

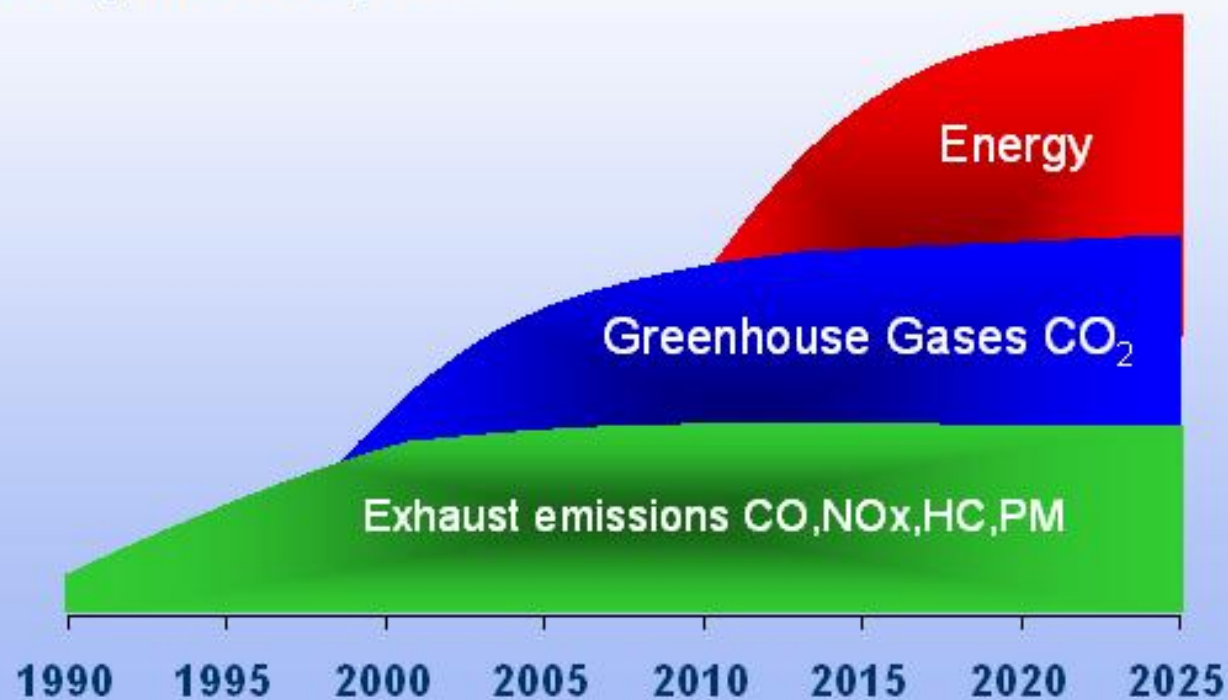
# Utilisation of Biofuels ( especially Biodiesel) on Internal Combustion Engines

