Fuel Cell Exploration

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1. Background

Duke Energy's Mount Holly site is a testing facility for upcoming energy technology. The goal is to create an autonomous system that runs on renewable energy with natural gas as a backup. They recently bought a GKN Hydrogen Fuel Cell to test in place of lithium-ion batteries. Lithium-Ion batteries have a 4-6 hour range, so they are hoping to replace this long term with a different energy storage, such as the GKN fuel cell.

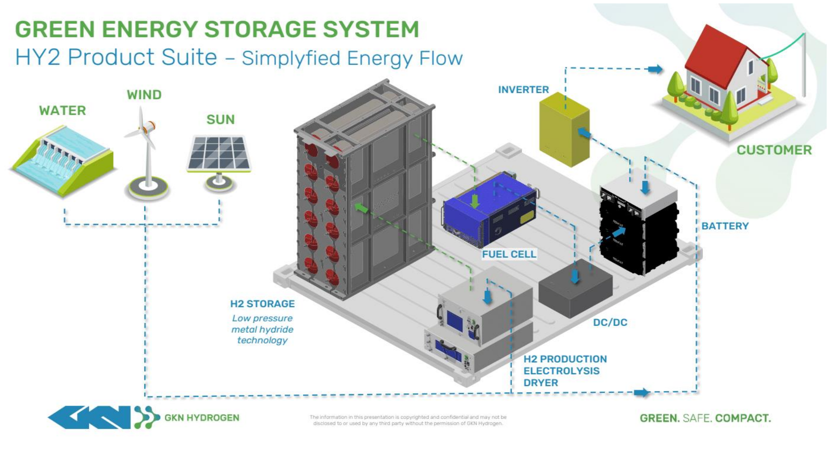
2. Goals

- Explore the scalability and long term use of the GKN Fuel Cell.
- Create a safety test plan with a focus on hydrogen in the unit.
- Compare hydrogen fuel cells to other energy sources with a focus on lithium-ion batteries.

3. GKN Fuel Cell Overview

The HY2MINI consists of a few major components:

- Electrolyzer
- Metal Hydride Storage
- Fuel cell



GKN Hydrogen, *"HY2MINI Product Sheet (2021),"* CHE 450 Senior Design Handout, Duke Energy, Charlotte, NC.

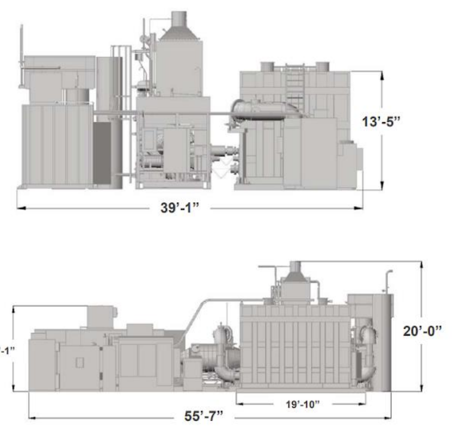
Energy Storage Capacity	165 - 420 kWh electrical 10 - 25 kg H_2 at max. 40 bar
Nominal Load	8 kW
Peak Load	14 kW (30 min)
Output Voltages	120 V / 230 V / 400 V - 50 Hz
Power During Outage	8 kW for 18-52 h
Electrolyzer	1 - 4 kg hydrogen per 24 h

- Electrolyzer: Utilizes water and renewable energy to produce hydrogen
- Metal Hydride Storage: Stores hydrogen until needed
- Fuel Cell: Converts hydrogen to usable electricity

4. Comparing Energy Sources

Fuel Cell Energy SureSource 1500

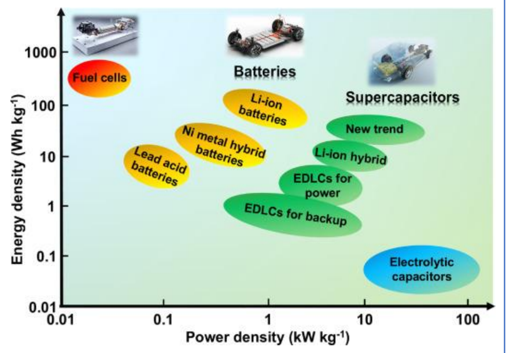
- Output in 1.4 MW increments
- 2100 ft^2 of land vs 100 ft^2
- Requires natural gas to operate
- More expensive and requires more maintenance



Fuel Cell Energy, *SureSource 1500*, at https://www.fuelcellenergy.com/wp-content/uploads/2017/02/Product-Spec-SureSource-1500.pdf, last accessed October 2, 2022.

