

**Methanol
Dynamics**

Fuel Cell

Jack, Karam, Max
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Fuel Cell Market

- [11 Billion](#) dollar global market by 2029
- Uses: electricity production, vehicles, energy storage
- Methanol in particular- less developed



SWOT Analysis

Strength

Energy Density

Methanol has a higher volumetric energy density than other fuel cell materials like hydrogen. When considering conversion efficiency it is competitive with gasoline.

Weakness

Toxicity and Flamability

Methanol is toxic and can cause vomiting, blindness, and liver damage if accidentally consumed. In addition it has a high vapor pressure and is flammable.

Opportunity

Ease of Operation

Methanol fuel cells can be fed with a dilute liquid feed. This makes fuel storage easy and operation relatively risk-free when compared with other fuels and materials.

Threat

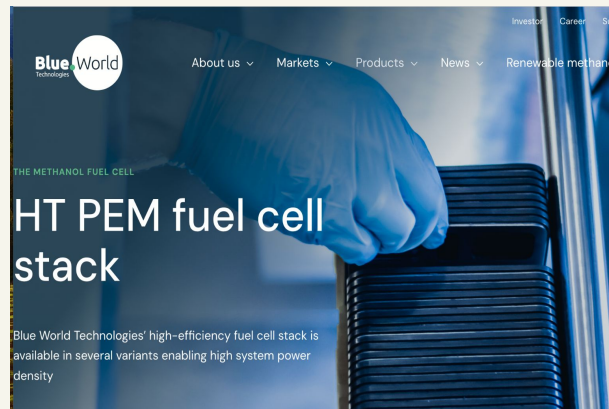
Competition from Hydrogen

Hydrogen fuel cell technology is much more well-known and has received more research and attention, leading to less focus on methanol.

Competitor Analysis

- DMFCs used today in 1. *portable power applications* and 2. *Defense*
- Popular for portable power applications due to their modularity and high power density
- Popular with defense due to low noise and minimal thermal signatures, i.e. applicable to covert military operations
- Portable power applications spotlight:
Blue World Technologies ApS (Danish)
- Defense spotlight:
SFC Energy (German)

HT PEM fuel cell stack
(Blue World)
vapor feed
operates at -30°C to +50 °C
39 kg / 57 kg
9 kW/ 18 kW
43 V / 77 V output voltage
\$4,500 / \$ 9,000



SFC Fuel Cells
for tactical and professional
applications

For the special requirements of military users and security applications, SFC Energy offers a special fuel cell portfolio as well as a coordinated power management systems.

SFC Public Security

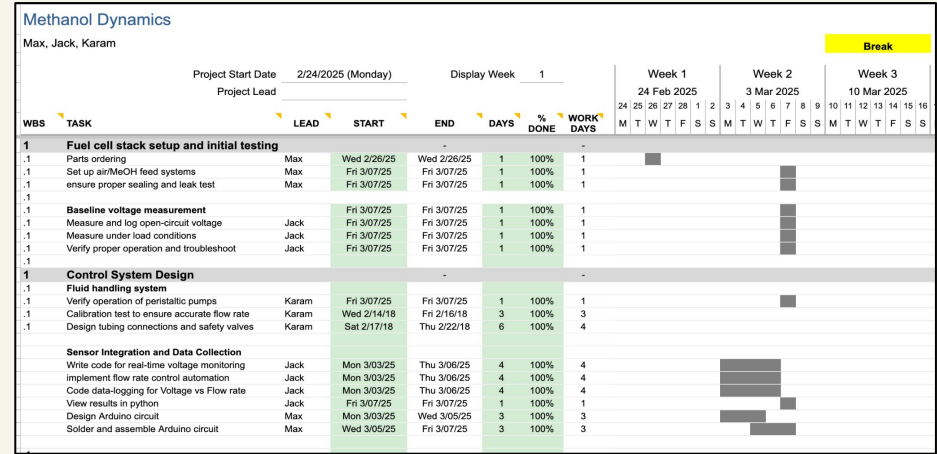
EMILY3000 (SFC Energy)
liquid feed
10L fuel cartridge
operates at -25°C to +50 °C
12 kg
88 hours at 3000 Wh/day (full cartridge)
12-24 V output voltage
\$20,000-\$30,000 range

