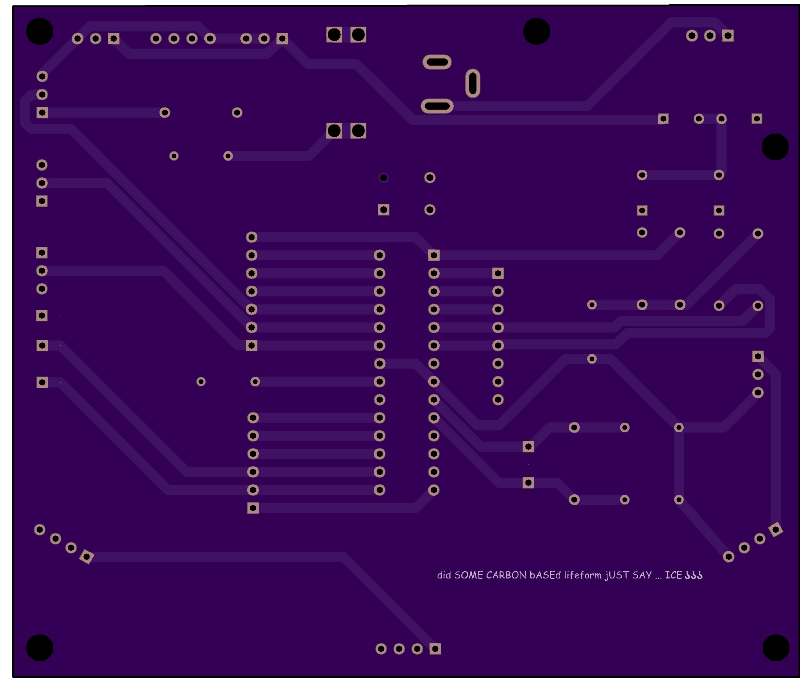
- ✓ Power flow analysis efficiency report - Ajey
- ✓ Battery gauge - Ajey & Jason

Test & optimize feedback controllers - Nick & Ajey

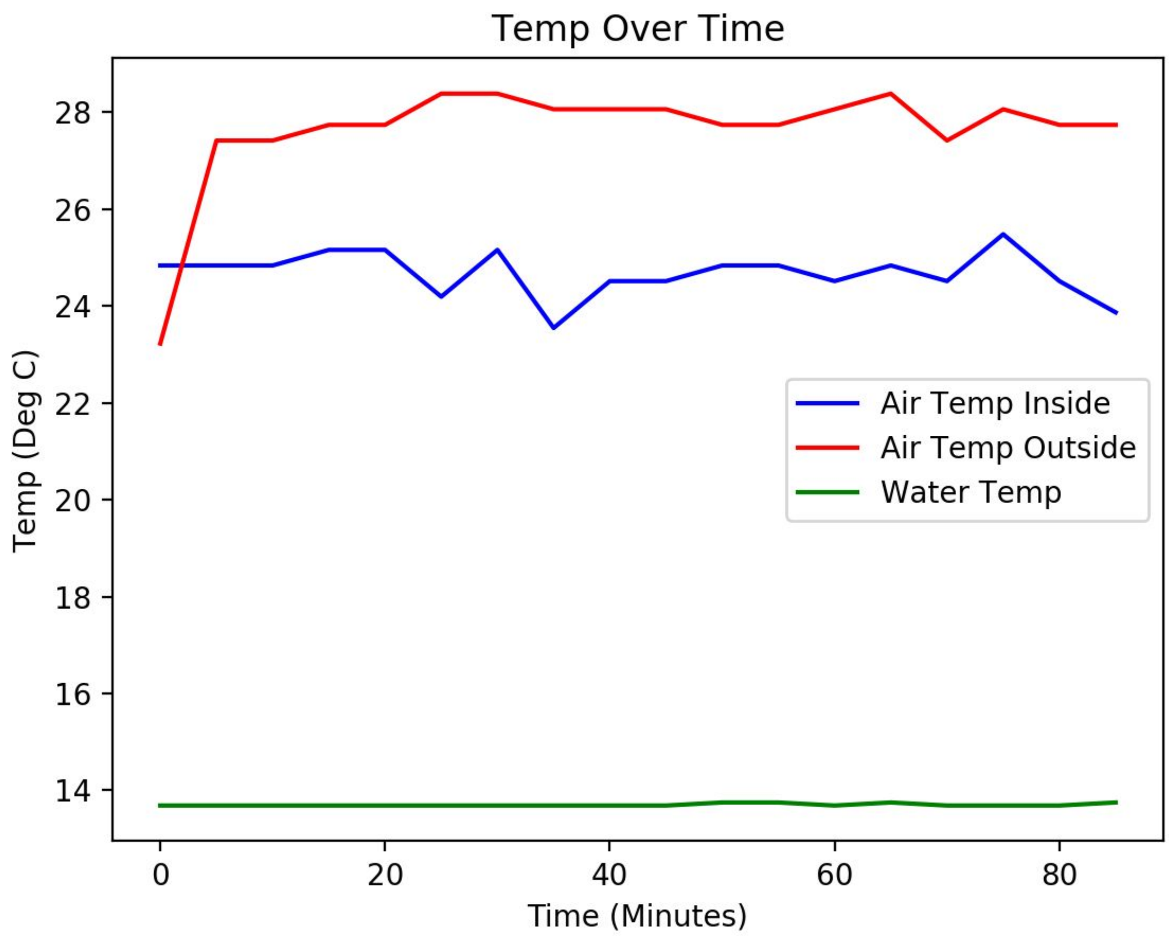
```
Loop:
  [baseTemp, fanSpeed] = readInput()
  tankTemp = readTank()
  if tankTemp > baseTemp:
    powerTEC(on)
  else
    powerTEC(off)
  fanPWM(fanSpeed)
  delay(1 min)
```

