



# Workshop Heavy Duty Dual-Fuel Retrofits

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1. Introduction Prins Autogassystems B.V.
2. Why Dual-Fuel ?
3. Applications
4. Technical explanation
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# Part 1

## Introduction Prins



- 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



## 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 2<sup>nd</sup> generation] 2011 >
- VSI-DI LPG [VSI-Direct Injection] 2009 >
- VSI-CNG 2007 >
- VSI-2.0 CNG [ VSI 2<sup>nd</sup> 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

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

<u>Data used for calculation:</u>	
<b>LPG composition</b>	
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
<b>100% Diesel mode:</b>	
Liters diesel used:	36.000 l/year
Driving range	1.200 km <small>assumes 90% usable tank volume</small>
Total fuel cost per year:	41.400 Euro
CO2 emissions per year	97,2 ton
<b>Dieselblend-LPG mode:</b>	
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 <small>assumes 90% usable tank volume</small>
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





**250 Liter / 376 Liter LPG**



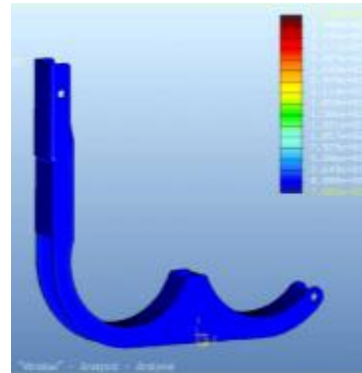
## Applications heavy duty CNG



# Applications heavy duty CNG

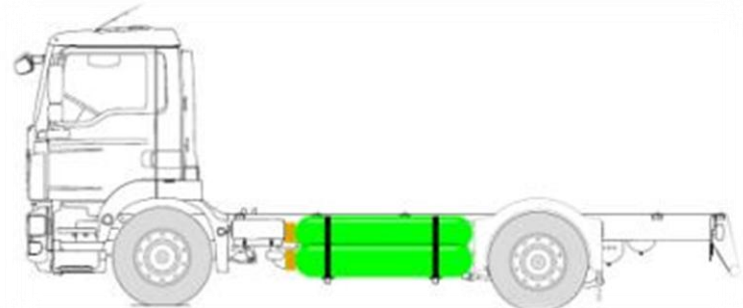
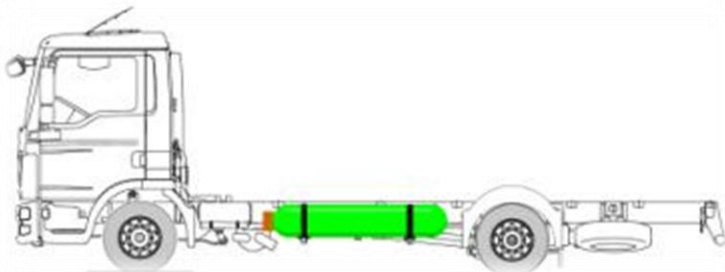
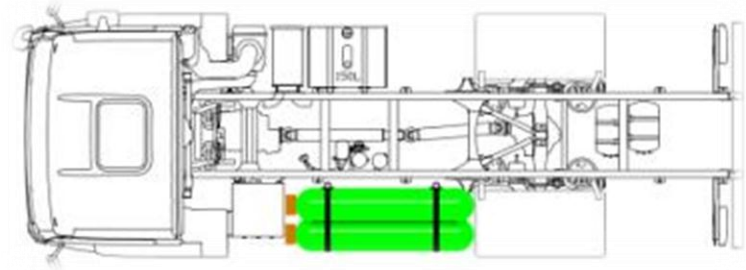
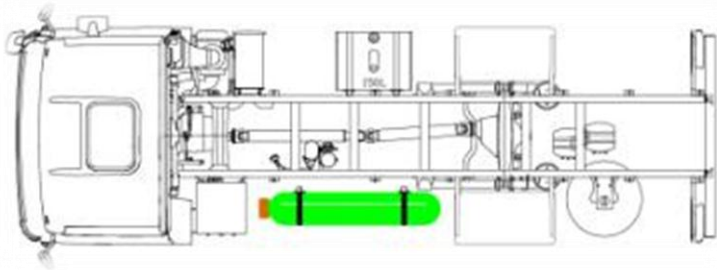
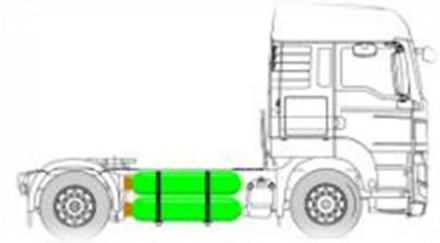
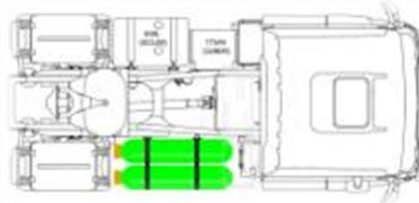
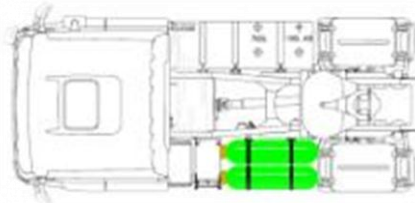
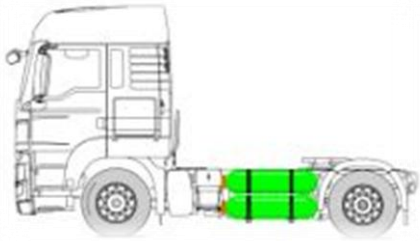


