Battery Electric-Natural Gas Hybrid Generator for Microgrid Power Applications

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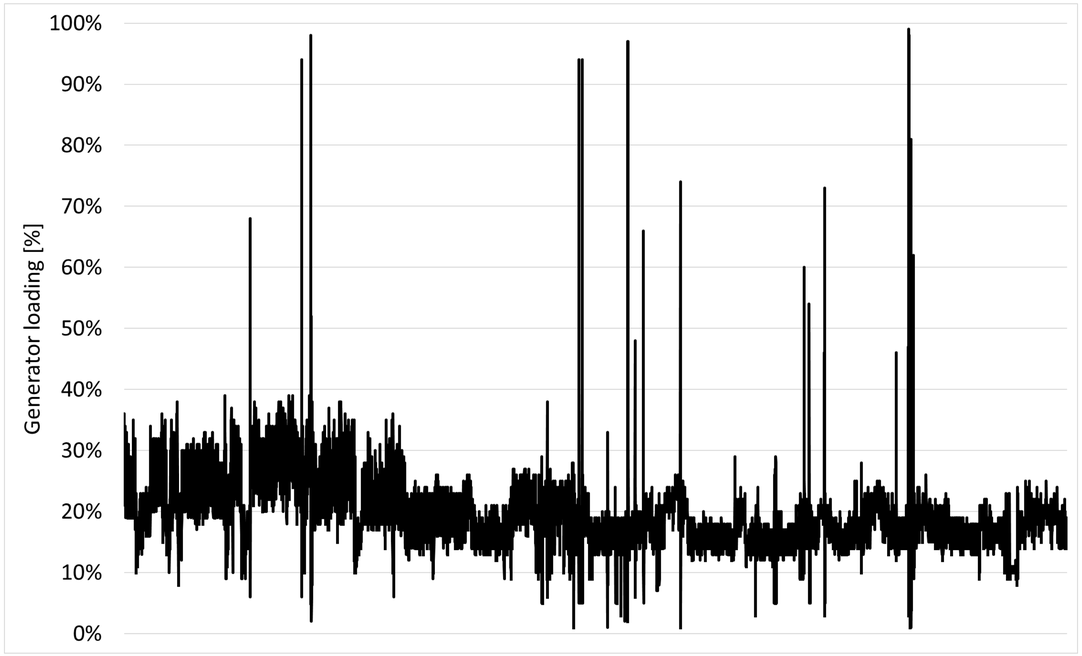
Background and Motivation

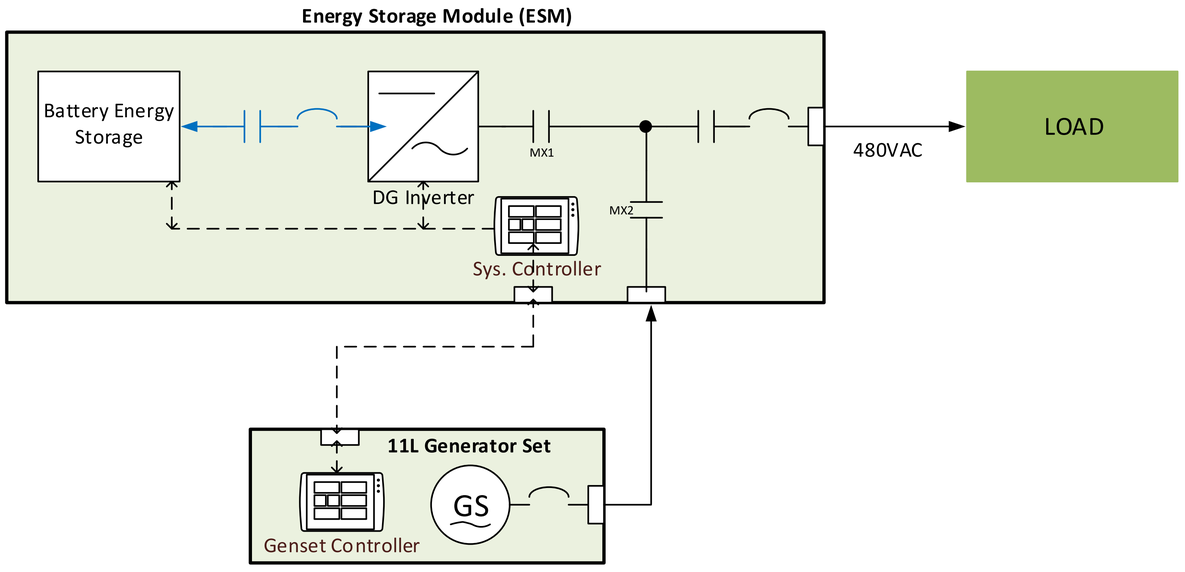
Natural gas is a cleaner-burning fuel compared to diesel. However, gas engines are not as responsive to step load changes compared to diesel generators. One solution is to combine a natural gas generator with an energy storage system and grid-forming inverter. Such a hybrid generator would provide improved voltage and frequency stability for off-grid microgrids, while reducing fuel consumption and emissions.

Existing Moser generators are often loaded 20-30% of their capacity, meaning a smaller generator could meet the load demand the majority of the time, with the battery energy storage supporting intermittent load peaks.



