

A Retro-Fit Viewpoint

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Clean Air Power: Background

- 1st Dual-Fuel™ patent filed in 1995
- Original patent holder remains with the company
- Approximately 200 man-years of Dual-Fuel™ know-how
- Listed on the London Stock Exchange (AIM:CAP)
- Tier 1 supplier of components to Volvo, Mercedes-Benz, L3
- Complementary business: Emissions reduction
- Headquarters and operations in UK
Engineering R&D & Component production in San Diego, USA



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2000+ Dual-Fuel™ Vehicles



USA 410 HP 12 liter



USA 250 hp 7 liter - Refuse



UK 440 HP 13 liter
Euro 5 FM13 Genesis



Australia 500 HP 15 liter
Road-Train



USA 410 HP 12 liter



USA 315 hp 10 liter - refuse



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Dual-Fuel™ Product Options

Dual-Fuel™

Genesis (Retro fit)

- Delivers GHG & fuel cost savings
- Beats diesel NOx & PM
- E5 compliance independently verified
- Average gas substitution ≈ 50/60%
- Retro-fit only by CAP or agent
- No OEM involvement in development

Genesis Products:

Current:

Europe & Australia - Volvo FM13 E5
- Renault Magnum 13I

Legacy:

Brazil and ROW - Mercedes & DAF E3

Interfaced (Factory fit)

- Diesel and Dual-Fuel™ control system software is interfaced
- Average gas substitution 70-90%
- Low emissions capability and certification
- Requires OEM support
- Retro-fit by OEM/CAP or OEM line-build
- Volvo product only available from OEM

Interfaced Products:

Current:

Europe - Volvo FM13 E5
- Renault Magnum 13I
- Volvo FM13 E3

Thailand

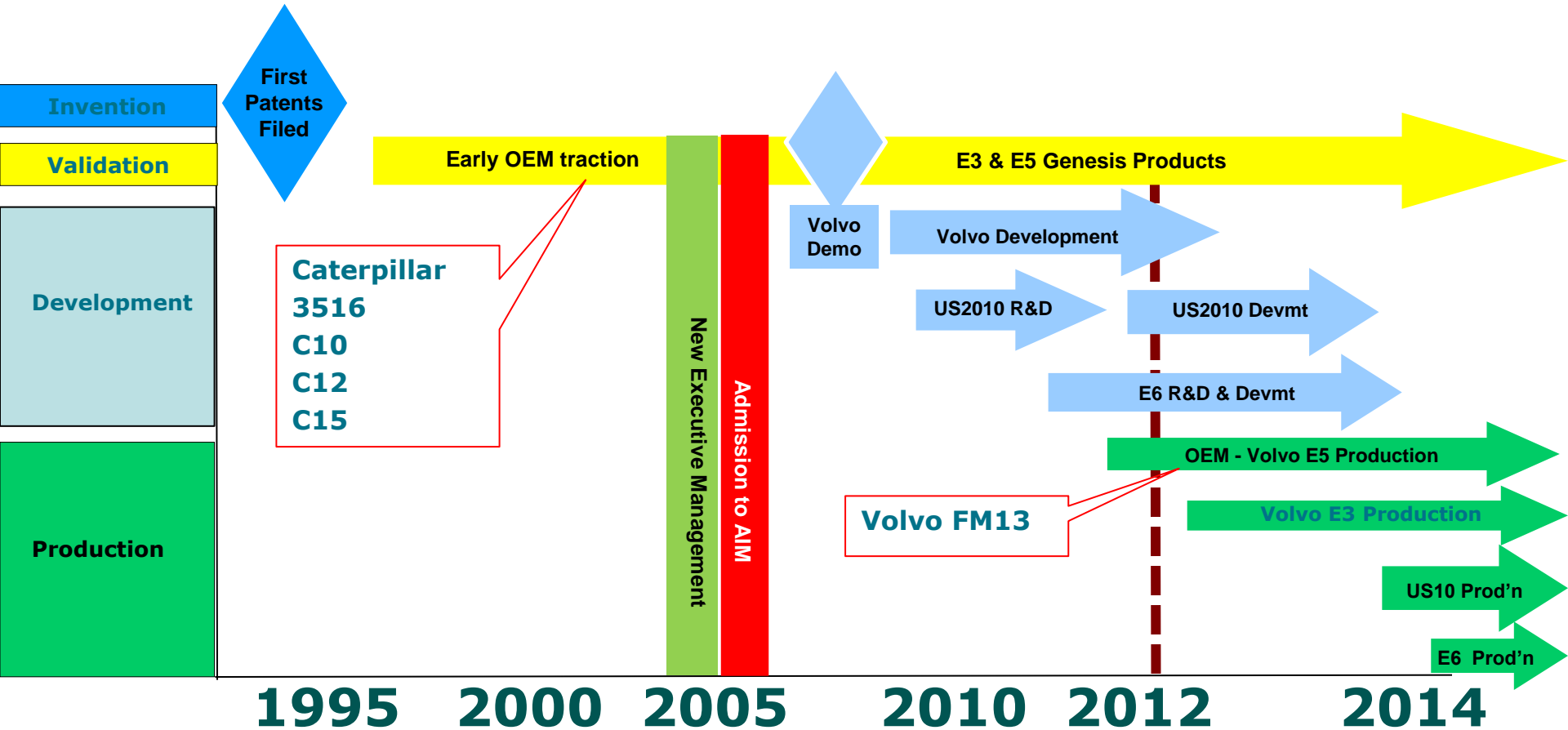
Legacy:

