Modeling of a Microgrid for Energy Resiliency

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Problem Statement

- Weather related events can cause power loss to critical infrastructure. The impact of such events paired with the immense importance of sustainable energy creates a need for systems to increase energy resiliency in a sustainable way.
- Microgrids are capable of operating independently of the main grid can increase electrical reliability.
- A microgrid capable of being transported could be used to power critical equipment in the event of a disaster.

Proposed Design

- Design and simulate a microgrid powered entirely by renewable resources. Simulation conducted in MATLAB/SIMULINK.
- Design the microgrid so that all components fit in a standard ISO 20' shipping container to ensure the microgrid is mobile.
- Intended Use: to power communications hub (12 kW)
- Intended Location: Kossuth County, IA
- Intended Users: National Guard/disaster response crews

Simulation

Wind Subsystem

- Permanent Magnet Synchronous Generator (PMSG)
- Rectifies three-phase AC to DC for inverter

Hydrogen

- Proton Exchange Membrane (PEM) Hydrogen fuel cell
- Generates DC electric power from compressed hydrogen and ambient oxygen
- Electrolyzer generates hydrogen from electricity

Battery

- 1000 Ah Lithium ion battery
- Buck/Boost converter used to determine when to charge/discharge battery
- Grid forming Inverter

Inverters

- Turns DC Voltage in AC
- Uses DC and AC inputs to determine output
- Regulates voltage magnitude and phase

Solar

- Temperature and Irradiance data input into solar array.
- Solar array rated at 6.1kW with Maximum Power Point Tracking (MPPT),
- DC output connected to grid inverter.

