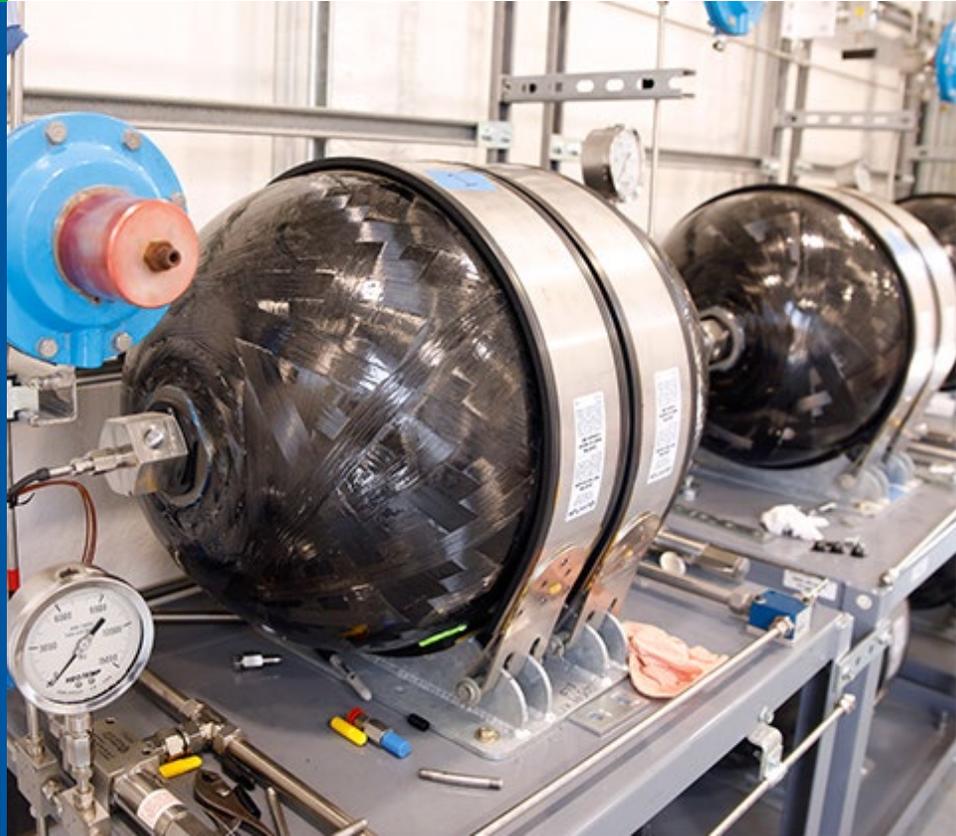




GTI ENERGY

solutions that transform

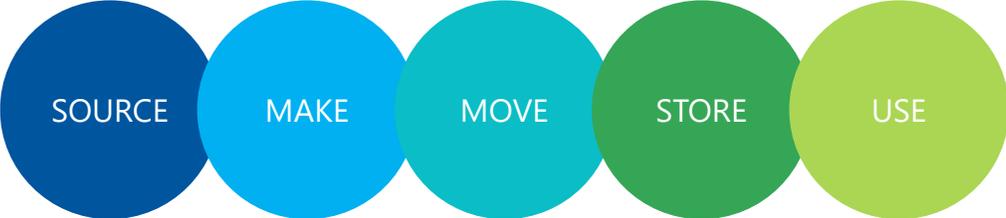


GTI Energy CNG Research Smart CNG Fueling Systems and Associated Projects

Ted Barnes, GTI Energy, Sr. Director – Mobility

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



500
Enterprise
Employees



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



GTI Energy – Main Campus



**Emerging
Energy
Technology
Campus**

**Main Offices
and Labs**

GTI Energy – Mobility Research Capabilities



- R&D Focus Areas

- Innovation, Design, Fabrication, Deployments, Data Collection/Analysis, Codes & Standards, Hazard Reviews
- Advanced vehicles, fueling stations, and fuel production
 - Hydrogen, renewable natural gas (RNG), electric, hybrids

- Testing Capabilities

- Large-Scale Environmental Chambers
 - Wide Temperature Range (-40 to 160° F)
 - Fully Instrumented - mass flow meters, gas detection, data acquisition
- Multi-Bank, High-Pressure Hydrogen and Natural Gas Cascade
- 10,000 psi hydrogen and natural gas testing



GTI Energy – Capabilities





NGV R&D Sponsors - Thank you!!!



