MHPGA
(Mobile Hybrid Power Generation Apparatus)

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ABSTRACT

- Grid connection not always an option for power, on-site power generation needed
- Hybrid power generation and storage options exist but not for cold climates such as northern Alberta
- Created project is intended to operate in -50C to +50C and includes:
  - AC powered generated by the client's gas-powered generator and charges a battery
  - DC power from battery goes through an inverter to power the desired electrical product
  - DC power used to:
    - Heat enclosure using PTCs
    - Circulate air for heating and cooling through fans
    - Power the user interface/control panel
  - Heating from generator exhaust
- Project is created to reduce generator run hours and fuel consumption

INTRODUCTION/PROBLEM

- Generators are sized by their peak load capacity but are often used for smaller loads. This increases generator costs and decrease efficiency [1] [2]
- Running a generator to charge a battery allows it to only be run at it's peak and most efficient load
- Battery energy storage systems (BESS) are rarely used due to their inability to operate in cold climates
- Lead-acid battery loose capacity when operated at cold temperatures (as low as 60% of max capacity at -20C)
- Lithium-iron phosphate batteries are damaged if charged below 0C
- Efficient heating needed to maintain battery capacity and safe charging, or cold resistant battery and other electronics required

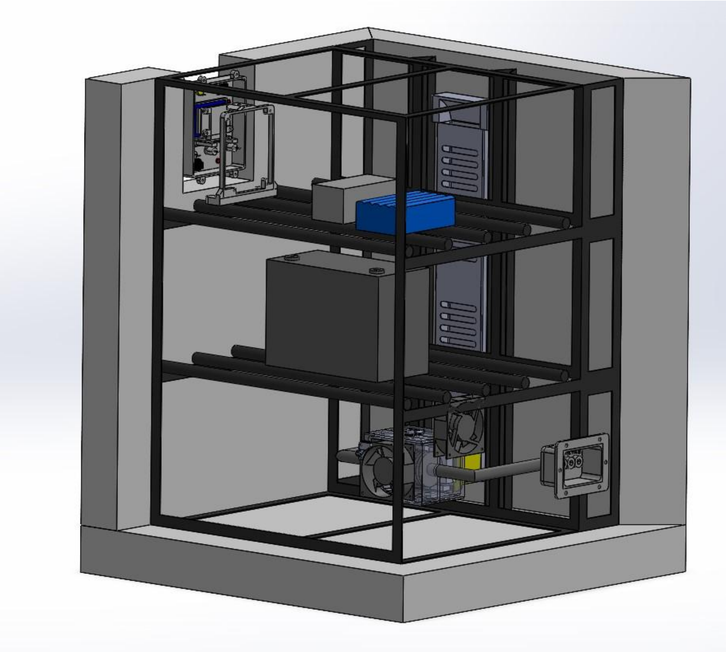


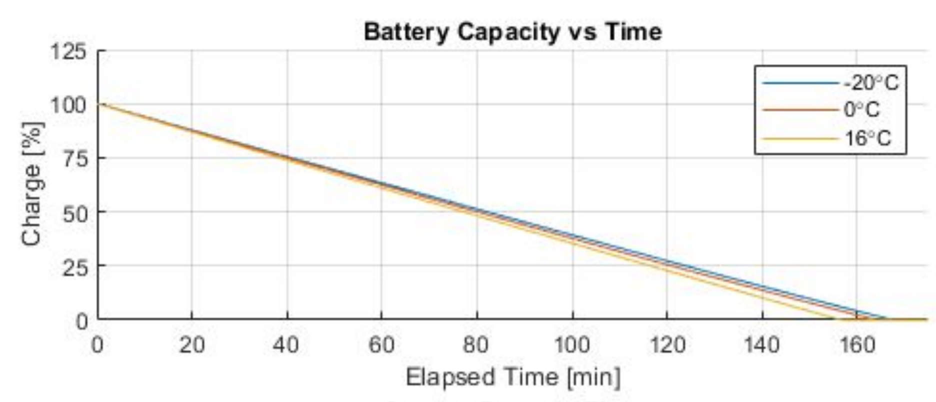
Figure 1. CAD Model.

