

## Introduction

- Mankind is using more than one million terajoules energy every day. The world's energy consumption is also expected to have increased by 50 percent by 2040.<sup>1</sup>
  - There is large promise in the future of hydrogen power. Its energy efficiency of around 50-75% is more than twice that of most other fuel sources<sup>2</sup>.
- The pitfalls and hurdles to overcome to make Hydrogen a viable fuel source were investigated for industrial and commercial purposes.
- Different Variables that were Targeted:
  - Efficiency; Safety/Optimization; (future: Cost Effective)

## Methods

- We compare the energy content of gasoline, diesel, hydrogen, and electricity in normal conditions to measure the efficiency of hydrogen.

**Table I: Energy content on different conditions of 4 fuels**

	Gasoline	Diesel	Hydrogen	Electricity
GGE	1 gallon	1.12 gallon	2.25 lbs	34 kWh
Energy Content (EC) on lower to	114,102 Btu/gal	128,488 Btu/gal	51,585 Btu/lb	3,414 Btu/kWh
EC on higher to	122,364 Btu/gal	138,490 Btu/gal	61,013 Btu/lb	3,414 Btu/kWh
EC in normal condition (MJ/kg)	45.8	45.3	142	0.5*

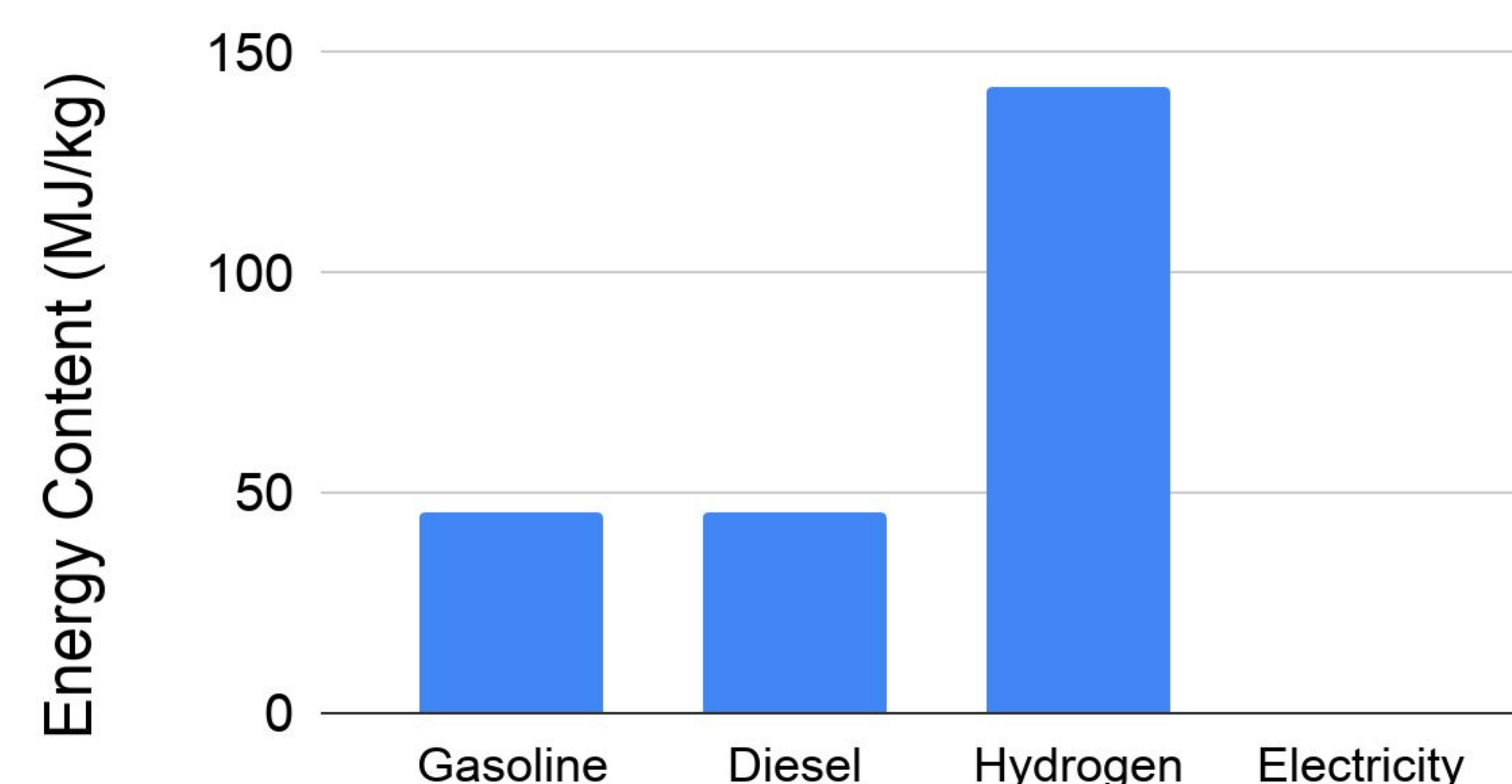
- The ideal gas law was used to estimate how many moles of gas can be carried in a tank when manipulating temperature.
  - The pressure and volume here are kept constant at 680 atm and 200 L, respectively.