Australia, US & S. America: - C-15/C-12



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Company Evolution



Global Markets – Twin Track Strategy

■ Genesis solution

- Product development timing under company control
- Proven commercial success in Europe
- US 2010 feasibility confirmed – project underway
- Global market is strong & product from Euro 3 – Euro 5 is available with LNG & CNG
- Also interesting to OEM divisions

■ OEM

- OEM product available in Europe
- Demonstrated ability to meet US 2010 emissions target
- Discussions with US OEMs are ongoing

Dual-Fuel™ Fundamentals

- **A Dual-Fuel™ engine is a diesel engine**
- **Dual-Fuel™ uses a diesel pilot injection to ignite a lean, homogeneous mixture of natural gas and air**
- **Retains diesel-cycle efficiency with low emissions benefits of lean natural gas combustion**
- **Gas for diesel substitution levels between 50-90%**
- **Dual-Fuel™ can operate on Bio-Diesel & Bio-Gas**
- **Engines can run on 100% diesel at any time**
 - **Compelling for immature gas markets**

Driven by Economics

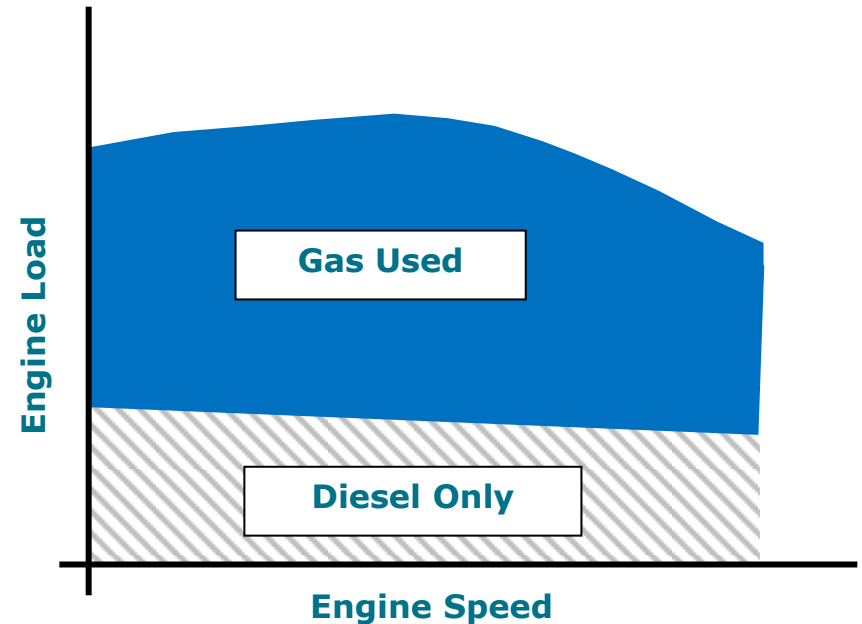
- **Natural gas is cheaper than diesel**
- **Typically an operator will spend £50,000 per year on diesel***
- **30% fuel savings**
- **Diesel is 35-50% of a truck's operating costs**