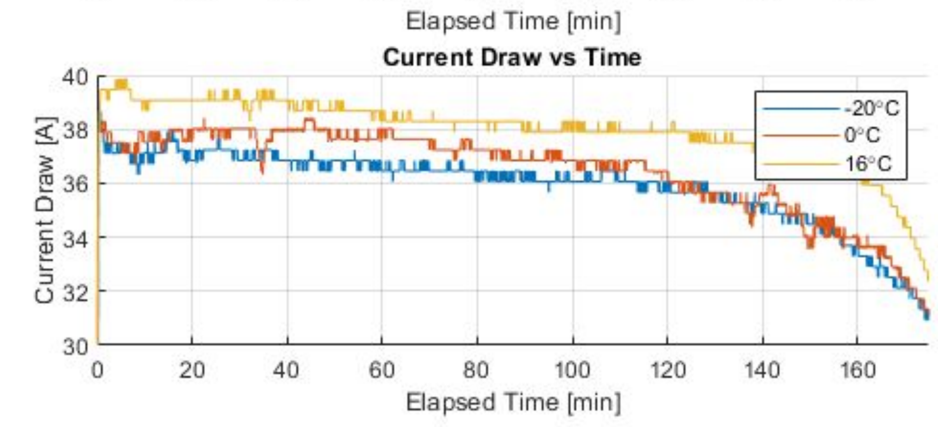
METHODS & MATERIALS

- CAD shown in figure [1] (bottom left)
- Frame:
  - Metal frame for rigidity and heat transmission
  - Mounts and other modifications welded on
- Enclosure: Build shown in figures [2] and [3]
  - R32 insulation foam for high heat retention
  - Removable door and control panel hatch for ease of access
  - Waterproof to resist the elements
- Castor wheels for mobility
- Heating box: shown in figure [4]
  - 3D printed from poly carbonate with a melting temperature of 100C
  - Contains the PTCs, radiator and circulation fan for heating
- PTCs:
  - Positive temperature coefficient heaters reach 120C and maintain that temperature
  - Electronic heating for when generator is not running
- Radiator:
  - Mild steel radiator tube routes generator exhaust
  - Air to air heat exchanger
  - Ball valve outside of enclosure on radiator tube to route exhaust into or out of enclosure
  - Vents to atmosphere
- Air duct:
  - Bent sheet metal (steel) to distribute hot air output
  - Attached to heat box output
- Cooling fan:
  - Intake and outtake for fresh air flow
  - Removable inserts client must remove for air flow
- Control Panel: shown in figure [5]
  - Facilitates user interface and displays data
  - Client can change temperature range for heating and cooling
  - USB input for data downloading and uploading software updates
  - Input and output voltages and currents displayed
  - LED lights show battery, heating and unit status
  - Switch to change generator control to on, off or automatic
  - Emergency software stop
- PCB
  - Main processing center for all information and control
- Relays
  - Switches power on and off for PTC heaters and generator
- Charger
  - Charges battery from AC input (wall plug charging)
- Inverter
  - Converts DC current from battery to AC for consumption
- Generator start/stop
  - Electronically controls generator
- Emergency stop
  - Emergency hard stop for all connections