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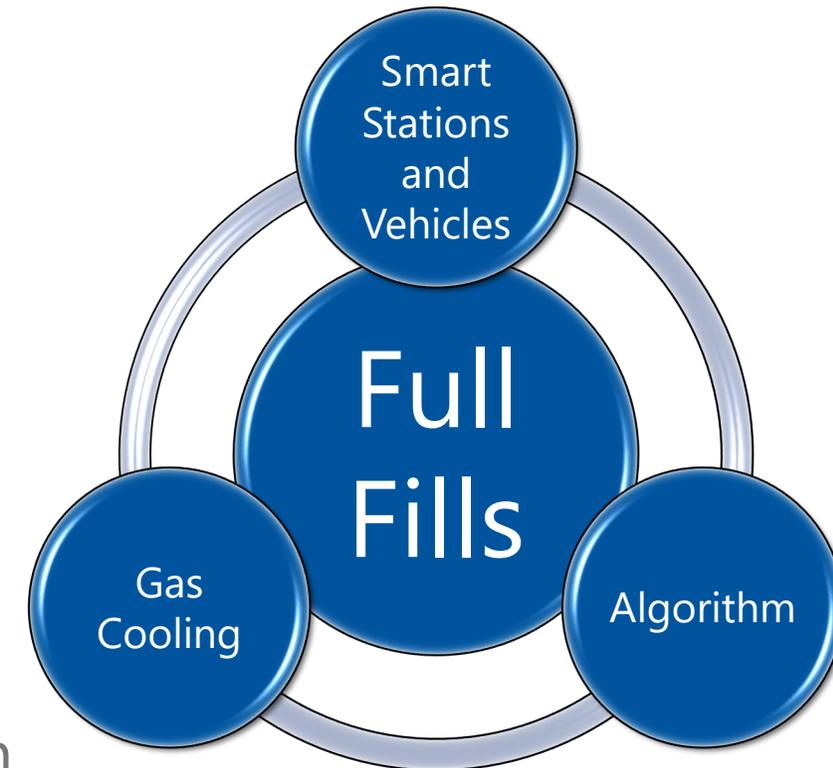
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Smart CNG Station

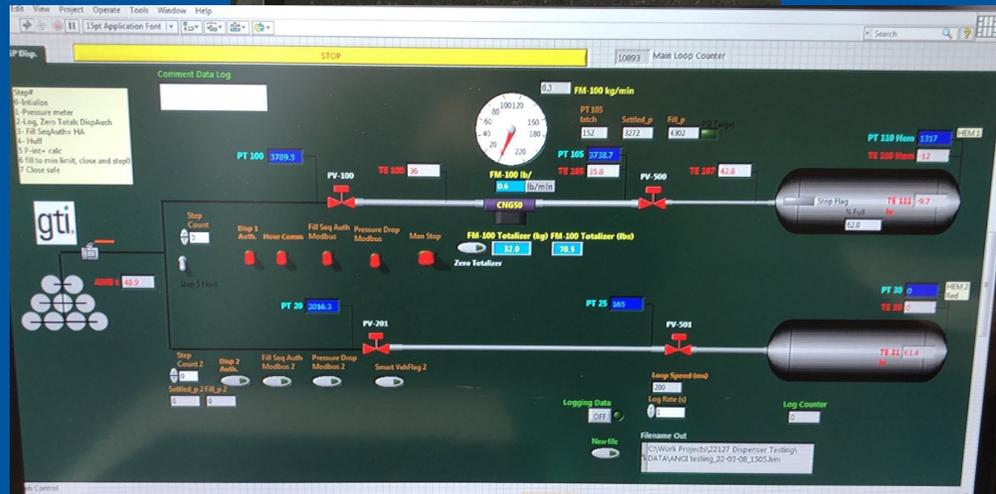
Project Objectives

- CNG full fills using:
 - Smart vehicles and dispensers
 - Advanced full fill algorithm
 - Cost effective pre-cooling
- Build test smart dispenser and vehicle
- Program dispenser with full fill algorithm
- Design and build isentropic CNG reciprocating piston expander/compressor
- Test and demonstrate full fills using expander/compressor to supply cold gas to smart dispenser and vehicle



