WERC: Smart Grids with Hydrogen Integration

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El Paso Electric

Design Challenge #2

El Paso Electric requested our engineering capstone team to design hydrogen-based technologies in combination with intermittent renewable energy technologies (photovoltaics) for the WERC Competition to demonstrate how intermittent renewable energies can be modified to become a dispatchable resource.

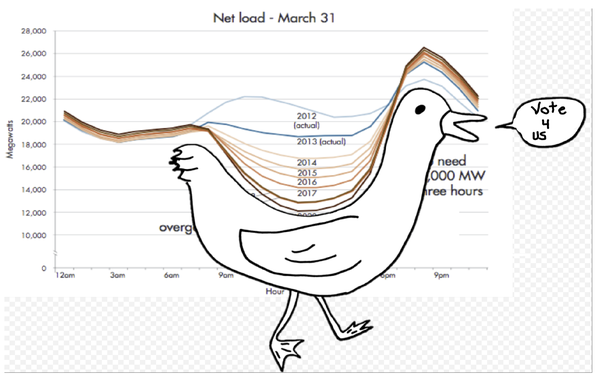
Our criteria for this project were:

- Create a small-scale model of a grid-tied DERMS
- Use hydrogen fuel cells to act as a backup renewable source of energy
- Minimize and possibly eliminate the duck curves seen in modern solar generation
- Withstand and recover from disruptive events

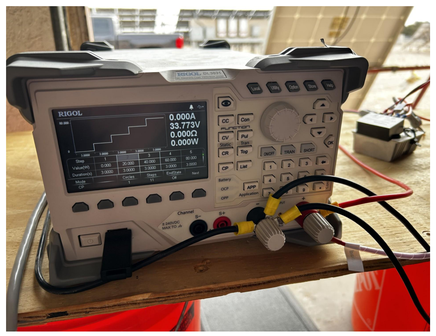
Our team worked diligently to meet and exceed the expectations of El Paso Electric and the WERC Competition.

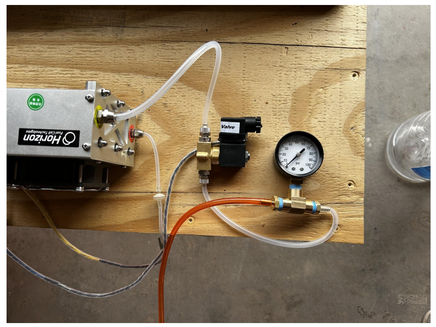
Research

- Electrolysis: The process of introducing an electric current to water to separate it into hydrogen/oxygen. The hydrogen is then stored and can be used to power fuel cells and other necessities.
- Hydrogen Integration: Hydrogen Gas is reintroduced to oxygen atoms and ran through a PEM (Photon Exchange Membrane) which steals electrons providing power flow from hydrogen.
- Hydrogen Fuel Cell: Environment friendly renewable battery through electrolysis and reverse electrolysis.
- Renewable Energy: A source of energy generation that can be used constantly. Solar cells used in the project use solar energy to produce energy generation.
- Duck Curve: Visual difference in power production and power demands.

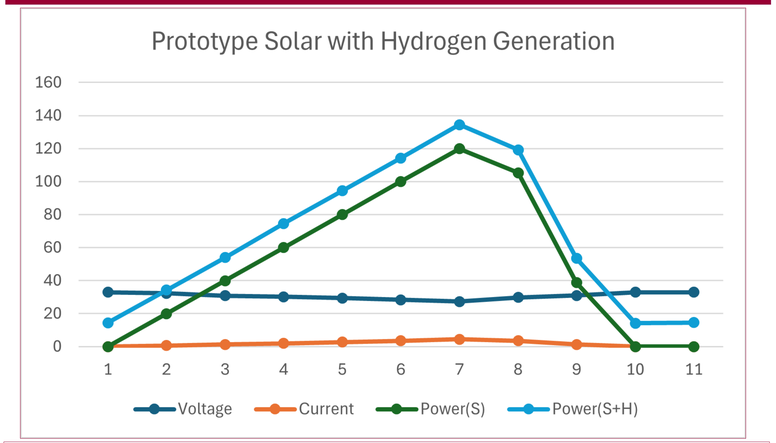


Final Design





Results



In the graph above, we can see the power output of both the pure solar generation and solar with hydrogen generation. We determined that the hydrogen fuel cells provided a 11.5% - 12.5% increase to the maximum load that the solar cell can handle on its own. With this result, we can safely say that we can effectively eliminate the solar duck curve as long as the peak of the duck curve is no higher than 12% of the solar generation at that given point.

Our final design is broken into two parallel paths from the solar panel to the load:

- The *Direct Path* from the solar panel to the DC load consists of 12AWG high temperature wiring connecting the solar panel to the load
- The *Hydrogen Fuel Cell Path* consists of two DC step down buck converters, an adjustable resistor, H200 hydrogen fuel cells, hydrogen storage tanks, and pressure regulators/gauges

Direct Path

- Making sure that the wire connecting the solar panel was rated high enough to safely handle the power of the solar panel
- Making sure that the DC load that is connected is rated to handle the maximum amount of power that the solar panel can produce

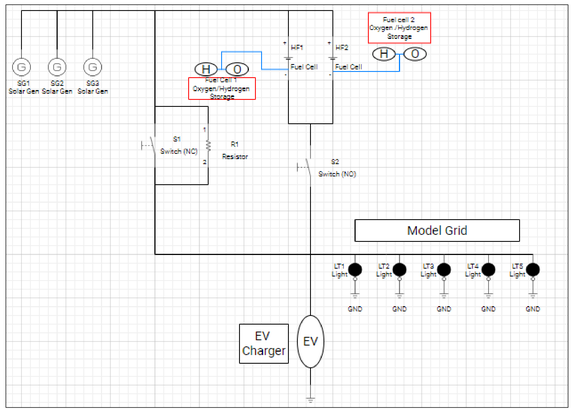
Hydrogen Fuel Cell Path

- Ensure that the voltage was stepped down to the correct operating voltage for the fuel cells to be effective which would be 13V (+/-1V)
- Make sure that the current that is running to the hydrogen fuel cell is a maximum of 5 amps to ensure fuel cell productivity
- Measure the adjustable resistor to correct number of ohms to take just over 5A from the parallel circuit to effectively lower the amperage entering the fuel cell.
- Making sure that the pressure of the hydrogen gas that is entering the fuel cell is in-between 0.45 and 0.55 bar (6.5 to 8 psi)
- Make sure that the hydrogen fuel cell is wired correctly to the DC load.

Concept Development

While developing our concept we kept in mind the various ways for us to be able to use the hydrogen fuel cells in the most efficient way possible.

- We placed the direct path from the load to the solar panel and the path through the fuel cells in parallel.
- We added switches to change the form of the fuel cells from generation and charging.
- We added a DC Load that can be easily modified for easier simulations



- Our load for this concept was both a heavy drawing load such as the EV charger and physical lights to visually see power transfer.

Concept received modifications during the design process of the prototype due to either safety or testing necessities.

- We dropped one hydrogen fuel cell and replaced it with a resistor due to the possibility of overloading our digital DC load.
- Ran hydrogen fuel cell testing without direct path connected due to back feed issues that were being introduced to the fuel cell.

References

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