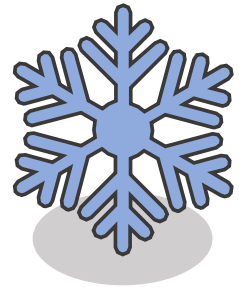
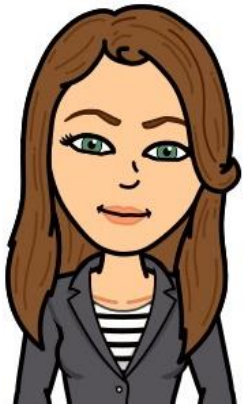
Team 523: Medi-Kool

EML4551-1



Temperature Sensitive Medication Storage During Natural Disaster

Team Introductions



Zoe Dillehay
Systems Integration Engineer

Travis Amaral
Project Manager & Research Engineer

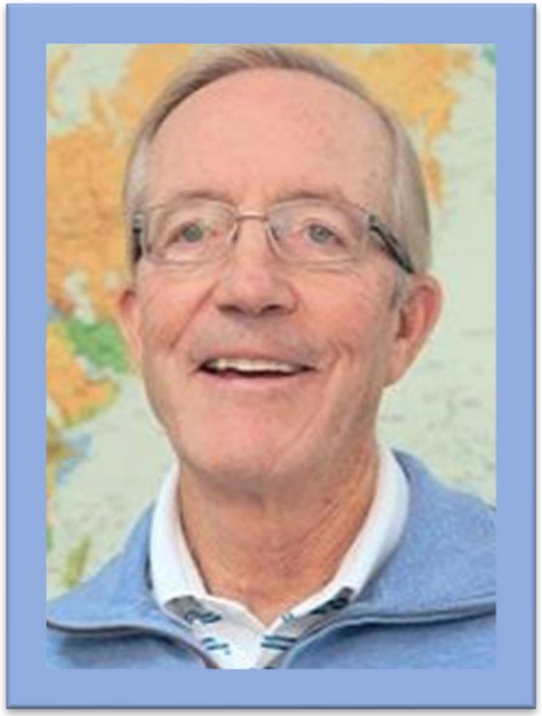
Nick Georgevich
Design Engineer

Keon Glass
Entrepreneurial Leader & Research Engineer

Diego Mendoza
Electrical Engineer

Andrew Sayers
Quality Control Engineer

Sponsors



Dr. Michael Devine

- Entrepreneur in Residence and an Adjunct Professor at FAMU-FSU College of Engineering
- Ph.D. in Mechanical Engineering (Operations Research)