**4 x 100 / 120 / 140 Liter LPG**



**1 x 100 / 120 / 140 Liter LPG**





## Toyota Landcruiser 3.0



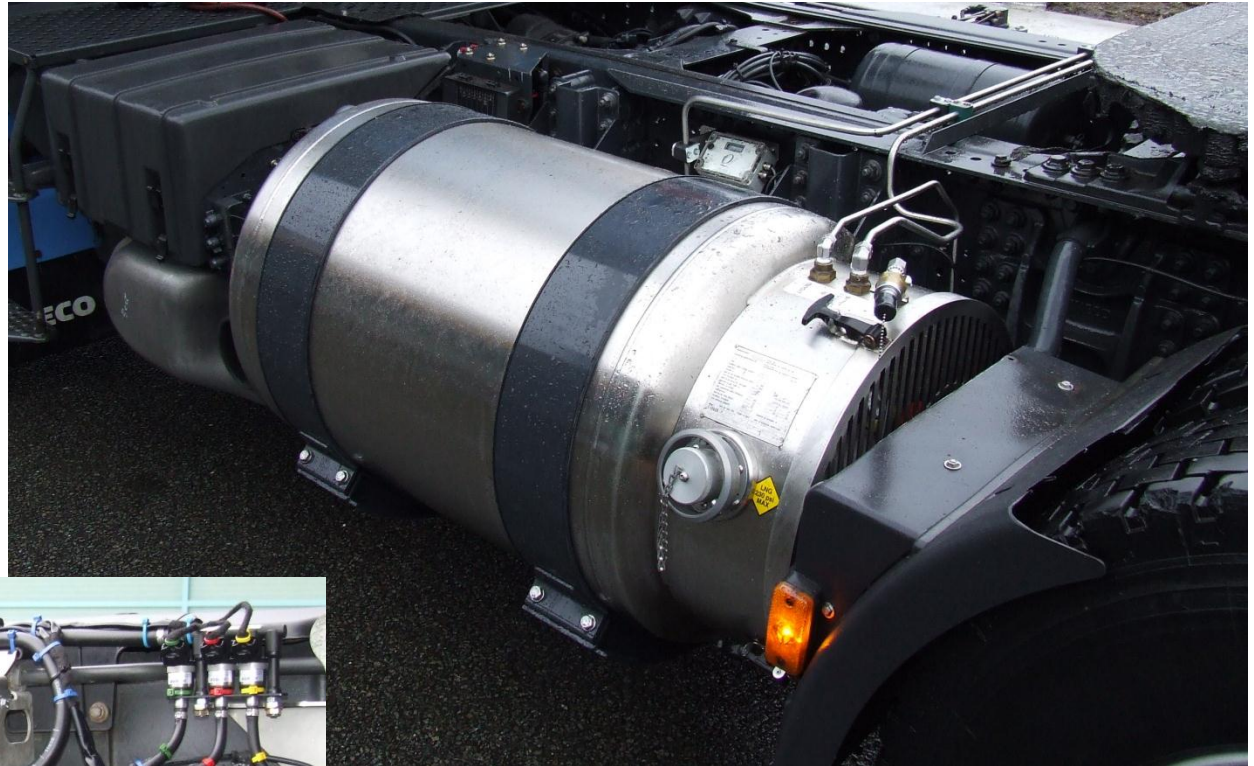
## Mitsubishi Canter 3.0



## Ford Transit 2.2/2.4











## Propane's promise

By Steve Bouchard

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

**S**AT 10:07 AM every day trucks leaving on the same shift as your backyard grill? Not surprisingly, the idea is not entirely new, and there have been propane-powered vehicles on the road for years, including a major courier and the London, ON, public transit. Furthermore, propane advantages are clear: It's cleaner than diesel. And cheaper—about half the price, actually (at the time of this writing, propane was selling for between 60 and 65 cents a liter). The price differential has remained consistent over the past decade.

Until now, however, propane engines were not suited to heavy duty commercial operations. (See "Turning Propane" pg. 34.)

However, a new Quebec company, TI, brought a new technological approach that could turn the tide.

TI, a company that originated a solution that converts trucks so they can operate on a 100% tank of dual-propane and TI, claims that the overall savings in fuel cost can easily reach the 15-percent mark.

"The system was first installed in buses and more recently in two class 8 trucks belonging to TTT Group of Trois-Rivières. The results are encouraging."

Tyler Bouchard is president of the three-year-old TI. In 2005, he approached Douglas LaBelle, a Program officer at Quebec's Transportation Department of Natural Resources and Wildlife, (a one industry insider put it, LaBelle is the Quebec's 10th man on the street, deciding whether certain technologies are worth investing in or not.)

LaBelle was intrigued because of the impressive results from fleets in Europe but he asked Bouchard to broaden his offer to include financing. ("See 'Pay It Forward' pg. 35.)

The project also qualified for the program TechnoAid, which funds the demonstration of green technology to reduce emissions of greenhouse gases, obtaining financial assistance of 50% (TI, TechnoAid supports the first 40 installations and TI, must in turn demonstrate the effectiveness of the system.

"We are still at a preliminary stage, but the tests are going well. Vehicles currently in operation will provide a good baseline and in six months, there has been no production" says LaBelle.

Another important player in the project is Superior Program. Mark Laroux, Director General for Quebec, believes that propane is undergoing a revival.

"The technology of propane injection did not allow the same speed as the engine injection system. Today, developments in injector technology and partnership with engine manufacturers in Europe mean that the use of propane in vehicles is becoming very interesting in terms of profitability," he says.

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**TTT TRUCKS IT AND LINES IT:** The Trois-Rivières City is using propane in local fire trucks and buses. One-upside is the local availability of the fuel.

