



GREEN WHEELS IN MOTION

European Biomethane Conference

“BIOMETHANE IN HEAVY DUTY TRUCKS”

Presented by: T L Fletcher BSc
Date: 8th September 2009



Road Transport & Distribution



Natural Gas Vehicle Technology



Natural Gas Fuel Supply & Infrastructure



Truck Dealership & Support Services



Concrete Safety Barriers for Highway & Security Application



Registered Training School



How and why did Hardstaff become involved?



In late 1999 and early 2000, Hardstaff was introduced to Natural Gas as a road fuel using Caterpillar dual fuel technology.

A database of information and statistics were compiled during a 20-week trial period - **proving the viability of Natural Gas as an alternative fuel.**



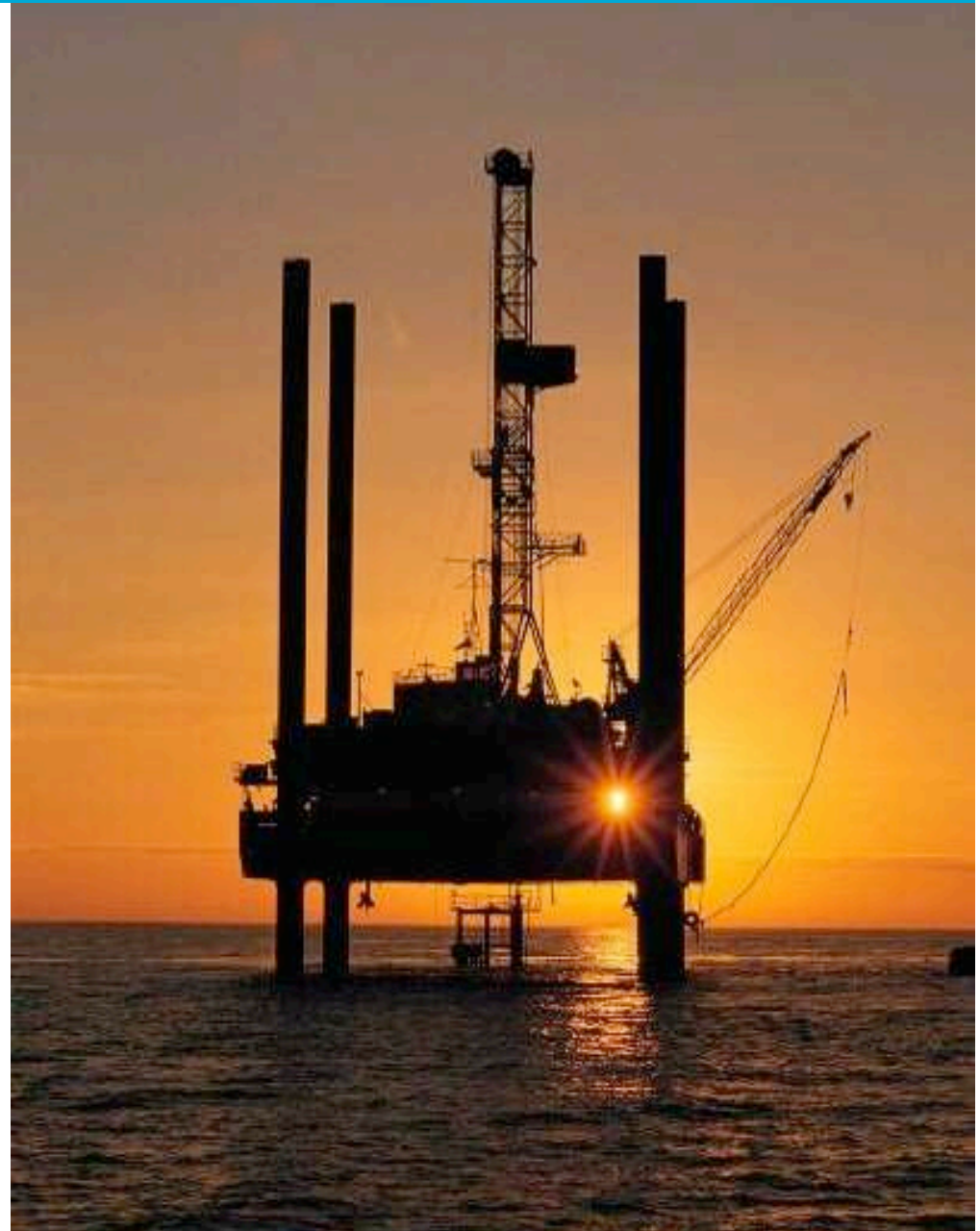
Insert vehicle description

We believed that despite the problematic nature of this early technology, natural gas would become the perfect solution for our industry, due to the rising fuel prices and urgent need for our industry to address environmental issues.

Early Motivating Factors



- Environmental obligations
- Fluctuating diesel prices
- Political influence
- Government objectives for renewable energy





“The instability of fiscal incentives to encourage the use of alternative fuels was the motivating factor for Hardstaff to develop a dual fuel system that did not require grant aid to be financially sustainable”

