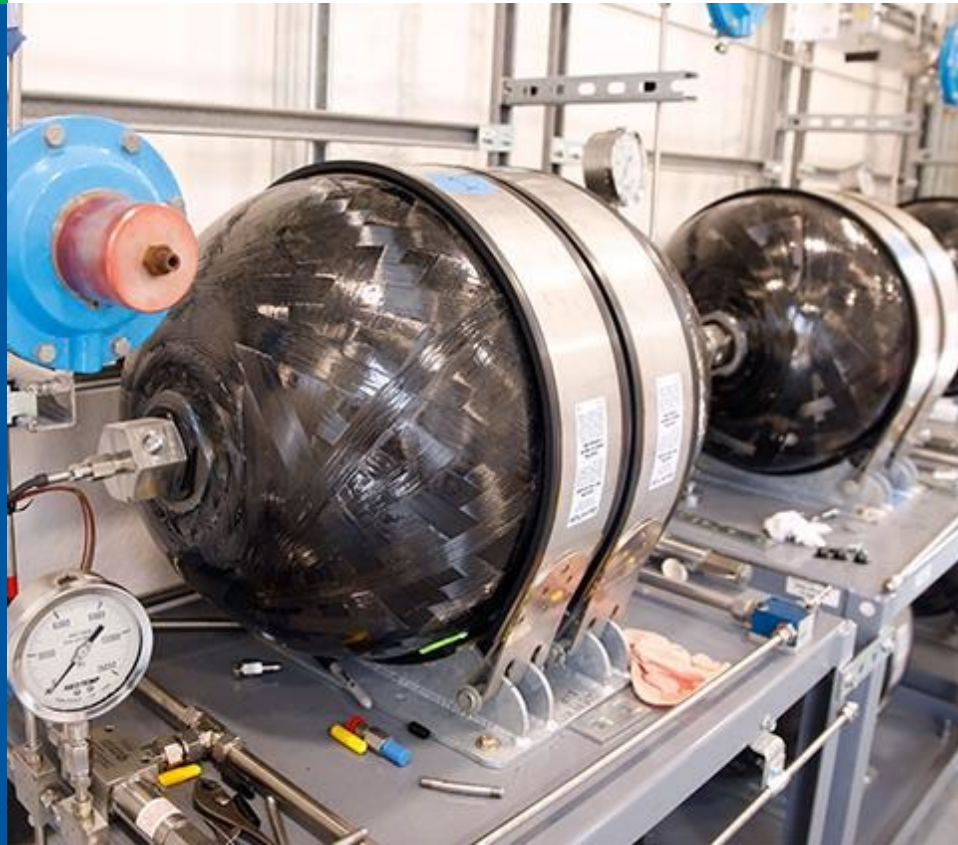




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solutions that transform



Hydrogen Fuel Cell Yard Truck Demonstration

Bart Sowa, *R&D Manager*

September, 2023



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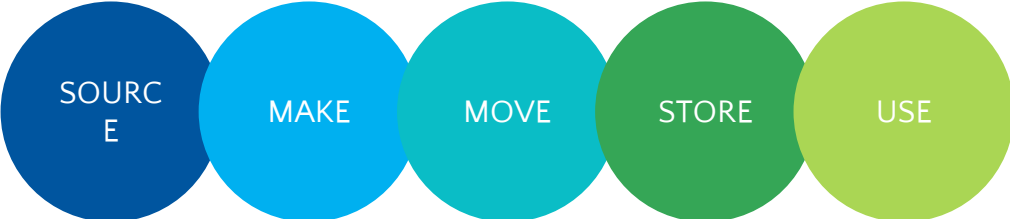
LIVES

ECONOMIES

ENVIRONMENT

GTI Energy develops innovative solutions that transform lives, economies, and the environment

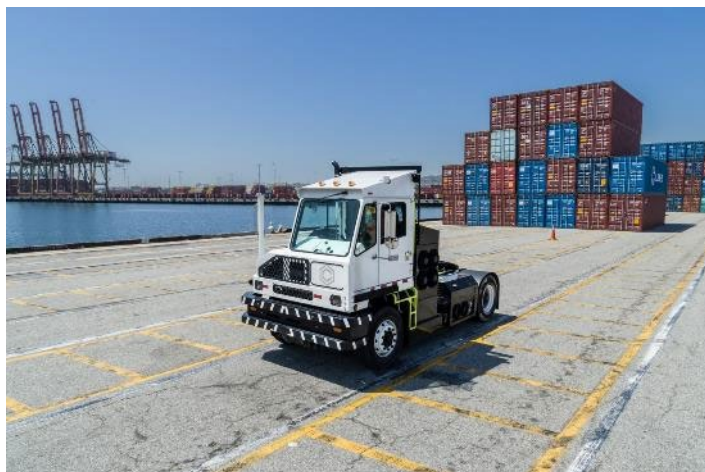
We develop, scale and deploy solutions in the transition to low-carbon, low-cost energy systems