32 TODAY'S TECHNOLOGY





**Gen-sets**





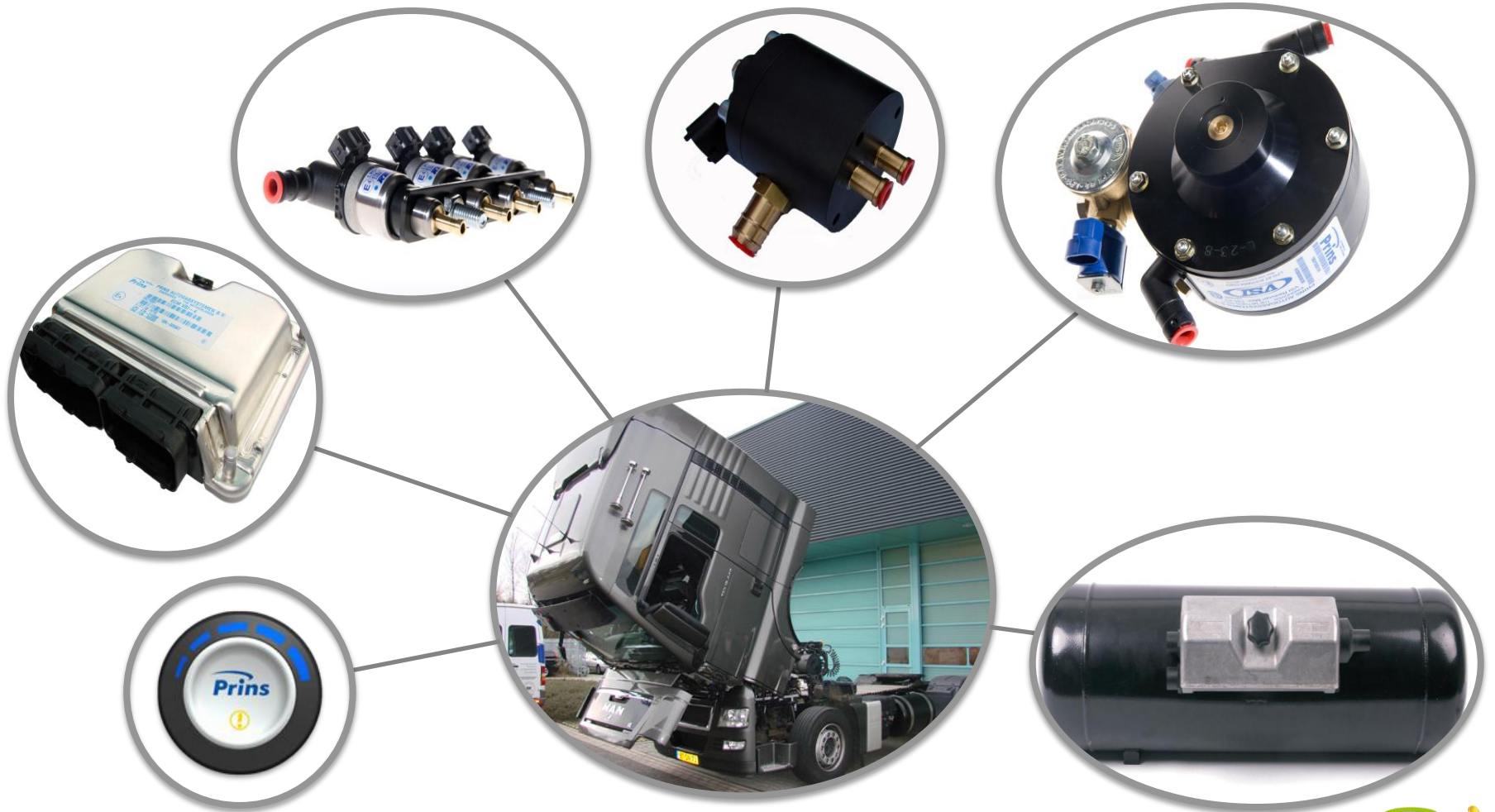
# Part 4

## Technical explanation



- 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).