**Table II: Varying Moles of Gas with Temperature (K)**

Temperature (K)	Moles of Gas Packed In
173.15	9566.141542
248.15	6674.903921
298.15	5555.517048
373.15	4438.905019

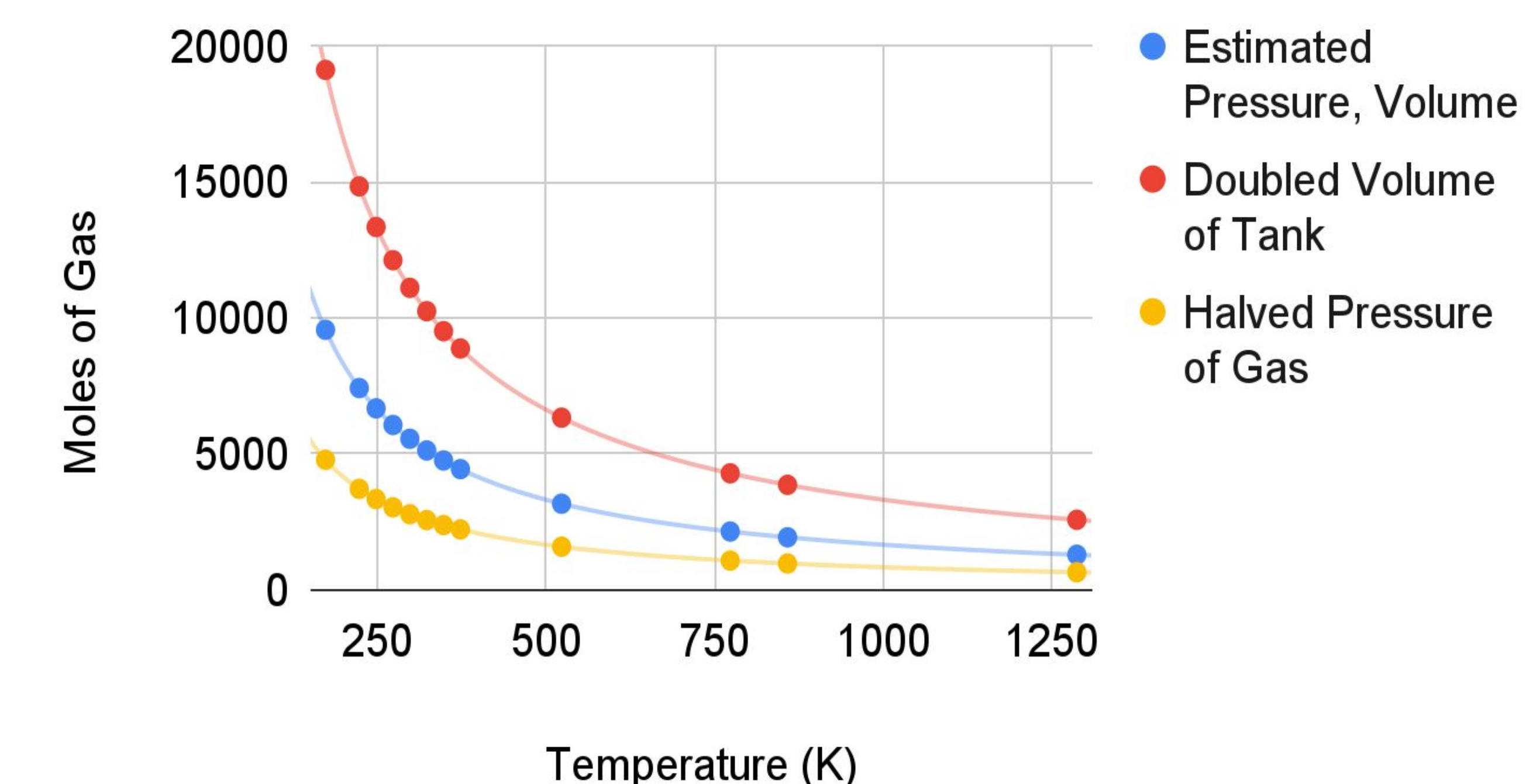
## Results

**Figure 1: Energy Content in normal condition**



- Gasoline contains approximately the same amount of energy as diesel.
- The highest energy content fuel is hydrogen, while electricity (lithium battery) has the lowest energy content.

**Figure 2: Safety and Optimization of Hydrogen Fuel Transport**



- From this, it can be seen that at constant pressure and volume, the lower the temperature, the higher the number of moles of hydrogen that can be transported.

## Discussion

- Even though hydrogen has more energy content than most other fuels, the gaseous form of hydrogen makes storing the fuel challenging. Moreover, hydrogen needs to be synthesized, which requires energy. On the other hand, electricity, specifically lithium battery for electric vehicles, contains the least amount of energy content, but is one of the most energy efficient storage devices.
- However, it costs money to decrease temperature through energy, which we are trying to avoid (Also about 4 times more expensive to cool than heat)
  - Keep at room temperature or cooler, depending on how much money is available and economically feasible

## Conclusion & Further Scope

- Hydrogen is more efficient than other fuels, but it is expensive to store and keep hydrogen safe.