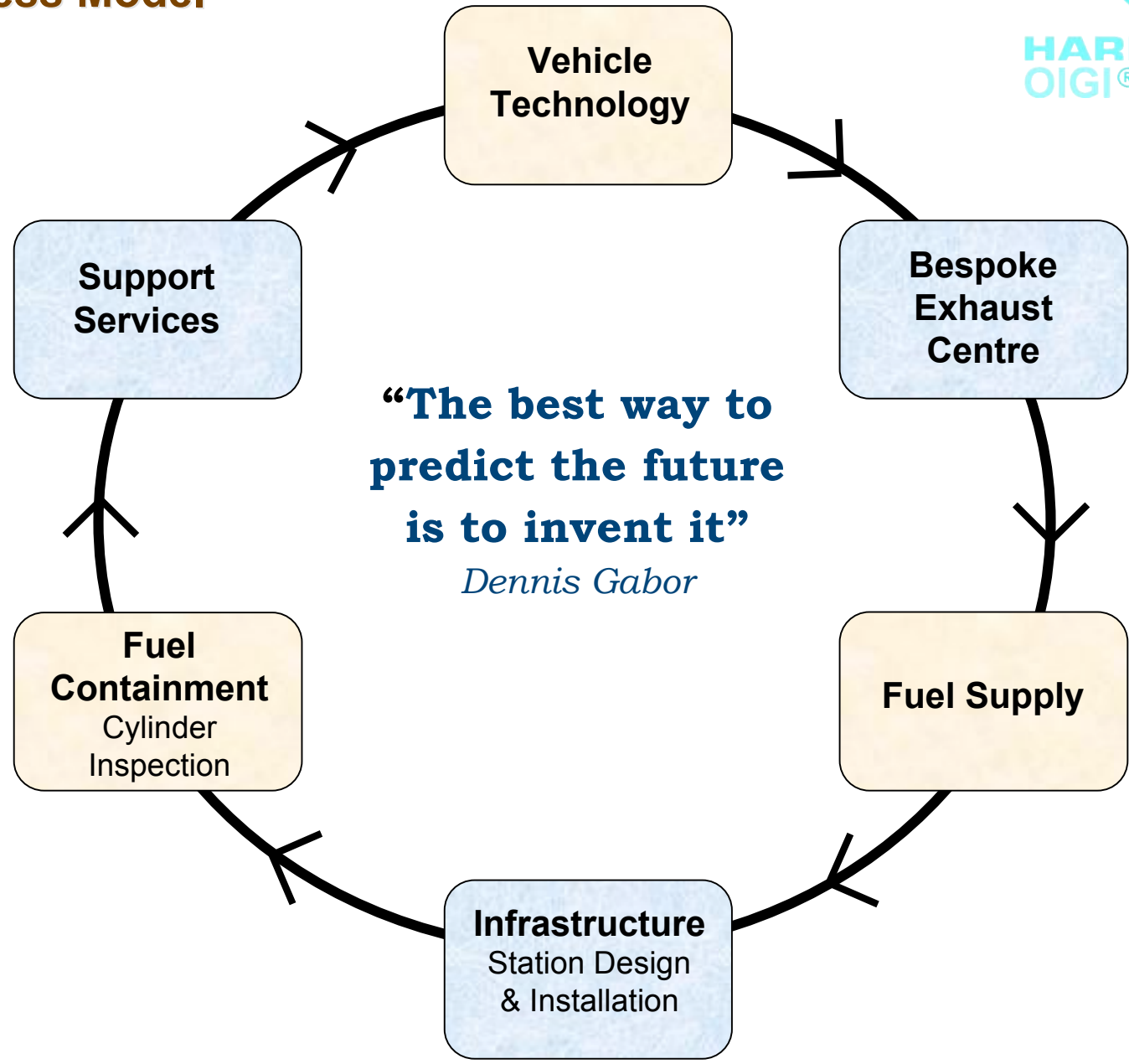
Duel Fuel Concept



- Supports government policy on sustainable procurement and actively encourages low cost entry into fuel diversification and growth in low carbon vehicles.
- Utilises existing technologies and is an ideal solution that allows transport operating companies to comply with the principles of corporate social responsibility.
- Confirms that there are alternatives to crude oil available on the market today and will act as a catalyst to future OEM product



Business Model



Milestones in the history of Hardstaff dual fuel



- 1999** The Hardstaff Innovative Transport and Environmental Scheme (H.I.T.E.S)
- 2002** We were the first Energy Saving Trust / Department for Transport Stakeholder for Dual Fuel systems and later for LCNG Stations
- 2003** Formed Portal Gas Services
- 2002-2004** CAP-Hardstaff Joint Venture
- 2006** Developed Hardstaff OIGI® patented Dual Fuel Technology
- 2008-2009** Developed OIGI® patented HDX-I Dual Fuel Technology that does not require access to the OEM's ECU.



Early Hardstaff dual fuel vehicle technology

Current and Future Plans



- **Automotive Test Cell Facility**
To evaluate and validate low carbon engine technologies
- **Expand Station Infrastructure**
- **Expand Customer Base**