Marketing Strategy and Opportunity

- **Target Recreational & Off-Grid Consumers** – Target campers, RV users, and outdoor enthusiasts seeking reliable, clean portable power
- **Target Military & Defense** – Focus on tactical applications requiring low-noise, low-thermal signature power for covert operations
- **Geographic Focus – Developed Markets** – Prioritize North America, where competitors dominate the European market
- **Geographic Focus – Emerging Markets** – Expand into Southeast Asia and Latin America, where grid instability drives demand for off-grid solutions
- **Leverage Green Energy Incentives** – Capitalize on tax benefits and government/corporate subsidies, though opportunities in North America may be limited (Trump administration)
- **Strategic Partnerships in Renewable Energy** – Collaborate with battery and renewable energy companies to develop hybrid systems

Progress & Timeline

- GANTT chart main tool for timeline setup and task distribution
- Log updated consistently to track progress in accordance with the GANTT chart
- Please consult GitHub page to access GANTT chart and log



Snapshot of the GANTT chart

| A | B | C | D |
|---------|--------------------------|------------------------------|-------|
| Circuit | <input type="checkbox"/> | Find and learn to use MOSFET | Jack |
| | <input type="checkbox"/> | Solder new circuit | Jack |
| | <input type="checkbox"/> | Solder battery attachments | Jack |
| | <input type="checkbox"/> | Close box | All |
| Code | <input type="checkbox"/> | Code the feedback loop | Max |
| | <input type="checkbox"/> | Code user friendly interface | Max |
| Others | <input type="checkbox"/> | Final Report | Karam |
| | <input type="checkbox"/> | Slide deck | Karam |
| | <input type="checkbox"/> | Website | All |
| | <input type="checkbox"/> | Run cell with water | All |

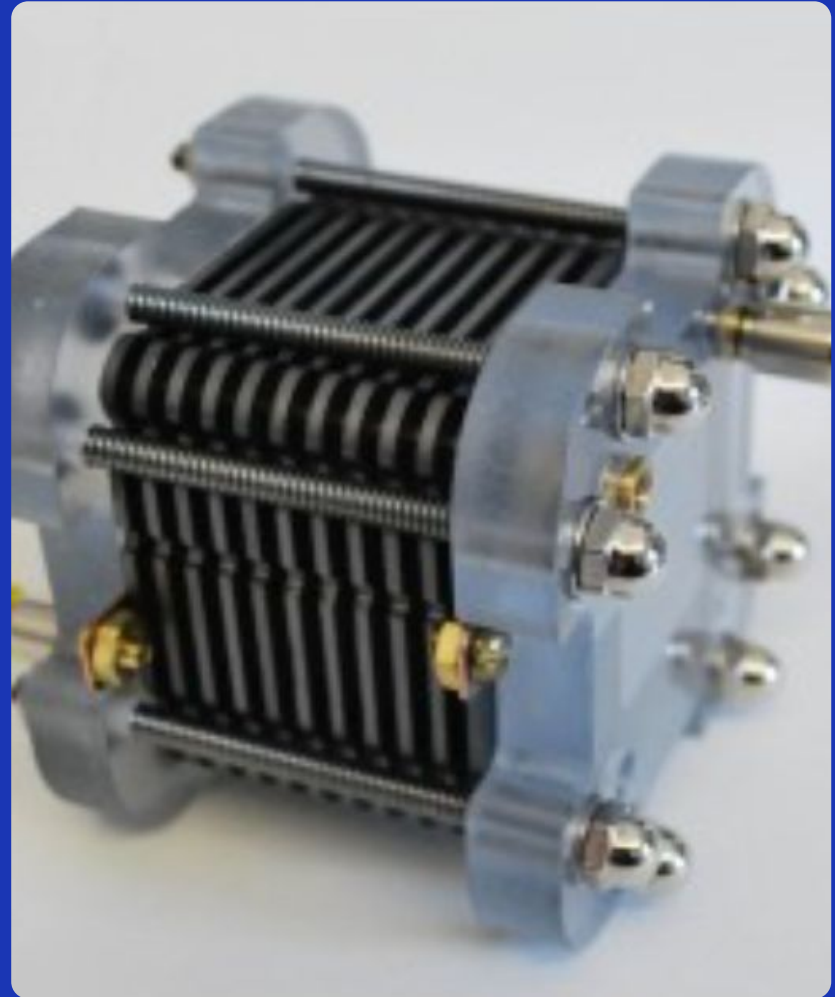
Final stretches to complete... (updated on GANTT chart)

