UMassAmherst

Preliminary Design Review

Solar Winds

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Department of Electrical and Computer Engineering

Meet the Team

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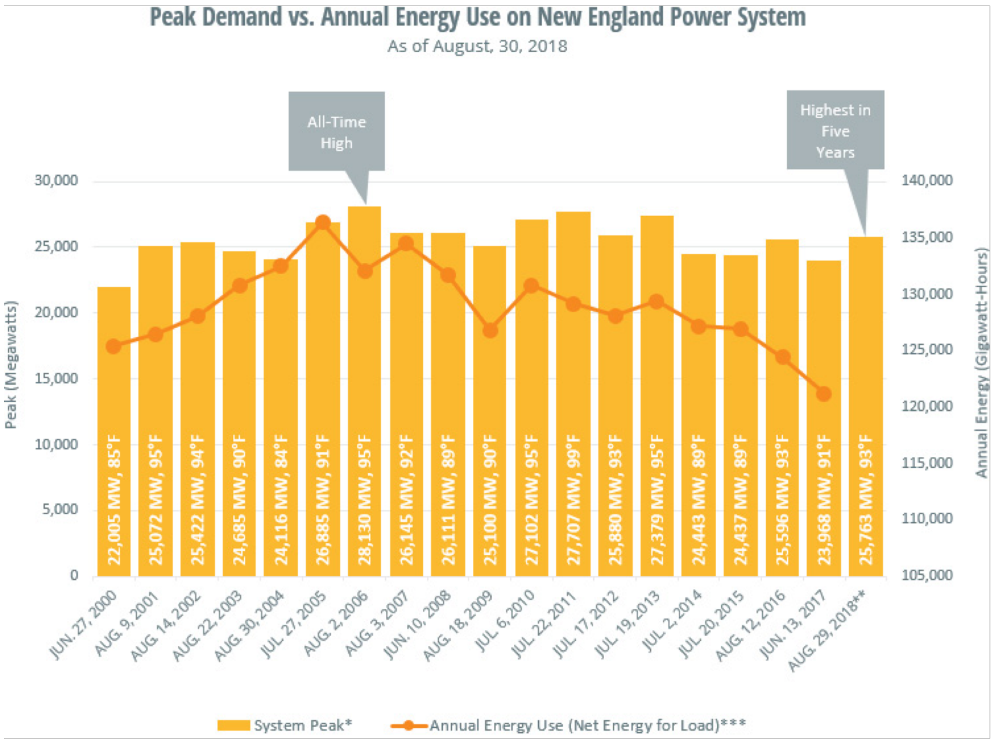
Problem: Cooling Takes Power

- Even small air-conditioners draw 100’s of watts during use
- A/C power comes from the grid, into users’ electricity bills
- Cooling is a significant portion of energy use
  - Especially in poorly insulated buildings, hot climates, summers

