CBE 3300B Power Estimates

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Power Estimations and Fuel Calculations

System Parameters

- **Fuel Cell Stack:** 10 cells in series
- **Active Area per Cell:** 10 cm^2
- **Estimated Current Density:** 50–100 mA/cm^2
- **Total Current Output:** 5 A (at 50 mA/cm^2)
- **Expected Voltage Output:** 3.8 V under load, 4.3 V open circuit
- **Expected Power Output:** 19 W at 50 mA/cm^2, up to 32 W at 100 mA/cm^2

Methanol Consumption Estimate

- **Feed Concentration:** 3% methanol by mass (approx. 1M)
- **Feed Rate:** 100 cc/min = 6 L/hr
- **Specific Gravity of Methanol:** 0.792 g/mL
- **Estimated Methanol Content:** $\sim$143 g/hr
- **Energy Density of Methanol:** 6 kWh/kg
- **Effective Power (20% conversion efficiency):**

$$P = 143\,g/hr \times \frac{6\,kWh}{1000\,g} \times 0.20 = 0.17\,kWh/hr = 170\,W$$

Discrepancy in Theoretical vs Experimental Power

- Power estimated from current density and area: 19–32 W
- Power estimated from fuel energy content and conversion efficiency: 170 W
- **Conclusion:** Discrepancy of nearly one order of magnitude suggests potential overestimation of methanol conversion efficiency or underestimation of actual current output. Further experimental validation is needed.

Charge Time Estimation

- **Battery Target:** 20,000 mAh at 4 V = 80 Wh
- **Assuming Ideal Output:**

$$t = \frac{80\,Wh}{19\,W} \approx 4.2\,hours$$

- **Optimistic Scenario:** 3 hours (with higher current or power output)
- **Conservative Target:** Charging within 24 hours would still represent a successful benchmark

Crossover and Efficiency Considerations

- Pure methanol leads to higher crossover, resulting in cathode poisoning and wasted fuel.
- Voltage decay due to crossover can reduce performance by up to 30% within the first few hours.
- **Decision:** Start with 1M methanol feed and incrementally increase concentration while monitoring crossover and power output. Crossover is especially significant for longer operating times.