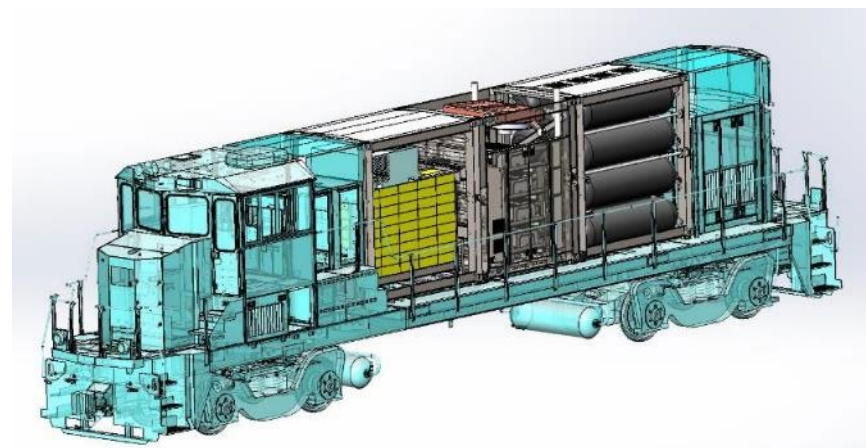
We work collaboratively to address critical energy challenges impacting gases, liquids, efficiency and infrastructure



Hydrogen mobility



- Endurance
- Weight
- Non-wires
- Refueling time



Zero Emissions for California Ports (ZECAP)

ZECAP is part of California Climate Investments, a statewide initiative that puts billions of Cap-and-Trade dollars to work reducing greenhouse gas emissions, strengthening the economy, and improving public health and the environment—particularly in disadvantaged communities.

www.calclimateinvestments.ca.gov

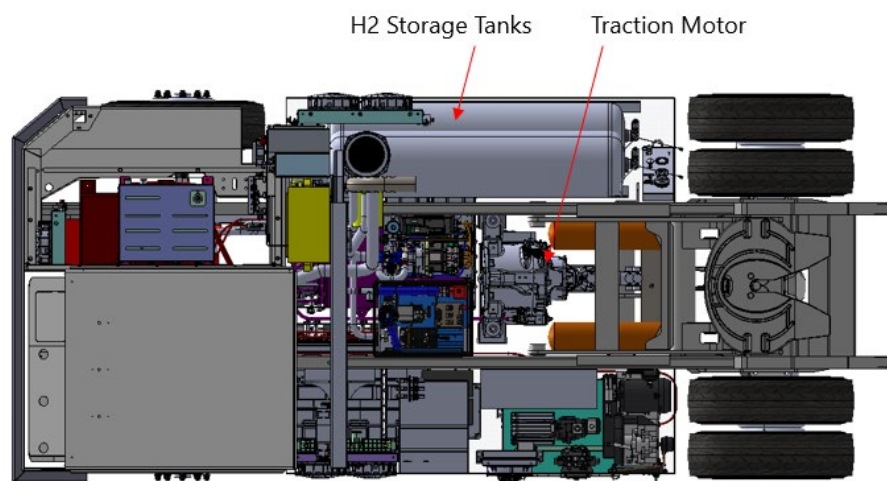
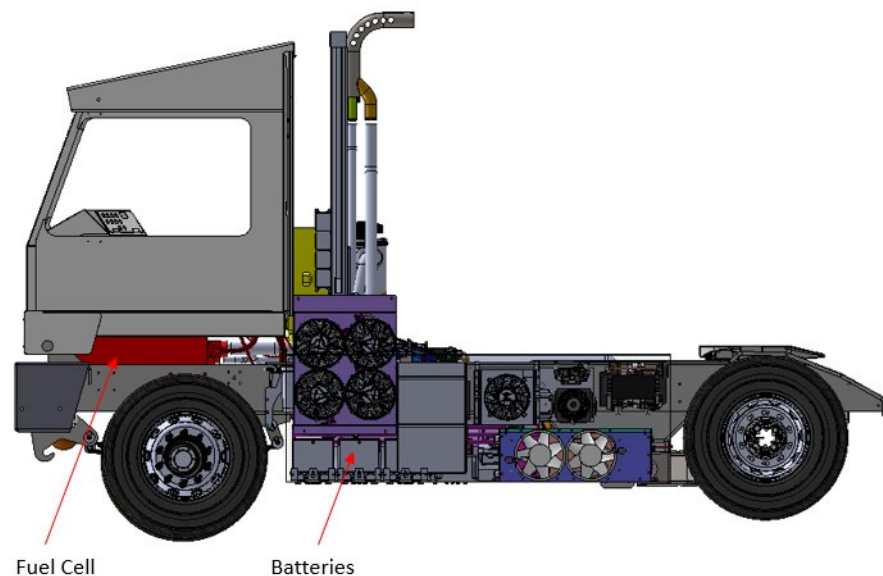