Preliminary Smart Dispenser Testing

Dispenser: ESP32 wired to LabVIEW

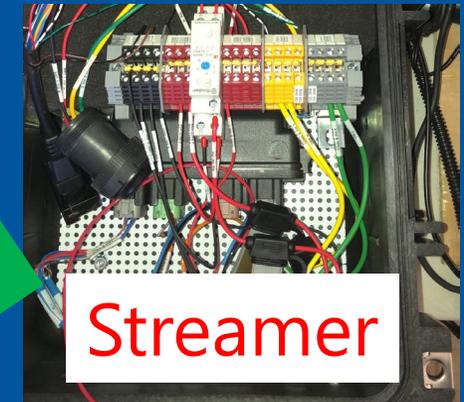


- Smart components installed in GTI test cell

Wi-Fi

- Collected preliminary filling data
- Achieved 95%+ full fills

Vehicle: HEM Streamer connected to tank sensors



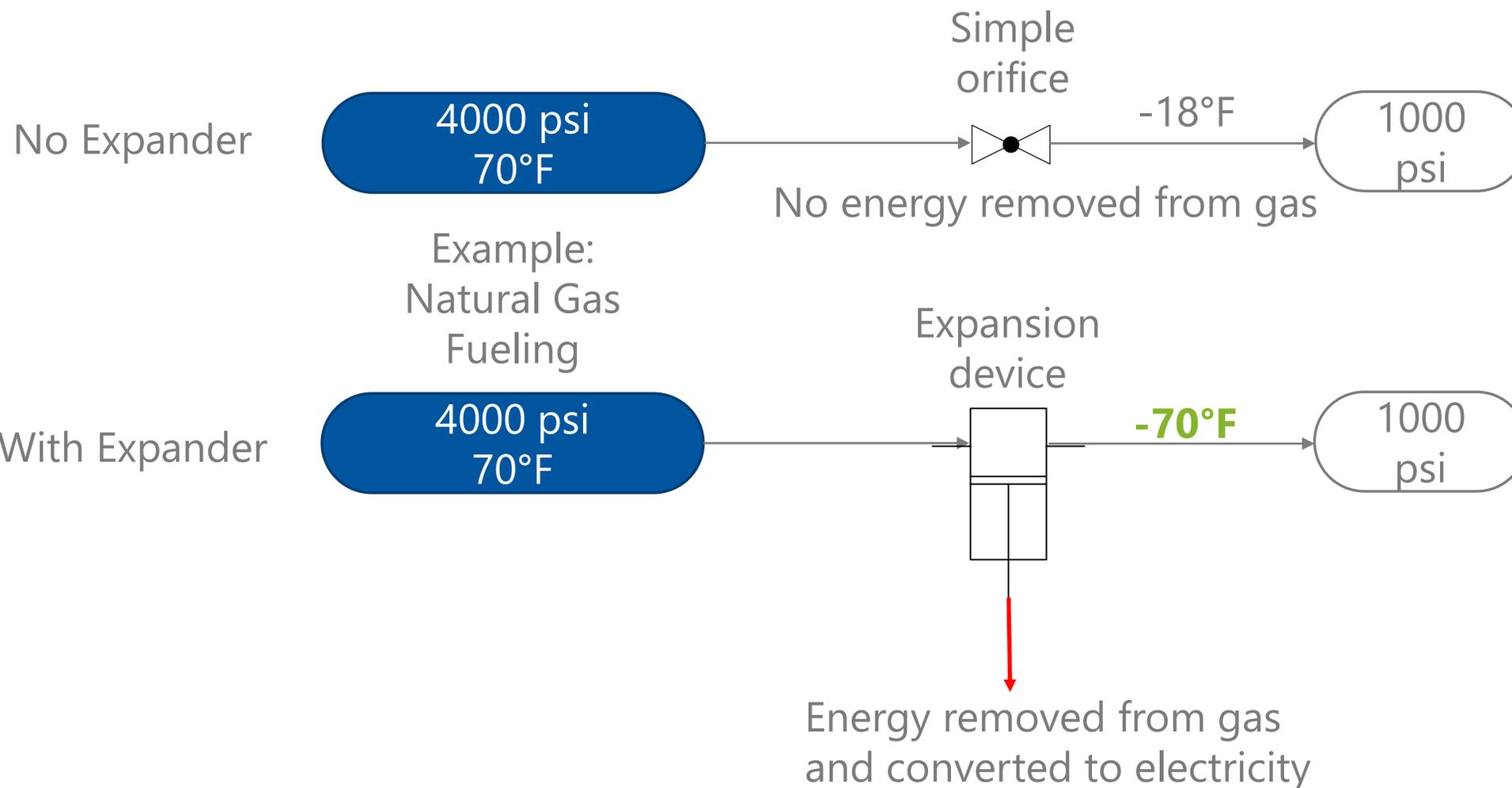
Next Step: Smart CNG Dispenser Development

- GTI installing commercial dispenser in lab to test smart fueling
- GTI is working with ANGI engineers to modify dispenser code
 - Smart components will send new target pressure to dispenser based on vehicle data
 - Otherwise, the dispenser will fill to default target
- Commercial dispenser testing will occur at GTI's facilities with real-world demonstration to follow



