ALTERNATIVE FUEL SYSTEMS

Prins

World leader in alternative fuel systems

Workshop Heavy Duty Dual-Fuel Retrofits

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Subjects

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	• AFC [Air Fuel Control]	1985-1990
	• AFS [Air Fuel System]	1990-2003
	• SCS [Saipa CNG System]	2005-2009
	• ECO [Electronic Control]	2009 >
2. Gas injection systems	• YPS [Yde Prins System]	1998-2002
	• VSI LPG [Vapour Sequential Injection]	2002 >
	• VSI-2.0 LPG [VSI 2nd generation]	2011 >
	• VSI-DI LPG [VSI-Direct Injection]	2009 >
	• VSI-CNG	2007 >
	• VSI-2.0 CNG [VSI 2nd 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

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

It is only possible / necessary to change the variabeles in the yellow marked cells!!

Data used for calculation:

LPG composition		
Percentage propane:	50	%
Percentage butane:	50	%
Kilometers/year:	120.000	kilometers
Fuel consumption diesel:	30	l/100 km
Fuel price diesel:	1,15	Euro/liter
Fuel price LPG:	0,69	Euro/liter
Average blend percentage	25	%
Fuel tank capacity Diesel	400	liter
Nett Fuel tank capacity LPG	200	liter

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	
Fuel consumption diesel	22,5	l/100 km	
Fuel consumption LPG	10,8	l/100 km	
Driving range diesel	1.600	km	assumes 90% usable tank volume
Driving range LPG	1.855	km	
Fuel cost diesel:	31.050	Euro	
Fuel cost LPG:	8.928	Euro	
Total fuel cost per year:	**39.978**	**Euro**	
CO2 emissions per year diese	72,9	ton	
CO2 emissions per year 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