LNG per DGE	£2.64
Diesel per UK Gallon	£5.09
Annual mileage	100,000
Fleet Avg MPG (Diesel)	9.5
Litres/100km	29.7
Total Cost	£24,500
Gas Substitution	60%
Net Savings per year	£15,231
Payback Period	19.3
Net Savings per mile	£0.15

*Above Data based on UK Market

Dual-Fuel™ Operating Modes

- Optimum Dual-Fuel zone where maximum gas quantities used and accurately controlled by CAP EMS
- Light-load region Dual-Fuel operates with 100% diesel due to excess air. Load at which transition occurs depends on engine, EGR rates, pilot injection quality.



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Dual-Fuel™ Engine System

Air System

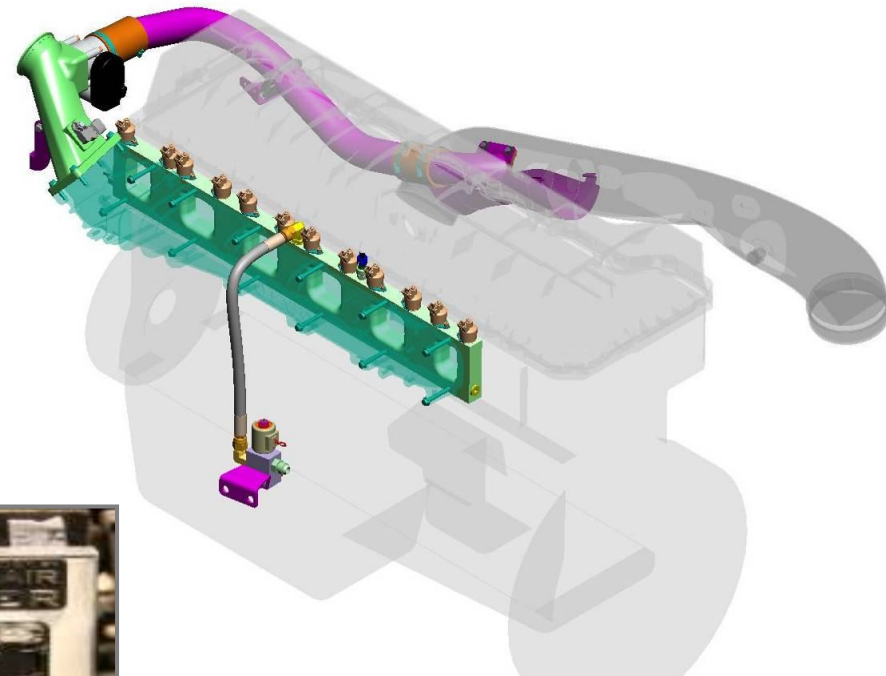
- Boost control system, VGT or CAP's boost bypass valve

Gas Injection System

- CAP Electronic gas injectors
- Single or Multi point injection
- Fed with gas at c.8bar
- Stored as LNG or CNG