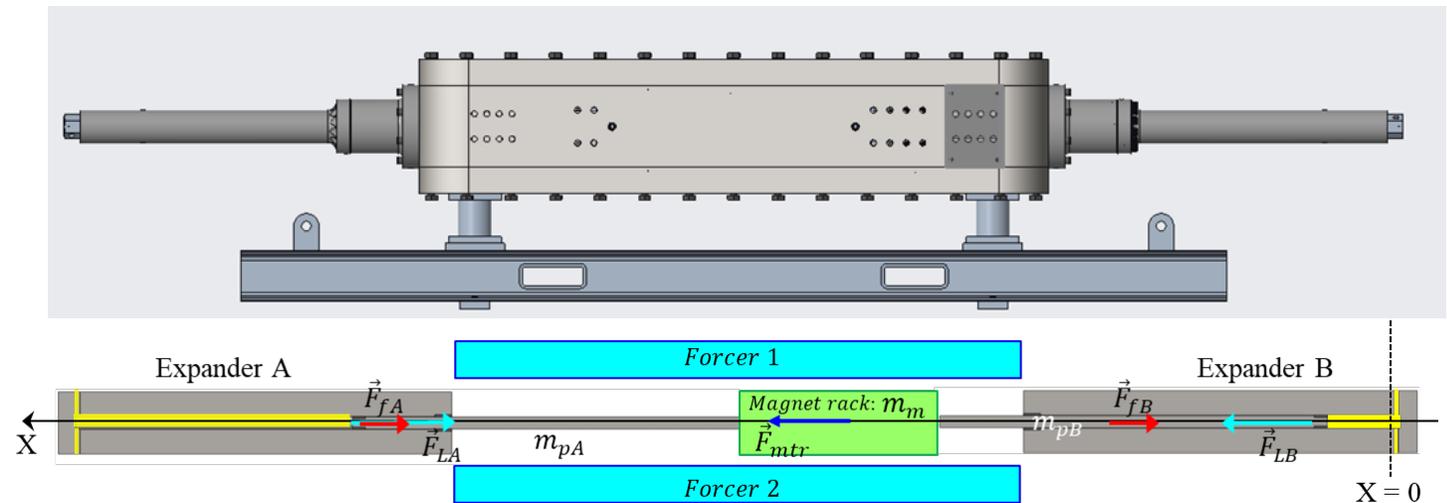
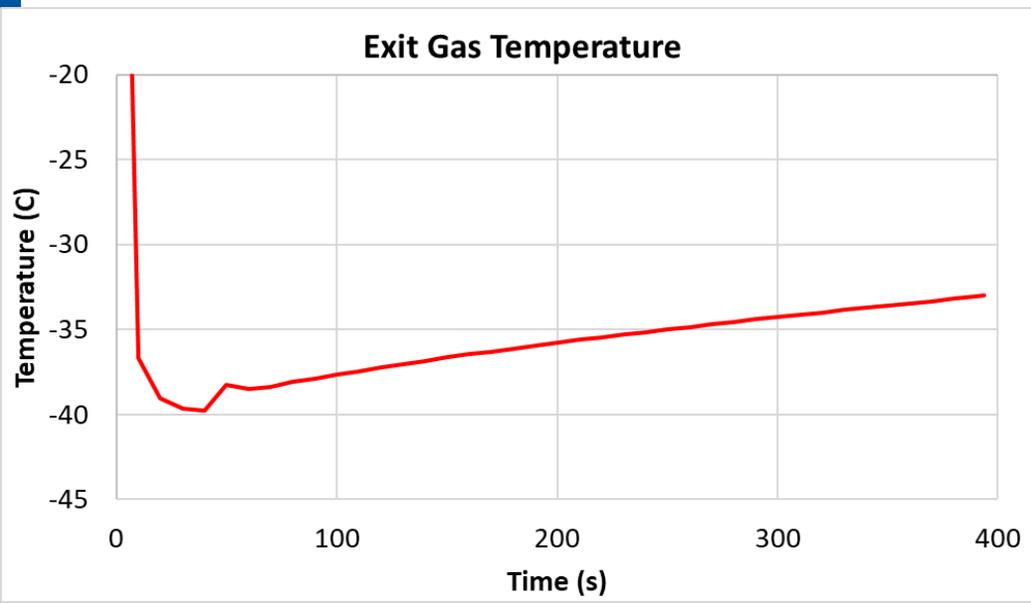
Free-Piston Expander for Pre-Cooling