Dr. Hartmut Heinrich

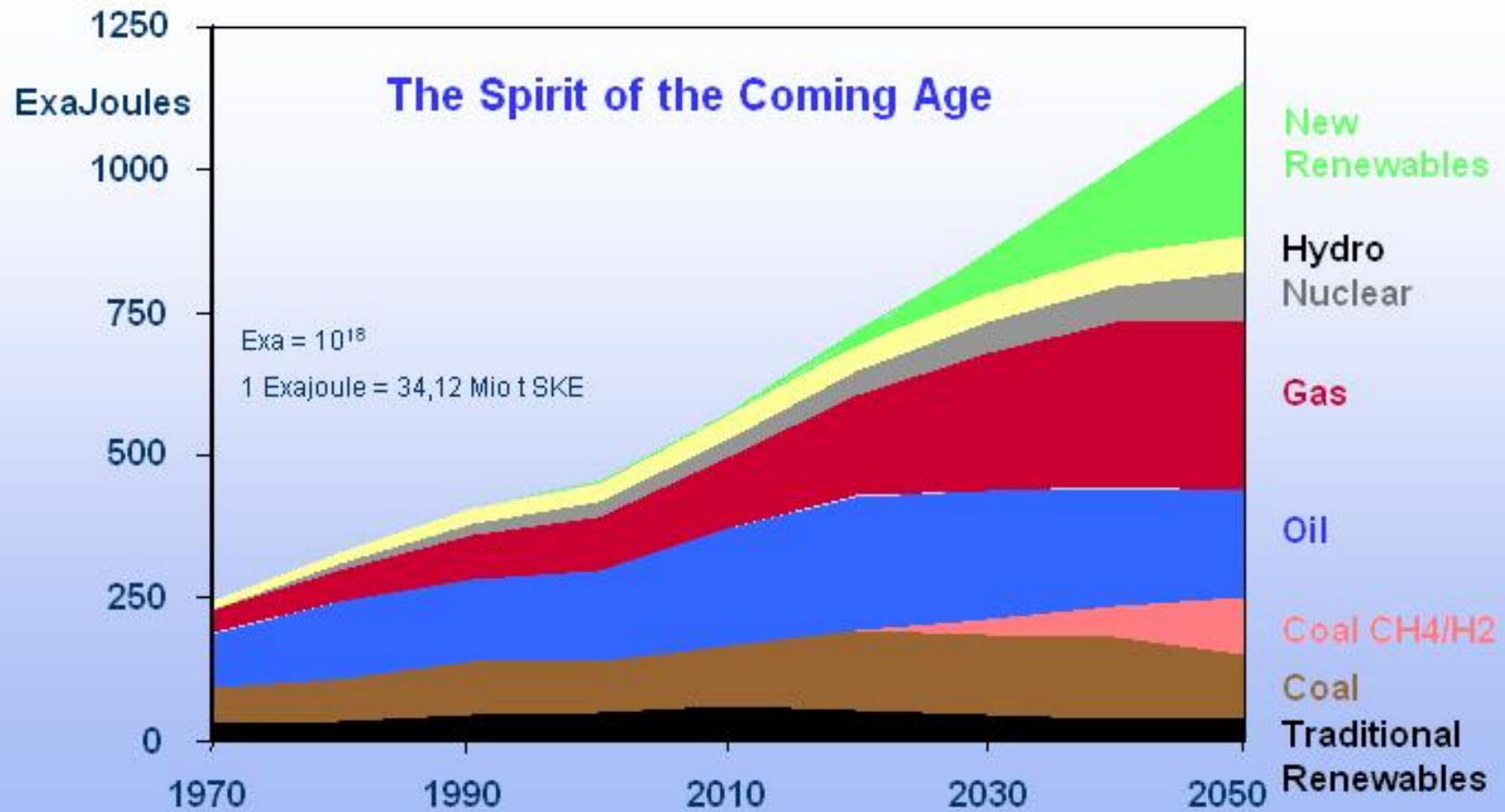
Club of Bologna, 16th Members' Meeting  
Bologna, November 12th 2005