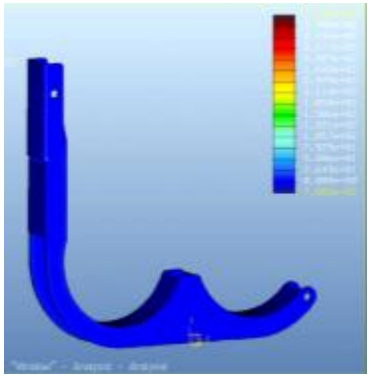
Applications heavy duty LPG

250 Liter / 376 Liter LPG

Applications heavy duty CNG

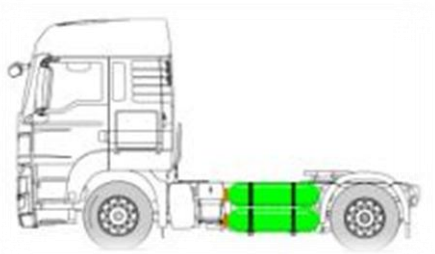
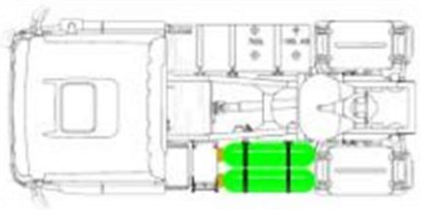
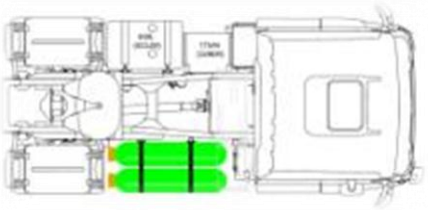
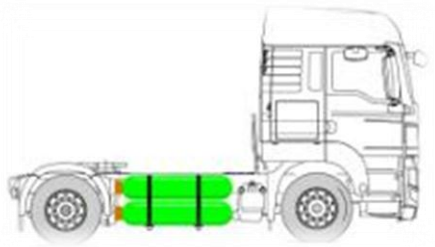
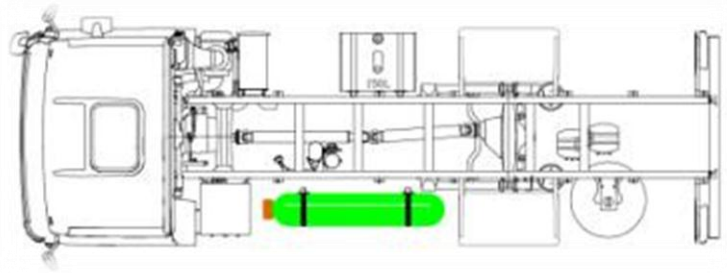
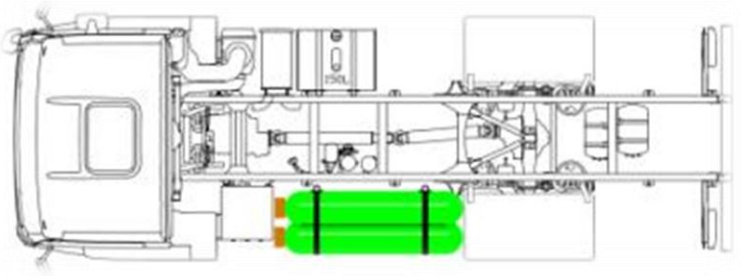
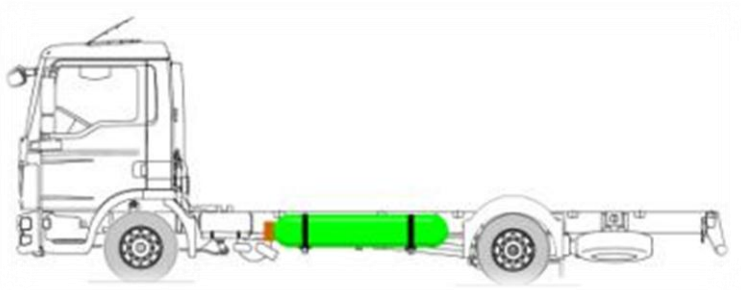
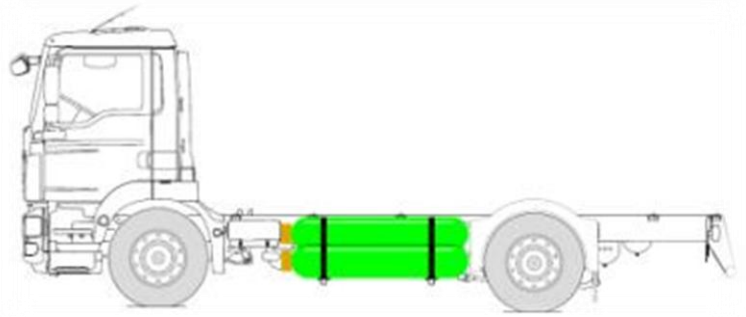
Applications heavy duty CNG