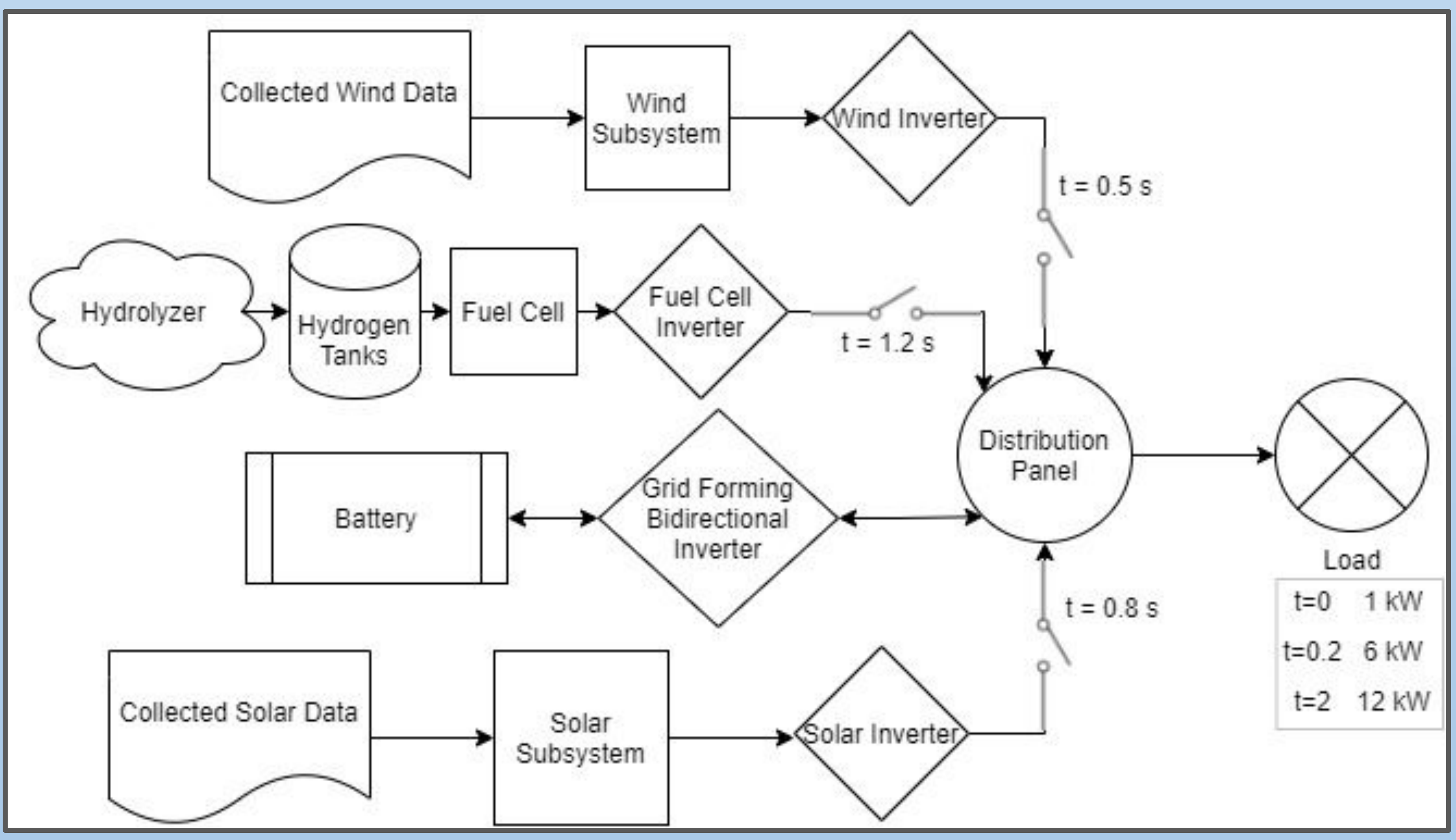

Fig. 1: One line diagram for microgrid simulation

Results

- Transients occur at the moment each component is connected to the system
- The voltage output of systems stabilizes around 120 Vrms
- Time need to reach steady state is dependant on the equipments, but usually less than 0.4 second.