## Main Topics

### Change in environment related development topics

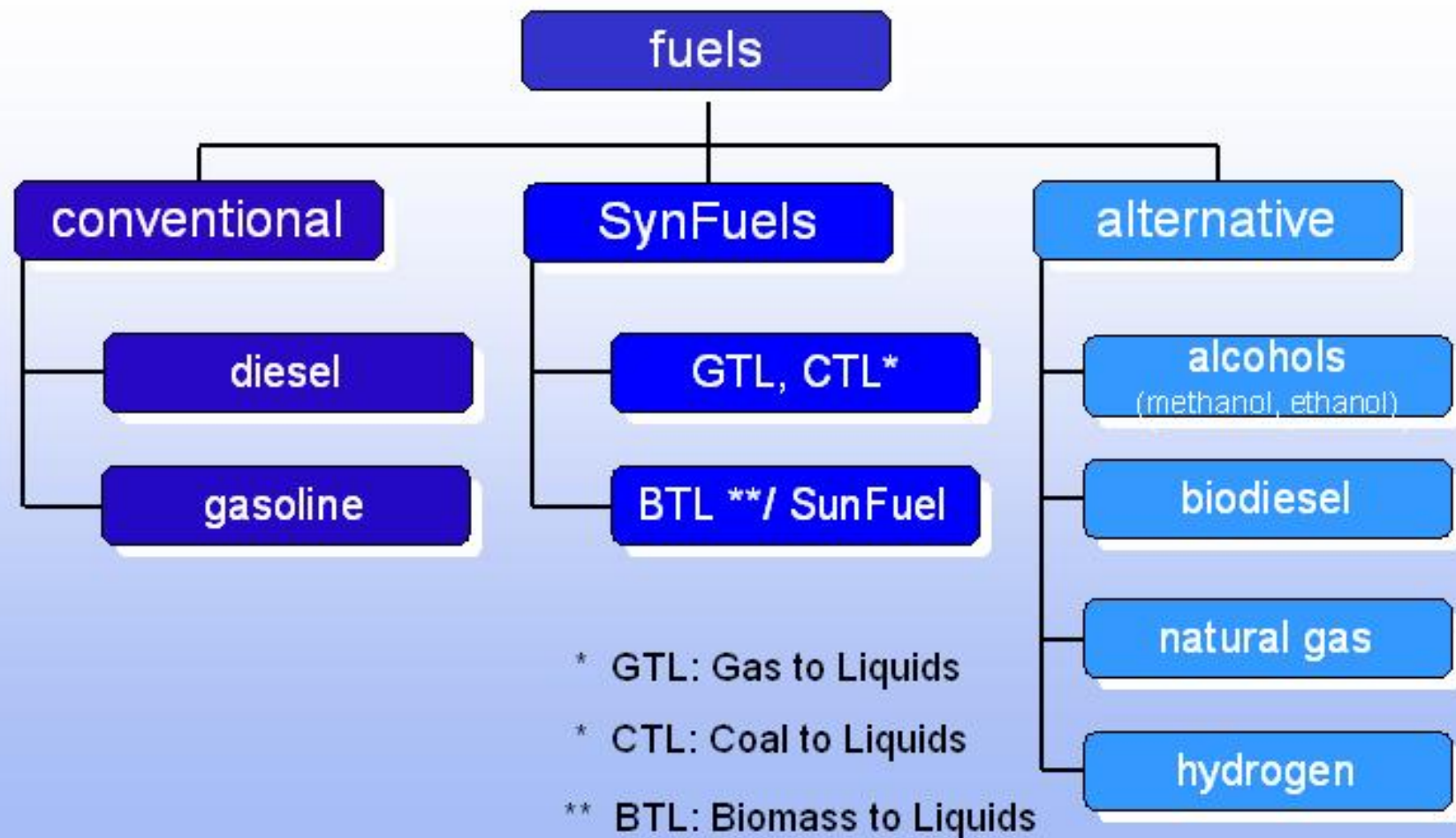


# World Energy Demand



Source: Shell International Ltd

# Fuels





## Demands on Future Fuels - 1

- safe supply
- easy handling and storage
- high energy density
- economically competitive
- consideration of environment and climate protection
  - low emissions (CO, HC, NO<sub>x</sub>, PM)
  - low CO<sub>2</sub>- emissions

diesel

LPG

ethanol

biodiesel

gasoline

methanol

natural gas

hydrogen

SunFuel

**No Single Energy Carrier will be  
Able to Fulfill these Demands**

## Demands on Future Fuels - 2

not to diversify on the fuels side  
→ economically unacceptable solution

- to blend into existing fuels  
→ relating to existing fuel specifications  
Ethanol ⇔ ETBE, biodiesel
- to diversify on the primary energy side  
from crude oil to natural gas, coal and biomass  
no hen and egg - problem