4 x 100 / 120 / 140 Liter LPG



1 x 100 / 120 / 140 Liter LPG

Tank configuraties

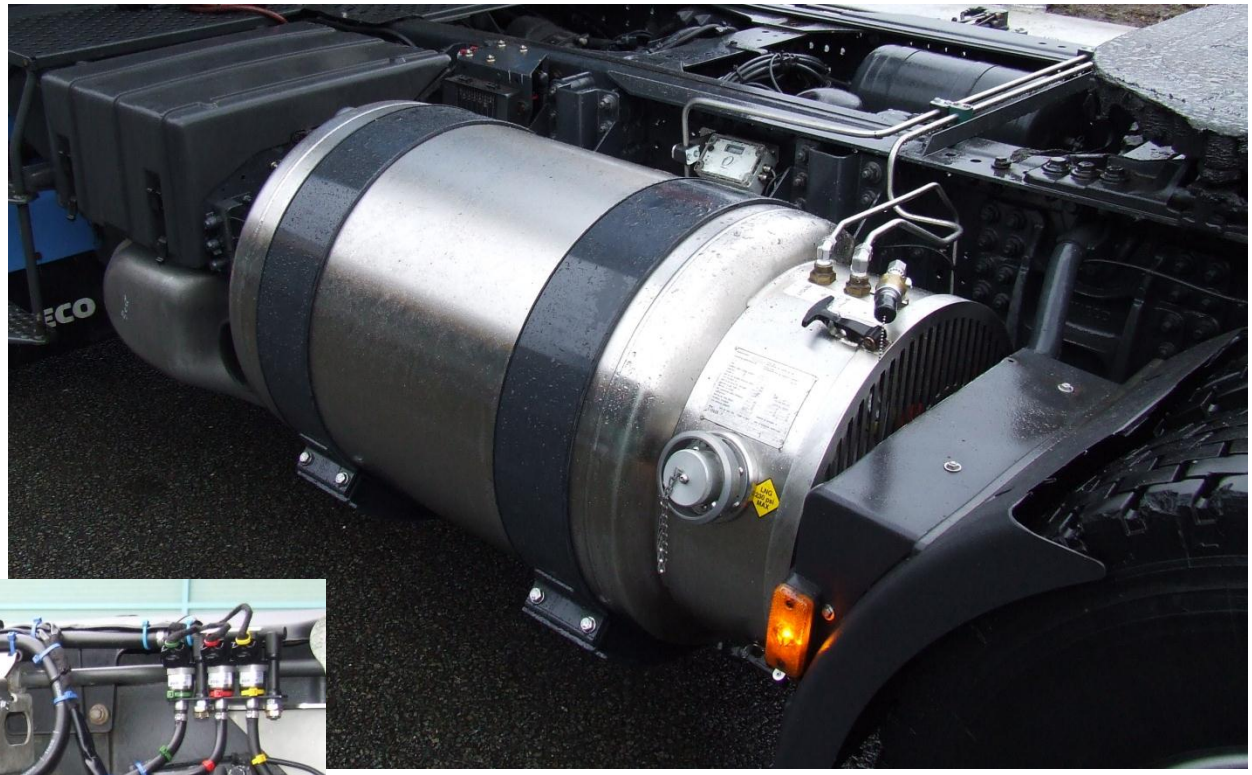
Applications medium duty

Toyota Landcruiser 3.0

Mitsubishi Canter 3.0

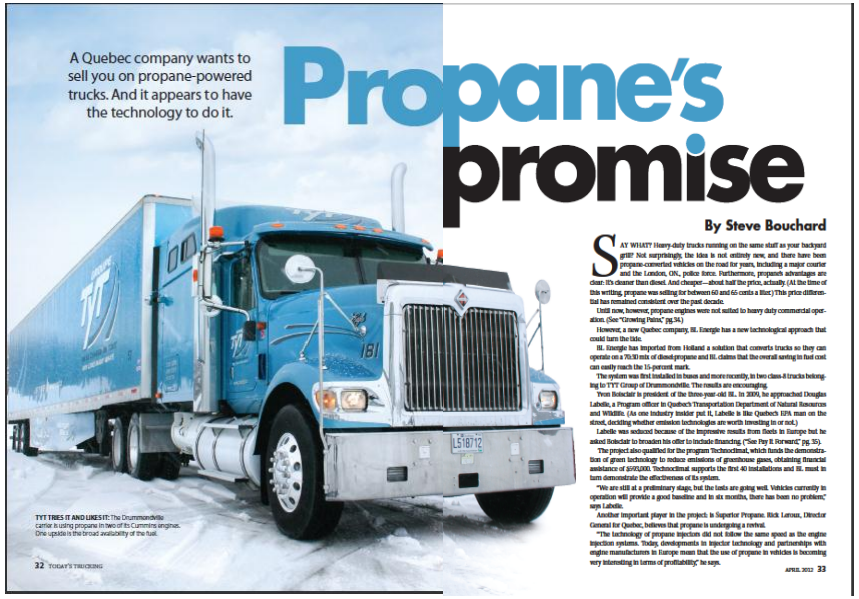
Ford Transit 2.2/2.4

Applications LNG



Applications Asia

Applications America



Applications Africa

Gen-sets

Requests worldwide

Part 4

Technical explanation

Central versus Sequential injection

- Central injection (single point) =>LPG/CNG injected before or after turbo charger.
- 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).

