Final Report

Non-Confidential

Advanced Dual-Fuel System Commercial Demonstration (ERA Project ID: T0160716)

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TRL (project start):	6
TRL (project end):	8
Total actual ERA funds received:	1,200,000 (total to be received)
Total actual project costs:	
$ 3,053,717.51	
Submission Date:	July 14, 2023

The project involves the commercial validation of Innovative Fuel System's (IFS) dual-fuel technology. This will entail using a large Alberta-based heavy-duty (HD) fleet to test and validate our technology in their daily operations for a period of 22 months. The objective of the project is to have two fleets validate the commercial use of dual-fuel technology (in Paccar MX-13 and Cummins X15 engines) and quantify fuel saving, diesel fuel displacement, and GHG emission reductions. To ensure the validity and portability of the results, IFS will use six (6) HD trucks for this project.

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Executive Summary

In September 2020, Innovative Fuel Systems and its project fleet partners, KAG Canada (formerly Westcan) and Natural Resource Recovery Group Inc. (NRRG), embarked on an ERA-supported project with the stated goal of commercializing IFS' dual-fuel (diesel and CNG) technology equipment in the heavy-duty trucking industry. The projected project benefits included a practical solution to reduce greenhouse gas (GHG) emissions and economic benefits to encourage market adoption. IFS also had the goal of augmenting its product technology to develop and capture another engine type beyond the PACCAR engine type. After developing technology for a Cummins engine, IFS determined it would be able to address 50%–60% of the domestic market.

Project Highlights

Financial:

- Original Budget = $3,076M
- Final Costs = $3,054M
- ERA Funding = $1,2M

Operational:

- Cummins engine type was successfully developed.
- Road testing occurred on all HD trucks for the stated periods.
- There were no environmental or safety issues encountered.
- Fuel displacement values at optimized conditions exceeded expectations.
- GHG emissions reductions were validated.

Commercialization:

- IFS achieved its stated goal of commercializing the technology, with its project partner placing an order for 20 initial units. Press release attached. https://www.newswire.ca/news-releases/ifs-announces-initial-1m-purchase-order-from-kag-canada-north-america-s-largest-tank-truck-transporter-851738105.html

Introduction and Technology Overview

Innovative Fuel Systems has developed a dual-fuel technology that allows existing heavy-duty diesel engines to displace up to 50% diesel fuel (on average) with a cleaner burning fuel, such as natural gas or hydrogen. This technology allows HD fleets to use IFS technology on their existing HD trucks to reduce GHG emissions and potentially reduce fuel costs. IFS' technology, which uses in-cylinder mixing, has sequential port injection. The greatest advantage of port injection is the elimination of alternative fuel waste during the engine rebreathing cycle when the intake and exhaust valves are open at the same time.

Project Background

Currently, HD trucks (those with GVWR > 33,000 pounds) contribute 9% of Canada's GHG emissions, and diesel trucks emit approximately 80% of the total black carbon emissions despite comprising only 1% of the vehicles on the road. Consequently, fleet operators face increasing pressure from both the government, who wants to see emissions reductions, and their customers, who want to see their Scope 3 emissions reduced. IFS' project partners, KAG and NRRG, want to test its natural gas dual-fuel technology in order quantify GHG reductions and potential fuel savings.

Project Objectives

- Commercially validate IFS' dual fuel technology.
- Optimize technology to maximize GHG reductions and diesel fuel displacement; GHG emissions cannot be increased.
- Optimize technology in cold commercial operations.
- Pass commercial durability and operational requirements set by commercial fleet.
- Complete system and packaging integration for commercial rollout.

Performance/Success Metrics

Success Metric	Commercialization Target	Project Target	Achievements to Date
Diesel displacement	> = 35%	> = 40%	50% diesel displacement
Engine performance	Equal to 100% diesel-fueled engine	• Equal to 100% diesel-fueled engine as indicated by driver's subjective assessment • No "check engine light" resulting from dual-fuel system; dealership to print report monthly	• Equal to 100% diesel-fueled engine, BUT only tested with IFS truck testing • Dynamometer testing has already indicated engine performance similar
System reliability	All engine and performance issues discovered in 12-month operation period are resolved	• All engine and performance issues discovered in 12-month operation period are resolved • Must not have any dual-fuel-related issue for at least 48,000 km (this is about one month of full operation in the Calgary to Edmonton run) • Must not have any dual-fuel-related issues for at least three trucks for an entire month of operation in both winter and summer	• No engine performance issues encountered • No dual-fuel or operational issues in commercial runs
CO2e emissions reductions	Any reductions in CO2e emissions	A CO2e emissions reduction target of greater than 4%	CO2e emissions reductions ~10% in Paccar MX-13 engine and greater than 11% in Cummins X15 engine

The IFS dual-fuel system achieves an impressive 50% displacement of diesel with compressed natural gas (CNG). The core principle guiding our system's design is an energy balance methodology. During the engine's development stages, we conducted extensive testing to measure the fuel consumption across various load conditions, ranging from 10% to 100% engine loads. By measuring the fuel flow rate, we precisely determined the amount of diesel energy the truck required to produce power.