## Challenges of the Future

### Renewable fuels for the transportation sector

- **renewable liquid fuels**

⇒ biomass ⇒ **SunFuel (BTL)**,  
Biodiesel, Bioethanol

- **renewable gaseous fuels**


⇒ biogas  
biohydrogen





# Volkswagen Scenario for the Evolution of Fuels


## Evolution of Fuels



 **Gasoline/ Diesel**  
based on crude oil  
(with blends of biofuels  
according to fuel speci-  
fications)

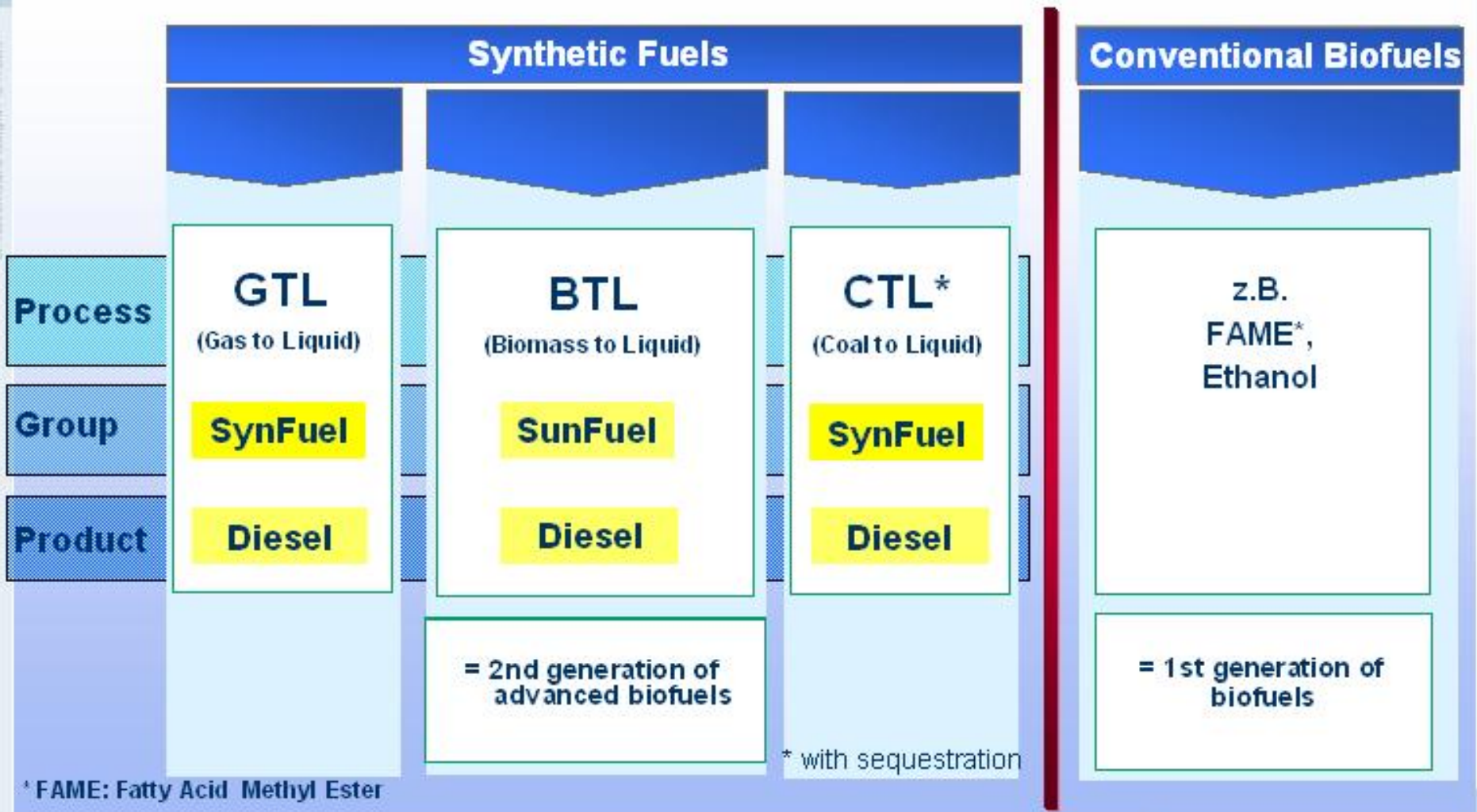
 **SynFuel**  
based on  
natural gas,  
coal (with sequestration)