Expanders use pressure difference to do work



Current Unit Build and Test

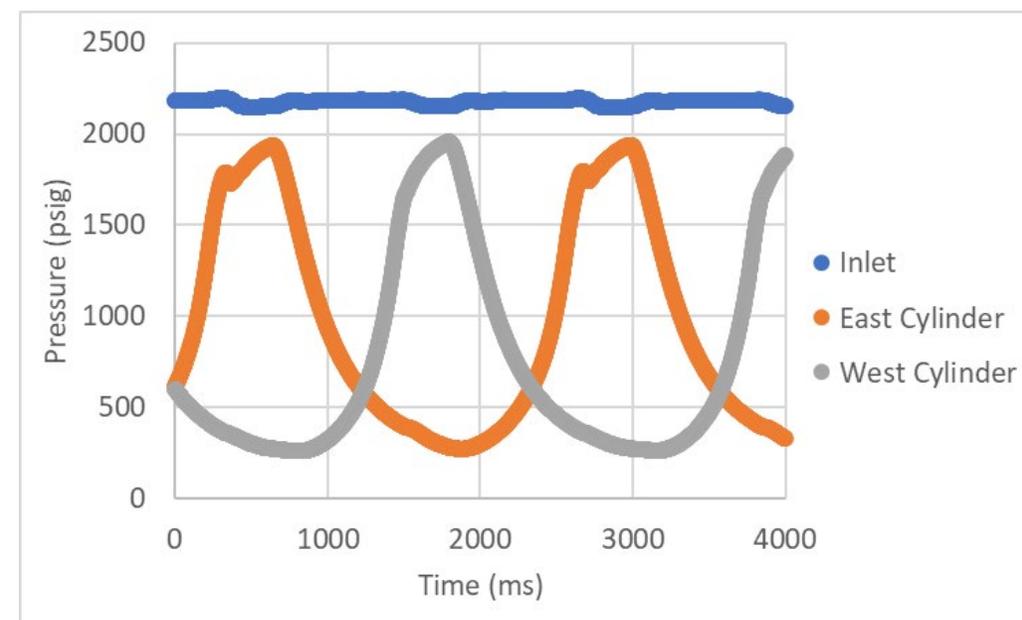
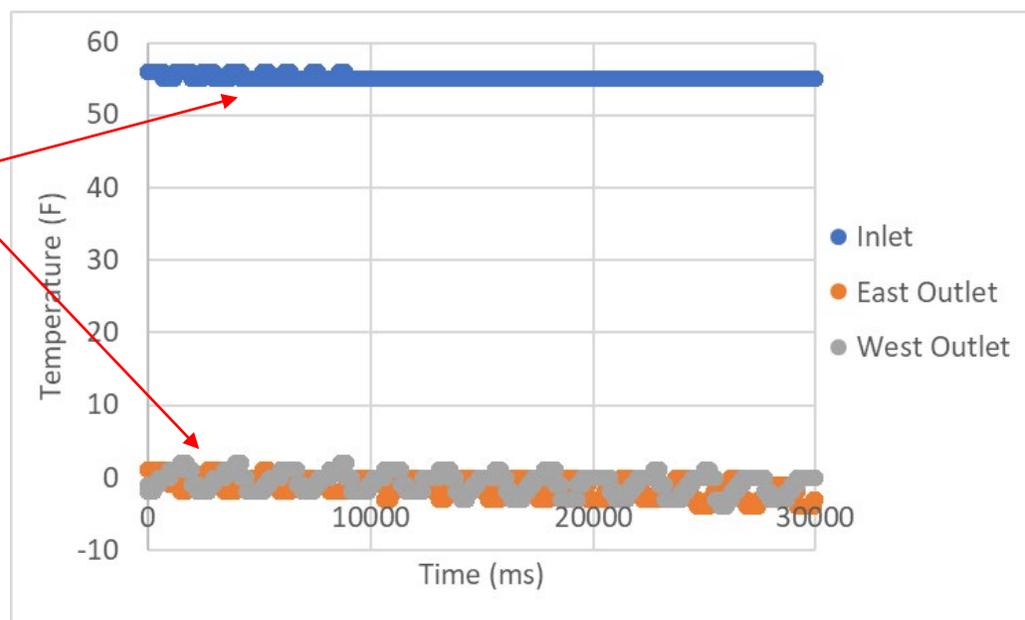
- Extensive modeling and design completed
- Linear expander commissioned in Jan 2023
- Currently testing with nitrogen
 - Next is hydrogen
 - Then natural gas



Nitrogen expansion test data

- Current testing at operating pressure of 2000 psig
 - Slowly increasing to 12,500 psig

Temp Drop of 55F!



Smooth pressure curves indicate proper functioning

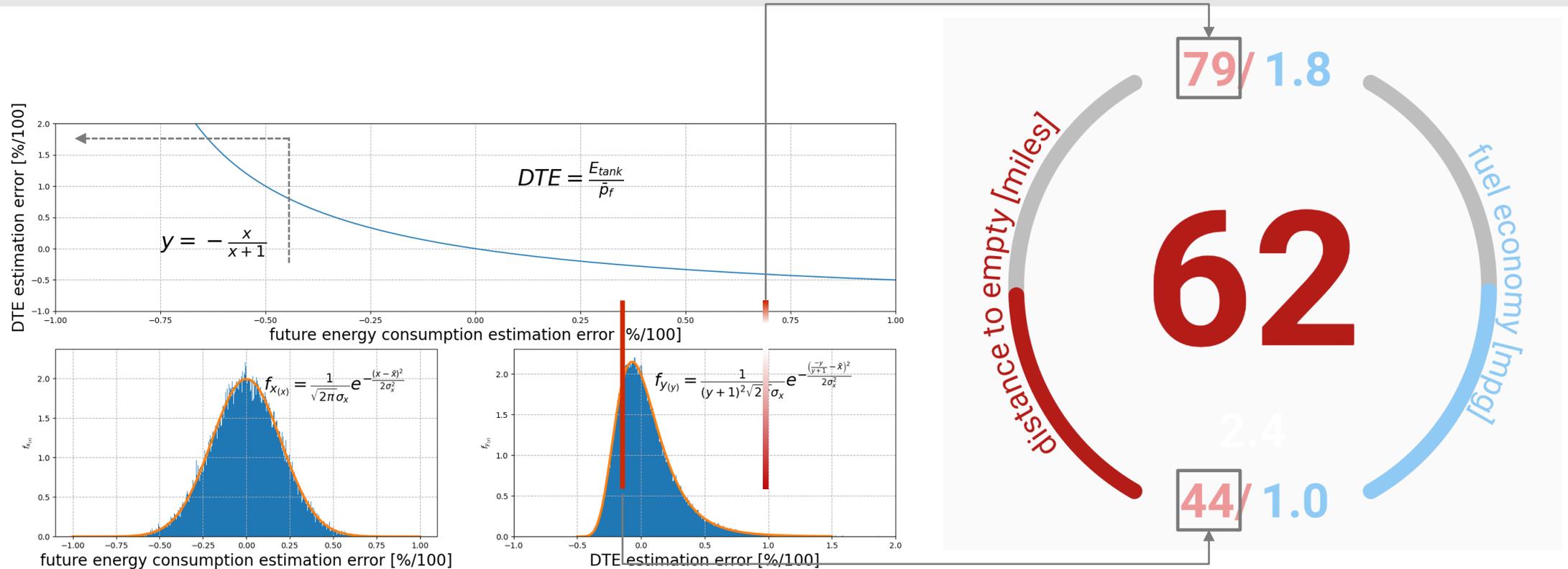
Next-Generation Driver Information System

