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 its 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 -20°C).
- Lithium-iron phosphate batteries are damaged if charged below 0°C.
- Efficient heating needed to maintain battery capacity and safe charging, or cold resistant battery and other electronics required.

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 -50°C to +50°C 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.

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 polycarbonate with a melting temperature of 100°C.
  - Contains the PTCs, radiator, and circulation fan for heating.
- PTCs:
  - Positive temperature coefficient heaters reach 120°C 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

- 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 -20°C [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 lead-acid) LiFePO4 chosen for lower cost.

DISCUSSION

- Battery capacity and current draw over time at different temperatures.
- Cool down time of unit from internal temperature of 20°C and external temperature is -18°C.
- Heating rate of PTC heaters and/or exhaust radiator to heat the unit.

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