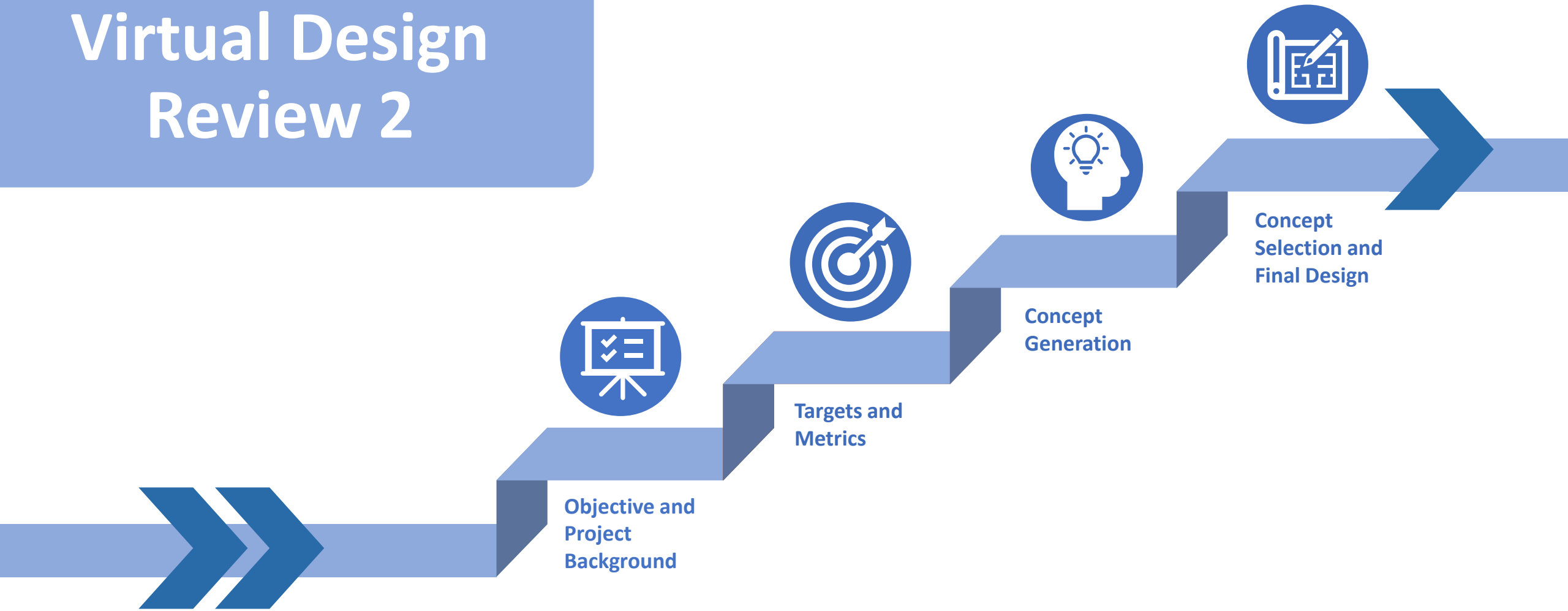
FAMU-FSU College of Engineering

Advisor

Dr. Shayne McConomy

- Teaching instructor at FAMU-FSU College of Engineering
- Ph.D. in Automotive Engineering

