



Sustainable Fleet Technology Conference

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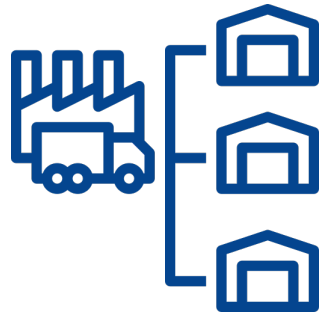


Overview

- Overview of Westport Fuel Systems
- HPDI: What is it?
- Hydrogen Combustion with HPDI

Westport Fuel Systems Inc. : Headquartered in Vancouver

Leading supplier of advanced gaseous fuel systems and components for the global automotive industry



Tier 1
Automotive Supplier



1,400+
Patents &
Applications



70
Countries (Sales)

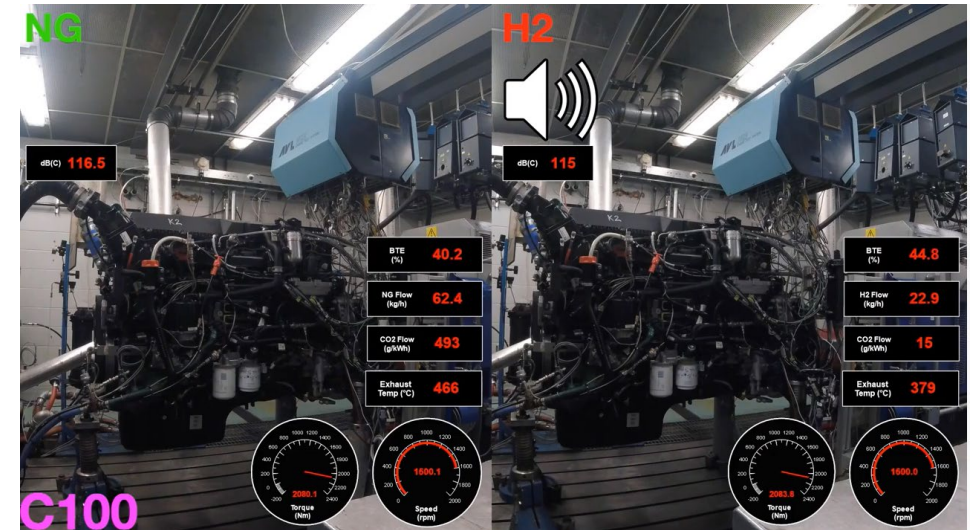
Broad Applications



Alternative Fuels



7 Tech Centers: 3 Canadian, 4 European, 200+ tech staff



> <https://www.youtube.com/watch?v=E3FZjMoDRZO>

Westport Fuels Systems Inc.



Diverse Product and Brand Portfolio – for a variety of applications and markets



Leading Technology Position

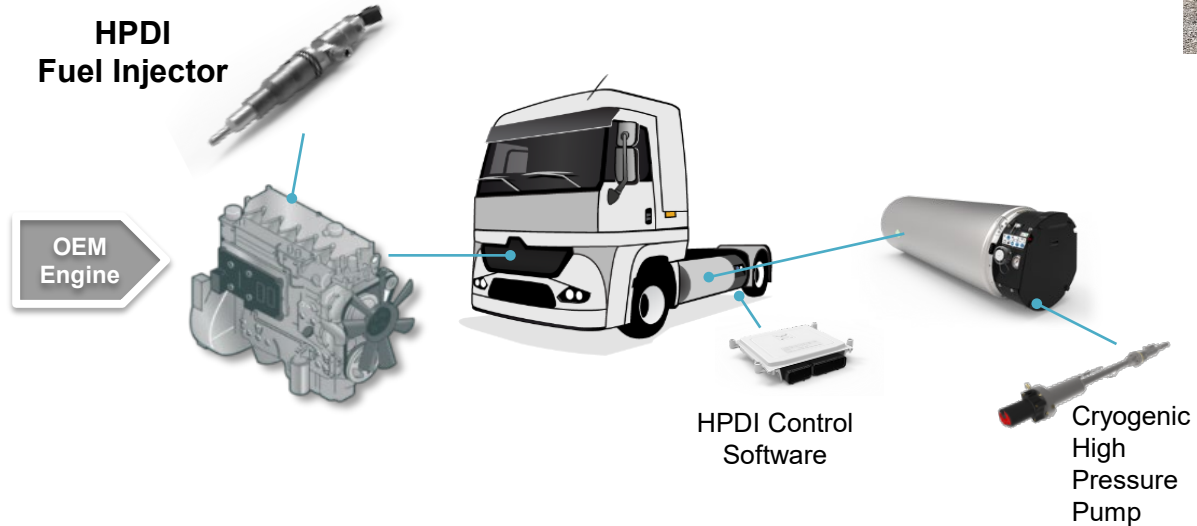
- Long history and deep technology innovation and engineering capabilities
- Strong Intellectual Property position
- Existing and applied-for patents covering CNG, LNG, LPG and H2 components and systems worldwide
- Significant investment in research and development for gaseous fueled transportation applications