Hawk™ Control System

- Mototron ECU
- Sensors
- Harnesses
- CAN interface

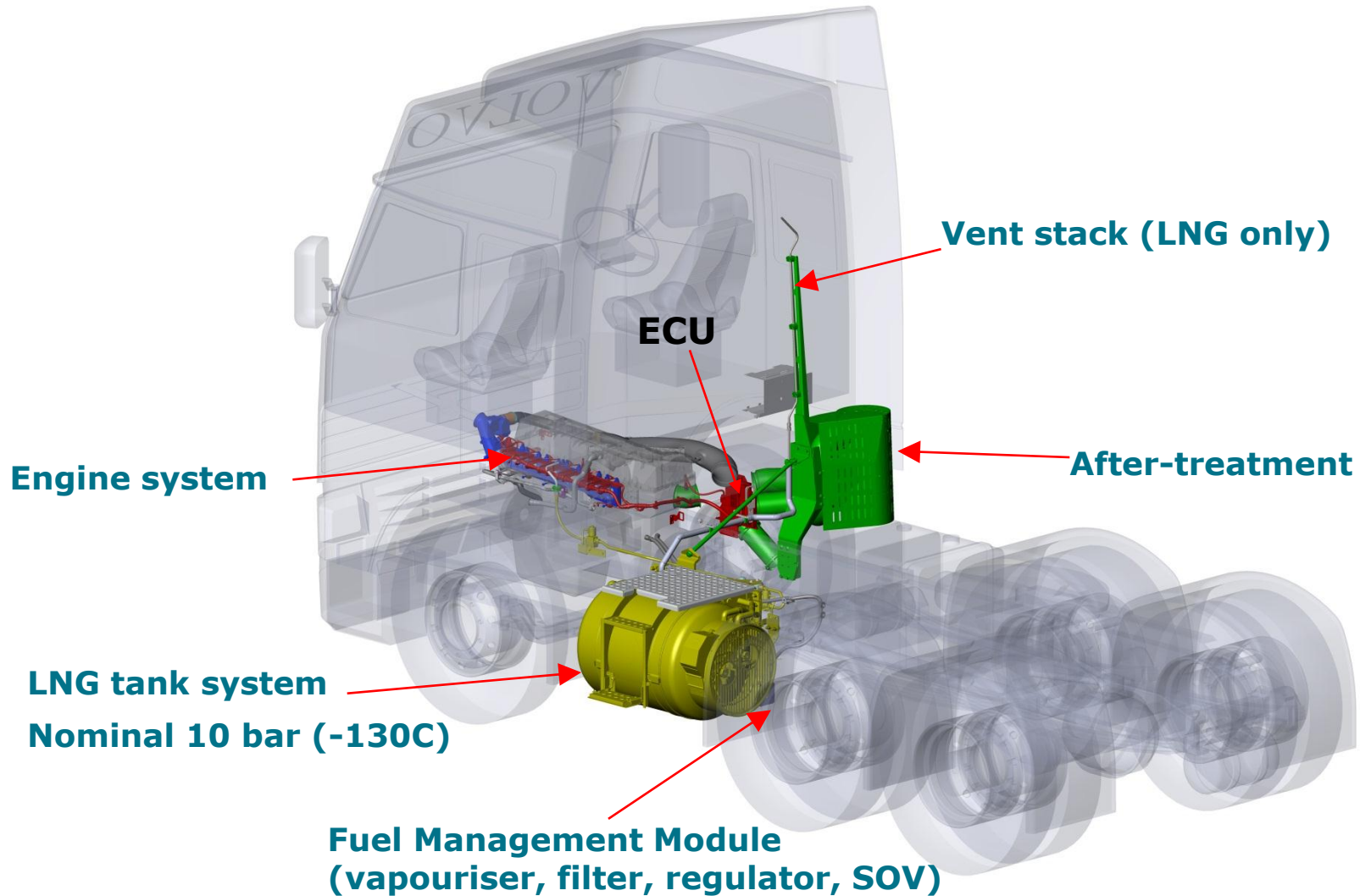


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LNG Dual-Fuel™ Vehicle System



Dual Fuel Case Study

- CAP Genesis-EDGE retro-fit system
- Large logistics company running c.30 DF trucks
- Mileage 200kkm @ 33 lit/100km
- Customer “must-have” diesel fall-back capability
- Payback in 16 months. Guaranteed residuals