 **SunFuel**  
based on renewables

 **Hydrogen**  
based on  
renewables



# Classification of Synthetic Fuels



## EU-Scenario for Alternative Fuels

### (BioFuels-Directive)

Year	Biofuels %	Natural Gas %	Hydrogen %	Total %
2005	2			2
2010	5,75	2		7,75
2015	(7)	5	2	(14)
2020	(8)	10	5	(23)



# Bioethanol: Position of the Automotive Industry

- **Blending of EtOH to gasoline (according to EN 228)**
  - 1. priority: 15% ETBE (EtOH content: 47 %) or
  - 2. priority: 5% EtOH (today: approx. 6 Mio t for EU 25)
  - 3. priority: automotive industry is open for 10% blending (E10) if all gasoline in EU is blended to the limit of 5%. But this case has to be examined in cooperation with all parties:
    - new specification within CEN for gasoline E10
    - review of the automotive blending EtOH specification
- **higher percentages in combination with flex. fuel vehicles are rejected by the majority of the car companies due to the relatively small amount of EtOH in Europe which does not justify the development of those cars as well as the introduction of a new distribution system for E85**
- **blending of EtOH to diesel fuel is strongly rejected on account of both safety and mechanical incompatibility**



## Neat Vegetable Oil



*"It has been proved  
that Diesel engines  
can be worked on earth-nut oil  
without any difficulty"*

Rudolph Diesel: The Diesel Oil-Engine.  
Engineering Vol. 93, pp. 395 - 406, 1912.

## Properties of Neat Vegetable Oil

- ten times higher viscosity leads to poorer fuel spray quality, subsequently leading to deposits in the combustion chamber, coking of the piston rings and thus to insufficient engine lifetime
- penetration of vegetable oil into the engine oil leads to polymerisation of the engine oil and thus to blockage the lubrication with engine failure
- noncompliance with emissions standards as EU 2,3,4 and US-FTP
- filter plugging by fungus and bacterium contamination of the fuel system
- no flowability at low temperatures
- insufficient cold start performance

