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Smart Compressed Natural Gas (CNG) Station Deployment

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Overview

Timeline

Project start date: October 2019 Project end date: December 2023 Percent complete: 20%

Budget

Total project budget: \$3,999,781 Total recipient budget: \$1,999,992 Total federal share: \$1,999,789 Total DOE funds spent*: \$182,543 *As of 04/30/2021

Barriers

CNG vehicle underfilling caused by uncertainty about state of cylinder during filling

Vehicle cost and range are improved

Partners

Ozinga Energy Clean Energy Kraus Global



Project Objectives

Objective

- Measure and quantify CNG vehicle underfilling at existing stations
- Develop communications system between vehicle and dispenser to improve filling accuracy and safety
- Demonstrate improved fills at field sites

Impact

- Improve range of CNG vehicles by enabling fuller, more consistent fills
- Improve safety of CNG vehicles
- Reduce CNG vehicle cost by reducing total volume of CNG storage needed

VTO Goals

- National Security: Increases alternative fuel use
- Affordability for Business and Consumers: Lower cost CNG vehicles
- Reliability/Resilience: Safer CNG fills. More consistent fills.



Project Approach

Budget Period 1

- Develop vehicle data acquisition systems
- Deploy data acquisition systems onboard CNG vehicles
- Collect vehicle operating and filling data to verify underfilling
- Design smart vehicle and dispenser communication components

Budget Period 2

- Test smart vehicle and dispenser communication components in lab
- Integrate smart vehicle and dispenser components onto vehicles and dispensers
- Install smart dispensers at test sites
- Verify data collection from test sites

Budget Period 3

- Collect operational data
- Verify improved fills
- Verify system benefits justify the cost of additional communications equipment

Milestones

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Budget Period 1	Туре	Description	Progress
Data Acquisition Design Complete	Technical	Design of station and vehicle data acquisitions systems is complete and has flexibility to capture relevant data points across vehicle platforms.	100%
Preliminary Design of Smart Modules Complete	Technical	Specifications and requirements for smart modules have been fully defined, documented and sourcing of components has started.	100%
Data Acquisition Installation Complete	Technical	Vehicle and station baseline data acquisition have been installed at demonstration sites.	50%
Detailed Design of Smart Modules Complete	Technical	CAD models complete, and the components have been selected for smart modules.	90%
Baseline Data Validates Underfilling	Go/No Go	Baseline data collected from demonstration sites demonstrates that vehicles are underfilled by 10-25% depending on filling conditions.	10%
Budget Period 2			
Test Environment Installation Complete	Technical	Installation of smart modules into test environment is complete.	0%
Smart Module Laboratory Testing Complete	Technical	Smart modules have successfully completed pre-defined matrix of test conditions.	0%
Integration of Smart Module into Test Dispensers Complete	Technical	Smart module successfully integrated into test dispenser and control code has enabled smart filling protocol when smart vehicle is connected.	0%
Smart Station Installation Complete	Technical	Installation of smart CNG demonstration systems is complete.	0%
Data collection at Smart CNG Stations has Started	Go/No Go	Project team is actively collecting data from operational smart vehicle and station.	0%
Budget Period 3			
Smart Station Data Collected	Technical	Project team actively collecting smart station data from demonstration sites.	0%
Preliminary Data Analyzed	Technical	Data demonstrates improved fill performance compared to baseline.	0%
Preliminary Economic Analysis Complete	Technical	Full fill economics demonstrate value to fleets and CNG vehicle owners.	0%
Commercialization Plan Complete	Technical	Project team has fully developed path to market for smart CNG systems.	0%

Project Accomplishments: Data Acquisition Design

- GTI developed two DAS options. HEM and Campbell
- Campbell development was halted due to bandwidth issues
- HEM system design was finalized
 - CAN bus and fuel system data collected
 - Cellular to cloud storage
 - Wi-Fi to local device (Phone or Dispenser)



xx Hz – frequency when key switch is powered, and first hour after off xx Hz – frequency when key switch has been off for 1 hr - 24 hr