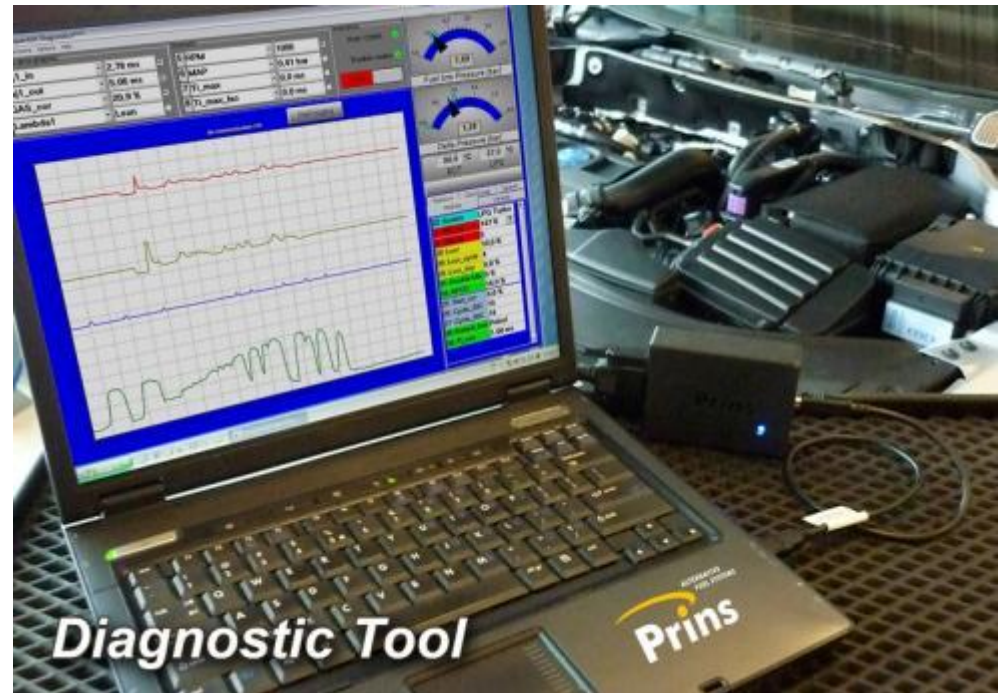






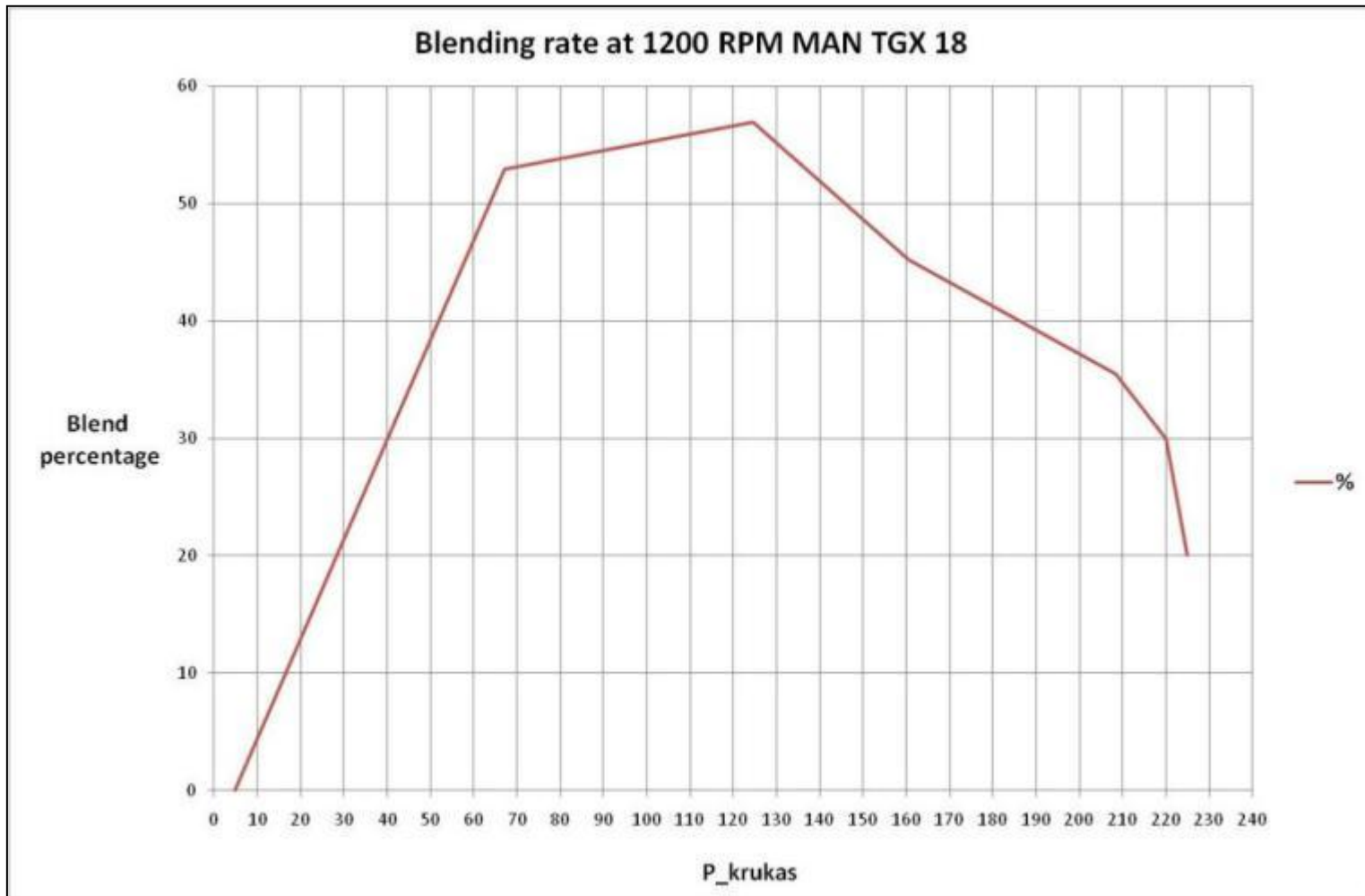
Fuel must be injected as near to the inlet valve as possible.