Virtual Design Review 2

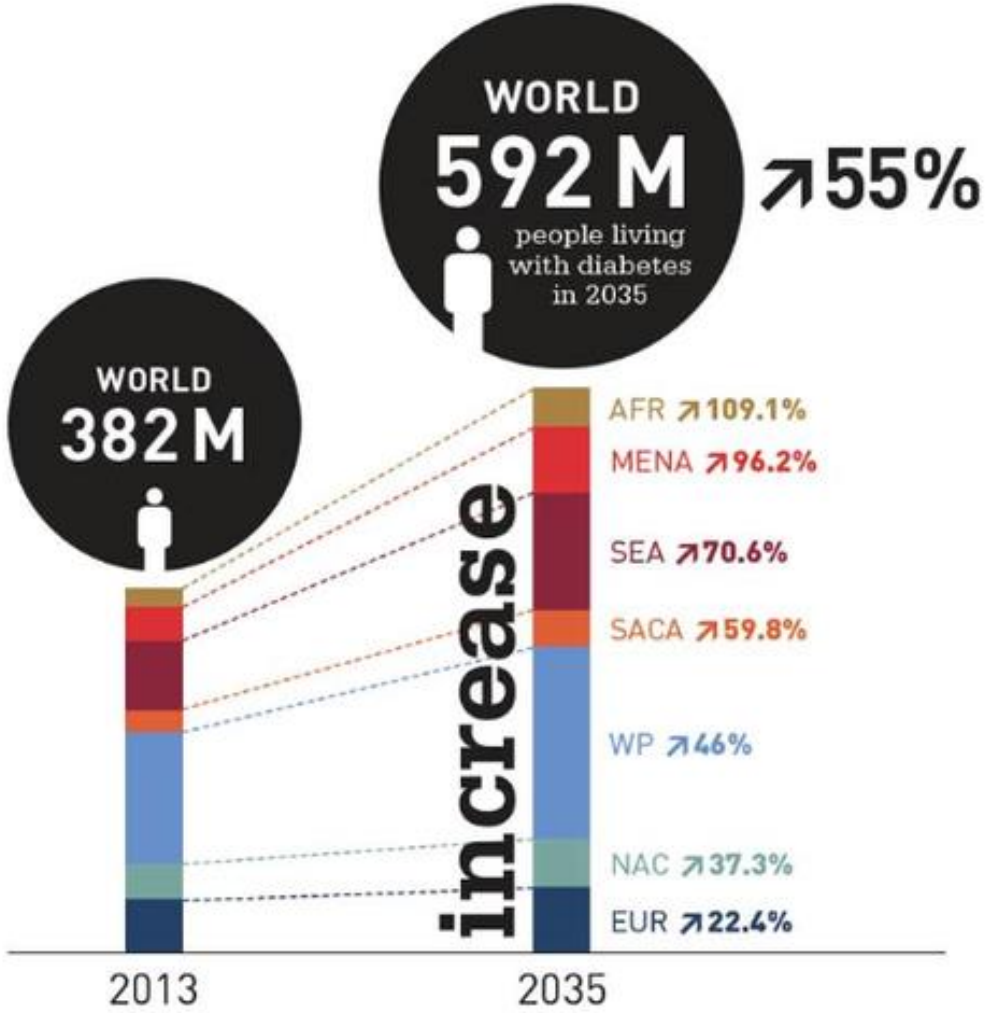


Objective

The objective of the project is to develop a device that stores and maintains the quality of temperature sensitive medication in the event of a natural disaster that causes mass power outages

Background

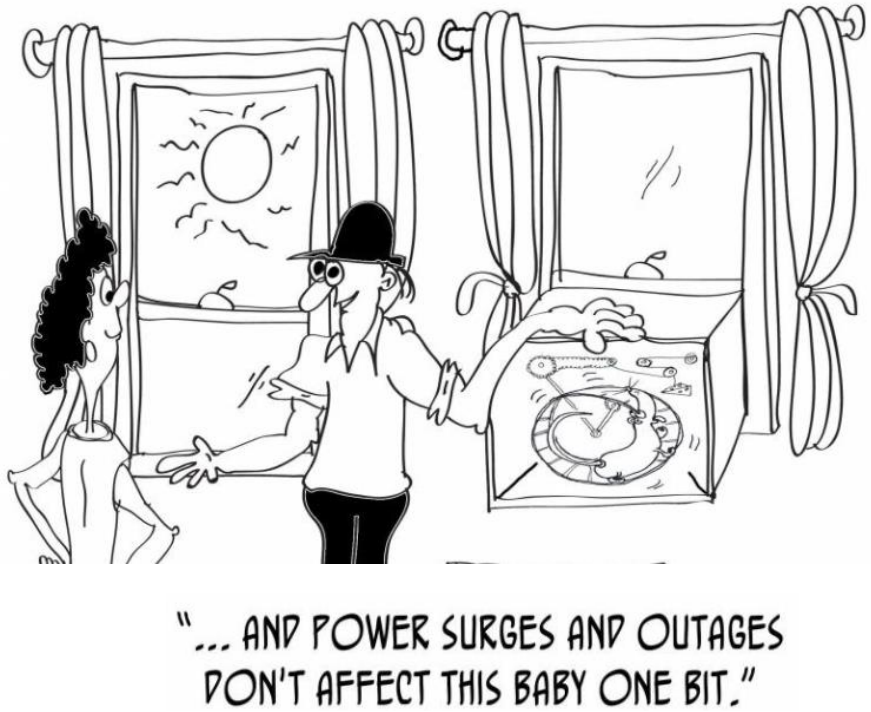
- Diabetes has been a continuous top 10 leading cause of death globally
- Insulin requires refrigeration at temperatures between 2°C and 8°C (35°F and 46°F)



https://www.huffpost.com/entry/diabetes-stats_b_4273505

Motivation

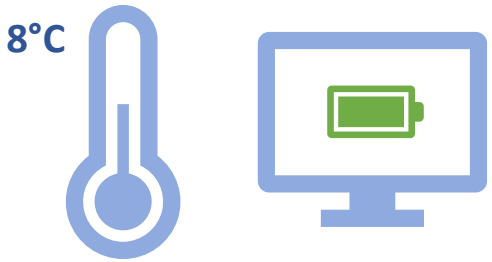
- Hurricanes cause power outages that can last for weeks on end
- Preventable diabetes-related deaths skyrocket
- Individuals with diabetes need access to a reliable way to preserve their medication



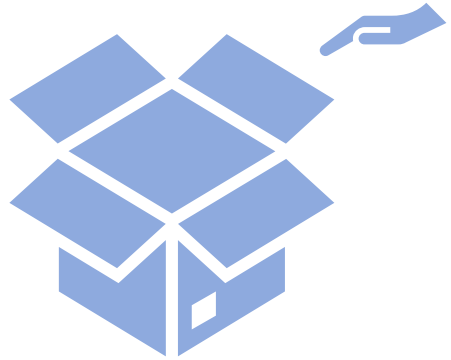
Lowest Level Functions

- Contain Contents

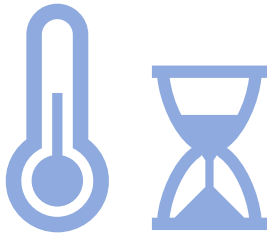
- Display Status



- Operate Device

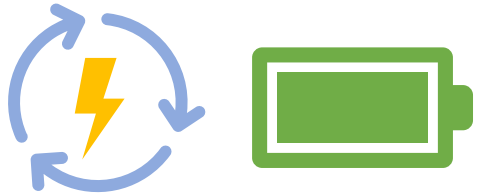


- Maintain Temperature



- Preserve Contents

- Store Power



Targets and Metrics

Determined from:

- Functional Decomposition
- Researching Industry Standards
- Consulting with Previous Team Members
- Customer Interviews

Targets and Metrics: Critical Targets

Store Medication

Sense Temperature

Secure Contents

Store Power

Targets and Metrics: Critical Targets

Store Medication 

TARGET		METRIC
Accommodate a 30-day supply of insulin	→	Successfully fit 3 insulin pens or vials
Attain an internal volume between 1,000 cm^3 to 5,000 cm^3	→	Measure dimensions and calculate volume
Access medication within 2 seconds	→	Test with stopwatch

Targets and Metrics: Critical Targets

Sense Temperature 

TARGET		METRIC
Read current temperature and detect when medication is outside the 2°C to 8°C range	→	Read temperature using thermocouple
Maintain appropriate temperature for 14 days	→	Conduct 14-day test using grid power to isolate the temperature system

Targets and Metrics: Critical Targets

Secure Contents

TARGET		METRIC
Protect the physical integrity of the medication (0 broken vials/pens)	→	Ensure all vials and pens are intact throughout testing
Durability enough to withstand mild impact (27 N)	→	Simulate impact resistance with a drop test from typical conditions

Targets and Metrics: Critical Targets

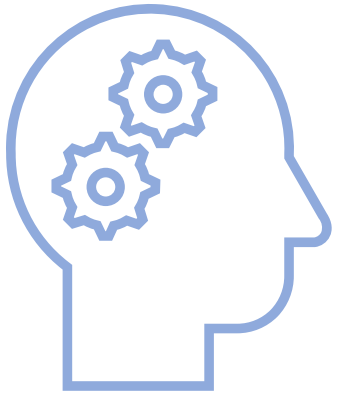
Store Power

TARGET		METRIC
Operate system on no more than 12 V, 6 A, 60W	→	Test values with a multimeter
Maintain power delivery for 14 days	→	Run device for 14 days with only attached power source