Next-Generation Driver Information System

- Improved fuel gauge with 98% accuracy for remaining fuel
- Gauge displays upper and lower bounds for distance-to-empty based on remaining fuel and recent driving patterns.
- Gauge has been installed on in-use Ozinga truck
- After a validation period, install on remaining 9 trucks



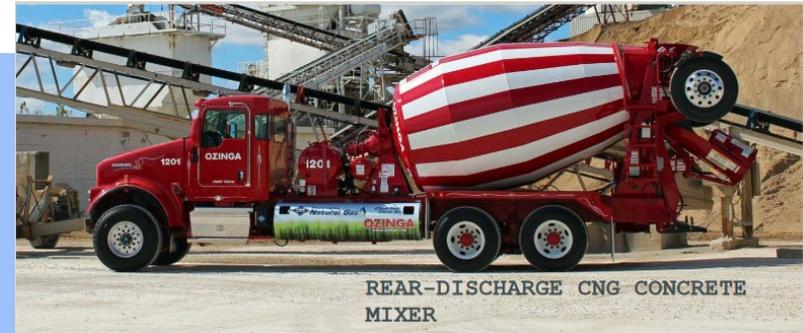
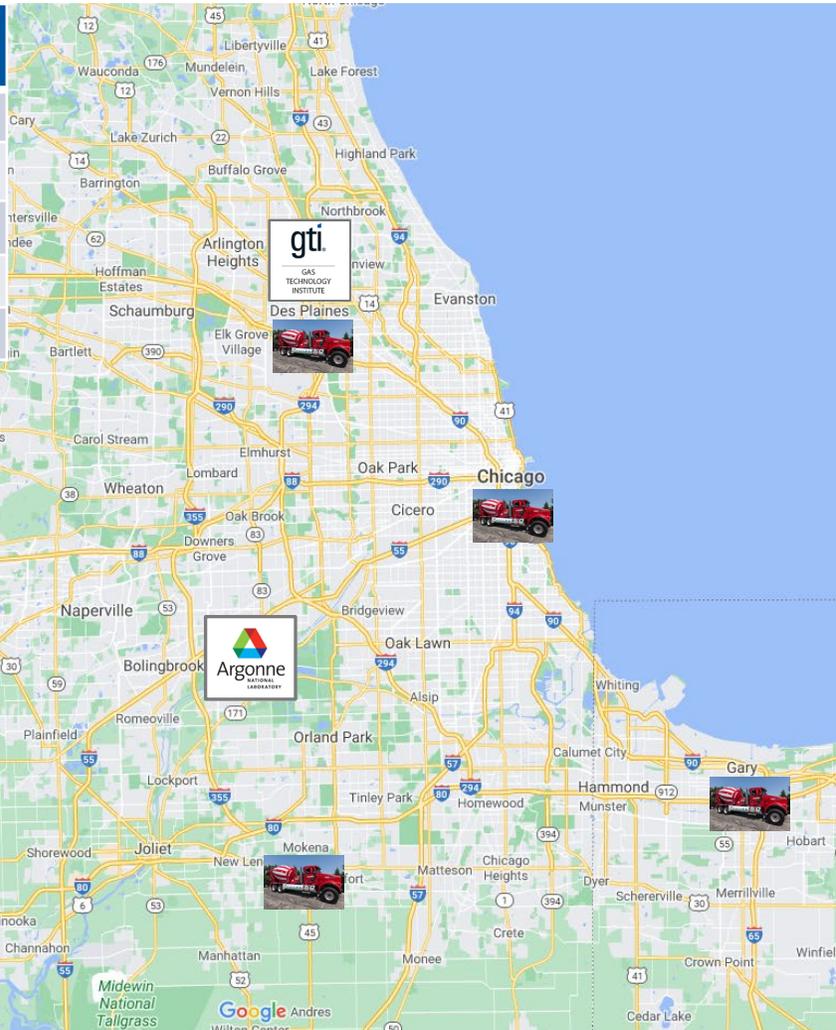
Distance to empty (DTE) calculation