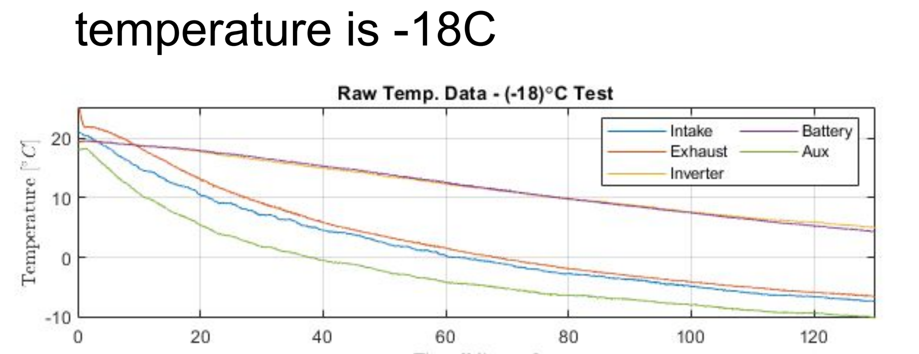
TESTING & RESULTS

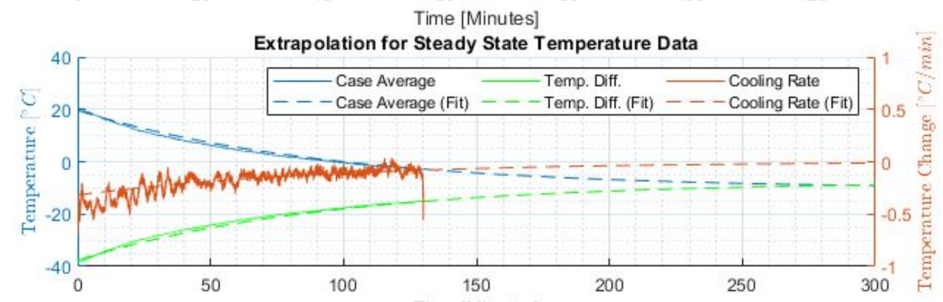
- Battery capacity and current draw over time at different temperatures





- Cool down time of unit from internal temperature of 20C and external temperature is -18C