Fuel Cell Design

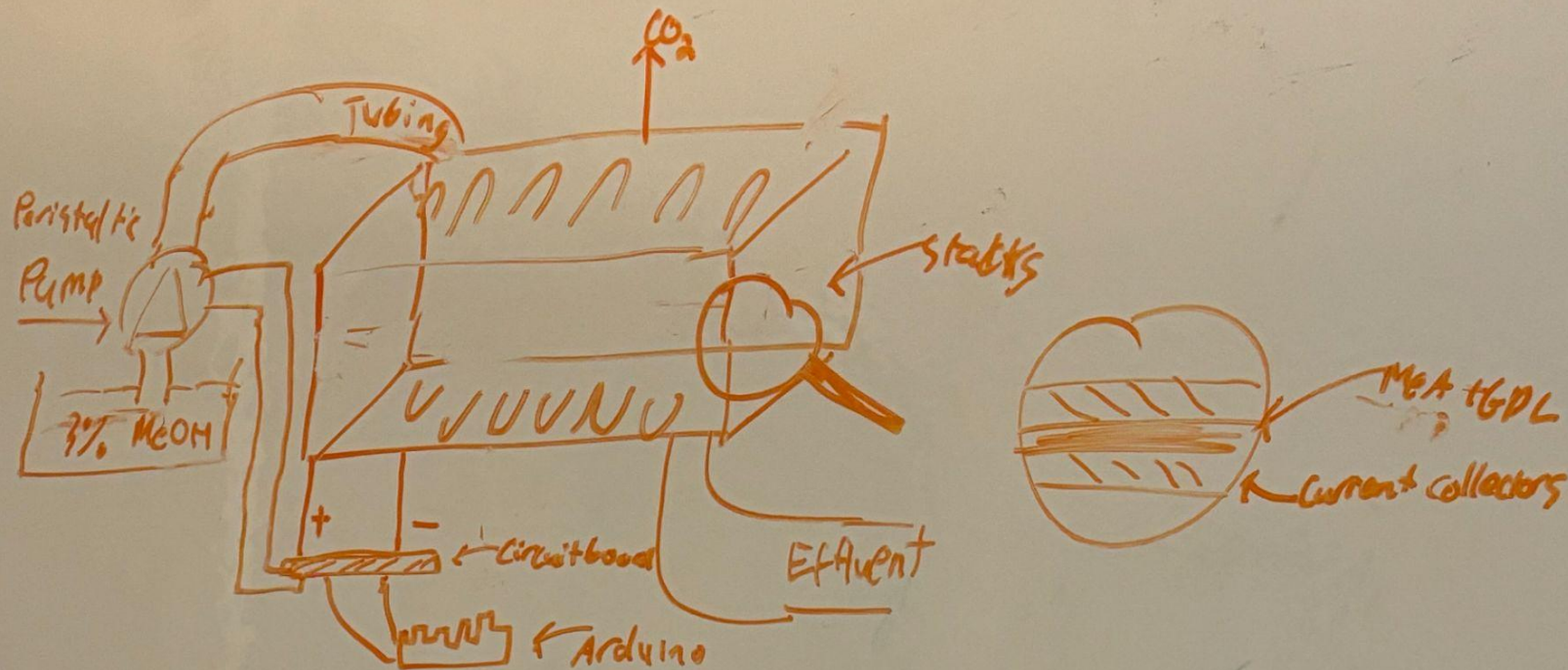
Circuitry
Feed
Pump and Casing

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