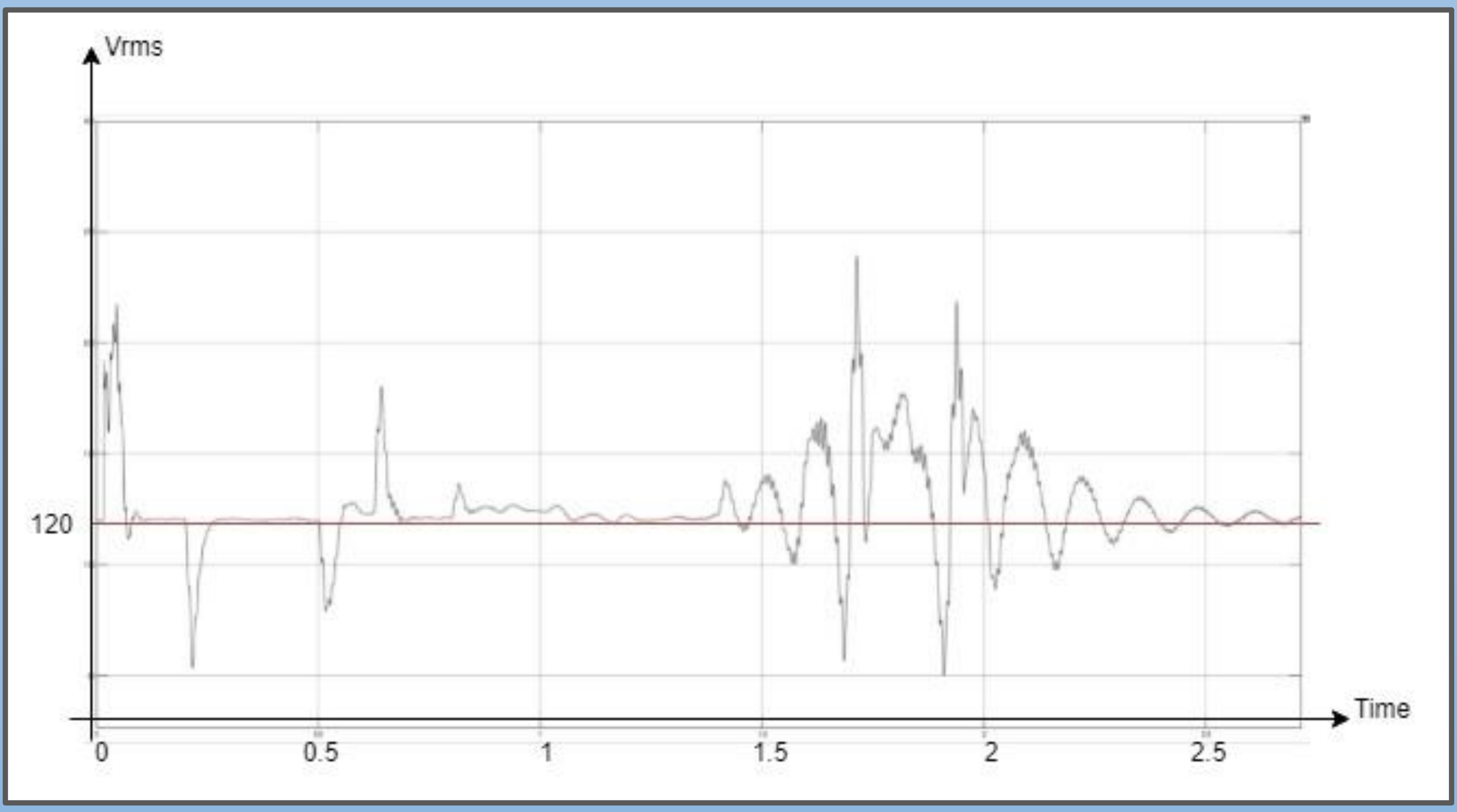

Fig. 2: RMS Voltage of the microgrid system output

Nanogrid Experiments

- The team applied for and received a $5,000 grant from GridEd
- The grant was used to buy 100W solar panel, 518 Wh battery and 30W Fuel cell stack