Market-Ready Solutions

- LPG & CNG kits and components for aftermarket vehicle conversions and Delayed OEM installations
- Components and systems for Tier 1 OEM supply in LPG, CNG & H2, including Engine Management Systems and Engine Controllers ready for the latest emission regulations
- **Westport HPDI, the solution for heavy-duty trucking**

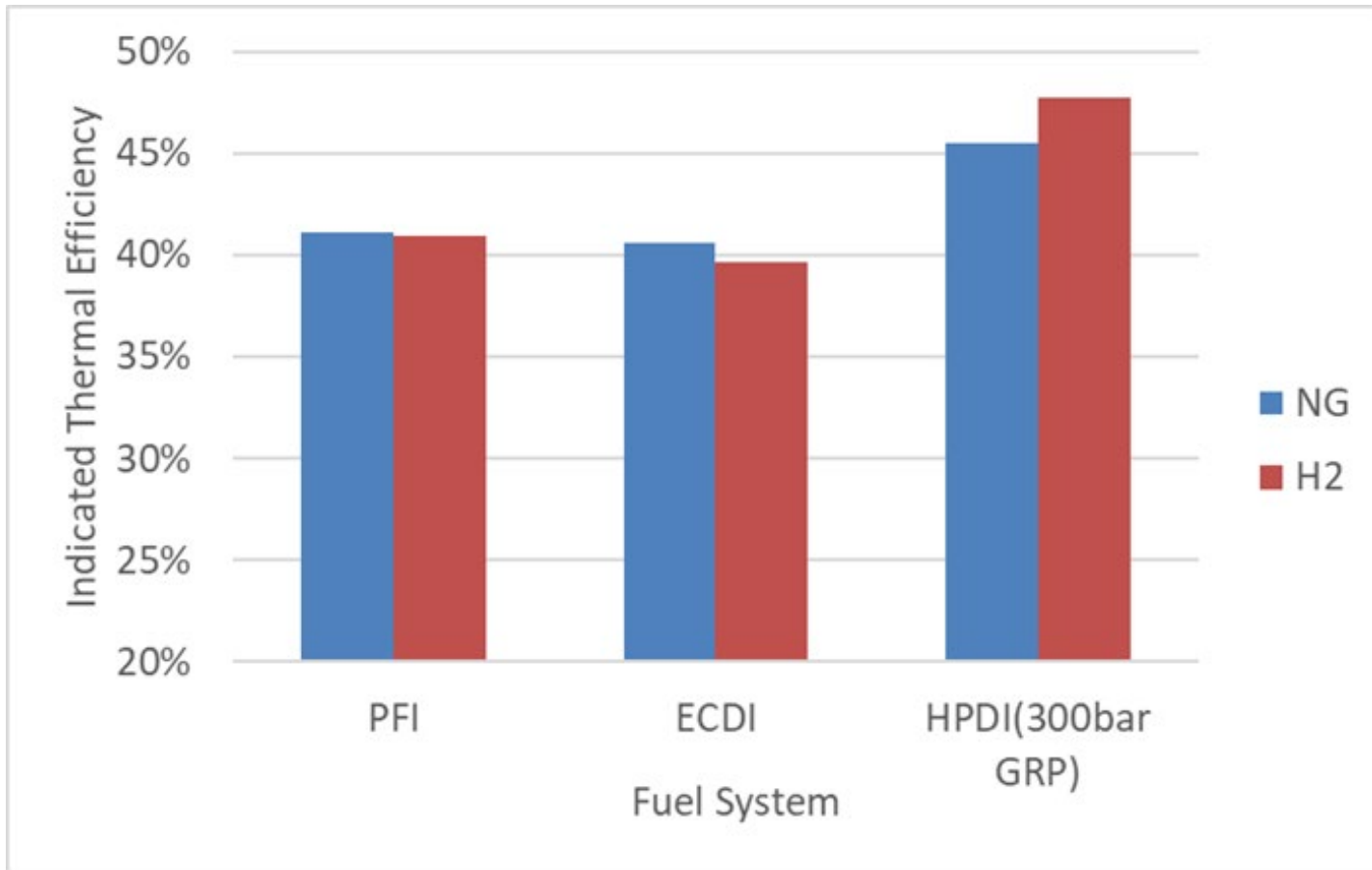
What Is Westport HPDI™ ?