Tesla Powerwall

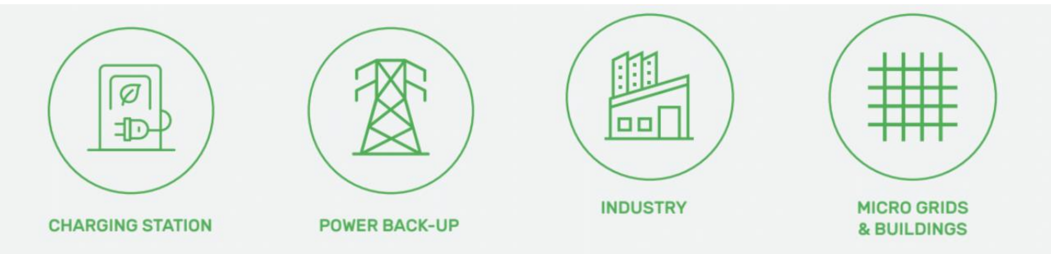
- Captures energy using solar power
- Max energy storage of 14 vs 420 kWh
- Less energy density
- Higher power density



Luo, Yang, Yinghong Wu, Bo Li, Tiande Mo, Yu Li, Shien-Ping Feng, Jingkui Qu, and Paul K. Chu. "Development and Application of Fuel Cells in the Automobile Industry," *Journal of Energy Storage* **42**, 103124 (2021).

5. Applications

There are several applications of hydrogen fuel cells that people could benefit from.



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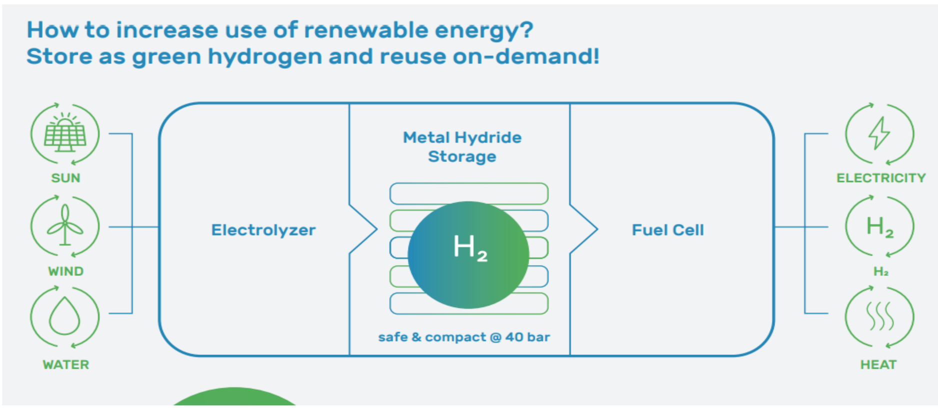
One key difference between previous applications of fuel cells and the HY2MINI is that the HY2MINI contains all the components in one unit, removing much of the transportation and infrastructure requirements.

6. Test Plan

Hydrogen leaks are inevitable and extremely difficult to find due to it being so small. Three leak tests need to be done:

- Surface hydrogen detection
- Soap bubble testing
- Pressure drop testing



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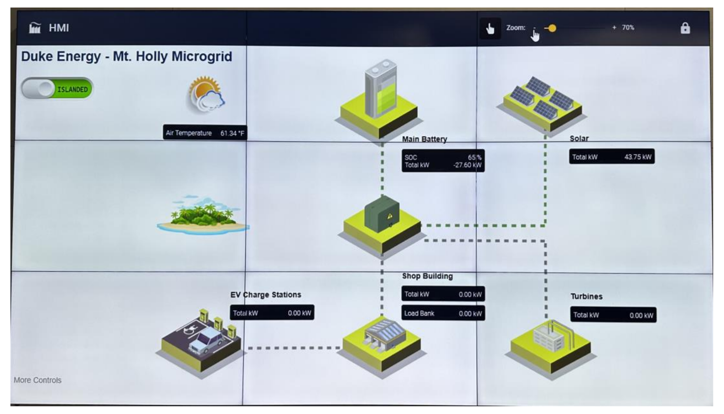
The feasibility of oxygen capture was assessed for the unit in the test plan and we determined it was not economical. The hydrogen purge streams are mixed with oxygen so it would require a separation and oxygen is relatively inexpensive.

7. Conclusion

The future of renewable energy is hydrogen based systems. Places like California have already started incorporating hydrogen into everyday life through cars, and as our understanding of hydrogen deepens, their impact will only grow larger.



8. Acknowledgments

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