Project Accomplishment: Data Acquisition Systems Installed

- Preliminary test DAS was installed on concrete mixer
 - System was successfully tested
 - Now transmitting CAN bus and fuel system data
- Components for remaining systems were purchased
- Additional systems were assembled and tested
 - 3G Cell services was no longer supported
 - Systems were upgraded to 4G, debugged, and are now operational
- Nearly all systems assembled and ready for installation



Project Accomplishment: Preliminary Design of Smart Vehicle and Dispenser

- Vehicle data acquisition system can also be used as smart vehicle device
 - Data can be transmitted wirelessly to local devices
 - All CAN bus and fuel system data is available
- Dispenser reciever will wirelessly connect to vehicle, calculate percent full, and send data to Modbus table for dispenser to read
- Approach was discussed with dispenser manufacturers that verified this design should work with their systems



Project Accomplishment: Detailed Design of Smart Vehicle and Dispenser

- Vehicle identification, connection and control logic complete
- Programming and bench testing vehicle transmitter and dispenser reciever
 - CAN shield represents vehicle
 - Reciever selects connected vehicle by scanning transmitters
 - Reciever processes data and provide dispenser with percent full and select CAN bus data





Project Accomplishment: Test Area

- GTI built a new CNG / H2 test area
- Multiple test chambers are being installed
- Gas and environmental testing will be possible (-40 to 60C)
- Area will be used to test CNG full fills across a range of temperatures
- CNG test chamber was recently approved for construction





Project Accomplishment: Codes and Standards

- GTI is actively participating on NGV 4.3 technical committee
 - NGV 4.3 will cover dispenser certification
 - Ultimately used to determine if dispenser algorithm is safe
 - NGV 4.3 will be used to test GTI algorithm safety
- CNG dispenser standard is not prescriptive
- New algorithms can be developed
- Algorithm simply needs to pass a defined test protocol to be certified
- GTI is working to ensure nothing in standard prohibits proposed full fill improvements



Collaboration and Coordination Among Team Members

- GTI is managing project
- GTI is lead developer of smart components
- Ozinga operates a large fleet of CNG vehicles
- Clean Energy operates a large network of CNG stations
- Kraus manufactures CNG dispensers



Overall Impact

Completed Achievements

- Developed vehicle DAS that can collect and transmit all vehicle and fuel system data to local devices and the cloud
- Validated operation of first vehicle DAS
- <u>Completed CNG dispenser manufacturer survey to verify proposed operation of dispenser</u> reciever

Upcoming:

- Deploy remaining data acquisition systems onboard vehicles
- Lab test smart vehicle and dispenser operation during CNG fill
- Discussing integration of vehicle safety signals into dispenser communication with major CNG equipment manufacturers
- Discussing hydrogen vehicle communication with major manufacturers

Summary

Goal	 Quantify CNG vehicle underfilling during fast fills Develop smart vehicle and dispenser components that enable fuller, safer CNG fills 	
Approach	 Deploy vehicle data acquisition systems to gather baseline data Design, test, and deploy smart vehicle and dispenser prototype Validate improved fills during field deployment 	
Accomplishments	 Designed data acquisition systems Deployed first data acquisition system Designed smart vehicle and dispenser components 	
Next Steps	 Lab test smart vehicle and dispenser systems Deploy smart components into the field Collect data and verify improved fills 	



Technical Backup and Additional Information



Related Work

- GTI is developing a CNG expander to overcome heat of compression
- Smart station components and improved algorithm can fully leverage chilled gas entering vehicle to achieve full fills
- GTI is planning a lab demonstration of smart station component performance when combined with pre-cooled gas from expander



Technology Transfer Activities

- Investigating other applications of smart station components
 - Virtual pipeline filling accuracy
 - Hydrogen vehicle filling
- GTI is discussing project with multiple dispenser manufacturers that have expressed an interest in integrating the technology
- GTI has discussed safety related applications with CNG manufacturers
- GTI is discussing licensing terms with dispenser manufacturers