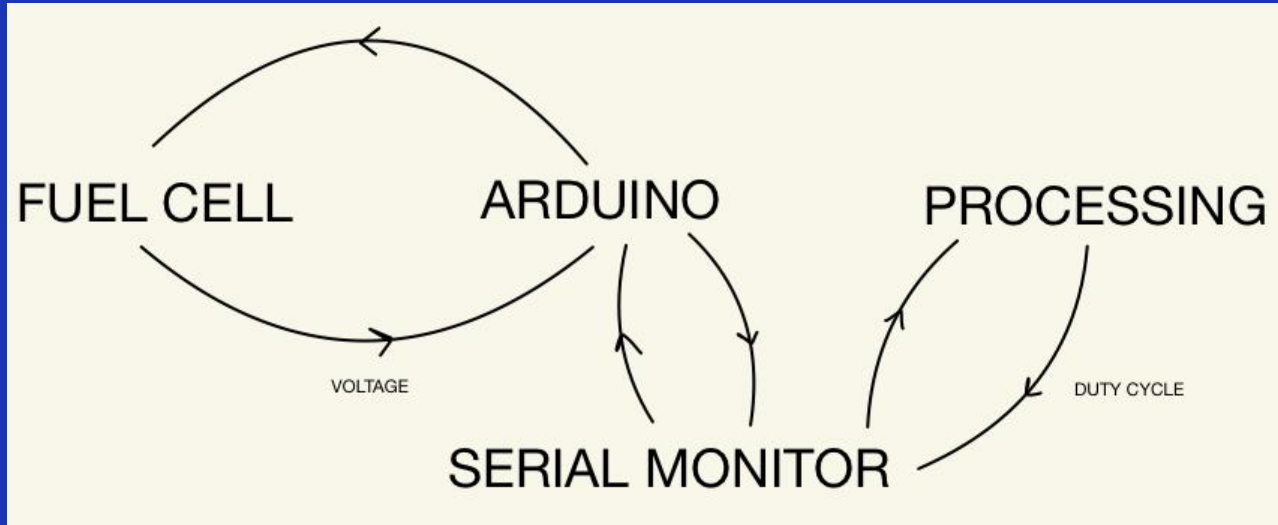
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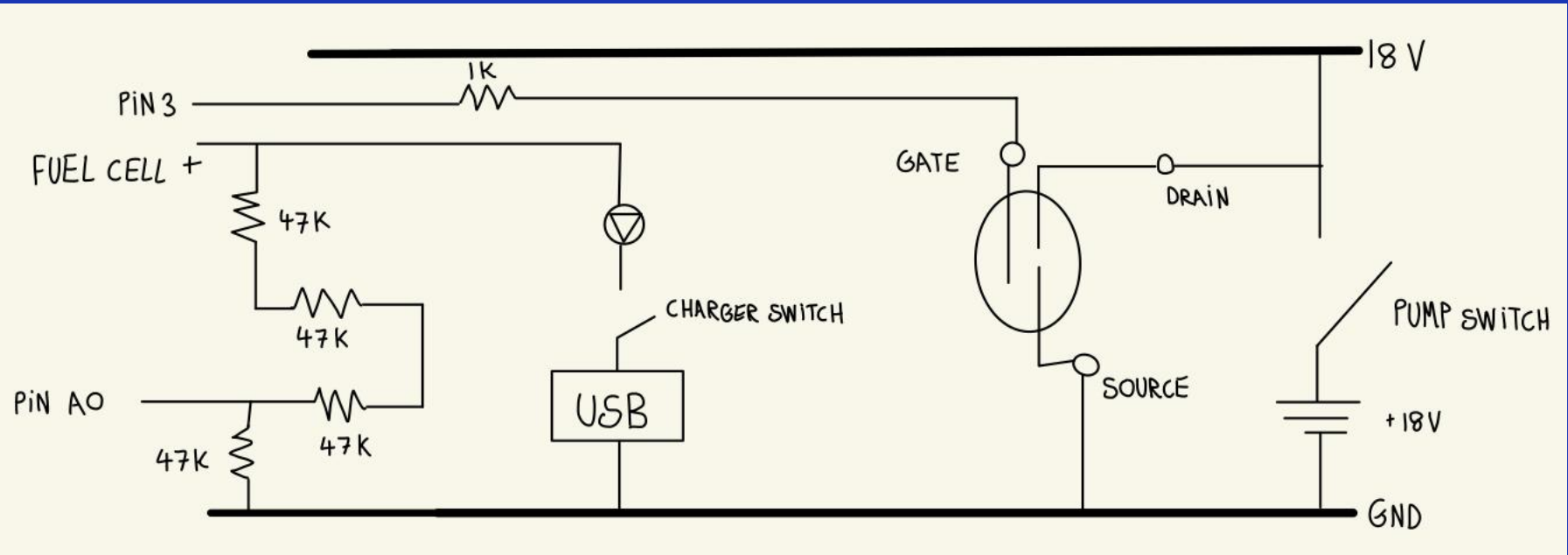
Initial Design Plan



