Workshop Heavy Duty Dual-Fuel Retrofits
Brussel 13-12-2012

Jasper van Sambeek, Product Manager Dieselblend
1. Introduction Prins Autogassystems B.V.
2. Why Dual-Fuel?
3. Applications
4. Technical explanation
5. Emissions
6. Why retrofit regulation?
Part 1

Introduction Prins
Prins Autogassystemen B.V.

• Dutch designer and manufacturer of alternative fuel systems since 1986
• Headquarter in Eindhoven, the Netherlands
• Subsidiary of SHV Energy, world leader in the distribution of LPG
• In-house product development, test and training facilities
• Customers in over 50 countries include OEMs, Country Importers and Distributors worldwide
• Prins works with A-quality partners like Keihin (Japan) for its A-quality brand
## System groups

### 1. Mixer systems
- ECO [Electronic Control] 2009 >

### 2. Gas injection systems
- VSI LPG [Vapour Sequential Injection] 2002 >
- VSI-2.0 LPG [VSI 2\textsuperscript{nd} generation] 2011 >
- VSI-DI LPG [VSI-Direct Injection] 2009 >
- VSI-CNG 2007 >
- VSI-2.0 CNG [VSI 2\textsuperscript{nd} generation] 2012 >

### 3. Diesel blend systems
- Diesel blend LPG 2009-2011
- Diesel blend-2.0 LPG 2012 >
- Diesel blend CNG 2009-2011
- Diesel blend-2.0 CNG 2012 >

### 4. Liquid gas injection systems
- LiquiMax 2011 >
- Direct LiquiMax 2011 >
Part 2

Why Dual-Fuel?
Why Diesel blending?

• Costs reduction.
  – Up to 15% fuel savings
• Significant reduction of emissions by using alternative fuels.
  – contributes to “green” image of your company
  – meets demand for environmentally conscious ECO-transport
• Low system costs.
  – Not necessary to rebuild a diesel engine into an otto-engine [mono fuel LPG/CNG]
• Truck maintenance interval stays the same.
• No downtime when system fails.
  – Able to switch back to full diesel operation
Savings depending on:

- Vehicle /engine type
- Vehicle use
- Type of load
- Type of fuel blending LPG-CNG - LNG
- Local fuel prices

- Savings are achieved because a percentage of the diesel is replaced with LPG/CNG which is far cheaper
  
  LPG : 25-30 % average blend rates
  CNG : 35-40 % average blend rates

- The more miles covered the greater the savings!!
Prins Calculator for LPG or CNG

---

**Data used for calculation:**

<table>
<thead>
<tr>
<th>LPG composition</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage propane:</td>
<td>50 %</td>
</tr>
<tr>
<td>Percentage butane:</td>
<td>50 %</td>
</tr>
<tr>
<td>Kilometers/year:</td>
<td>120,000 kilometers</td>
</tr>
<tr>
<td>Fuel consumption diesel:</td>
<td>30 l/100 km</td>
</tr>
<tr>
<td>Fuel price diesel:</td>
<td>1.15 Euro/liter</td>
</tr>
<tr>
<td>Fuel price LPG:</td>
<td>0.69 Euro/liter</td>
</tr>
<tr>
<td>Average blend percentage</td>
<td>25 %</td>
</tr>
<tr>
<td>Fuel tank capacity Diesel</td>
<td>400 liter</td>
</tr>
<tr>
<td>Nett Fuel tank capacity LPG</td>
<td>200 liter</td>
</tr>
</tbody>
</table>

---

**Calculation results:**

1 liter diesel is equivalent to: 1.44 liter LPG

**100% Diesel mode:**

- Liters diesel used: 36,000 l/year
- Driving range: 1,200 km
- Assumes 90% usable tank volume
- Total fuel cost per year: 41,400 Euro
- CO2 emissions per year: 97.2 ton

**Dieselblend-LPG mode:**

- Liters diesel used: 27,000 l/year
- Liters LPG used: 12,940 l/year
- Driving range diesel: 1,600 km
- Driving range LPG: 1,855 km
- Assumes 90% usable tank volume
- Fuel cost diesel: 31,050 Euro
- Fuel cost LPG: 8,928 Euro
- Total fuel cost per year: 39,978 Euro
- CO2 emissions per year:
  - Diesel: 72.9 ton
  - LPG: 20.1 ton
  - Total CO2 emissions per year: 93.0 ton

**Fuel cost saving:** 1,422 Euro/year
**CO2 emission reduction:** 4.2 ton
Part 3
Applications
Applications heavy duty LPG
Applications heavy duty LPG

250 Liter / 376 Liter LPG
Applications heavy duty CNG
Applications heavy duty CNG

4 x 100 / 120 / 140 Liter LPG

1 x 100 / 120 / 140 Liter LPG
Tank configurations
Applications medium duty

Toyota Landcruiser 3.0

Mitsubishi Canter 3.0

Ford Transit 2.2/2.4
A Quebec company wants to sell you on propane-powered trucks. And it appears to have the technology to do it.