Methods of Concept Generation

Morphological Chart

Biomimicry



Crap Shoot

SCAMPER

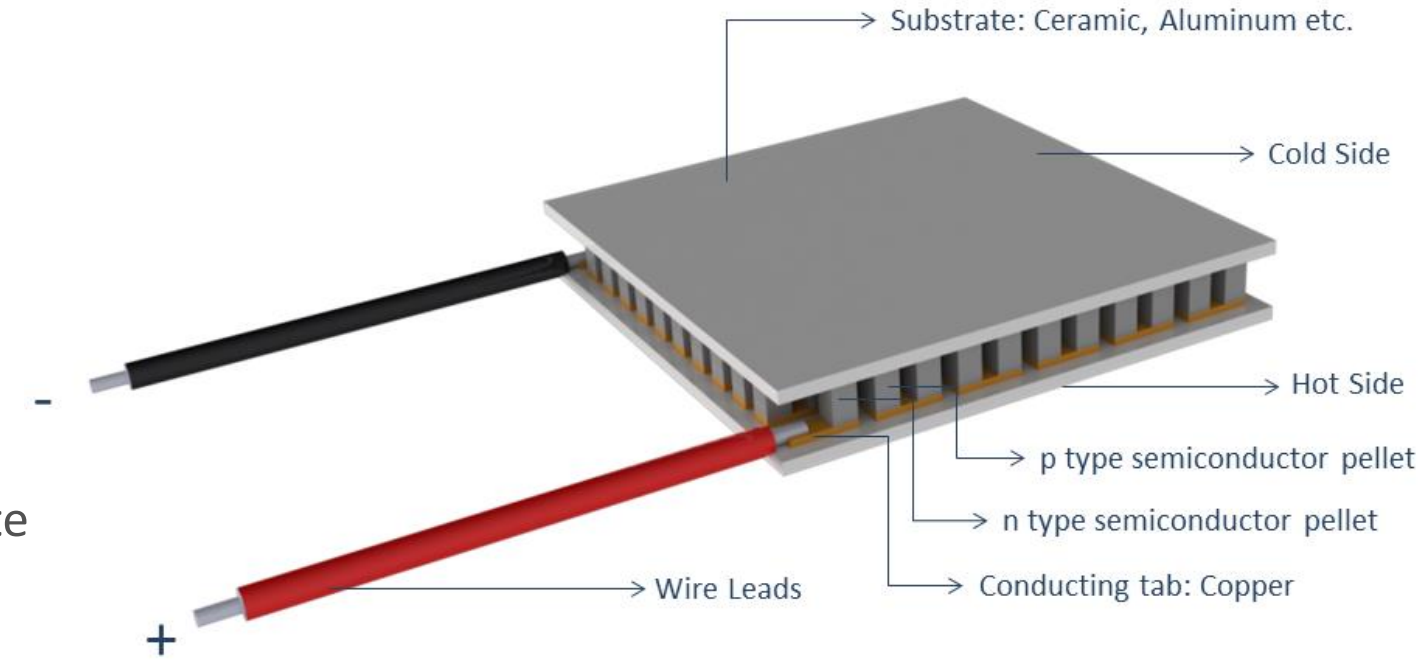
General Concept

- Hard-plastic cooler
- Battery powered
  - Solar panel charging
  - Mounted on the outside of the cooler
- Added Insulation
- Main differences are cooling systems

Concept #1

Bottom-Mounted Conductive TEC System

- TEC – Thermo-Electric Cooler
- Utilizes Peltier plate
- Medicine is pressed against cold-plate to maintain surface contact



Concept #2

Conductive Tunnel System

- Heat exchanger utilizes cross flow ventilation and Peltier plate for cooling
    - Designed to cool an aluminum plate via conduction

Concept #3

Liquid Heat Exchanger System

- Utilizes liquid to carry heat away and blows cold air into the system
- Maintain fluid

Concept #4

Convective Fan TEC System

Utilizes convective cooling means with a fan + heatsink on

both sides of Peltier plate

Concept #5

Alternating Liquid Compressor and TEC system

- Liquid compressor cooler
  - Used only when there's a reliable power source
- Peltier cooling system

Concept #6

Aluminum Mesh Conductive TEC System

Cold plate adapter with thin pieces of aluminum mesh to increase contact area

Concept #7

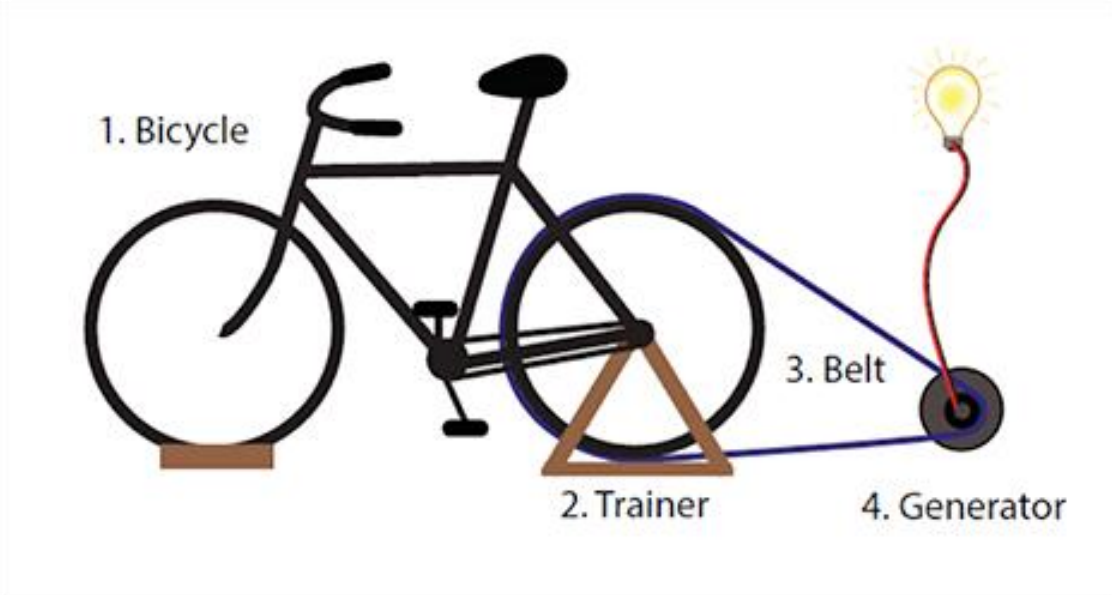
Side-Mounted Conductive TEC System

- Mounted to the side of the cooler
- Medication is secured to cold plate using elastic bands

