Westport Innovations Inc. and Fuel Systems Solutions Inc. merged on June 1, 2016 to create Westport Fuel Systems Inc.

A premier, global company for the engineering, manufacturing and supply of alternative fuel systems and components.
Family of Brands and Breadth of Reach

FAMILY OF BRANDS

BREADTH OF REACH

- Passenger Car & Light Truck
- Medium-Duty
- Heavy-Duty
- Industrial
- High Horsepower
- CNG Refueling
Opportunity
Gasoline-Derived Near Zero NOx Engines

» HD gasoline engines certify to same standards as diesel engines

» Established Near Zero (NZ) NOx techniques could be readily transferred to NG versions of these engines to bring them to the optional 0.02 g/bhp-hr standard

» NZ NOx engines are much more cost effective than BEVs in applications such as shuttle buses

» But will NZ NGVs qualify under the California SIP?

Ref: “Game Changer, Next Generation Heavy Duty Natural Gas Engines Fueled By Renewable Natural Gas, Gladstein, Neandross and Associates, 2016
<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>FUEL CHOICE</th>
<th>ENGINE TECHNOLOGIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Horsepower</td>
<td>LNG</td>
<td>high pressure direct injection</td>
</tr>
<tr>
<td>• mining</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• rail</td>
<td></td>
<td></td>
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<tr>
<td>• marine</td>
<td></td>
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</tr>
<tr>
<td>Heavy-Duty Vehicles</td>
<td>CNG</td>
<td>high efficiency spark ignited</td>
</tr>
<tr>
<td>• on-highway trucks</td>
<td></td>
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<tr>
<td>Medium-Duty Vehicles</td>
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<td></td>
</tr>
<tr>
<td>Light-Duty Vehicles</td>
<td></td>
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</tr>
</tbody>
</table>
Product Progression

- **2010**: HPDI 1.0 Launched
- **2013**: HPDI 1.0 Production Ended
- **2017**: Start HPDI 2.0 Program
- **2017**: LAUNCH*

*Series production components available for delivery to OEMs
Technology Progression: Injector

Gen 1

Gen 2
Technology Progression: IGM

Gen 1

Gen 2

Integrated Gas Module (IGM)
Westport LNG Tank Module

» Completely Re-Designed
» Cost Reduced, Quality Improved
» Integrated LNG Pump
» High & Low Pressure Variants
» Enables cold LNG for increased range and longer hold times
LNG Tank Validation Testing

» Example tests:
  - Bonfire
  - Vibration
  - Drop
LNG Pump (HHP)

High Horsepower Applications
Mining, Rail & Marine
# GHG Legislation for Commercial Vehicles

<table>
<thead>
<tr>
<th>Naming</th>
<th>Status</th>
<th>Introduction/Validity</th>
<th>Evaluation Method</th>
<th>Limits</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG &amp; Fuel Economy Phase 1</td>
<td>In place – fully phased in by 2018</td>
<td>Until 2020</td>
<td>Engine: Transient duty cycle Sim. vehicle standard: GEM 2.0.1</td>
<td>Engine: n475 g/km⋅hr GHG 72 g/ton⋅mile</td>
<td>Moderate</td>
</tr>
<tr>
<td>GHG Phase 2</td>
<td>In publication</td>
<td>2021 – 2027</td>
<td>Engine: Transient duty cycle Sim. vehicle standard: GEM 3.0</td>
<td>Engine: approx. –7% GHG up to -25% (vs. 2017)</td>
<td>Severe</td>
</tr>
<tr>
<td>CO₂ Emission monitoring and declaration</td>
<td>Under discussion</td>
<td>In 2018</td>
<td>VECTO vehicle simulation</td>
<td>Monitoring and declaration to public</td>
<td>Severe</td>
</tr>
<tr>
<td>CO2 limits</td>
<td>Under discussion</td>
<td>Exp. in 2022</td>
<td>VECTO vehicle simulation</td>
<td>Limits TBD</td>
<td>-</td>
</tr>
<tr>
<td>Fuel Efficiency for Diesel Vehicles 2015</td>
<td>In place</td>
<td>Since 2015</td>
<td>JE05 &amp; constant speed 80km/h</td>
<td>Tractor: 2.01 km/L (-12.2% vs 2002 level)</td>
<td>Moderate</td>
</tr>
<tr>
<td>2025</td>
<td>Under discussion</td>
<td>Exp. in 2025</td>
<td>JE05 &amp; constant speed 80km/h</td>
<td>Tractor reduction: -15%</td>
<td>Severe</td>
</tr>
<tr>
<td>Fuel Efficiency Standard</td>
<td>Under discussion</td>
<td>Exp. in 2018/21</td>
<td>Constant speed 40/60km/h</td>
<td>In L/100km</td>
<td>Moderate</td>
</tr>
<tr>
<td>Fuel Cons. Stage 2</td>
<td>In place</td>
<td>Since 2014</td>
<td>C-WTVC, Simulation based demonstration</td>
<td>Tractor av. 45 L/100km</td>
<td>Moderate</td>
</tr>
<tr>
<td>Fuel Cons. Stage 3</td>
<td>Draft</td>
<td>Exp. 2019</td>
<td>C-WTVC, Simulation based demonstration</td>
<td>Tractor av. 38 L/100km, -15%</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
STEPS TO ACHIEVE TARGET CO$_2$ REDUCTION