Problem: Cooling Is A "Peaky" Load

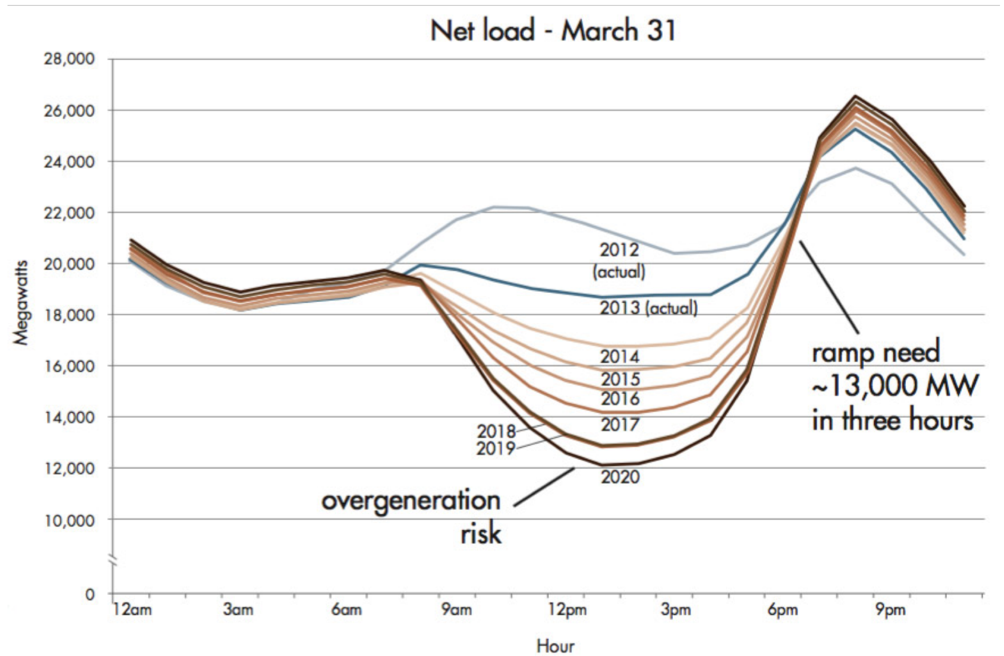
- Electricity users generally use cooling at same time--when it's hot!
- Daily, cooling peaks around 3-4PM*
- Annually, cooling peaks in late summer



Rob LeTellier, Holyoke Gas & Electric

Problem: Solar Power Returns "Duck Curves"

- Peak solar generation is during middle of day
- Peak power use is in evening
- Solar will make peaks even "peakier" without *energy storage*



CA ISO (2013)

Problem: Grid-Scale Storage Is In Progress

- Lithium-ion battery storage:
  - Is expensive at large scale
  - Is potentially volatile or explosive
  - Degrades over time
  - Requires extraction from brine
- Research happening at NY-BEST, U.S. National Labs, Fraunhofer CEI

Requirement Analysis

- Provide ample cooling
- Store thermal energy and use it when needed
- Reduce demand from the grid
- Accessible:
  - Relatively small form factor
  - Does not depend on pre existing systems
  - Portable