Zero Emissions for California Ports (ZECAP)



[Discover the ZECAP project on YouTube](#)
3-minute video

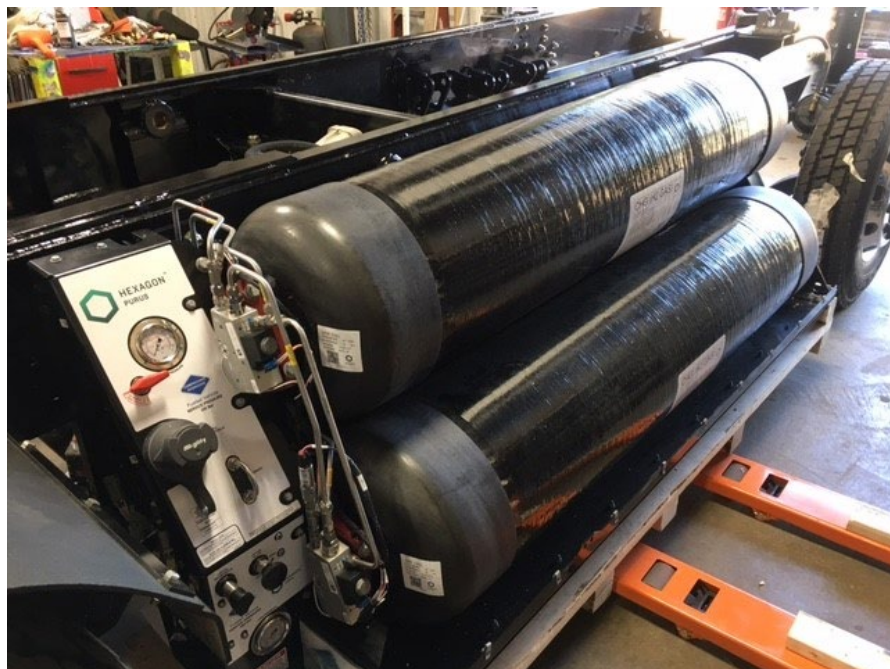
Design



Attribute	
Chassis/Cab	TJ9000 tractor platform
Propulsion System	650V, 200kW
Batteries	85 kWh, 650V, NMC
Axle	Conventional
Plug-in charging	Yes
Onboard charger	Yes
Battery-only range	5 hours*
Fuel Cell	85kWh Ballard, operating at 50kW
Onboard hydrogen storage	9.1 kg @ 5000 psi (350 bar)
Fill Time	10-15 min
Combined Range	16 Hours*

*on evaluated duty cycle

Hydrogen storage



9.1kg @ 5000 psi (350 bar)
103 gallons / 350 lbs



182kg hydrogen storage with dispenser

Infrastructure

- Site plan, setbacks
- Permitting (LADBS, LAFD, LAHD)
- AHJ, first responder coordination
- Commissioning
- Safety training
- Maintenance



Operation



- Trucks operated Feb 2022 – Feb 2023
- Used in “support duty”