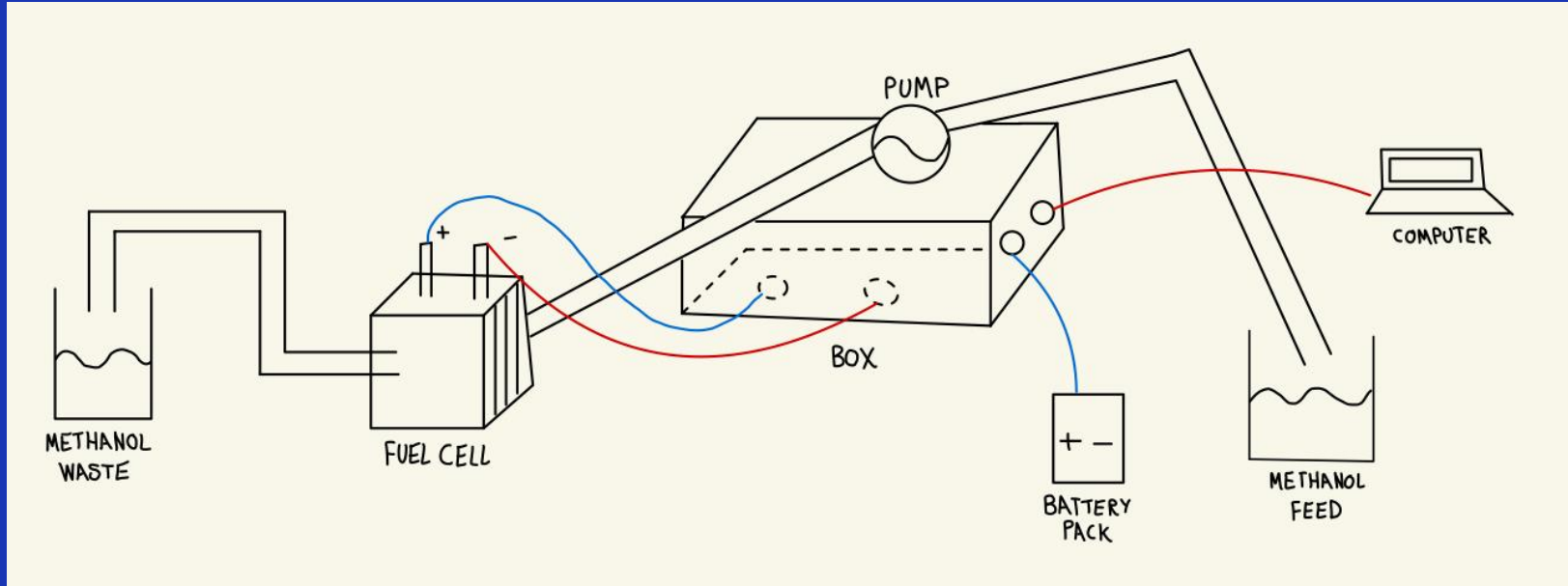
Final Design Plan: *Information Flow*



Final Design Plan: *Circuitry*

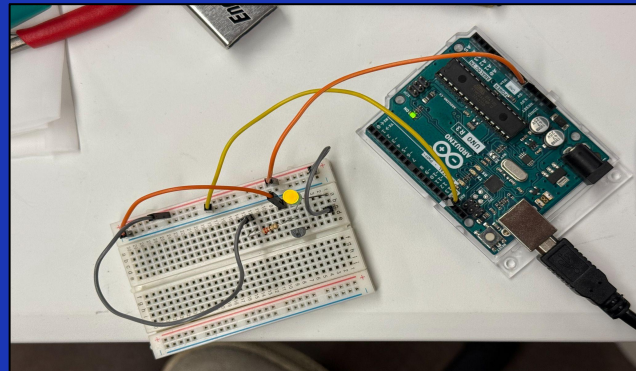


Final Design Plan: *Architecture*



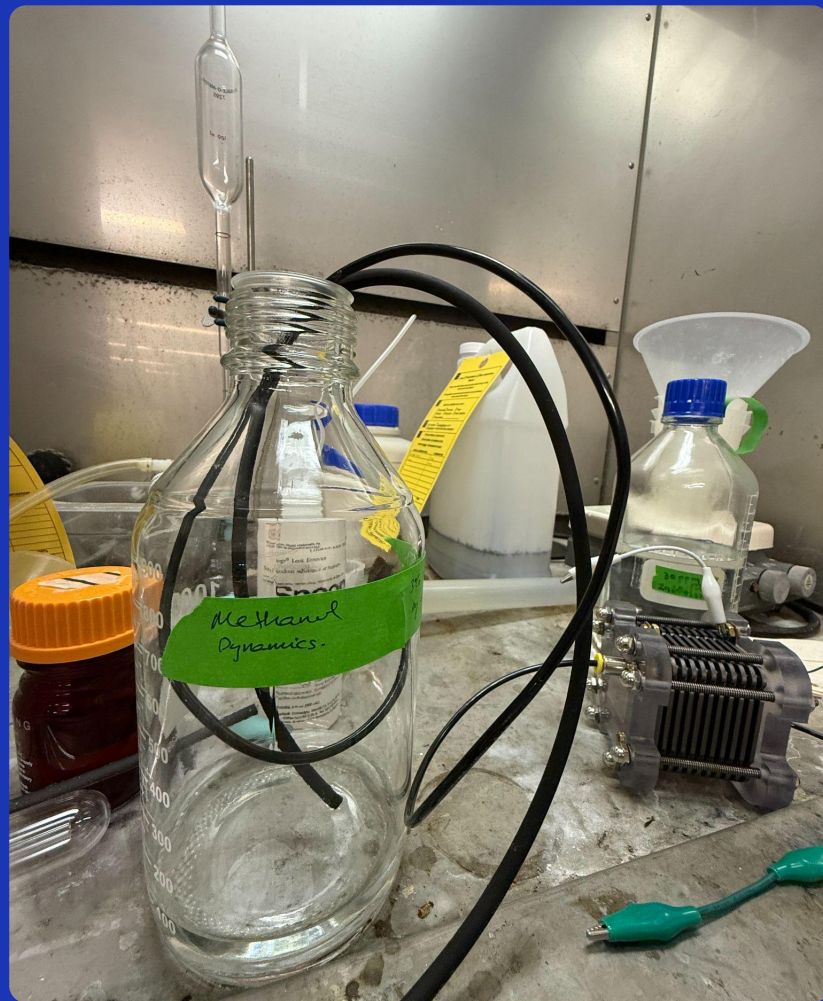
Circuitry

- Goal to charge a 20,000 mAh power bank in < 24 hours
- Desired current: 833 mA
(20,000 mAh / 24h = 833 mA)
- Desired voltage: 12V
(operating voltage of pump)
- Desired power: 3.75 W
(Wh = (20,000 mAh * 4.5V)/(1000) = 90 Wh)
(90 Wh / 24 h = 3.75 W)
- 33% voltage efficiency thus far given our actual 4.5 V output
- Arduino script modulates pump by rapidly switching it on/off at a set frequency to achieve desired power output
- MOSFET transistors (voltage-mediated) instead of BJT transistors (current-mediated)