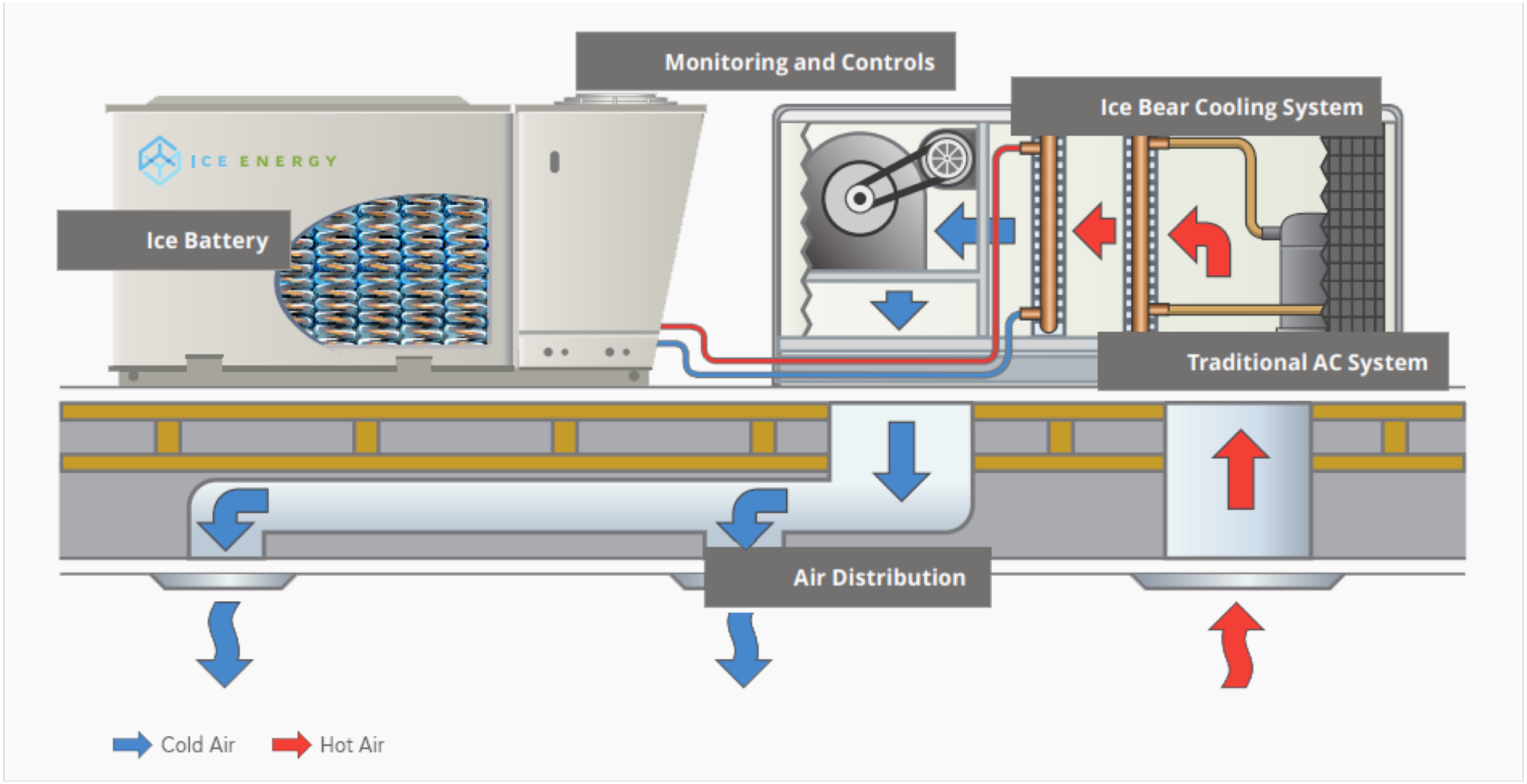
Design Alternative: Fan

- Compact and easy to move around
- Requires connection to power
- Moves air, does not cool air

Design Alternative: Air Conditioner

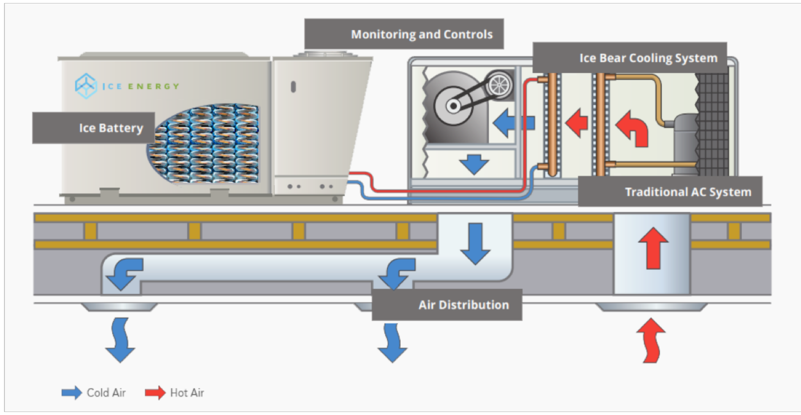
- Powerful and reliable cooling
  - A small A/C units are 5000+ BTU/hour
- Requires a lot of power
- Requires grid connection
- Hottest temperatures during peak power usage hours
  - Leads to heavy draw on the grid
  - Most expensive time to run system