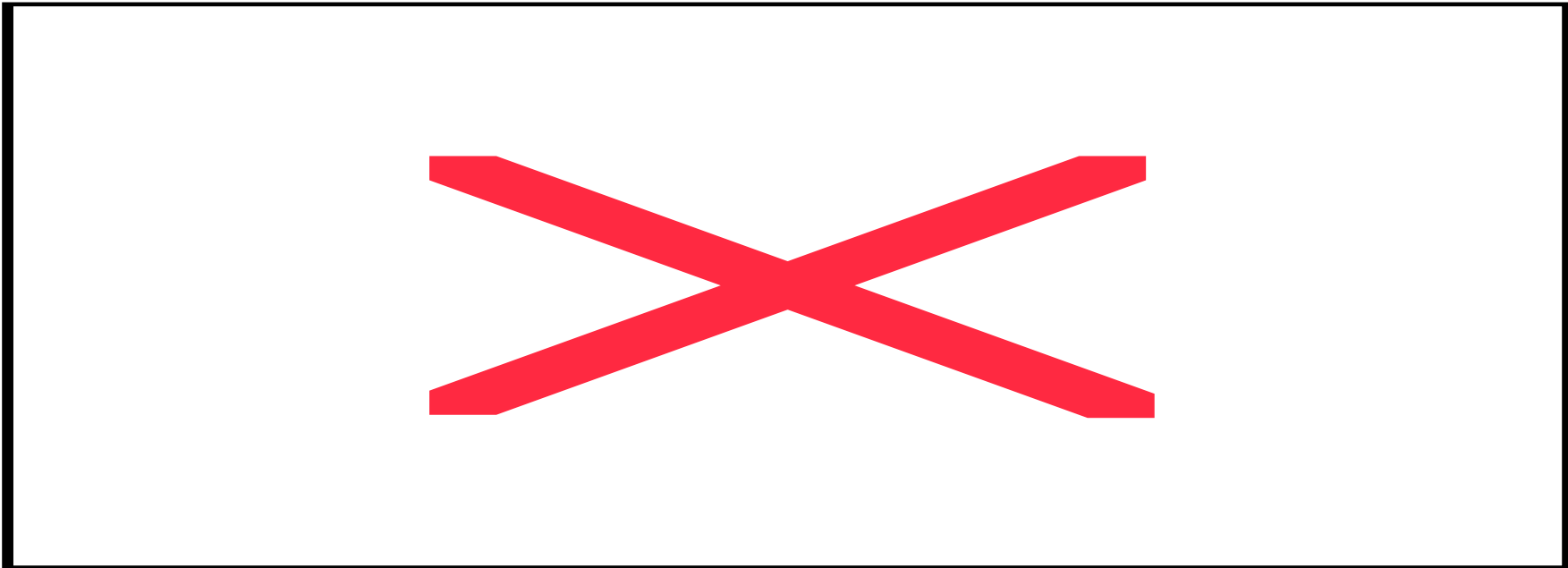


"The principles in which our forefathers believed, guide us today"

The Benefits



