Demonstration NEV with an Element 1 Methanol-to-Hydrogen Generator

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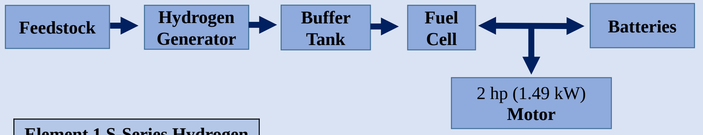
1. Introduction

An Element 1 hydrogen generator uses methanol to supply the fuel cell that powers the Neighborhood Electric Vehicle (NEV). Compared to conventional internal combustion engine technologies, the Element 1 NEV may offer carbon emission reductions for transportation applications.

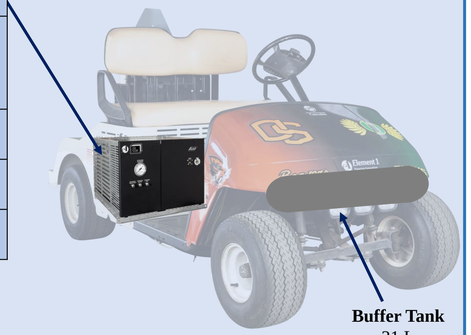
2. System Components

Element 1 Hydrogen Generator
- Converts methanol water feedstock to hydrogen

Intelligent Energy Fuel Cell Module
- Uses hydrogen from the buffer tank
- Powers the batteries and NEV motor

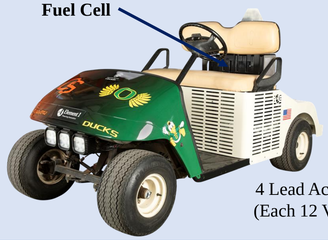


Element 1 S-Series Hydrogen Generator	
Feedstock Composition	62.5 wt.% methanol, balance DI water
Hydrogen Purity	> 99.97%
Hydrogen Output	35 sLm to >130 sLm
LHV Efficiency	> 75 %

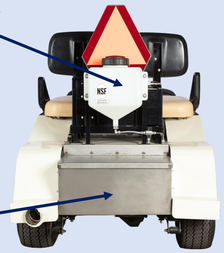


Buffer Tank
21 L
10 - 30 psig

Intelligent Energy 801
48 VDC
1.2 kW
Fuel Cell



Feedstock Tank
9.5 L

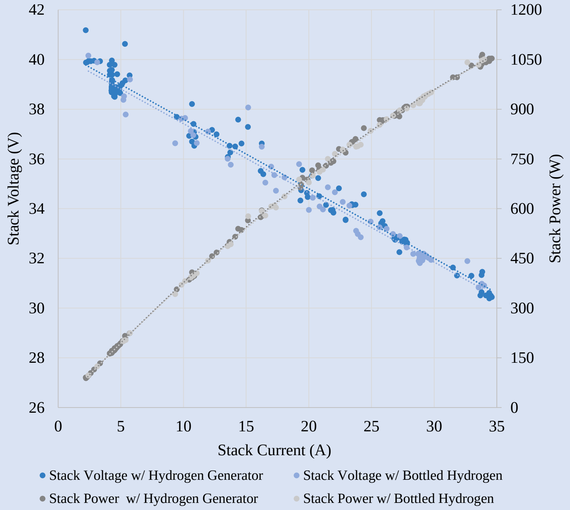


4 Lead Acid **Batteries**
(Each 12 VDC, 35 Ah)

3. Methods

1) Fuel cell testing with bottled hydrogen and the hydrogen generator

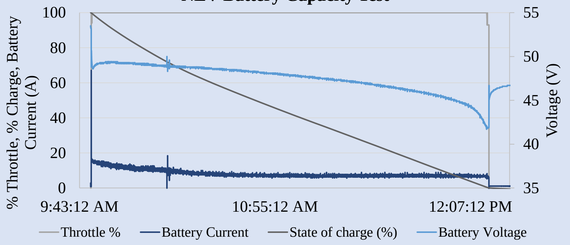
Fuel Cell Performance with Element 1 Hydrogen Generator and Bottled Hydrogen



2) Hydrogen generator parameter selection for load following

3) Integration of the fuel cell and hydrogen generator with the electric cart
- Battery capacity test
  - 19.91A h from fully charged to low battery warning