Design Alternative: Ice Energy - Ice Bear



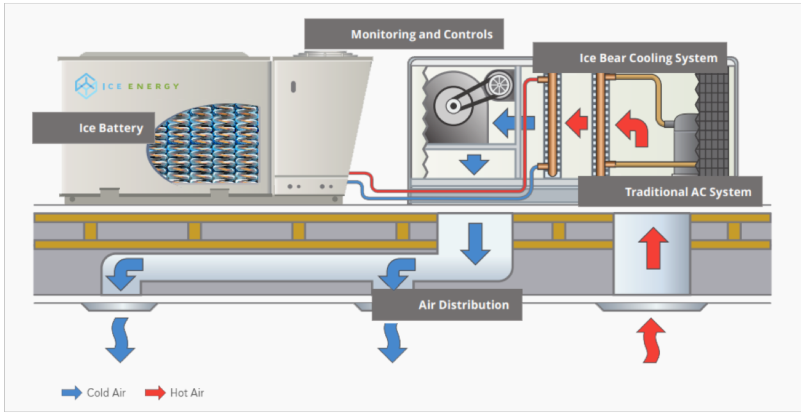
Design Alternative: Ice Energy - Ice Bear

- Integrates with traditional A/C unit
- Ice battery stores energy during off-peak usage hours
- During peak hours:
  - AC compressor is bypassed
  - Air is run across ice to provide cooling
- Storage capacity does not degrade over time



Design Alternative: Ice Energy - Ice Bear

- Drawbacks:
  - Requires air conditioning unit
  - Requires large amount of power
  - Not portable



Specifications: Solar Wind

1. Freeze 5 gallons of water for storage in 3.5 hours
   - Requires ~ 6000 BTU of energy to freeze at room temp
   - At 75% cooling efficiency, a 735W system would supply this
2. Form factor for two people to carry into a pickup truck
3. DC power backup for receiving excess power
   - Fills in gaps from solar power
4. 30 mins of maximum cooling with no PV input
5. System can be easily disassembled

Specifications: Caclulations

5 gallons of water/ice = 41.7lbs

41.7lbs × 144BTU/lbs = 6000 BTU

AT a 75% cooling efficiency, 8000BTU of cooling

8000BTU = 2.3kWh

Using a 735W system, this would take **3.1 hours**

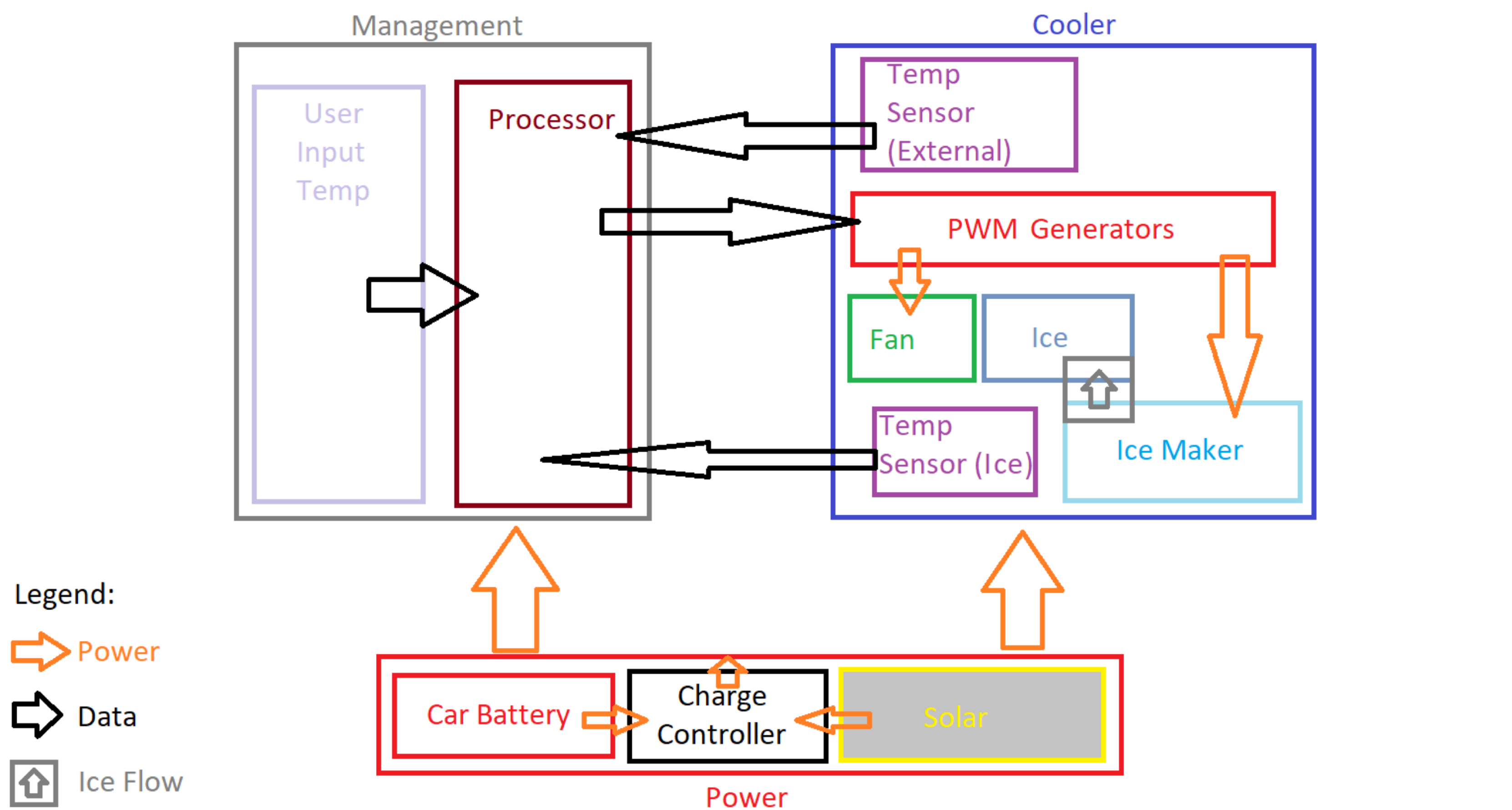
735W system = 3x 245W solar panels (standard size)