By Steve Bouchard

The story of propane-powered trucks is a tale of innovation and perseverance. It began with a vision to reduce the environmental impact of transportation and has evolved into a reality that promises significant benefits.

Propane's promise is not just about fuel efficiency; it's about sustainability and the future of energy. As we strive toward a cleaner environment, propane-powered vehicles offer a viable solution that can make a difference.

*Image of a propane-powered truck.*
Applications Africa

Gen-sets
Requests worldwide
Part 4

Technical explanation
Central versus Sequential injection

- Central injection (single point) => LPG/CNG injected before or after turbocharger.
- Sequential injection => LPG/CNG injected per cylinder into the intake manifold just before the inlet valve.
- Disadvantages central gas injection before/after turbocharger:
  - Large volume explosive air/fuel mixture in intercooler and intake;
  - High risk of LPG/CNG leakage in the intercooler and intake system;
    - Diesel engines have no gas-tight seals in the turbocharger;
  - Slow response of engine fueling;
  - During valve overlap a portion of the air fuel mixture will be wasted directly into the exhaust [higher HC emissions].
- Central injection easier to program (universal kits).
Prins

Dieselblend-2.0 CNG
Engine compartment
Fuel must be injected as near to the inlet valve as possible.
<table>
<thead>
<tr>
<th>load</th>
<th>Engine RPM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>600</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>55</td>
<td>0</td>
</tr>
<tr>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td>85</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>
Blending rate at 1200 RPM MAN TGX 18
Part 5

Emissions
• Same torque output
• CO₂ reduction 4,3 %
• NOₓ reduction 8,9 %

<table>
<thead>
<tr>
<th>DAF XE1260 (European Transient Cycle)</th>
<th>Diesel</th>
<th>Dual fuel</th>
<th>Euro 3 limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>1,72</td>
<td>6,8</td>
<td>5,45</td>
</tr>
<tr>
<td>NOx</td>
<td>5,41</td>
<td>4,93</td>
<td>5,00</td>
</tr>
<tr>
<td>NMHC</td>
<td>0,13</td>
<td>2,75</td>
<td>0,78</td>
</tr>
<tr>
<td>PM</td>
<td>0,087</td>
<td>0,094</td>
<td>0,16</td>
</tr>
<tr>
<td>CO2</td>
<td>628</td>
<td>601</td>
<td>g/kWh</td>
</tr>
</tbody>
</table>
MAN TGX 18.400 (Euro 5) CNG TNO

Emission test TNO
Average advantage :
• CO2 reduction 5 %
• NOx reduction 16,4 %

<table>
<thead>
<tr>
<th>MAN TGX 18.400 CNG European Transient Cycle</th>
<th>Diesel</th>
<th>Dual fuel</th>
<th>Euro 5 limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>0,16</td>
<td>1,26</td>
<td>1,50</td>
</tr>
<tr>
<td>NOx</td>
<td>2,25</td>
<td>1,88</td>
<td>2,00</td>
</tr>
<tr>
<td>THC</td>
<td>0,02</td>
<td>1,5</td>
<td>0,46</td>
</tr>
<tr>
<td>PM</td>
<td>0,033</td>
<td>0,033</td>
<td>0,02</td>
</tr>
<tr>
<td>CO2</td>
<td>684</td>
<td>650</td>
<td></td>
</tr>
</tbody>
</table>
Portable Emission Measurement system (PEMS test)
Part 6

Why retrofit regulation?
Why retrofit regulation?

- Worldwide Dual-Fuel applications
- Installing systems without homologation /safety check
- No entry of market without homologation (Germany)
  Entering EU countries possible without regulation
- Regulation (R115 ?) with HC dispensation?
  Big investments required for after treatment systems
- Regulation (R115 ?) only possible if emission test are affordable!
  Family building
- Can the Euro 6 engines been converted with a retrofit system?