- Unique fuel injection system of natural gas
- Fully factory integrated OEM system
- Matches diesel engine power and torque
- Matches diesel fuel efficiency (within 1%)
- Same drivability and engine braking



Hydrogen Combustion with HPDI

Comparison of Indicated Thermal Efficiency for Three Combustion Systems for Natural Gas and Hydrogen

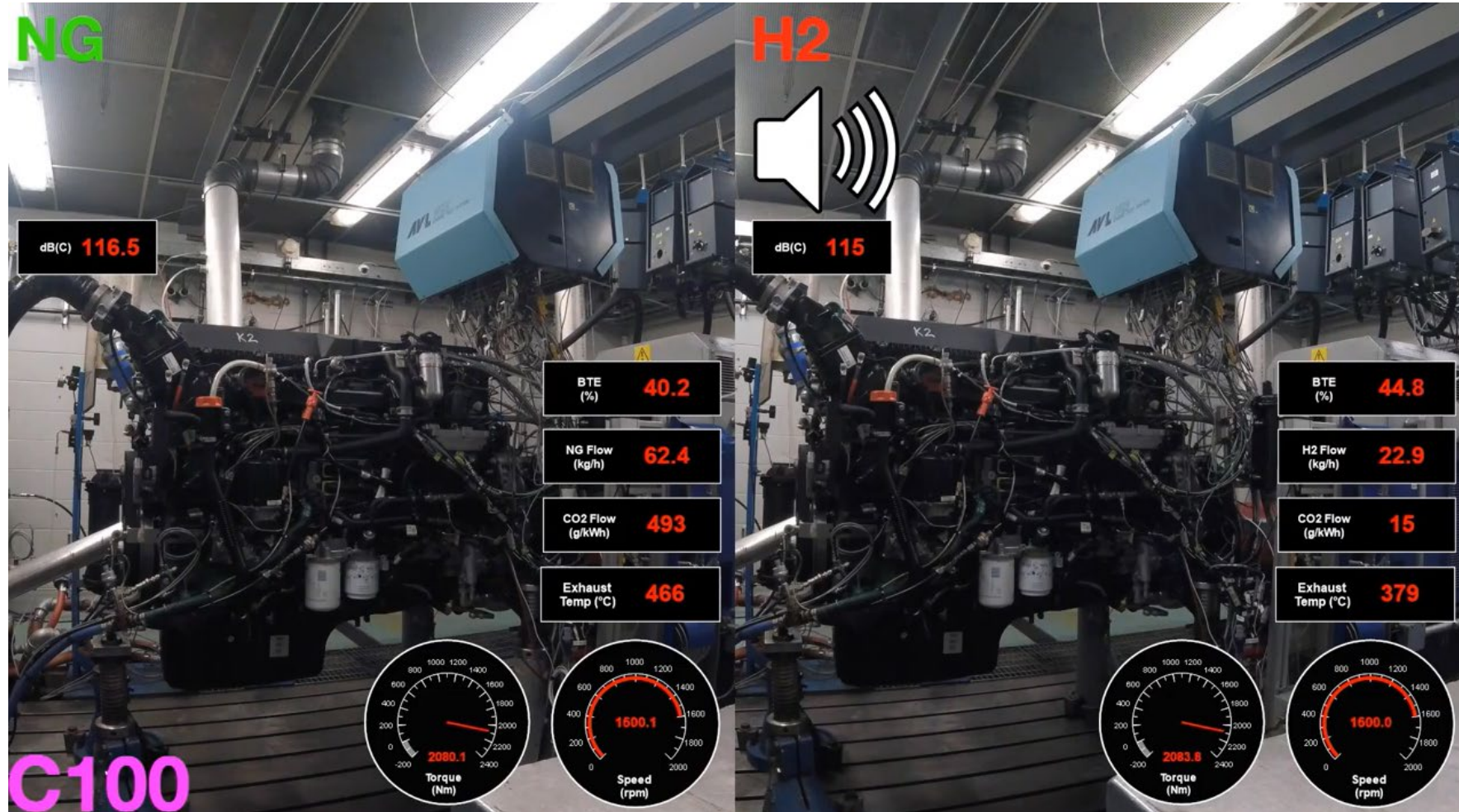


Combustion Approaches:

- Port Fuel Injection with Spark Ignition (PFI SI)
- Early Cycle Direct Injection (ECI DI)
- HPDI (High Pressure Direct Injection)

Conclusion: HPDI can leverage the combustion characteristics of H2 into significantly higher efficiency.

WFS Currently Operating H2-HPDI in Vancouver Test Cell



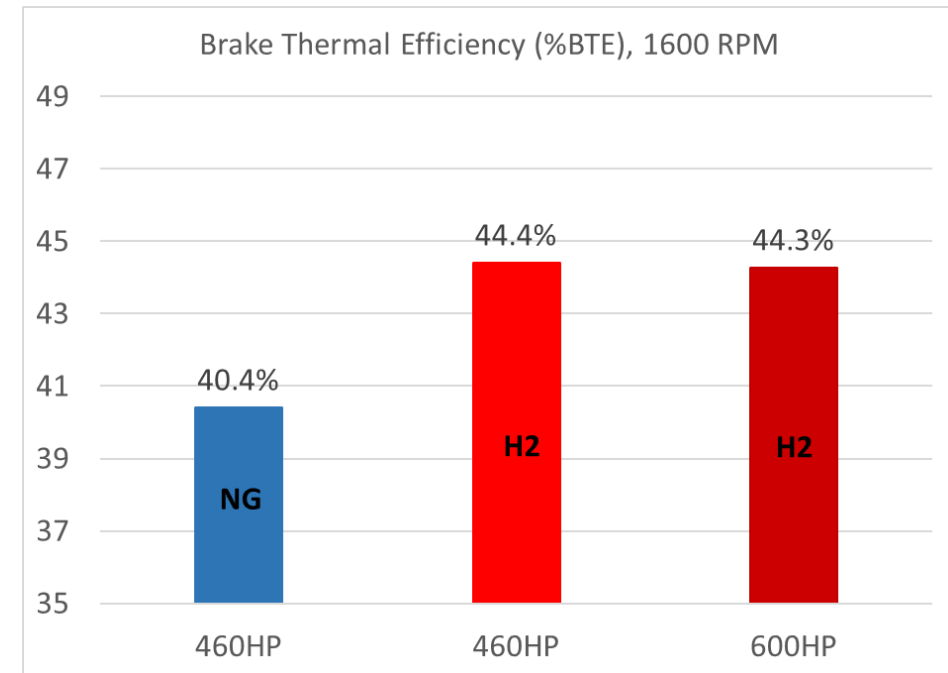
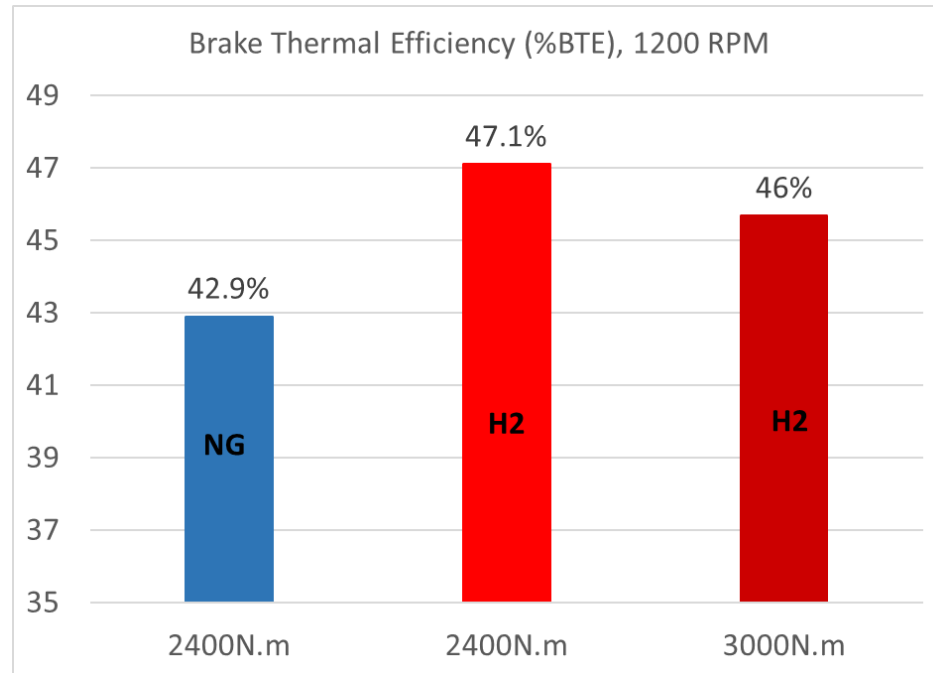
<https://www.youtube.com/watch?v=E3FZjMoDRZ0>