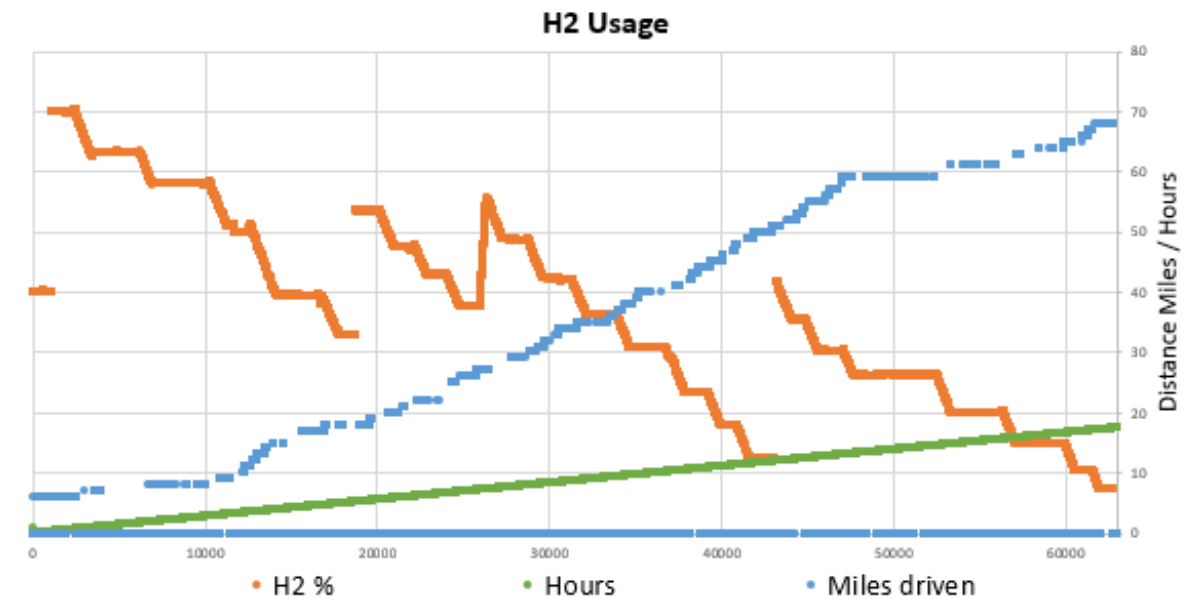
- No hardware failures
- Telematics can be challenging with Evs / port environment



Lessons learned

Performance

- Hydrogen consumption 0.71 kg/hr (23.6kWh)
- Compared to diesel 1.75 gal/hr (71.2kWh)
- 67% improvement in efficiency
- Endurance on TraPac duty:
17hr [11hr H2 + 6hr EV]
- Est. 340kWh usable onboard energy storage
(H2 + battery)
- 15-20 minute refueling
- Opportunity for further efficiency gains