Typical system field loading [%]

System Description



System block diagram

System Mode Descriptions

- **Silent watch:** system is on, connected, and ready to support load
- **Silent run:** during low loads, system runs on battery power only
- **Gen mode:** generator runs at fixed load, excess power charges battery
- **Hybrid Mode:** battery discharges in parallel with generator to supply load
- **Peak mode:** battery/inverter discharges to meet temporary peak loads

Experimental testing

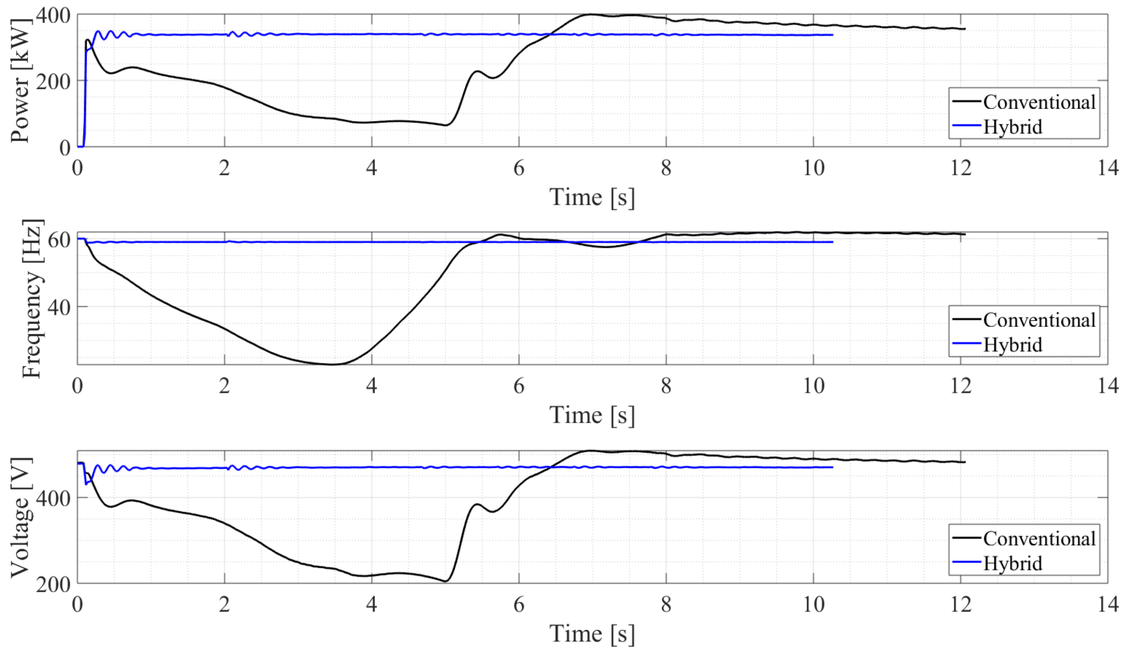
- Conventional and hybrid generators were subjected to identical steady state and intermittent load profiles derived from field loading data
- Power output, fuel flow, and emissions were monitored during testing
- All testing conducted at CSU Powerhouse Energy Campus

Hybrid Generator

Conventional 22L Generator

Improved Transient Stability

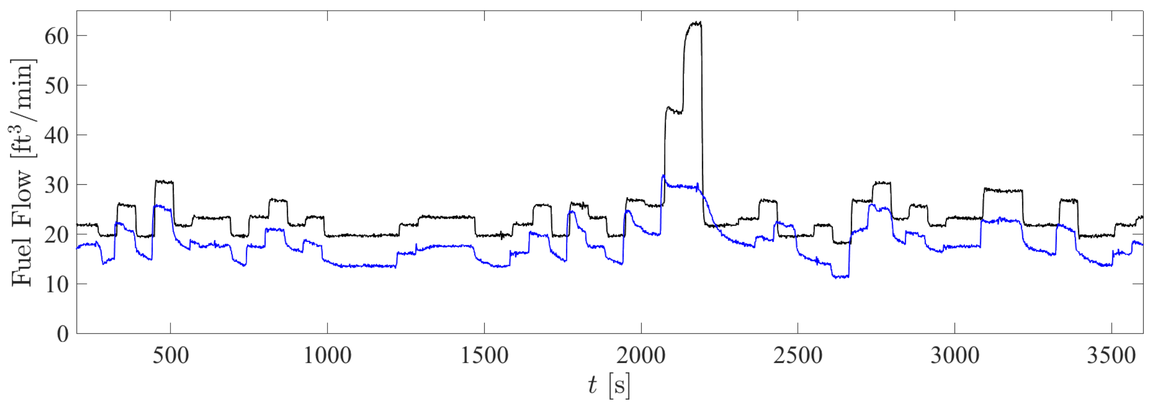
- Frequency deviation <1.5 Hz on 0-350 kW load step for hybrid system vs. >30 Hz for conventional system
- Voltage deviation of 11% on 0-350 kW load step for hybrid system vs. 56% for conventional system
- Hybrid system recovers frequency within one cycle and voltage within 1.5 sec



Conventional vs. hybrid step load response for 0-350kW load step

Fuel Savings

- Low loads can be carried by battery
- Generator maintained at or near fixed load point, reducing throttling
- Fuel savings up to 25% during testing



Conventional generator fuel consumption (black) vs. hybrid (blue)

Reduced Emissions

- Less fuel means fewer emissions
- Higher generator loading reduces combustion slip
- Total hydrocarbon emissions reduced 45% during testing
- Carbon dioxide emissions reduced of 17% during testing

Potential Applications

- Critical backup power
- Microgrid support
- Off-grid power
- Renewable integration
- Electric vehicle charging