*Sarah Fisken, Washington University

Specifications: Use Cases

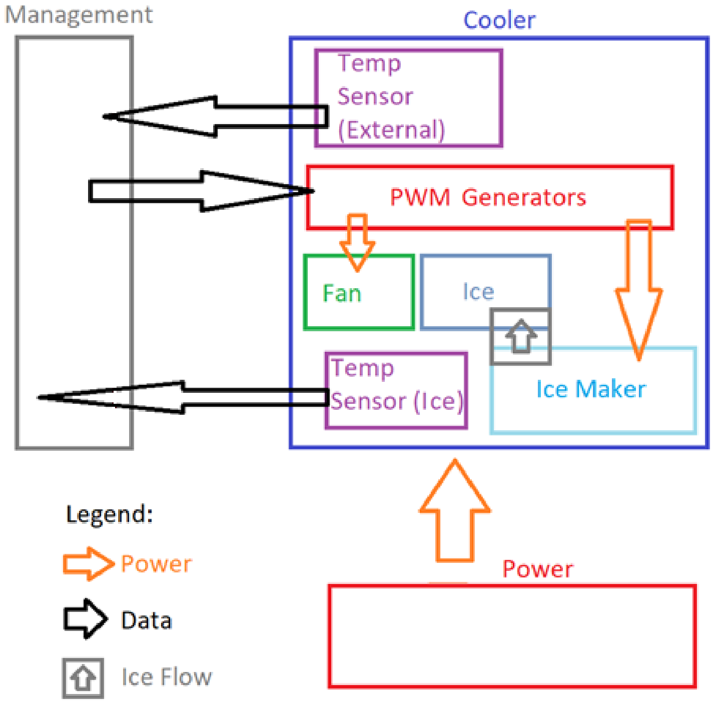
- Replace window A/C units in residential settings
- Portable cooling system in a tent
- Developing Countries