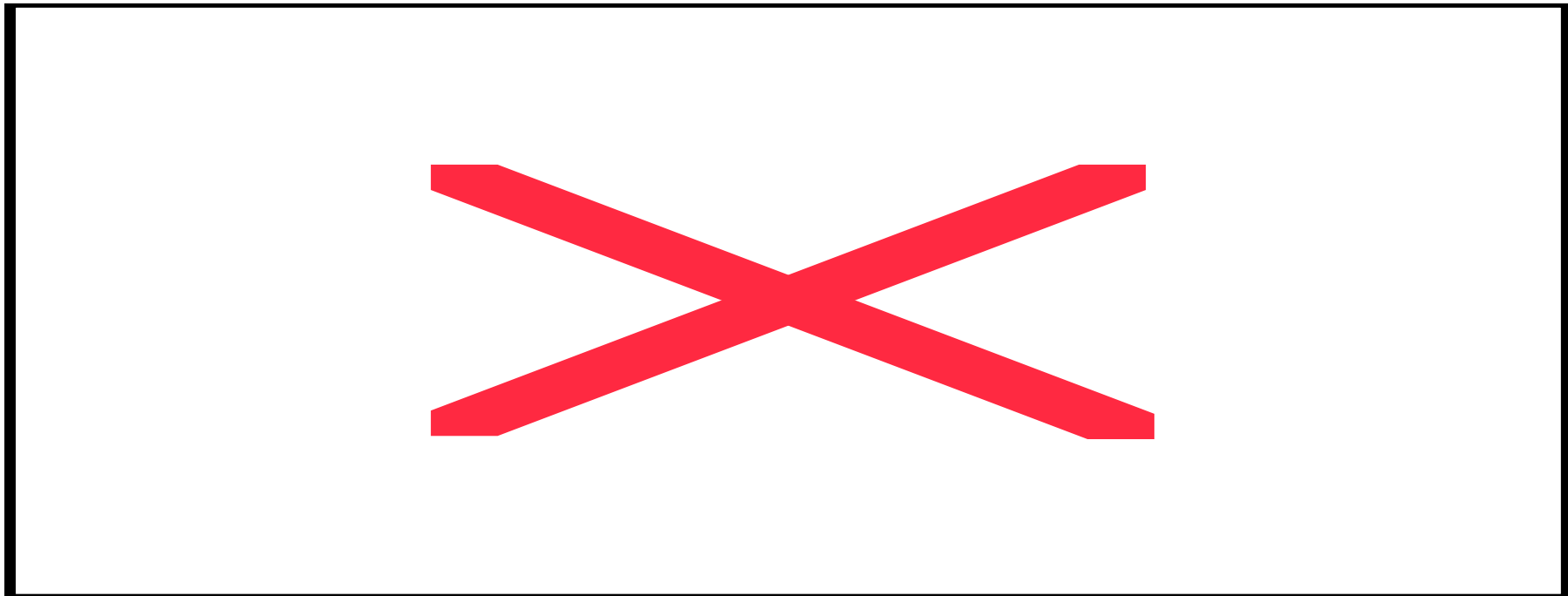
5 Year Life CO2 kgs Per Unit - 104,605 Km's per annum (Savings 190,512 kgs- 95,256 kgs)