Attribute	In-Service Delivery
Average Gas Substitution	57%
Total Fuel Economy difference	<2%
Average cost saving €/km	0.13 €/km
Annual projected cost saving (including R&M)	€25,000
Annual CO ₂ saving	25 tonnes
Operational impact	None

Diesel = €1.45/lit LNG = €1.05/kg

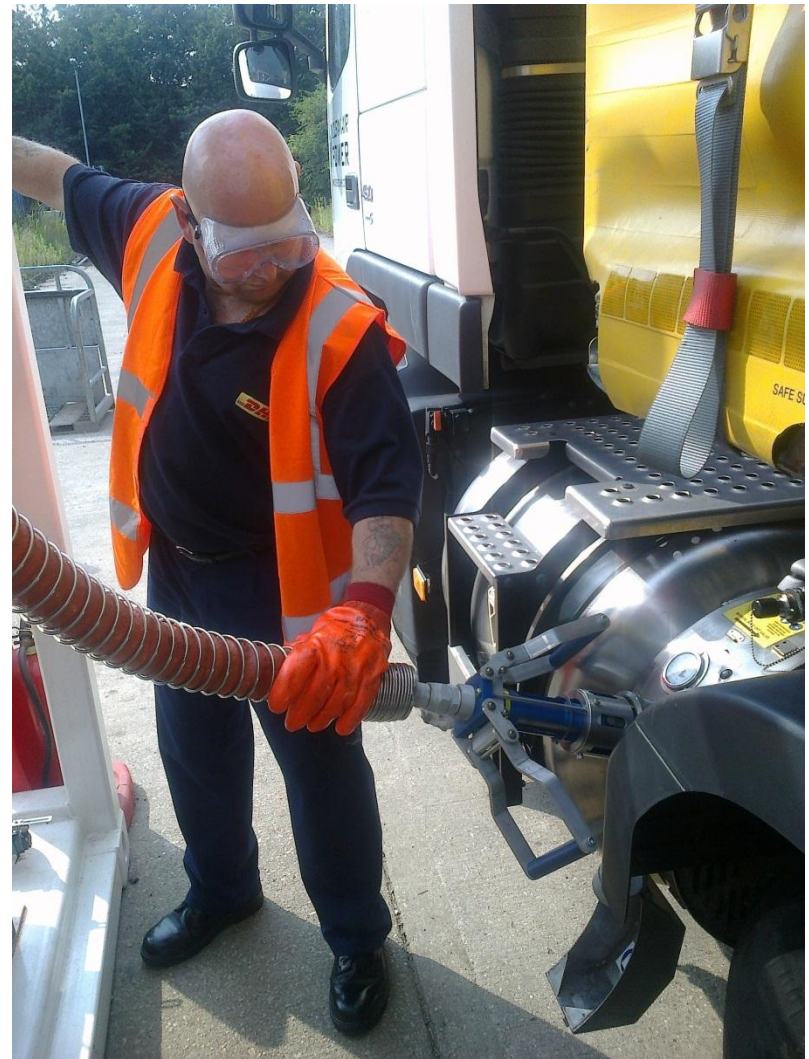


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LNG Refuelling Case Study

- LNG refuelling station installed and serviced by BOC
- Located on customer site
- Customer drivers trained to refuel
- Unique storage system maintains optimum LNG pressure & temperature
- Delivers easy & fast LNG refuelling operation consistent with that of diesel
- No operational impact



Benefits of Retrofit

- Built on customer demand – otherwise why bother?
- Pioneering activity with minimal risk to OEMs
 - Not always supported & often undermined
 - Mostly mistrusted – sometimes with good reasons
 - “You can tell that they are pioneers because they have arrows in their backs”
- Retrofits kick-start the market
 - Identify a need
 - Force infrastructure, technology & culture development
- OEMs can join the maturing market to great advantage
 - “It’s the second mouse that gets the cheese”

Problems with Retrofit

- A concerning level of retrofit technology is built on “pseudoscience” and “cowboy” engineering practice that promise attributes that break the laws of thermodynamics.....and don't deliver
 - “Beware, the travelling medicine man”
- The lack of regulation and rigor leads to proliferation of corner-cutting and false-promises
 - Technical regulations
 - Corporate governance of small companies
- Uncertainty is usually exploited by unethical & un-regulated companies
- This creates big problems for ethical retrofit companies

Retrofit – Is it a Good or Bad Thing?

