

Ultra-Low Emission Natural Gas Engines for On-Road Heavy-Duty Vehicles

Clean Fuels Advisory Meeting
September 3, 2015



Richard Carlson



Cleaning the Air That We Breathe...

Development Objectives

- 0.02 g/bhp-hr NO_x
- 0.01 g/bhp-hr PM
- 0.14 g/bhp-hr HC
- 10 ppm ammonia
- Minimal energy economy penalty
- Equivalent performance as diesel
- Durable system

Project Requirements

3 Step Program



Engine
Development



Chassis
Integration



On-Road
Demonstration

Funding Sources

<u>Sponsor</u>	<u>Amount</u>
SCAQMD	\$2,750,000
California Energy Commission	\$4,000,000
Southern California Gas Company	\$1,250,000
TOTAL	\$8,000,000

Selected Projects

<u>Manufacturer</u>	<u>Engine</u>	<u>Target Vehicles</u>
Cummins, Inc.	15L*	Class 8 HHDD
Cummins-Westport, Inc.	8.9L	Class 7-8 MHDD
Power Solutions Int'l., Inc.	8.8L	Class 4-7 LHDD

*Contract change to 12L pending CEC approval

Project Status

Project Proponent

Status

Cummins, Inc.

Development nearly completed
Demonstration deferred

Cummins-Westport, Inc.

Development nearly completed
Demonstration beginning

Power Solutions Int'l.

Project kickoff in September

Engine Configuration

	CI	CWI	PSI
Approach	New Design	Enhance	Enhance
Size	15L I-6	8.9 I-6	8.8 V-8
Fuel Inj. System	SFI	TBI	SFI
Ignition	Spark	Spark	Spark
AFR	Stoic.	Stoic.	Stoic.
EGR	Cooled	Cooled	Cooled
Turbocharger	Yes	Yes	Yes
Charge Cooling	Yes	Yes	Yes
Catalyst	TWC	TWC	TWC

Development Status

8.9L and 15L Engines

- Technology alternatives evaluated
- Technology strategies selected
- Test engines have been built and tested

8.9L Engine

- Hardware and calibrations finalized
- Emissions meeting targets demonstrated (not ammonia)
- Application submitted for 0.02 g optional standard
- FC/GHG equal or better than 0.2 g NO_x NG engines

8.9L Demonstration

Vehicles:

- 1 truck for first on-road trial of about 3 months
- 9 transit buses in revenue service (San Diego and Los Angeles)
- 7 trash collection trucks in revenue service (Los Angeles & Oakland)

Integration/Installation

- Same envelope as current 0.2 g NO_x engine
- Retrofit vehicle with enhanced engine/after-treatment components
- Installation by fleets with assistance from Cummins dealer

Operations

- Minimum 6 months operation
- Monitor and record performance and fuel economy
- 1 vehicle selected for chassis dynamometer emission tests

Commercialization

CWI 8.9L Engine

- Software calibration updates from demonstration
- Pilot production in 2015
- Serial production in 2016
- Initial focus on transit buses
- Trash collection and other truck applications follow
- Informational marketing to California dealers/customers in 2015

CI 15L Engine

- Complete development activities in 2015
- Defer commercialization to 2020-2023 due to market conditions
- Apply technology elements to other engine platforms

Next Steps

8.9L Engine

- Complete EPA/CARB certification in 2015
- Fleet marketing beginning in 2015
- Integration with vehicle OEMs in 2015/2016
- First fit sales in 2016 based on fleet orders
- Further developments to reduce ammonia emissions
- HD OBD development in 2016/2017

Next Steps

Proposed CWI 12L Engine

- Apply CWI 8.9L technology
- Provide funds to pull commercialization forward 24 months
- Build and test prototype engines in 2016
- Conduct demonstrations in 2016/2017
- Complete EPA/CARB certification in 2016
- Fleet marketing beginning in 2016
- Integration with vehicle OEMs in 2016/2017
- First fit sales in 2017 based on fleet orders
- HD OBD development in 2016/2017

Next Steps

8.8L PSI Engine

- Build and test prototype engines in 2016
- Complete engine development in early 2017
- Prepare commercialization plan early 2017