**Graph:**
- X-axis: Years [ - ]
- Y-axis: Reduction of fuel consumption [%]
- Data point: Example: Long haul truck Diesel

**Steps for CO$_2$ Reduction:**
- High torque engine, Therm. Eff. 50%
- 12/24/48V electrical system
- Low rear axle ratio, advanced AMT
- Electrified Auxiliaries on Demand, incl. e-WHR
- Mild hybrid
- Predictive Energy Mgmt.
- Predictive shifting
- ADAS
Is there a single technology that can reduce CO₂ by more than 20% (e.g. GHG Ph2)

Best in Class HD Diesel Engine

Natural Gas Engine

Brake Thermal Efficiency AVL Test Results

22% Less CO₂
CO2 REDUCTION POTENTIAL OF NATURAL GAS DIRECT INJECTION (HPDI)

- SAME POWER DENSITY AS DIESEL
- >20% CO₂ REDUCTION
- CO₂ REDUCTION IN THE WHOLE MAP

AVL TEST RESULTS

SAE INTERNATIONAL
Help Needed

» Industry & Government support needed to bring HPDI 2.0 to North America

» Natural Gas was excluded from DOE’s SuperTruck I and II Programs with $135M and $80M in funding, respectively
### Timeline of Diesel-Derived Spark-Ignited NG Engine Innovations

**Lean Burn Technology**
Cummins L10G launched 1st CNG bus engine

1992

**Stoichiometric with Cooled EGR Technology**
1st demonstrated in 2004
1st launched - CWI ISL G - in 2007

2004

**High Efficiency SI (HESI) Technology**
1st demonstrated

2007

- Oxygen-free exhaust using cooled EGR → 3-way catalyst
- 15-25% lower peak torque than diesel

2014

- Retains stoich + EGR combustion
- Removes constraint of common cylinder head with diesel engine
- Higher peak torque than diesel
- Enables downsizing

- Tumble air motion
- High turbulent kinetic energy (TKE) at point of ignition

High excess air with turbocharging
Much lower NOx & PM than diesel
25% lower peak torque than diesel
Gasoline Still by Far the Largest Share of Fuel Consumption Mix

» 60% of transportation fuel is finished motor gasoline (including 4% ethanol)
» Mainly used in passenger cars, light and medium duty trucks

Fuel used for U.S. transportation, 2014

- gasoline (petroleum) 56%
- diesel (petroleum) 22%
- jet fuel (petroleum) 11%
- natural gas 3%
- biofuels 5%
- other 3%

1 Based on energy content
2 Motor gasoline and aviation gas, excludes ethanol
3 Excludes biodiesel
4 Electricity, liquid petroleum gas, lubricants, residual fuel oil, and other fuels

Note: Due to rounding, data may not sum to exactly 100%.

Source: U.S. Energy Information Administration, Monthly Energy Review (March 2015), Tables 2.5 and 3.8c, preliminary data
Heavy Duty Pickup Trucks (Class 2b/3)

Option prices relative to gasoline today:
- Diesel: $8,600 – $9,300
- CNG*: $9,500 - $11,000

* Refers to today’s gasoline-derived NG engines with conventional CNG cylinders

Figure 2. New 2012 heavy-duty vehicle registrations by class and fuel type (Polk, 2013)
HD Pickup Truck Engine Power & Torque

GASOLINE / CNG

DIESEL / HESI CNG

Diesel and HESI NG have 2x Torque
Conformable CNG Tanks

- Folds to fit anywhere
- Lighter, lower-cost systems
- Seamless design
- Continuous manufacturing
- Industry standard materials
Early Compliance & Credit Generation

HD Diesel Pick Up Truck

- HESI Natural Gas
- Phase II Final Rule

Credit Opportunity

Representative Work Factor of 5838 lbs

CO2 emissions (g/mile)

Model Year

2020 2021 2022 2023 2024 2025 2026 2027 2028

16%
Proposed SuperPickupTruck Program

» One year ago: Proposed $50M from DOE:
  ▪ Follow-up to arpa-e MOVE program
  ▪ Low-cost home refuelling
  ▪ Conformable CNG tanks
  ▪ High efficiency, high performance powertrains
  ▪ Self-refueling vehicles
  ▪ Adsorbed NG

» Have since de-scoped to $12M program:
  ▪ Conformable CNG tanks
  ▪ High efficiency, high performance powertrains
  ▪ Consortium funding nearly there – still $2-4M short!
Summary of Opportunities

1. NZ NOx CNG shuttle buses

2. >20% GHG reduction LNG HD trucks

3. -16% GHG MD/LD trucks

SuperPickup Truck Program
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