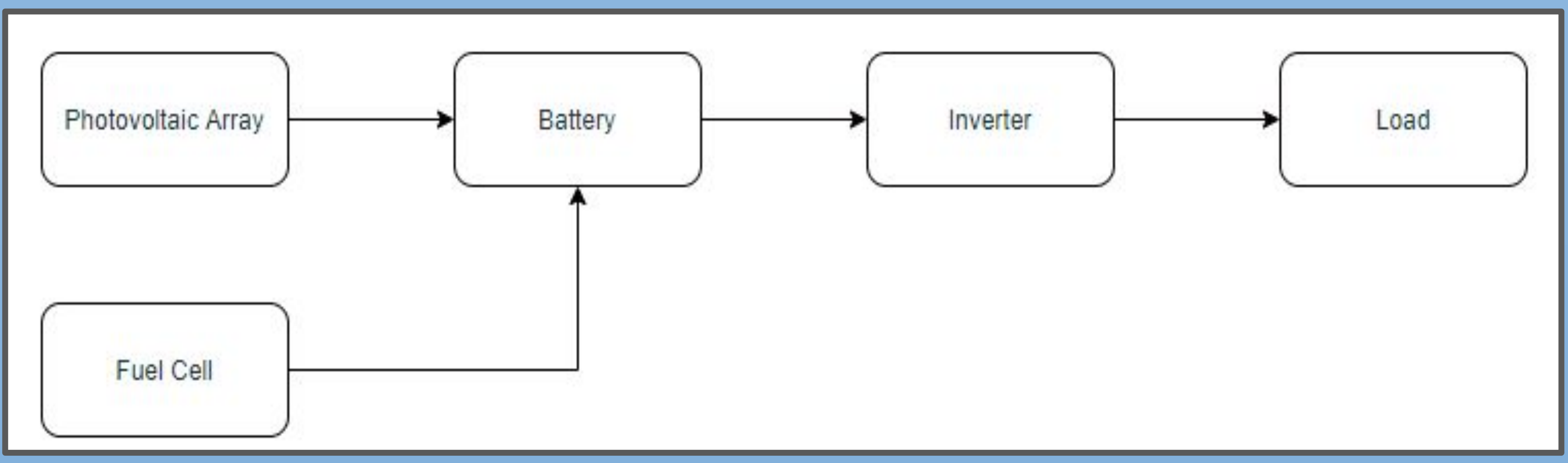

Fig. 3: One line diagram for nanogrid

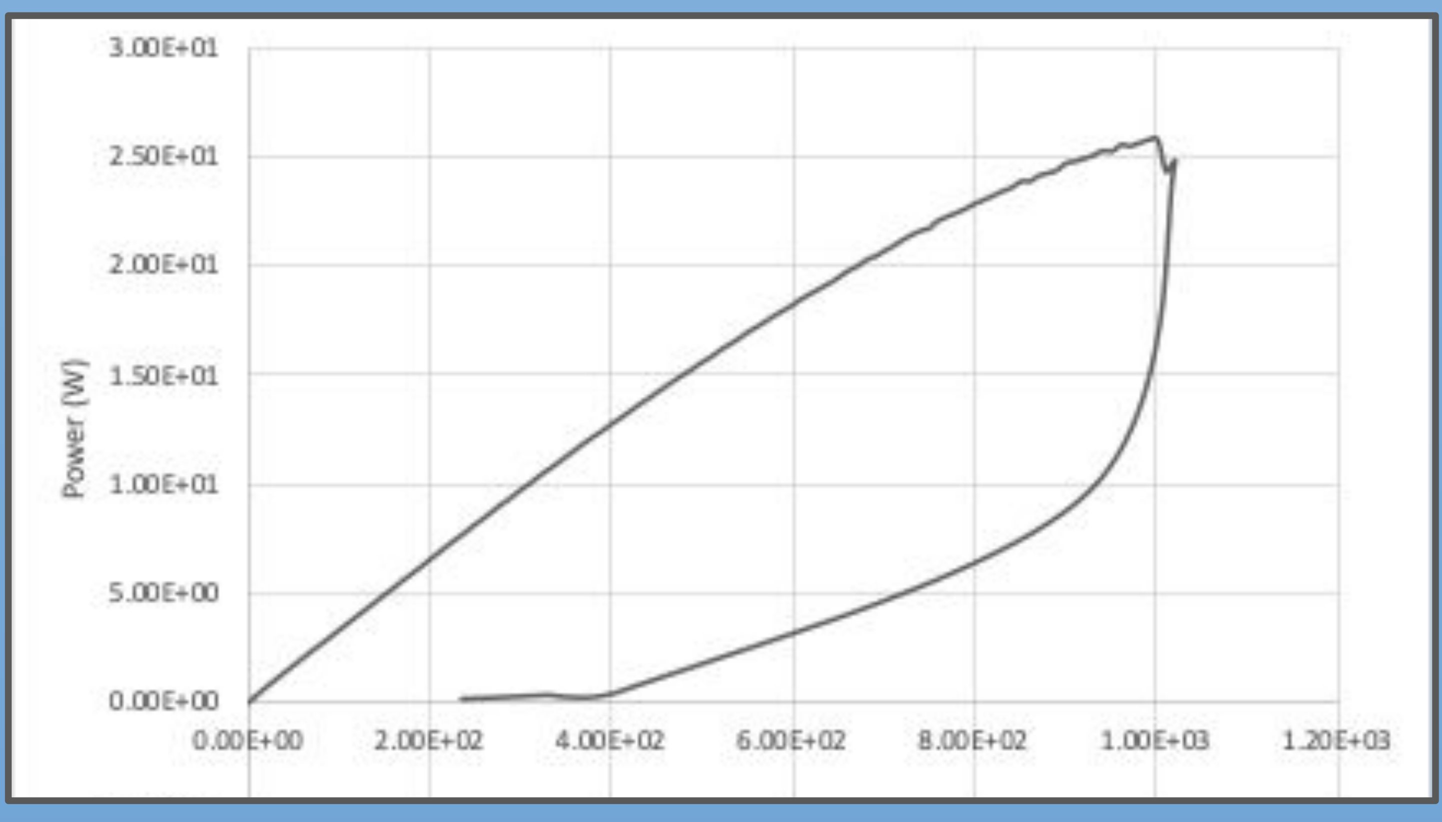