- Further Scope: Looking into cost-effectiveness and exact monetary prices on hydrogen and energy as a whole
  - So hard to do because costs fluctuate from state to state due on energy availability, state government support for cleaner energy programs, etc.

## References

1. "Facts and Figures". United Nations. <https://www.un.org/en/actnow/facts-and-figures>
2. 16.5 Batteries and Fuel Cells - Chemistry: Atoms First 2e." OpenStax, openstax.org/books/chemistry-atoms-first-2e/pages/16-5-batteries-and-fuel-cells. [https://docs.google.com/document/d/1pSbcvVGvWfcm8qL\\_vASogwk5Zoz95HBb2PCLKfS2pDc/edit](https://docs.google.com/document/d/1pSbcvVGvWfcm8qL_vASogwk5Zoz95HBb2PCLKfS2pDc/edit)  
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[https://docs.google.com/presentation/d/1HBfQL2bSWpdwXeDVCmPOfmwUI0HH\\_2Xgiu7yDpgWVEI/edit#slide=d.p1](https://docs.google.com/presentation/d/1HBfQL2bSWpdwXeDVCmPOfmwUI0HH_2Xgiu7yDpgWVEI/edit#slide=d.p1)  
Spreadsheet with or without actual data  
[https://docs.google.com/document/d/1yV\\_17-qxnVnU9S1ba-heMhgnTEePgmYkrKAvfsZVNDA/edit](https://docs.google.com/document/d/1yV_17-qxnVnU9S1ba-heMhgnTEePgmYkrKAvfsZVNDA/edit)  
<https://umass-amherst.zoom.us/j/3228520974>  
<https://openstax.org/books/chemistry-atoms-first-2e/pages/16-5-batteries-and-fuel-cells>  
Project Objective and Justification  
<https://docs.google.com/document/d/1i518hJbD6yZ2WAIH1jTLCP2I-BU0z1s-MwnJO2PhJA/edit>