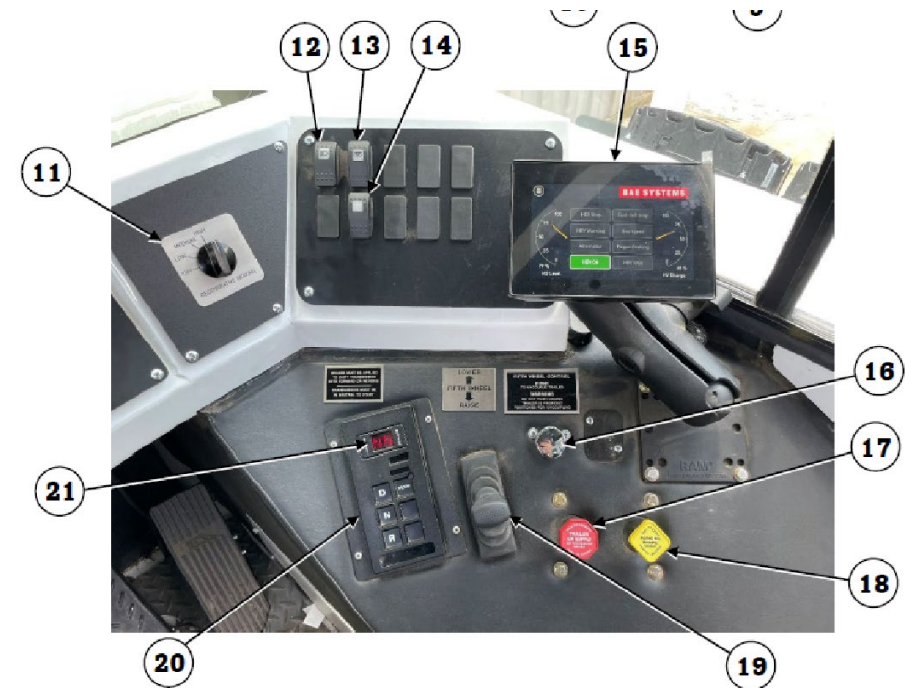


Performance

- Great feedback from drivers
- One-pedal driving

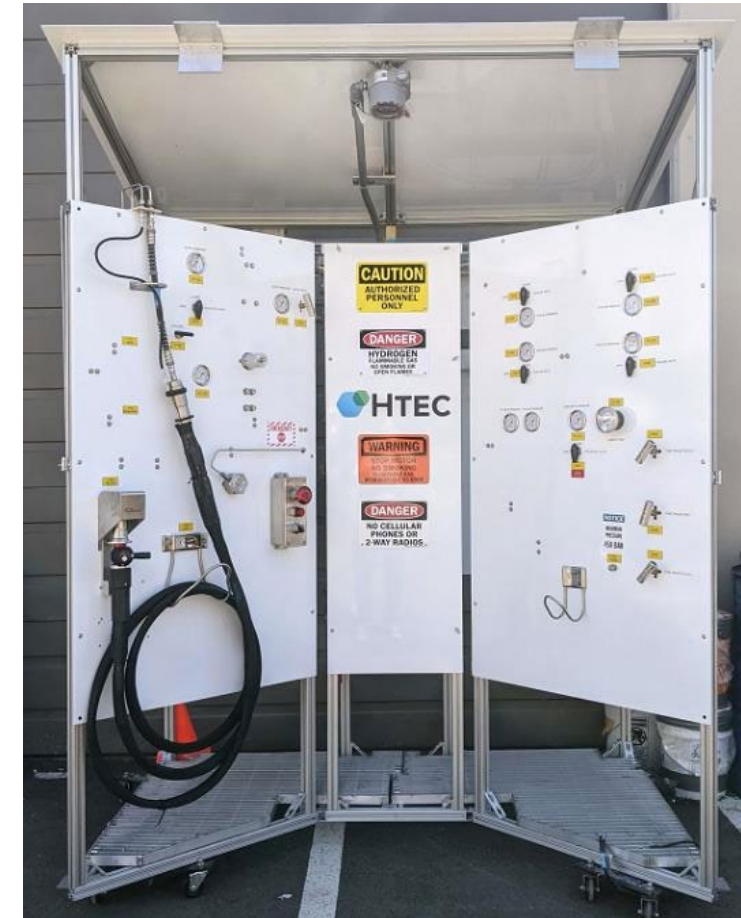
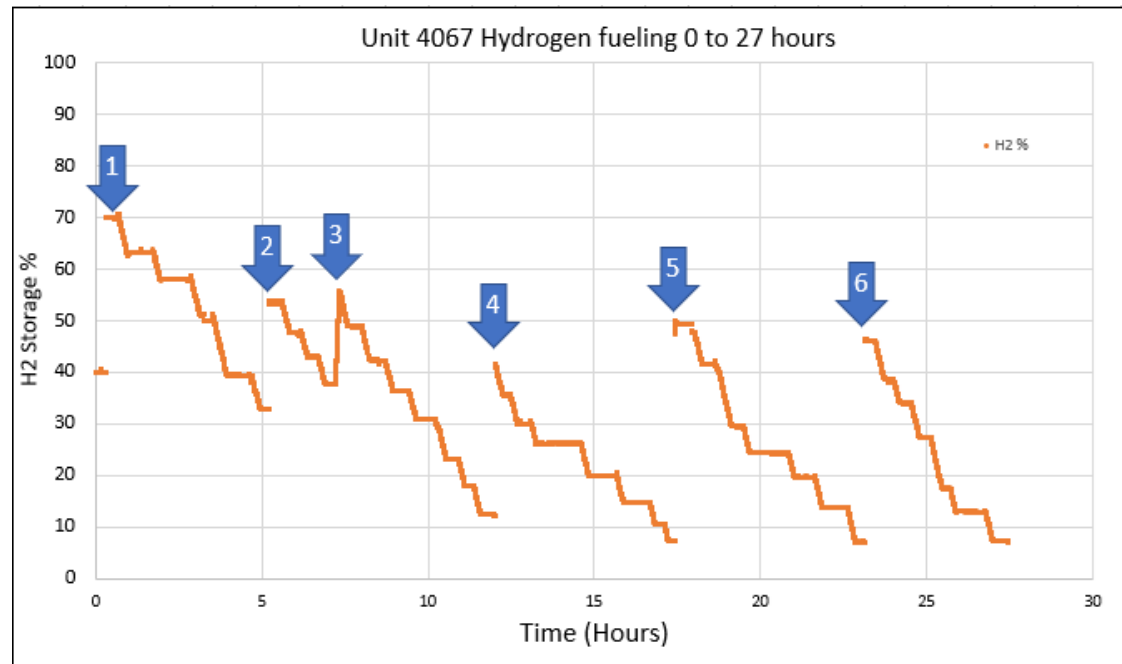