H2 HPDI - High Performance with High Efficiency

Analysis & modeling indicated the potential for H2 HPDI to achieve 15-20% higher BMEP than NG HPDI or diesel engines.

Testing has validated that H2 HPDI can yield significantly higher peak torque and power than the base NG HPDI or diesel engine, by leveraging the combustion characteristics of H2 and without exceeding engine mechanical limits.*

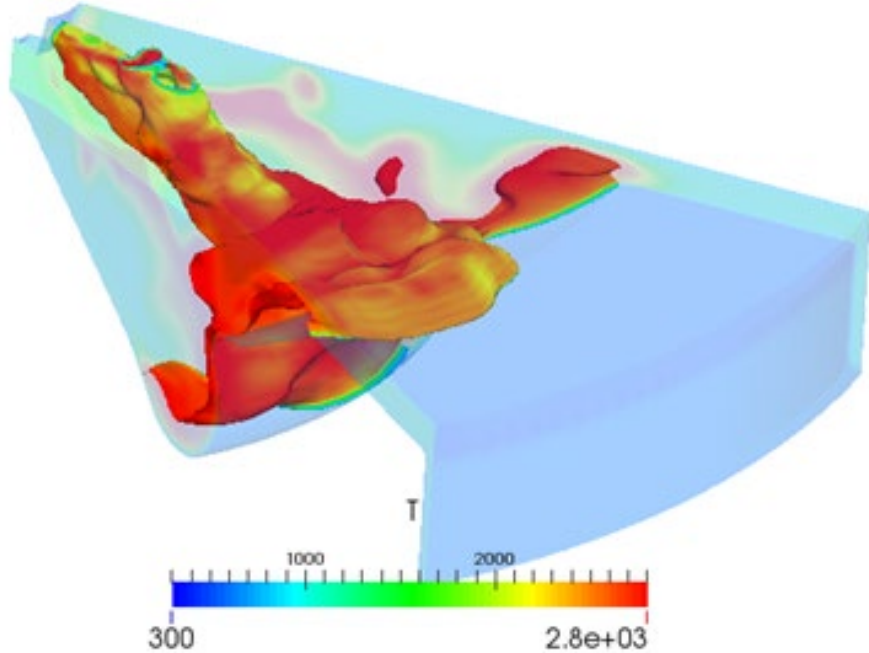
H2 HPDI enables higher vehicle performance and/or significant engine down-sizing, with associated cost savings.



* The NG baseline values shown in the figures above should not be interpreted as an upper limit for NG HPDI, as the NG HPDI torque and power shown above are known to have room for further improvement, as demonstrated in a separate program. For guidance, the actual improvement in maximum achievable H2 HPDI torque and power, as compared to the maximum achievable NG HPDI torque and power, is approximately 15-20%.