Dieselblend-2.0 LPG

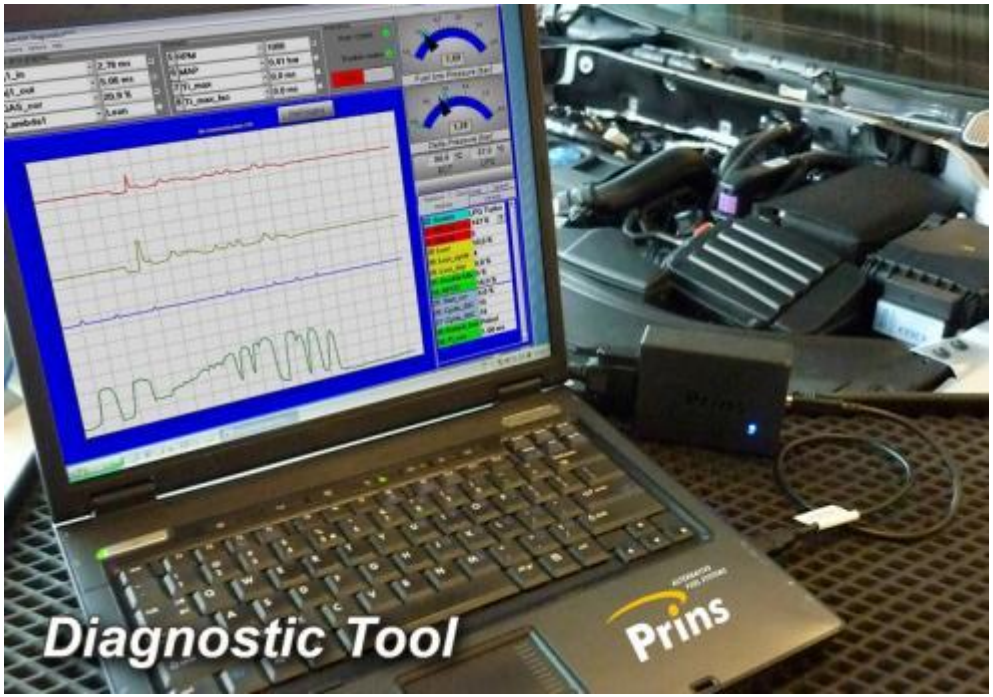
Dieselblend-2.0 CNG

Engine compartment

Injector inserts

Fuel must be injected as near to the inlet valve as possible.