The Benefits



5 Year Life Fuel Costs - 104,605 Km's per annum (Typical £54,205 Saving)



OIGI® Dual Fuel



1. OIGI® is an electronic system that simultaneously controls diesel reduction and gas injection on an energy equivalent basis to ensure the engine output in power and torque are maintained, without access to OEM's ECU
2. It maintains maximum engine integrity due to the low intrusive nature of the equipment
3. Multipoint, sequential gas injection via two gas injectors per cylinder enable precise power and torque matches across load and speed ranges.
4. Capable of using either CNG or LNG including biomethane maximising the environmental benefits associated with this fuel.

Application



Long-term sustainability of technology through its wide range of application:

7.5 tonne



18 tonne



44 tonne



Buses & Coaches



Refuse Vehicles



Technology Characteristics



- Utilises sequential multi point gas injection in conjunction with the diesel reduction ECU to provide precise control of the gas and diesel injected via accurate timing and metering, which is essential for meeting strict emission limits.
- Closed-loop system that maintains equivalent performance to the base diesel engine.
- OBD compliant
- Adapted to Euro 3, 4 or 5 electronically controlled engines with a diesel only fall back mode.
- The vehicle can revert back to 100% standard diesel operation with very little on-cost, and the re-sale value of the vehicle is unaffected
- Components of the Hardstaff OIGI® system are ECE R110 certified, and are also in alignment with ISO standards



Bespoke Exhaust Technology



Hardstaff have designed and built bespoke exhaust after-treatment reducing both Non-Methane Hydrocarbons and Methane below current European emission limits.



The exhaust system incorporates methane oxidising catalysts, optimised to maximise methane reduction and provide easy packaging within the engine/chassis envelope.



Our after-treatment systems are designed to work in conjunction with Selective Catalytic Reduction Systems at OBD1 and OBD2 levels and offer significant enhancement to current systems.