Concept #8

Mechanically Powered TEC System

- Use of a conductive Peltier module
- Mechanical generator charges battery



Concept Selection

Selection Tools Utilized

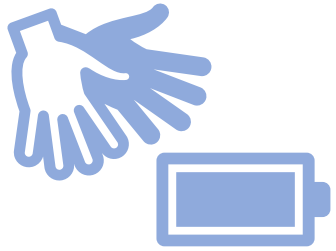
- Binary Pairwise Comparison
- House of Quality
- Pugh Chart
- Analytical Hierarchy Process (AHP)

Binary Pairwise Comparison

- Compares the customer needs to establish which are the most important
- Used in weighing the customer needs for HOQ

Customer Requirements			
Top Level (4-6)	Store Power	Securing Medication	Appropriate Temp for Extended Time
Mid-Level (1-3)	Ease of Operation	Display Status	
Low Level (0)	Portable		

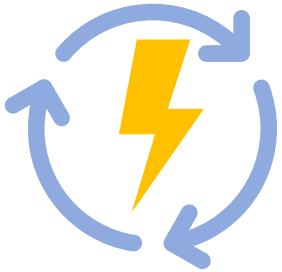
House of Quality



Access Power Supply

Activate Cooling

Access Contents



Regulate Power

Insulate Compartments

Cost

Pugh Chart - Competitor

HomeCare Portable Medicine Refrigerator

- Meant for one insulin pen
- Plugged directly into a wall
- Cooled by convection
- LCD screen and buttons to adjust the temperature of the device

Pugh Chart

- Concept 1: Conductive TEC mounted to the bottom
- Concept 2: Conductive Tunnel Heat Exchanger
- Concept 6: Convective TEC
- Concept 7: Conductive TEC mounted to the side

Selection Criteria	HomeCare Portable Medicine Refrigerator	1	2	3	4	5	6	7	8
# of pluses		4	4	3	3	3	4	4	3
# of minuses		1	2	1	2	2	1	1	3
# of S		1	0	2	1	1	1	1	0