- App can create predictive future fuel economy and DTE based on mapping and connection with dispatch
- With challenging duty cycle (>50% idle time), different approach needed to achieve 5% accuracy of DTE

Ozinga locations w/ NG trucks

# of Trucks	Location	Installed
2	Des Plaines	2/2
3	Chinatown	3/3
2	Montgomery	2/2
3	Mokena	3/3
2	Gary	2/2



REAR-DISCHARGE CNG CONCRETE MIXER



Free Piston Linear Motor Compressor for Methane Leak Recovery

Methane Leak Recovery

- Midstream compressor stations have concentrated methane leaks
 - Compressor packing
 - Engine starters
 - Valves
 - Blowdowns
- Existing solutions are often costly and only partially address leaks
- GTI is developing a unique, linear motor driven compressor
 - Recover gas from any/all sources
 - Compress leaks directly back to pipeline
 - Minimize impact on existing equipment



Project Scope

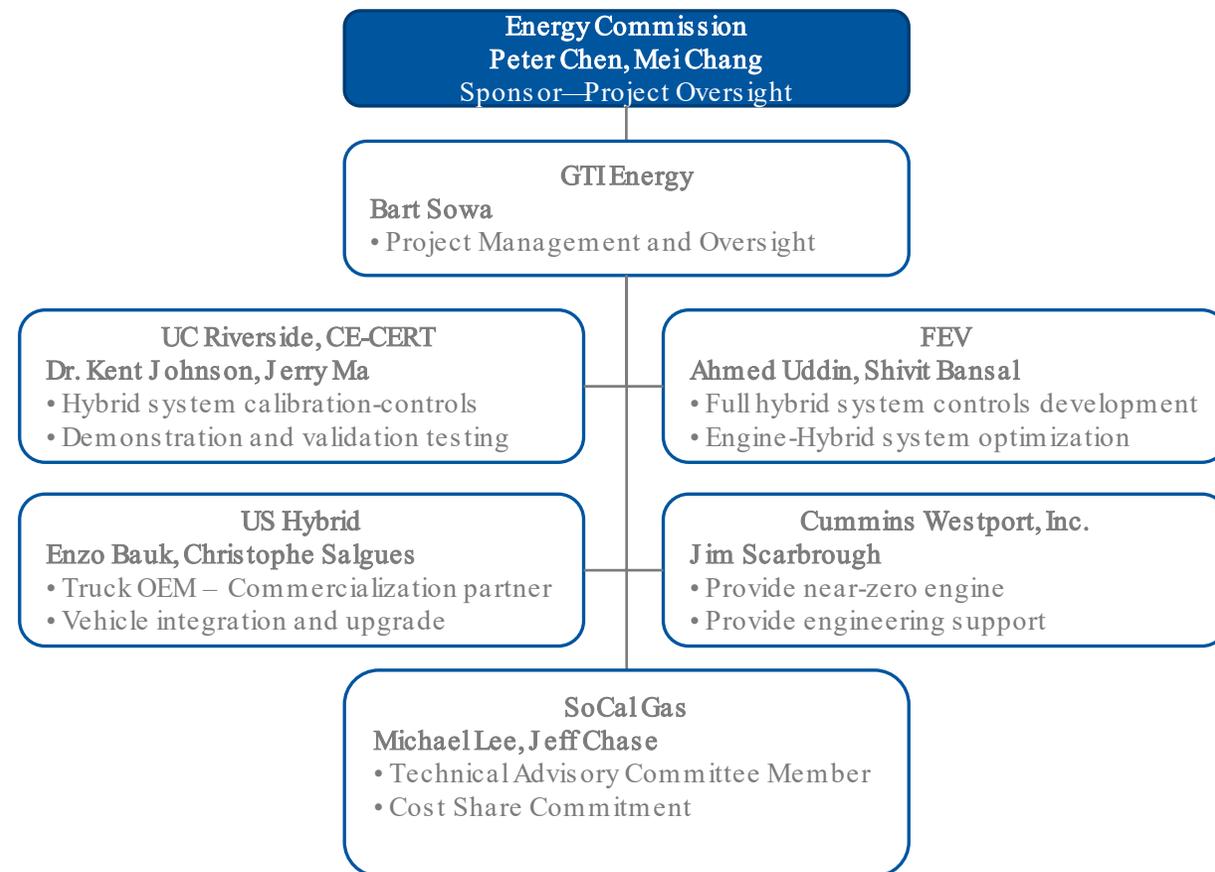
- Design a linear motor leak recovery compressor
 - Inlet: Near atmospheric (0 to 0.25 psig)
 - Discharge: 1500 psig
 - Target flow: 60 SCFM
- Integrate compressor into leak recovery skid
- Install compressor and recovery skid in GTI's environmentally controlled test chamber
- Extensively test complete linear motor leak recovery skid to verify performance and durability
- Success: Show durability and accurate flow control for a reasonable price