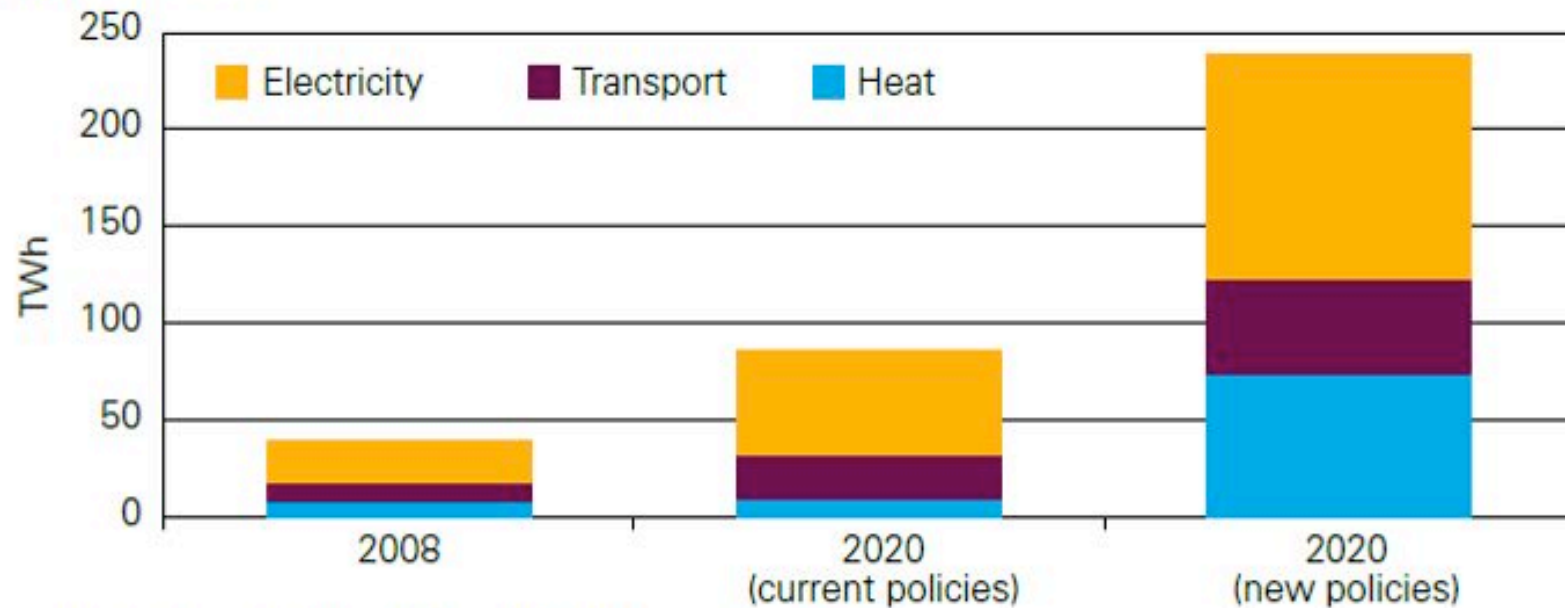
What are the Environmental Implications?

- Reduced dependency on crude oil
- Reduced CO₂ emissions by approximately 18% when compared with diesel
- Reduced CO₂ emissions in excess of 30% when compared with a dedicated gas engine
- The use of biomethane drives this down to a 70% well-to-wheel saving on diesel
- 35% to 65% reduction in NO_x output, offering a reduction in AdBlue use
- Very high gas substitution rates which reduce the particulate and non-methane hydrocarbon emissions
- 98% reduction in CO
- Reduced noise emissions



The UK Renewable Energy Strategy

The size of the challenge: A potential scenario to reach 15% renewable energy by 2020



Source: Energy Trends June 2009 and DECC internal analysis

- *Amend or replace the Renewable Transport Fuel Obligation* to impose an obligation designed to deliver 10% renewable energy consumed in transport by 2020, subject to sustainability controls. This will ensure that transport fuels contain a rising level of renewable biofuels automatically at the pump without the driver needing to take any specific action.

Emission Levels



| | Unit | ESC Euro 4 Diesel | ESC Euro 5 Diesel | ETC Euro 5 Diesel | ETC Euro 5 Gas | ESC Euro 5 Hardstaff D/F |
|-----------------|-------|-------------------|-------------------|-------------------|----------------|--------------------------|
| CO | g/kWh | 1.5 | 1.5 | 4.0 | 4.0 | 0 |
| HC | | 0.46 | 0.46 | 0.55 | - | - |
| NMHC | | - | - | - | 0.55 | 0.17 |
| CH ₄ | | - | - | - | 1.1 | 0.85 |
| NO _x | | 3.5 | 2.0 | 2.0 | 2.0 | 1.47 |
| P _m | | 0.2 | 0.2 | 0.03 | 0.03 | 0.03 |








Note: Currently there are no emission limits declared for Dual Fuel combustion engines. Working group ISO TC22/SC25 is currently in place to address this requirement. The current recommendation from the Chairman of the Gas Fuelled Vehicles working group at RDW - Holland is test at ESC Euro 5 for current Dual Fuel engines. The approach at this time is that Hardstaff will test and meet the lower limits set for diesel and gas engines.