Block Diagram



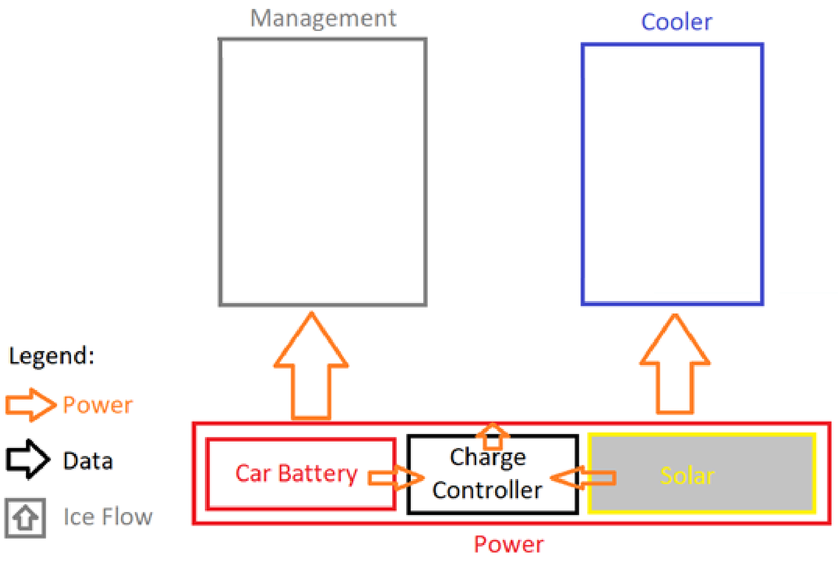
Subsystem: Cooler

- Contains temperature sensors
- Converts excess energy into ice
- Fan blows air over ice to provide cooling
- Ice maker and fan PWM



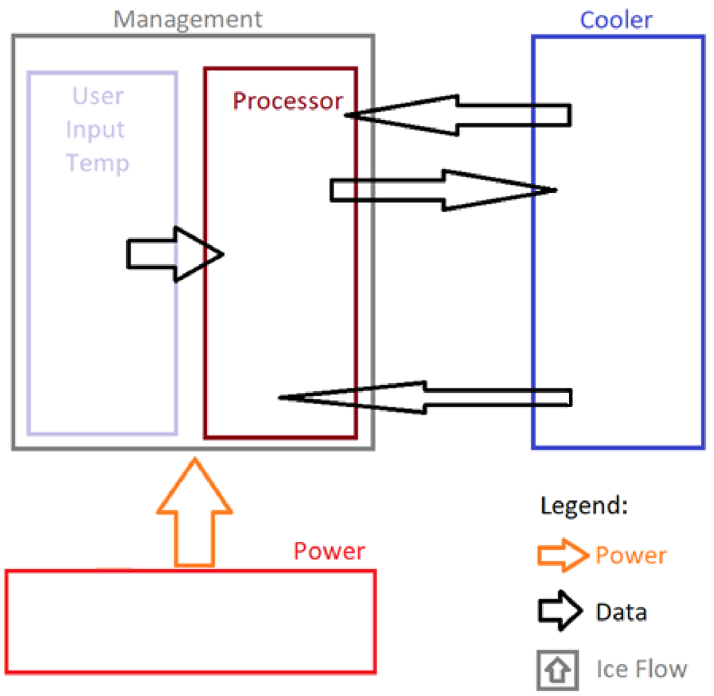
Subsystem: Power

- 12 Volt DC Solar panels
- 12V car battery for backup/storage
- Charge controller to regulate and distribute power



Subsystem: Management

- Simple 8-bit Microcontroller
- Collects sensor readings and user inputs
  - Dial for cooling stregth
- In charge of regulating temperature of the cooler via feedback control
- Handles data processing
- Low power



MDR Deliverables

- Design based out of drink cooler
- System running off car battery
- Freeze ice up to Specification 1, blow cool air through ice
- Prototype fan/cooler controller
- Stretch: PV input

Individual Responsibilities

- Jason: Control Electronics, PCB Design
- Ajey: Thermodynamic Calculations, Programming
- Richard: Building & Assembly and Power Module
- Nick: Sensor Electronics

QUESTIONS?