Optimization and Demonstration of a Near-Zero, Heavy-Duty, Hybrid-Electric Truck

Project Description

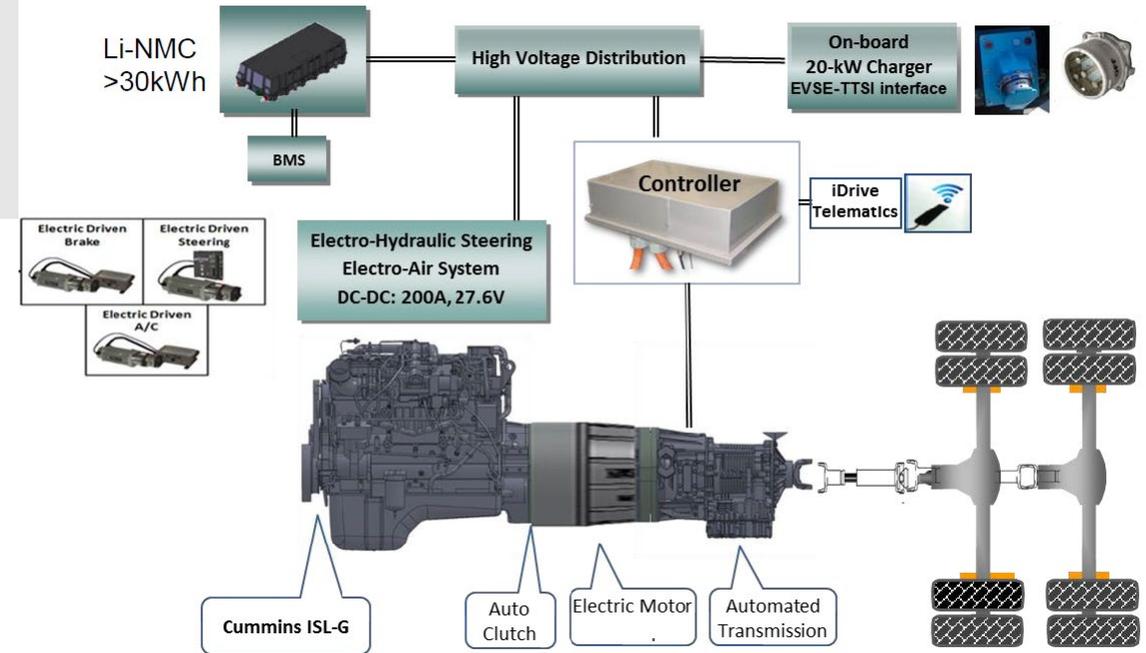
- Leverage extensive research and equipment from past programs
- Employ near-zero NOx engine and an operational heavy-duty hybrid vehicle
- Update vehicle powertrain with latest battery technology and required balance-of-plant
- Develop and demonstrate optimized hybrid vehicle controller
- Measure performance on chassis dynamometer



Agreement Term: 5/7/2018 – 12/30/2022

Results

- US Hybrid truck was paired with FEV optimized controller and tested at UC Riverside
- Testing was completed and final reports recently submitted to CEC



Key Findings

- 500+ HP in hybrid mode is equivalent to 15-liter diesel engine (necessary to negotiate steep grades)
- Hybrid truck fuel economy was 11% better than diesel on port cycles
- 0.002 g/bhp-hr NOx emissions* – 100x lower than current diesel technology
- NOx emissions may rival EV well-to-wheel emissions in certain scenarios – more research required
- Vehicles can be retrofitted with this technology
- More improvement opportunities identified, but industry support is needed (start/stop technology, engine and transmission control optimization, heated catalyst)

*in-use emissions measured on select drive cycles, ref:2013 UCR study

NGVAmerica
FY 2023 EERE NGV Funding Request

FY 2023 EERE NGV Funding NGVAmerica



- FY 2023 EERE Funding \$10M
- *To address technical barriers to the increased use of natural gas vehicles, with a focus on those utilizing non-fossil based, renewable natural gas. Technical barriers include demonstrations of advanced natural gas vehicles and fueling infrastructure, medium and heavy duty on-road natural gas engine research and development, energy efficiency improvements, emission reduction technologies, fueling infrastructure optimization, and renewable gas production research and development.*
- Time to start thinking about FY 2024 requests – we need your ideas!



Future R&D Needs NGV America



- NGV America Request To Appropriations Committees
- RNG and Hydrogen will remain important topics to leverage
- Interest in Off-Road applications are growing – Rail/Marine/Virtual Pipeline/Etc.
- Continue R&D topic list
 - Improve Engine Efficiency
 - Larger Engine Development
 - Advance Natural Gas Storage
 - Grow RNG as a Transportation Fuel
 - Support Virtual Pipelining
 - Consider Adsorption Technologies
 - Support Natural Gas Use in Marine and Rail Applications
 - Hydrogen blends
 - Station improvements
 - Market Analysis
 - Freight Operational Efficiency and Systems
 - ICE Powertrain, Fuels, and Emission Controls
 - Hydrogen and Fuel Cell Trucks
 - Methane catalyst to eliminate/control engine out methane emissions
 - Develop a FC/FCV that can reform CNG or LNG on-board with no pollution



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