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

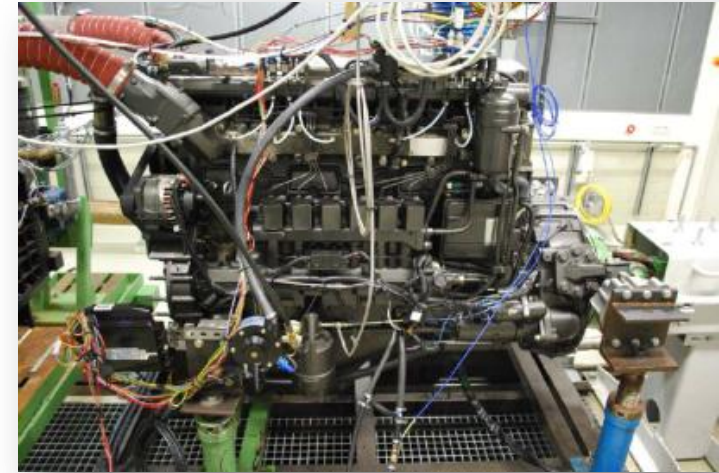
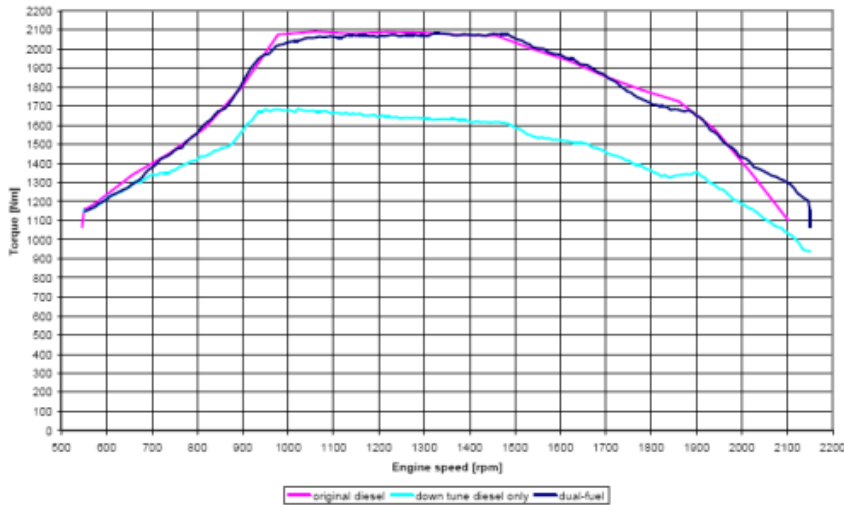




# Part 5

## Emissions





- Same torque output
- CO<sub>2</sub> reduction 4,3 %
- NO<sub>x</sub> reduction 8,9 %

### DAF XE1260 (European Transient Cycle)

	Diesel	Dual fuel	Euro 3 limit	
CO	1,72	6,8	5,45	g/kWh
NO <sub>x</sub>	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
CO <sub>2</sub>	628	601		g/kWh







### 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

Emission test TNO

Average advantage :

- CO<sub>2</sub> reduction 5 %
- NO<sub>x</sub> reduction 16,4 %



# Portable Emission Measurement system (PEMS test)



# Part 6

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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