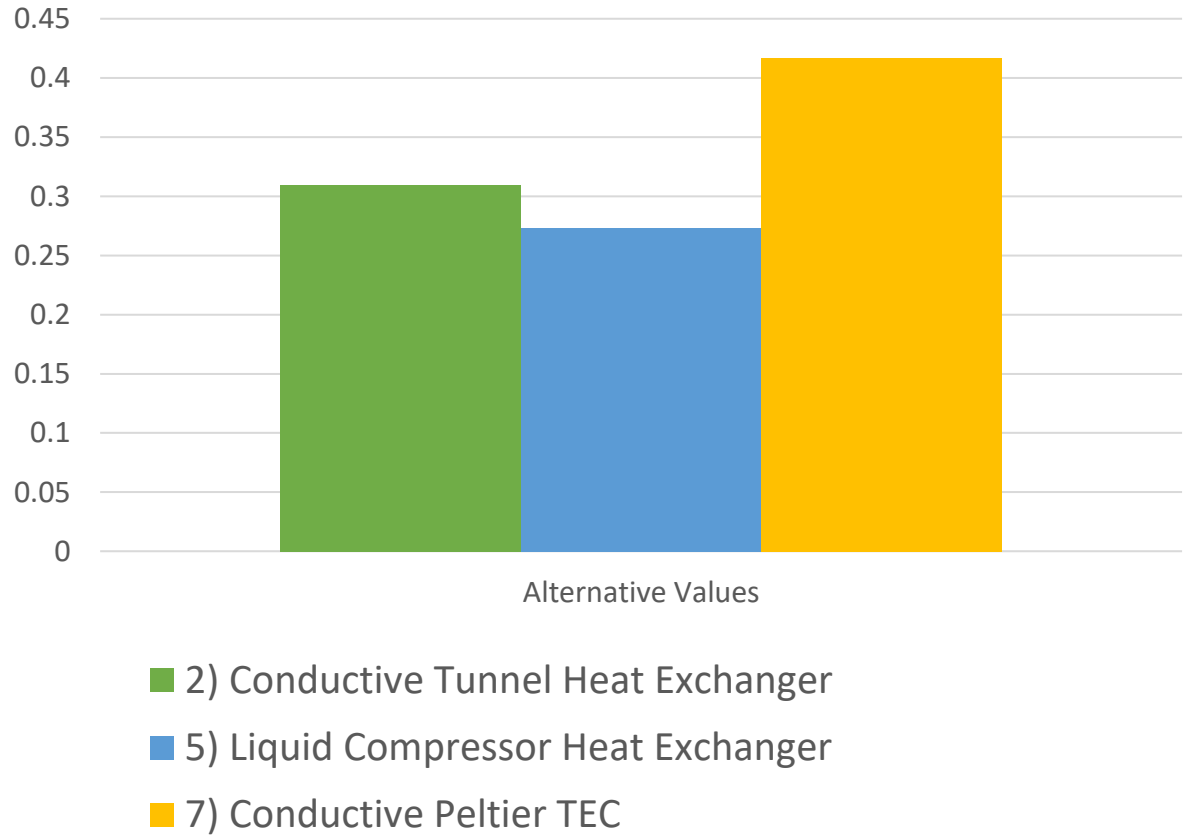
Pugh Chart

- Concepts 1 and 7 tied
- Both are Peltier TEC
- Only difference is mounted to side vs. mounted to bottom

Selection Criteria	Concept 2	1	6	7
# of pluses		3	3	3
# of minuses		0	1	0
# of S		3	2	3

Analytical Hierarchy Process

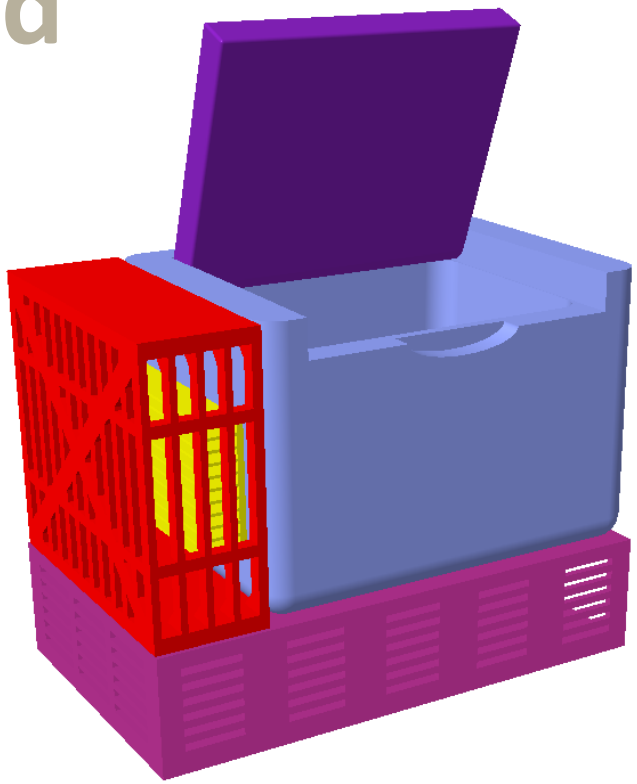
- Compare concepts 2, 5, and 7
- Establish numerical weights for our top engineering characteristics
- Concept 7: Conductive Peltier TEC mounted to the side was the winner