Fig. 4: Power vs. Current density of hydrogen fuel cells

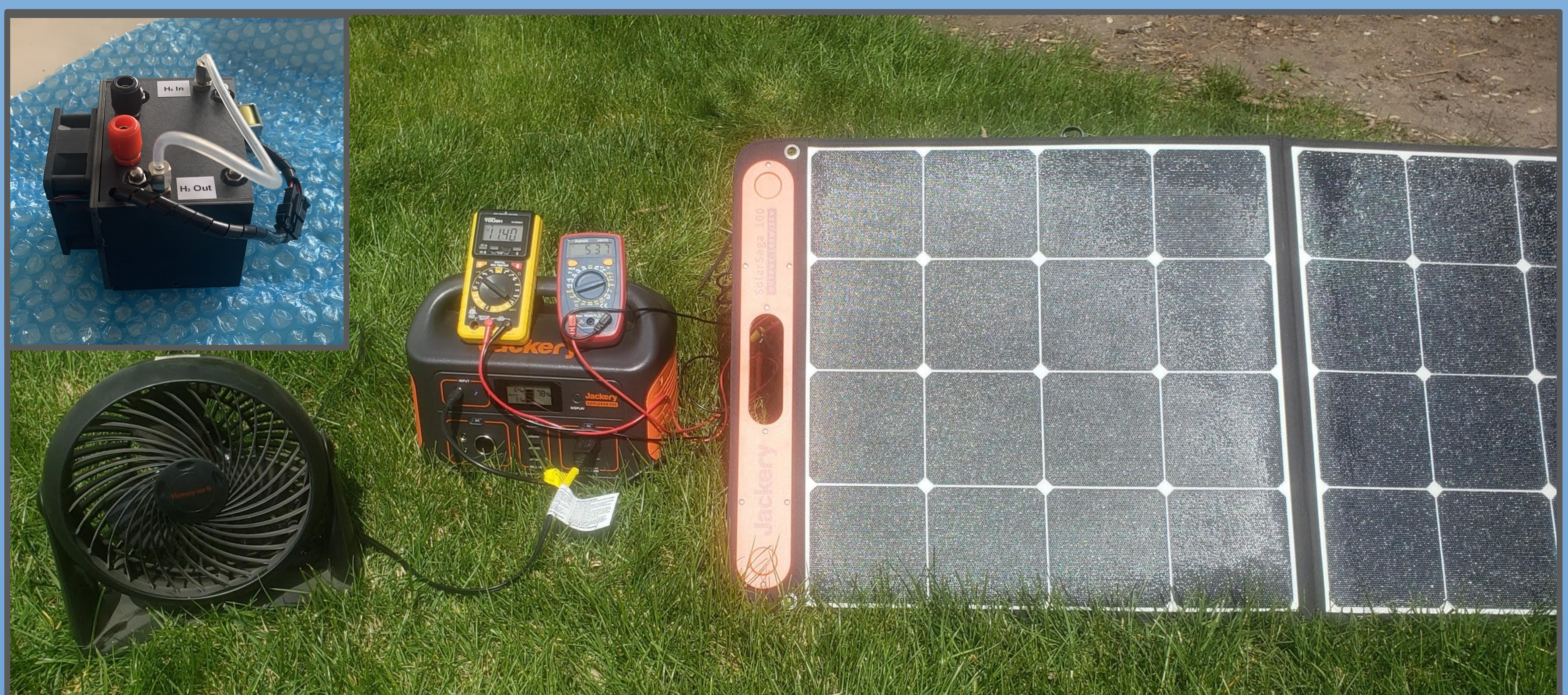

Fig. 5: Solar panel and battery testing.