In our system, we store the CNG at approximately 3000 psig, and our tank holds approximately 70–80 kg of natural gas. We have different tank styles—side mount, back mount—and depending on customer requirements, we increase or decrease the number of tanks.

The technology allows seamless operation in ambient temperature from -35 to +40 degrees Celsius.

Project Work Scope

In general, the stated objectives for the project were to:

1. Develop and apply for patent protection;
2. Work with project partners to acquire HD trucks for road testing;
3. Develop technology for use on IFS Cummins-engine-type HD trucks to augment technology already developed for the Paccar engine type and road test it;
4. Install and commission equipment on project partners' HD trucks (Paccar engine (KAG Canada, formerly Westcan) and Cummins engine (NRRG));
5. Perform road testing for 20 months on five KAG trucks and for 18 months on one NRRG truck; and
6. Perform emissions testing as specified.

Commercialization

Before start of this project, IFS' dual-fuel technology for the Paccar MX13 and Cummins X15 engines was TRL 7. The successful work completed in this project upgraded the technology to TRL 8 and made it fully commercial for the Paccar MX13 and Cummins X15 engines.

To validate the commercial viability of the technology, KAG Canada made an initial purchase of $1M of IFS' dual-fuel technology—a direct result of this project.

The project achieved the following technical and commercial objectives:

- Average diesel fuel displacement of close to 50%.
- Dual-fuel performance equal to diesel-only engine performance.
- No "check engine" lights during commercial runs.
- No issues related to dual-fuel operation.
- More than 9% CO2 emissions reductions.

Emissions Reduction Impact

GHGenius (Version 5.01g) was used to provide baseline emissions data derived from Alberta sources.

We used GHGenius modelling for GHG emissions based on a g/km basis rather than on an energy basis because "the problem with using energy as the functional unit is that if the engine efficiency is impacted by the use of natural gas, then the emission reductions will be overstated as more energy per kilometre is required compared to diesel. Using g/km takes into account changes in engine efficiency, which comparing on an energy basis does not do."

The project baseline uses petrol diesel for 100% of the fuel source of a HD truck. The emissions for petrol diesel per kilometre are modelled with GHGenius, as shown below. The CO2e reductions based on our emissions testing by EPA standards are as follows:

- 9.6% CO2e reductions in the Paccar MX13 engine
- 11.0% CO2e reductions in the Cummins X15 engine

Economic and Social Impacts

Customers can expect to save between $23K and $57K per year when using IFS' dual-fuel technology.

IFS' dual-fuel technology will provide many positive economic and social impacts, including:

- Enhanced energy diversification;
- Clean energy solutions;
- Achievement of GHG reduction targets, a low-carbon economy, and green industry growth;
- Strong markets for Canada's energy resources;
- Enhanced economic competitiveness of Canadian industries and technology;
- The opportunity to provide abundant low-cost Canadian natural gas resources;
- Lower-carbon fuel options for consumers;
- The positioning of Canadian companies to compete more effectively when carbon regulations for heavy-duty vehicles are implemented;
- Encouraging wider use of technologies to achieve economies of scale in production;
- Significant GHG reduction benefits associated with renewable natural gas;
- The ability to measure and quantify GHG reductions; and
- The potential reduction of fuel price volatility risks due to natural gas use.

Overall Conclusion

Summary of the project outcomes and the resulting GHG emissions reductions attributed to this project in Alberta and/or abroad.

The most significant and impactful outcome of the project was taking IFS' dual-fuel technology to TRL 8, deeming it a fully commercial technology. To validate the technology's commerciality, KAG Canada made an initial $1M purchase of IFS' dual-fuel technology—a direct result of this project.

All the project's technical and commercial objectives were achieved, specifically:

- Average diesel fuel displacement close to 50%.
- Dual-fuel performance equal to diesel-only engine performance.
- No "check engine" lights during commercial runs.
- No issues related to dual-fuel operation.
- More than 9% CO_2 emissions reductions.

During the project, only six trucks were provided with IFS dual-fuel technology. Most of the GHG emissions reductions will be achieved after project completion because IFS' dual-fuel technology will be implemented more broadly throughout Canada and the United States. This project helped commercialize IFS' dual-fuel technology, making its adoption quicker and broader.