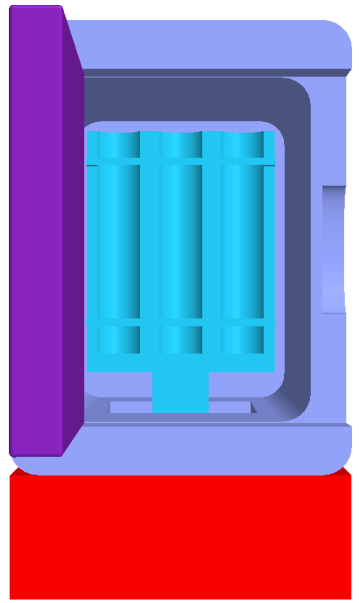


Final Concept Selected

Side-Mounted Conductive TEC System

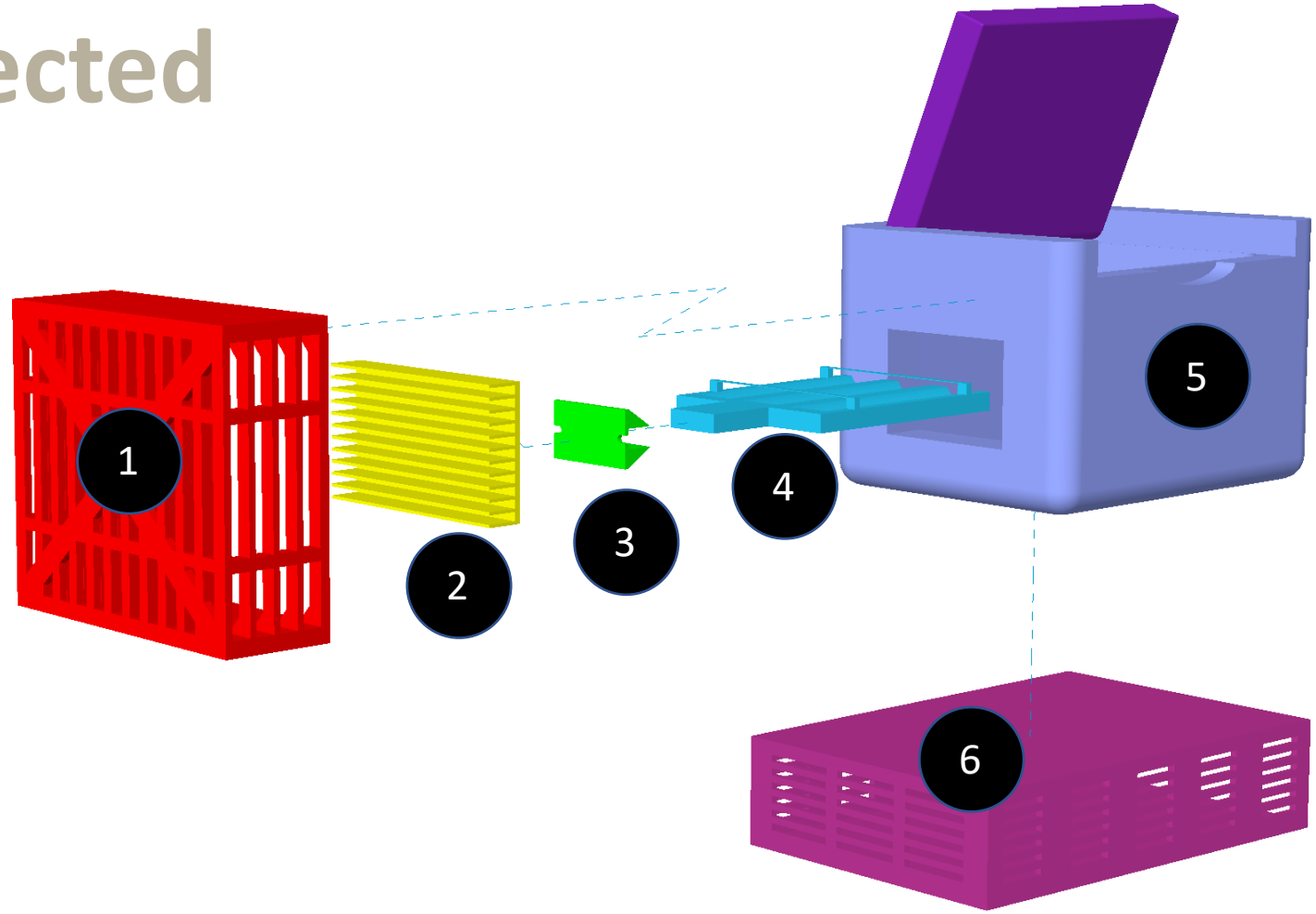
- Powered by battery and solar panel
- Temperature control switch
- Grooved cold plate + adapter
- Strap over cooling plate to hold contents





Final Concept Selected

1. Protective Fan Ventilation Gate
2. Thermoelectric Cooling Module with Peltier Plate
3. Cold Plate Adapter
4. Grooved Cold Plate with Elastic Bands
5. Cooler w/ Added Insulation and Seals
6. Battery Compartment



DESIGN TIMELINE

SEPTEMBER TO DECEMBER

2020 FALL