- Retrofit is a good thing because it:
 - Is built on customer demand
 - Grows new markets for OEMs
- Retrofit must be properly regulated because:
 - It can kill the whole market if its products are shoddy
- Retrofit should be encouraged within a fair regulatory framework:
 - Light-touch regulation with less complex/expensive testing protocol
 - “Don’t kill the goose that lays the golden egg”
- Retrofit should be INCLUDED not EXCLUDED

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Retrofit Regulation

- Retrofit HDDF should be considered within R115 with fair and logical test protocols and limits
- A retrofit HDDF could be a:
 - Type 1a or b
 - A – retrofit with no diesel mode typified by a unique diesel fuel injection equipment (FIE) sized to deliver micro-pilot ignition
 - B – retrofit with full diesel fall-back mode utilising existing diesel FIE capable of delivering micro-pilot ignition (such system do/will exist)
 - Type 2b
 - This will be the MAJORITY of HDDF cases
 - Type 1a makes NO economic sense – not a retrofit?
 - Type 3
 - This makes NO economic sense – not a retrofit?

Retrofit Regulation

- Retrofit HDDF will have a “MOTHER” engine
- Therefore, a REFERENCE will exist
- A good ethical position is that the “DAUGHTER” engine must not be more polluting than the “MOTHER”
- This can be the case for regulated pollutants and greenhouse gases
 - It would be good for the retrofit industry if it could be perceived in a “carbon-framework” as it already supported in the UK by CENEX and the Low-Carbon Vehicle Partnership
- For regulated emissions the prevailing levels can be applied as to the Mother engine
- For unregulated GHGs, the Mother engine can be used as a reference

Retrofit Regulation

- The test protocol should be kept to the steady-state 13-Mode ESC/WHSC because retrofit organisations cannot afford the level of complexity necessary to develop systems for the ETC/WHTC
- The GHG reduction of the HDDF engine should be recognised
 - Diesel engine THC will contain no methane (could be validated)
 - HDDF regulated HC limit should therefore be NMHC
 - HDDF methane emission should be captured in GHG and compared to Mother diesel engine
 - GHG must be less or equal to Mother diesel
- Overall, within test protocol, the environmental impact of the HDDF engine is no worse than diesel

Retrofit Regulation

- The test fuel should be the available market fuel for the product
- In the coming years it will be impossible to fix the fuel properties
- Retrofit organisations do not have the resource to develop HDDF on expensive blended reference fuels
- Vehicle fuels will be mostly LNG or LBM
- A sensible light-touch approach will be required

Retrofit Regulation

- The test protocol issue is CRITICAL
- Small retrofit organisations do not have the necessary resource to comply with the full transient requirements of OEM systems
- This is a fact – but retrofit organisations will not sell thousands of HD vehicles before the OEMs step in and take the market
- If we want to kill the HDDF retrofit market, then make the emissions testing protocols the same as those for OEM products
- It is a risk-reward business and nobody will take such a risk with such a limited reward

Retrofit Regulation

- Going forward, most of the retrofit regulation will apply to a global market ranging from Euro 3 to Euro 5
 - Europe will move to Euro 6 where very few retro-fit systems will be available due to technical complexity
 - This will naturally deplete most of the retrofit organisations
- UN-GFV should consider this and adopt a sensible amendment to R115 to cover developing market requirements
 - Integrate GHG – a global concern
 - Light touch approach – to encourage responsible growth
 - Do not preclude development for developing economies
- Delivers a unified regulation to NGV markets