- Heating rate of PTC heaters and/or exhaust radiator to heat the unit

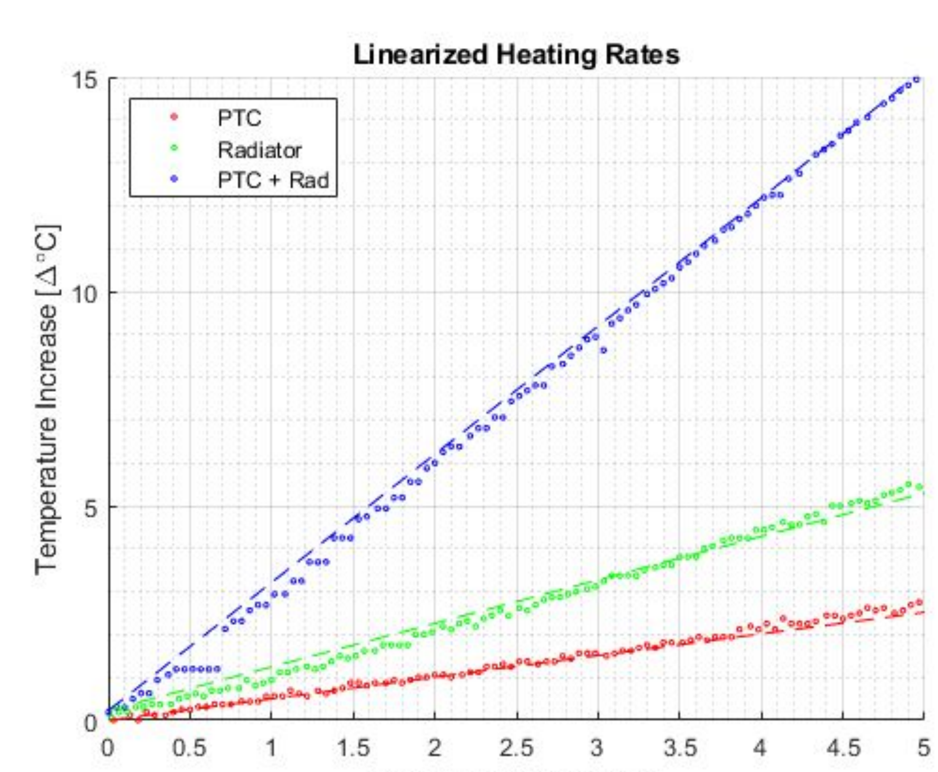


Figure 2. Enclosure of System

Figure 3. Inside View

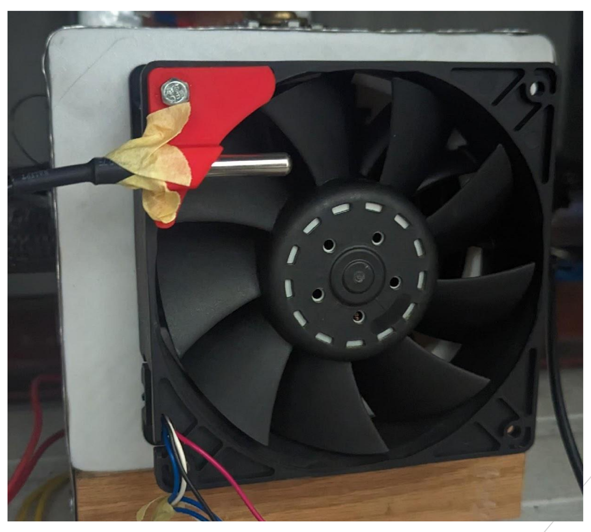
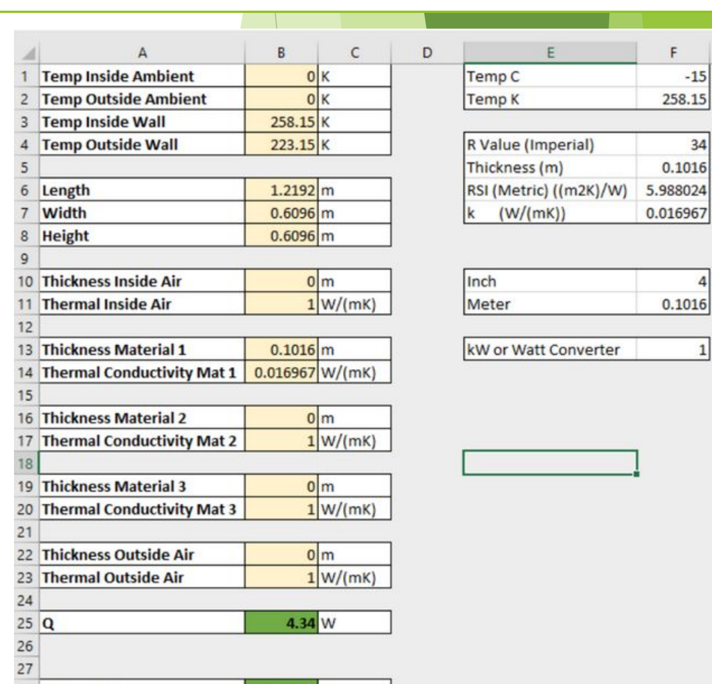


Figure 5. Heating Box

Figure 4. Control Panel

DISCUSSION

- Heating box & placement:
  - Heating box required to be on the bottom to create the shortest exhaust connection possible
  - Fan needed to be close to radiator to move hot air instantly and prevent overheating
  - PTCs also needed to be right beside fan to help cool to heaters and move the hot air instantly
  - Fan can only blow hot air, not suck in to prevent fan melting and overheating
  - Heating calculations were conducted to determine heat in wattage needed to reach desired temp. and maintain temp. (figure [6])
- Microprocessor decision:
  - Processor needed high SRAM to run all components and high refresh rate
  - 7-12V power supply
  - Low cost
  - >50kb flash memory
  - Arduino Mega fit all criteria (compared to Arduino Due, Uno, ESP32 and Rpi Zero) [3]
- Battery decision:
  - High-capacity at -20C [6] [7]
  - Preferably low cost
  - Typical life cycles >1000
  - Energy density >100 Wh/L [5]
  - C rating >20
  - Specific energy >60 Wh/kg [4]
  - Lithium titanate and lithium iron phosphate batteries passed all criteria but price (in comparison to nickel metal hydride and led acid) LiFePO4 chosen for lower cost.



	A	B	C	D	E	F
1	Temp Inside Ambient	0	K		Temp C	-15
2	Temp Outside Ambient	0	K		Temp K	258.15
3	Temp Inside Wall	258.15	K			
4	Temp Outside Wall	223.15	K		R Value (Imperial)	34
5					Thickness (m)	0.1016
6	Length	1.2192	m		RSI (Metric) ((m2K)/W)	5.988024
7	Width	0.6096	m		k (W/(mK))	0.016967
8	Height	0.6096	m			
9						
10	Thickness Inside Air	0	m		Inch	4
11	Thermal Inside Air	1	W/(mK)		Meter	0.1016
12						
13	Thickness Material 1	0.1016	m		kW or Watt Converter	1
14	Thermal Conductivity Mat 1	0.016967	W/(mK)			
15						
16	Thickness Material 2	0	m			
17	Thermal Conductivity Mat 2	1	W/(mK)			
18						
19	Thickness Material 3	0	m			
20	Thermal Conductivity Mat 3	1	W/(mK)			
21						
22	Thickness Outside Air	0	m			
23	Thermal Outside Air	1	W/(mK)			
24						
25	Q	4.34	W			
26						
27						
28	Q (System)	21.72	W			

Figure 6. Heat Calculations

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