H2-HPDI – Next Generation HD Engines (CFD)

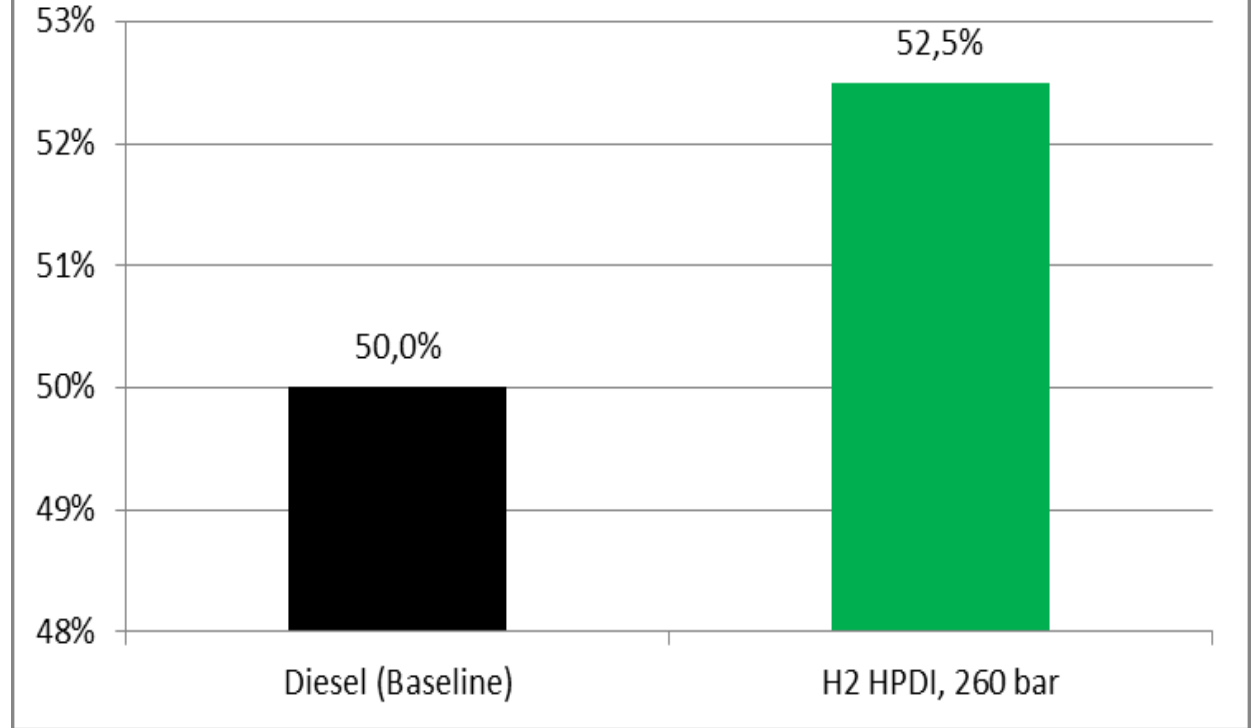
H2 HPDI at Mid-Load Condition,
Stoichiometric Surface of Fully Ignited
H2 Jet at 8 Degrees after Top Dead Center



Crank Angle: 8 Degrees After Top Dead Center

CFD visualization of the fully ignited hydrogen jet at mid-load condition (50% load at 1200 RPM).

Brake Thermal Efficiency (BTE) at Mid-Load



CFD comparison between diesel and hydrogen (H2) HPDI.

H₂ HPDI Fuel System

Compared with the diesel engine to which we apply the Westport™ HPDI fuel system:

- Up to 20% more power
- Up to 15% more torque
- Up to 10% more efficient

~97% CO₂ reduction

Lower TCO, lower cost of CO₂ abatement

- Total Cost of Ownership study in partnership with AVL *
- Reuse of existing IC Engine manufacturing enables cost savings and rapid deployment

For long-haul trucks, H₂ HPDI is a cost-effective, high-performance solution for heavy-duty transport



* Total Cost of Ownership Analysis (TCO) for Heavy Duty Hydrogen Fueled Powertrains

Summary & Next Steps

Combustion modelling and engine testing have demonstrated that among the combustion systems investigated (PFI SI, ECDI SI and HPDI), HPDI combustion offers the **highest power density**, **highest efficiency** and is the **most robust system** for using hydrogen in an internal combustion engine for **heavy duty applications**.

H2 HPDI provides near-zero CO2 emissions in its current configuration, with further CO2 reduction opportunities identified for future study and development.

H2 HPDI offers lower TCO and more cost-effective CO2 reductions than “zero” emission alternatives

➤ Total Cost of Ownership study in partnership with AVL *

H2 HPDI interest is growing from OEMs, with multiple H2 HPDI development projects recently announced and underway.

**Total Cost of Ownership Analysis (TCO) for Heavy Duty Hydrogen Fueled Powertrains*

Thank you!