NEV Battery Capacity Test

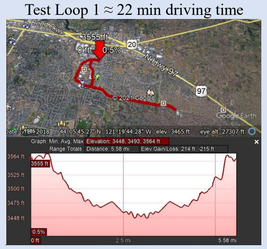


- Selection of motor control parameters to optimize NEV performance

4. Results

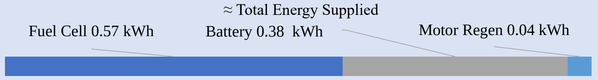
NEV test drive:
- Total distance ≈ 7.18 miles (11.6 km)
- Feedstock consumption ≈ 950 mL
- CO_2 emissions ≈ 100 g/mile with non-renewable methanol
  - Average US passenger vehicle emits 411 g CO_2 /mile [1]

Test Loop 1 ≈ 22 min driving time

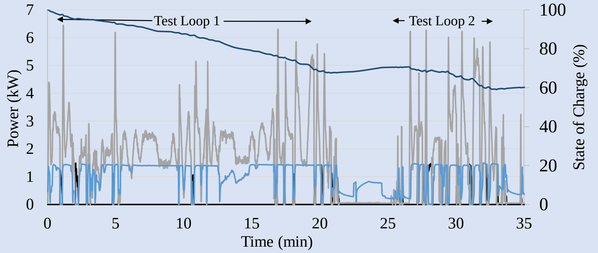


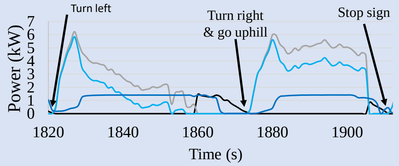
Test Loop 2 ≈ 7 min driving time

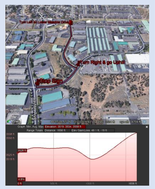
≈ Total Energy Supplied



Element 1 NEV Test Drive 8/22/2020





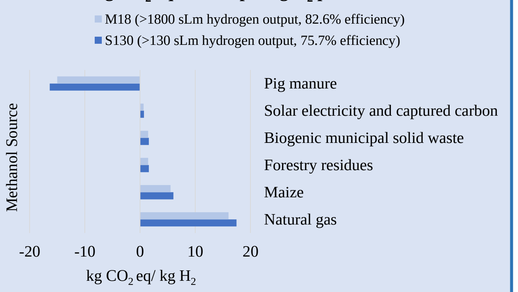


Regen (kW)
Power out to Motor (kW)
Power out of battery (kW)
FCM power to battery (kW)

5. Discussion

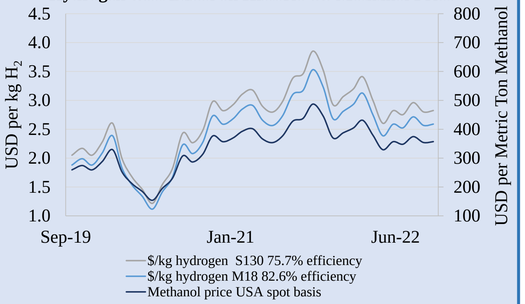
Well-to-wheels CO_2 emissions depend on hydrogen generator efficiency and methanol source:

kg CO_2 equivalent per kg H_2 produced [2]



Cost of hydrogen produced depends on methanol price and hydrogen generator efficiency:

Hydrogen Cost Based on Historic US Methanol Price [3]



For comparison, hydrogen from electrolysis costs ≈ $4 to $6/kg [4]

6. Conclusion

Electrification of transportation using hydrogen generated onboard a vehicle or vessel from methanol/water feedstock offers advantages over high-pressure or liquid hydrogen including favorable economics, increased range between fueling operations, and leveraging existing fueling infrastructure. Use of renewable methanol or carbon capture technology would significantly reduce net carbon emissions. Compared to compressed hydrogen, use of methanol/water feedstock offers advantages including lower cost of hydrogen, ease of storage and distribution, high volumetric energy density, and ready availability. The design concepts applied to the demonstration NEV may be scaled up and optimized for larger scale transportation applications.

References: 1) Greenhouse Gas Emissions from a Typical Passenger Vehicle, from https://nepis.epa.gov/ National Service Center for Environmental Publications (NSCEP), 2) Carbon footprint of methanol from The Methanol Institute, 3) https://www.methanol.org/methanol-price-supply-demand/, 4) https://www.hydrogen.energy.gov/pdfs/20004-cost-electrolytic-hydrogen-production.pdf, Maps from Google Earth