- Intuitive (familiar) driver environment
- Quiet, vibration- and odor-less



Fueling

- Cascade fueling limitations, complexity
- OK for demos, not for mission-critical duty
- Incomplete fills with depleted fueler



Fueling

- Hydrogen cost and availability are challenging
- Operational considerations
 - Fueling island vs. “wet hosing”
 - Cost and complexity of station
 - Onsite storage size vs. daily demand
 - Back-to-back fueling, fueling speed needs



Safety

- Training
- Misconceptions



No PPE required



Safety

Hydrogen



Hydrogen Gas Detector



Thermal Pressure Relief Devices (TPRD)

Natural Gas



FireEye



Pressure Relief Valve



Emergency Shutdown



Vent Stack

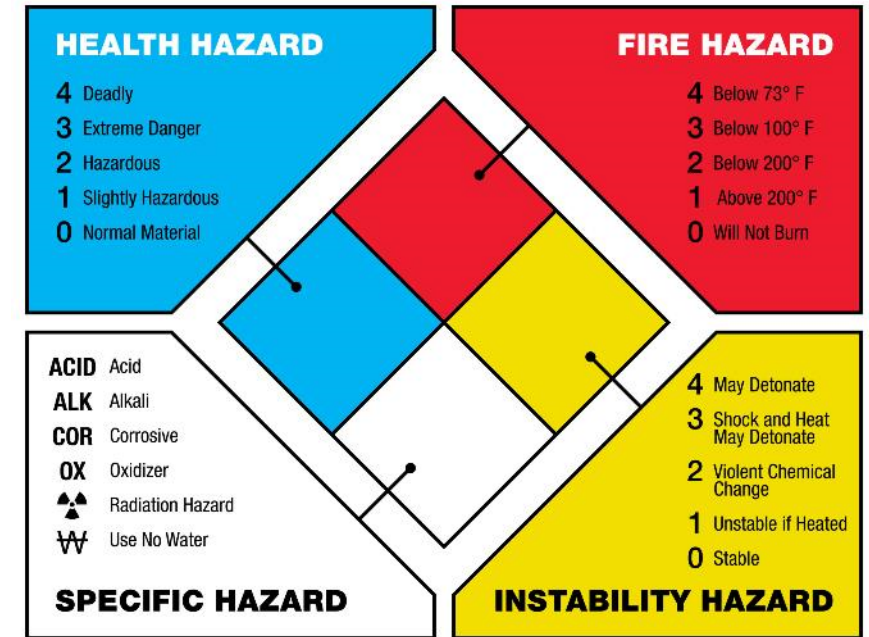
Gasoline



Beacons



Dispenser Hose Break-Away Devices



Source: HTEC

Next generation fuel cell Capacity Truck

- Partnership with Hyster
- New cab
- Optimized components
- BEV and FCEV versions
- In production Q4 2024



Cold weather considerations

- FC Transit Buses operating in cold climates for almost two decades
- No efficiency degradation due to the low temperatures
- No impact on fueling speed
- Fuel Cell manufacturers guarantee -13°F start / -22°F operation
- Likely need collaboration with OEMs and additional features /options for lower temperatures



What's next

- Cost will keep improving (batteries, fuel cells)
- Heavy-duty electric components (e-axles, accessories) development
- Need incentives to enable volumes and economy of scale
- Hydrogen cost will come down (Hydrogen Hubs, \$1/kg in 2031)
- Fueling solutions being developed and improved (target 10kg/min)
- Co-locating with other hydrogen equipment will help the economics
- Workforce (re-)development and education
- Demonstration and pilot grants coming
- Hydrogen “colors” irrelevant – focus on Carbon Intensity (CI)



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Thank you

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