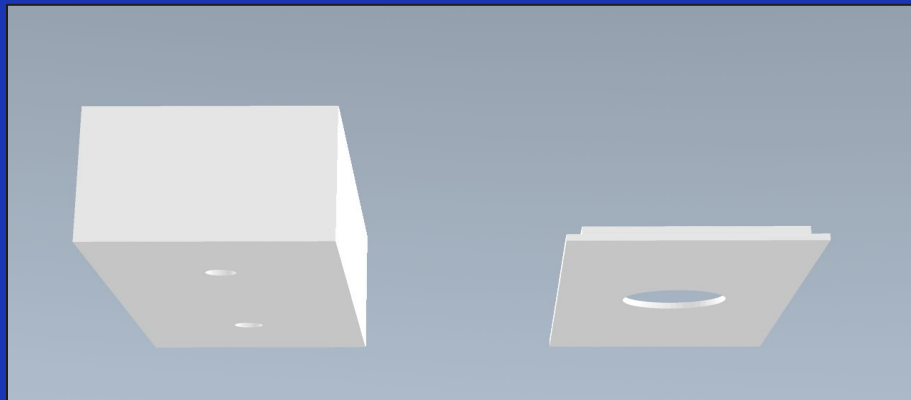
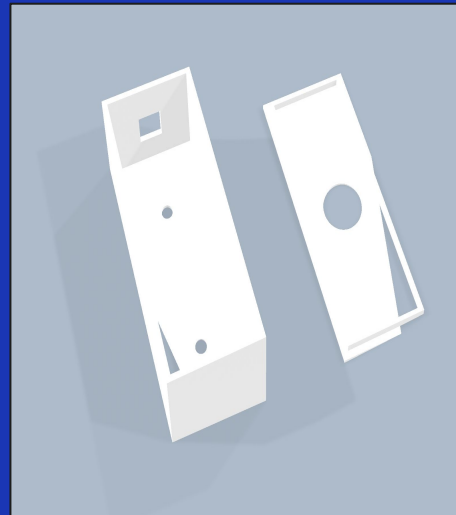
Feed

- 3% methanol (~1M) feed
- Possible byproducts include CO, CO₂, hydroxymethyl-group compounds
- Airflow may limit performance; fan supplies air to fuel cell
- 4.32 L methanol required; 10 L stocked ($3 \text{ mL/min} * 1440 \text{ min/day} = 4.32 \text{ L}$)
- Assume 24h feed



Pump and Casing

- 100-150 mA, 12V peristaltic pump
- 3D-printed casing to house circuitry
- Larger hole in lid to accommodate for pump
- Two smaller holes on bottom of box to accommodate for leads to fuel cell (ground, voltage circuit, USB)
- Square hole on side of box to accommodate for USB connection to Arduino



Setbacks, opportunities, and growth

- **Unable to confirm if air was a limiting factor due to lack of control over airflow**
 - **Lower-than-expected voltage efficiency (~33%), limiting effective power delivery**
 - **Occasional transistor failures ("frying") from voltage or thermal issues**
 - **Low current delivery; implying low conversion of methanol**
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- **Explore adjustable-flow pumps to eliminate the need for Arduino-based modulation**
 - **Replace MOSFET setup with a more efficient DC-DC converter for stable output**
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- **Applied mass and energy balances to design fuel and air feed systems**
 - **Applied chemical process safety principles, particularly in handling methanol**
 - **Gained hands-on skills in soldering and Arduino script programming**