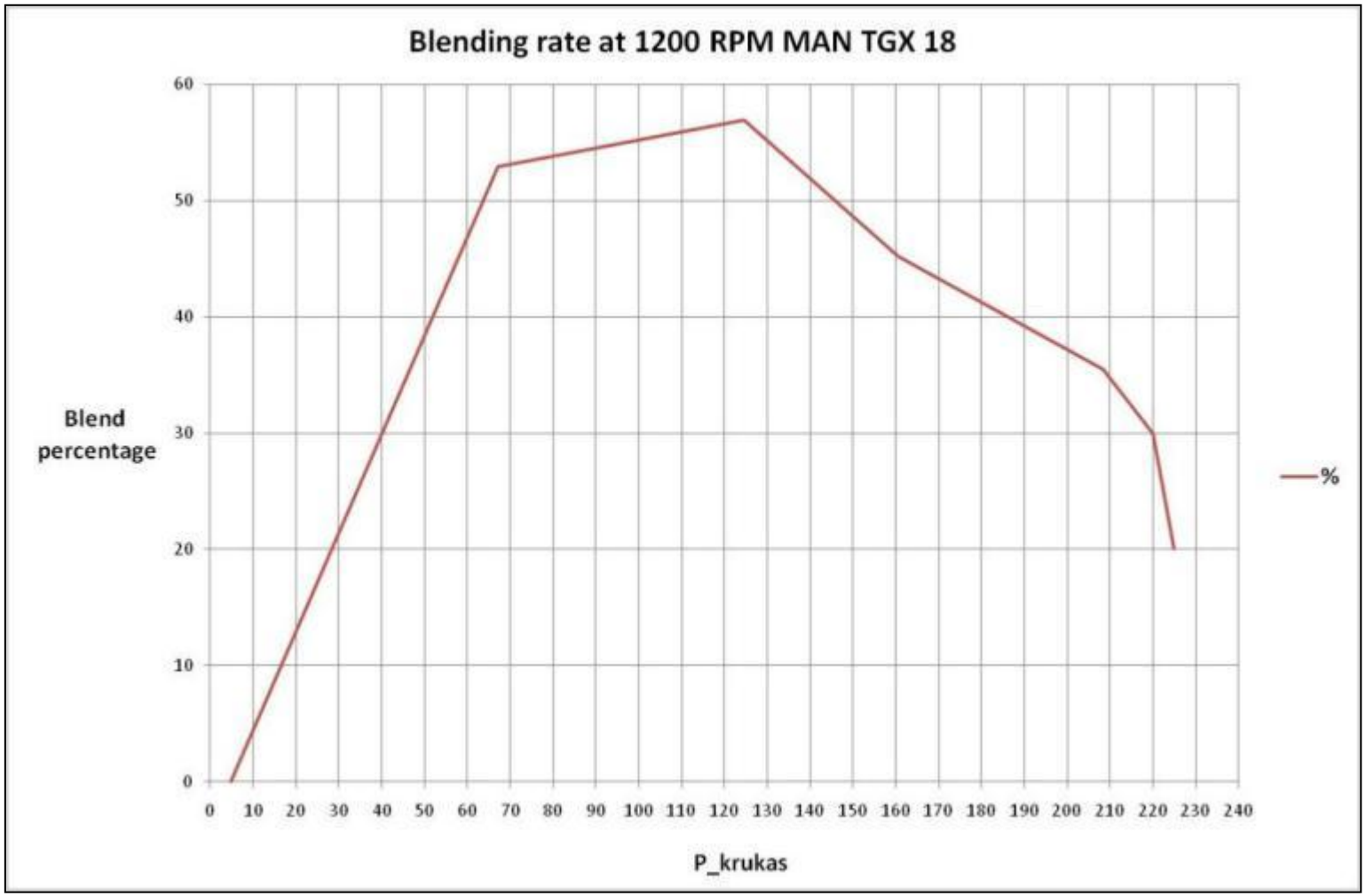
Prins Diagnostic Tool



Blend rate

load	Engine RPM							
	600	800	1000	1200	1400	1600	1800	2000
10	0	0	0	0	0	0	0	0
25	0	29	37	35	35	38	32	0
40	0	38	46	49	47	47	45	0
55	0	41	47	47	43	45	44	0
70	0	32	41	41	39	40	39	0
85	0	27	35	38	32	32	27	0
100	0	10	20	20	20	17	8	0

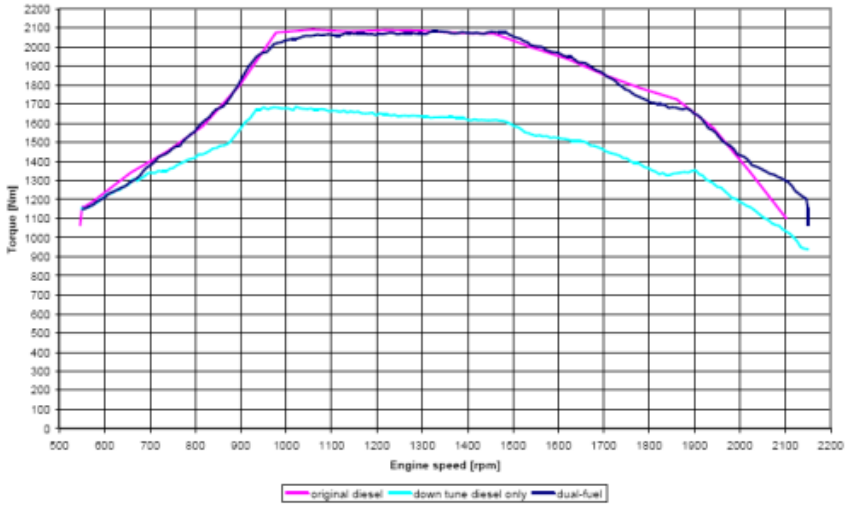
Blend percentage



Part 5

Emissions

DAF XE 1260 (Euro 3) LPG TNO



- Same torque output
- CO_2 reduction 4,3 %
- NO_x reduction 8,9 %

DAF XE1260 (EuropeanTransient Cycle)				
	Diesel	**Dual fuel**	**Euro 3 limit**	
CO	1,72	6,8	5,45	g/kWh
NOx	5,41	4,93	5,00	g/kWh
NMHC	0,13	2,75	0,78	g/kWh
PM	0,087	0,094	0,16	g/kWh
CO2	628	601		g/kWh

MAN TGX 18.400 (Euro 5) CNG TNO

Emission test TNO
Average advantage :

- CO2 reduction 5 %
- NO_x reduction 16,4 %

MAN TGX 18.400 CNG European Transient Cycle				
	Diesel	**Dual fuel**	**Euro 5 limit**	
CO	0,16	1,26	1,50	g/kWh
NOx	2,25	1,88	2,00	g/kWh
THC	0,02	1,5	0,46	g/kWh
PM	0,033	0,033	0,02	g/kWh
CO2	684	650		g/kWh

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 ?

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