CO2 Emission Reduction

| Substitution rate | CO2 reduction % |
|-------------------|-----------------|
| 50% | 13.06% |
| 55% | 14.33% |
| 60% | 15.60% |
| 65% | 16.94% |
| 70% | 18.21% |
| 75% | 19.55% |
| 80% | 20.82% |
| 85% | 22.16% |
| 90% | 23.44% |

Note: 1 litre of diesel emits 2.61Kg CO2. If the supply of biomethane is via a renewable source the savings per vehicle (kg) can be multiplied by a factor of 2

Biomethane as a Vehicle Fuel

-  Biomethane is widely used as a vehicle fuel - worldwide
-  Significantly reduces CO2 output
-  100% renewable fuel source fully compatible with current mainstream production engines
-  Contributes towards meeting Renewable Transport Fuel Obligations
-  Fuel source is CNG from Anaerobic Digester or LNG from landfill
-  Upgraded methane from landfill is cleaner than pipeline gas and has a very high energy content
-  Transported economically in liquefied state – compliant with well established legislation and standards



Summary of Advantages and Gains



Investing in clean and renewable energy



Financial benefits and tax incentives



Environmental benefits (reduction of pollution into atmosphere and noise



reductions)



Manages legal liability for compliance with European legislation

Improved environmental policy and performance

Responsible corporate behaviour

Biomethane in the UK – The Challenge

Although the UK is the second largest user of Biogas, its primary use is for electricity: -

- It is not price competitive
- There are no fiscal benefits in the UK
- No promotional factors
- No CO2 credits





Infrastructure



“The final piece of the jigsaw”

Station size and type depends on a number of factors including location, limitations and the specific needs of the customer.

Portal Gas Services (PGS) has the expertise to assist with selection and will match the customer's needs with a refuelling system to suit.

PGS facilitate the design and installation of a range of refuelling facilities that enable the operator to move between different supply levels as their business and fleet numbers grow.

By sizing the refuelling system to the exact customer's requirement the fuel remains simple, convenient and operating at optimum performance.

Infrastructure Considerations

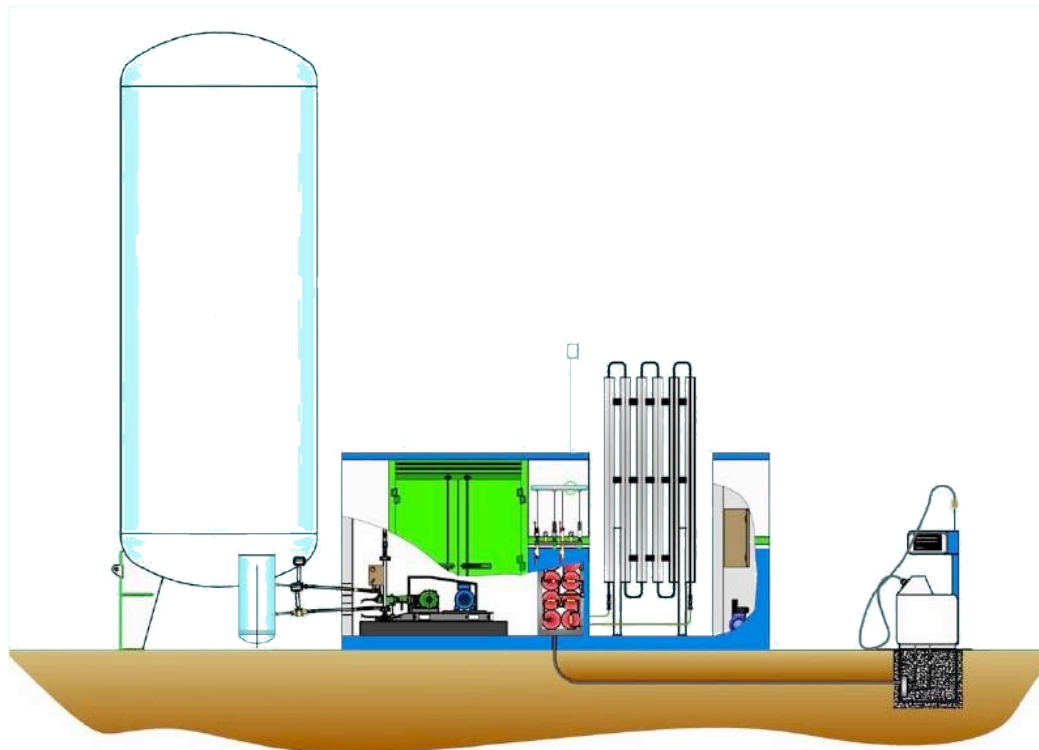
The following issues must be taken into consideration when determining the size and type of refuelling facility:

- Location and limitations
- Accessibility of pipeline gas
- Planning
- Customer requirement
- Cost in low capacity requirement
- Health and Safety
- Flexible growth
- Sustainability



LCNG Station

- LNG is delivered by road trailers and is off-loaded and stored at a very low temperature (typically -150°C) in the cryogenic storage vessel. The LNG is pumped to 300 bar through the atmospheric vaporizer. The vaporizer converts the high pressure LNG into a gaseous form by absorbing the required heat energy from the surrounding atmosphere to evaporate it. The high pressure gas; CNG, is stored in buffer cylinders ready for refuelling.



Advantages over Compressor Station:

- Not limited by location
- Lower Power consumption
- No oil carry over into the vehicle tanks
- Higher methane content
- Easy access to Bio – methane
- Lower maintenance costs
- Option for LNG dispensing

Disadvantages:

- Possible planning permission issues with large vertical LNG storage tanks

Economic & Commercial Sense



1. Economically driven with short payback and reduced fuel costs
2. Immediate improvement in air quality
3. Makes use of renewable fuels, reducing world reliance on crude oil
4. Eliminates need to replace vehicle for environmental compliance
5. Proven effective in road transport operation
6. Complies with tougher environmental standards and emission levels
7. No loss of power or performance
8. Driver approved (retains driving characteristics of a diesel engine)
9. 100% diesel fall back should gas supply be disrupted
10. Residual value not affected
11. Backed by major OEM's
12. Infrastructure sized to suit requirement (including trial vehicles)
13. Fully warranted with training and support packages



Helping our customers reduce their costs



Current Industry Status (1/2)

Technology Supported by major OEM's

- MERCEDES-BENZ
- VOLVO
- DENNIS EAGLE
- OPTARE



Current Industry Status (2/2)

Major Customers Include:

- BAKERIES
- FOOD DELIVERY / SUPERMARKETS
- WASTE MANAGEMENT
- COUNTY COUNCILS
- BUS & COACH
- HOME DELIVERY
- CONSTRUCTION INDUSTRY
- ROAD TRANSPORT



Worldwide Recognition



HARVEST
DIGI® Dual Fuel



UK
Brazil
Russia
India
China
Taiwan
Australia
Sweden
Holland
Norway
Italy
Spain
France
Germany
Croatia
USA

Total Solution Providers

Hardstaff is a total solution provider and through its group activities is perfectly positioned to provide all disciplines required for successful integration of product, including:

- ◆ **Dual fuel technology**
- ◆ **Vehicle**
- ◆ **Refuelling station, bespoke design and build options**
- ◆ **Fuel - Natural Gas in CNG or LNG form and Biomethane in LBG or CBG form**
- ◆ **Support services**
- ◆ **Warranty**



Technological

Environmental

Economic

A conceptual image showing two human hands, one above and one below, gently cradling a small, realistic model of the Earth. The Earth is centered in the frame, showing continents and oceans. The background is a dark, deep blue space filled with numerous small, white stars, suggesting a cosmic or global perspective. The lighting is soft, highlighting the texture of the hands and the details of the planet.

The world needs dual fuel



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