Refine printed circuit board (PCB) - Jason

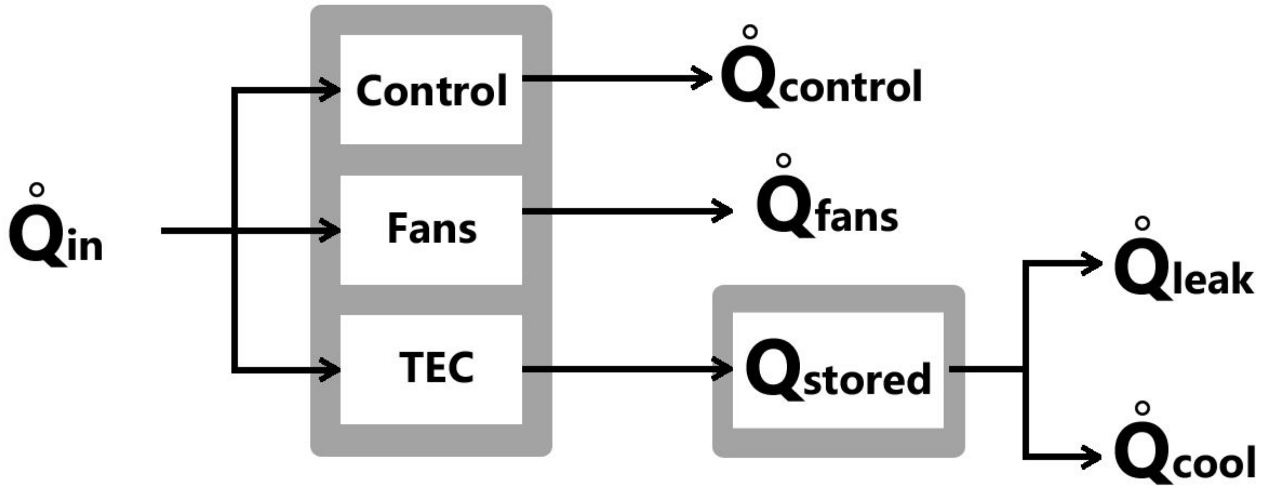




Graphical data presentation tool - Jayme



Power flow analysis efficiency report - Ajey



Mapping of Power Flow

- Storage rate / total power input: 2.9%
- Storage rate / TEC power input: 3.5%
- Efficiency could be improved by:
  - Replacing TEC with heat engine cooling system
  - Adjusting circulation flow rate

Cost Breakdown

Device	Quantity	Cost for 1 Unit	Cost For 1000 Units
12V DC Power Supply	1	$20	$20
24V DC Power Supply	1	$35	$30
ATmega328	1	$1.96	$1.62
Closed Loop Coolers	2	$75	$75
Enclosure	1	$25	$25
Insulation	11.2 $ft.^2$	$6	$3
Thermocouple	1	$8	$5
PCB	1	$27	$13
PC High Volume Fan	1	$12	$8
Pump	2	$12	$9
Raspberry PI	1	$30	$22
TEC	2	$150	$138
Tubing	15 ft.	$3	$1.50
Total	**-**	**$404**	**$351**

Plans for Compelling Demo Days

1. Water lines clamped in front with food coloring
2. *Plexiglass top to show audience internals of system*
3. *Drain and Fill Pumps*

Note: Italicization to indicate Good faith Reach Goals

Demonstration