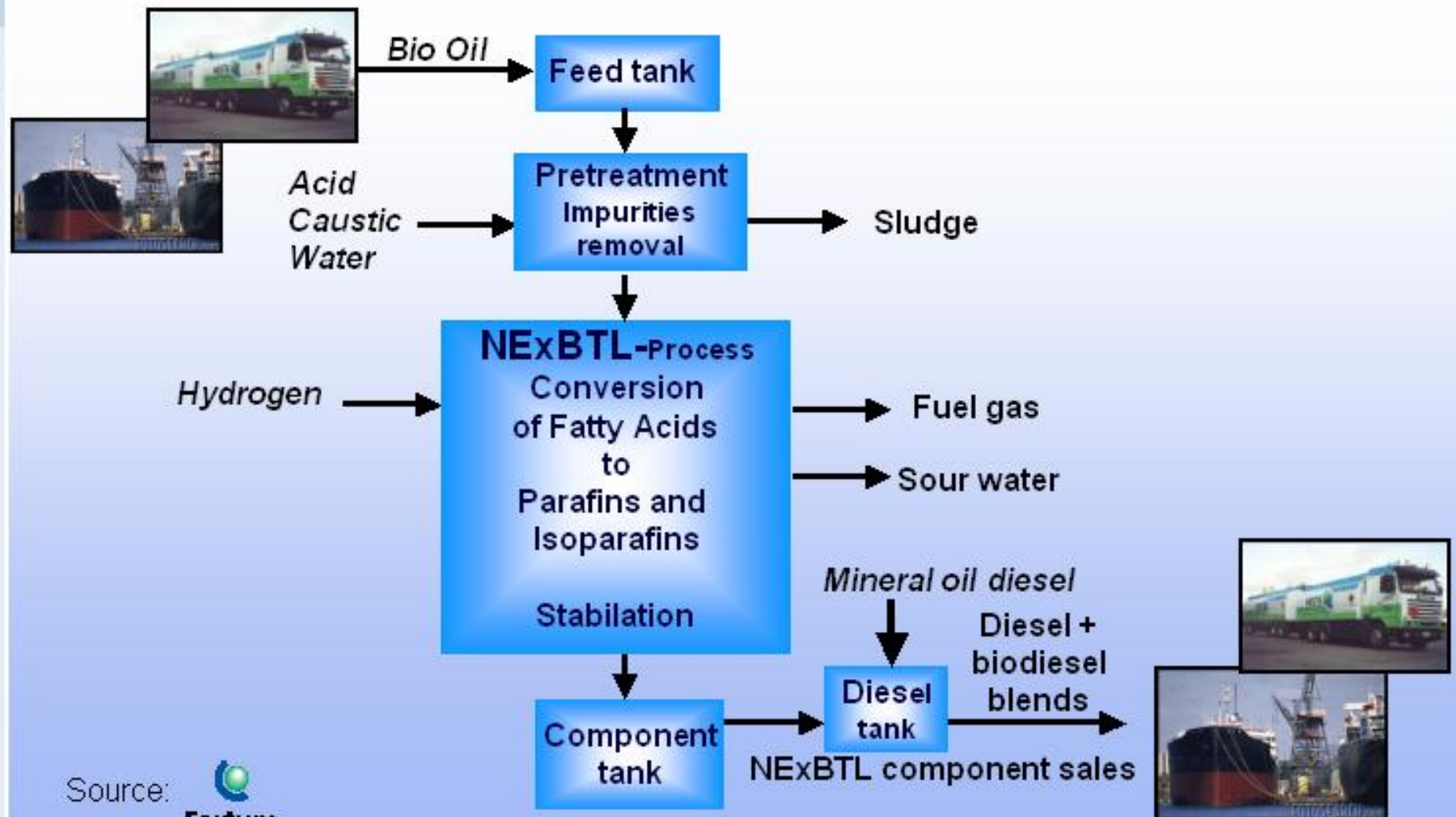


## Pure Vegetable Oil: Position of the Automotive Industry

- Pure vegetable oils as well as their blending to diesel fuel is strongly rejected by the automotive industry due to the partly negative properties of pure vegetable oils which prevent their usage in small passenger car engines in consideration of the quality criteria of the automotive industry.
- But pure vegetable oils can be added to crude oil in the refinery generating a diesel fuel which is partly based on pure vegetable oil as it has already been shown by Volkswagen and VEBA oil at the beginning of the 90ies.



# Refinery Based NExBTL Unit (Neste Oil and Total)



Source:   
**Fortum**

**Group Research**  
Powertrain, Fuels and Lubricants

**VOLKSWAGEN AG**

## Biodiesel: Volkswagen's Investigations in the 80ies





## Historic Position of Biodiesel (RME)

- In the 80ies: investigation of Biodiesel (100 % biodiesel, due to the German mineraloil tax law) in VW-research department
- 1992: aftermarket kit for Biodiesel for Golf-class
- MY 1996: Volkswagen as the only car manufacturer gave release for all Diesel cars for Biodiesel (RME) according to the German Standard E DIN 51606
- 2003: Volkswagen had to communicate a revocation of the RME-Biodiesel release for the new models, as a reaction on changed basic conditions:
  - nonfulfilment of EU 4 – emission standards
  - no compatibility with diesel particulate filters
  - no compatibility with preheaters
  - customers' complaints about engine and injection pump failures due to insufficient fuel quality



## Biodiesel: Which VW Models can Use which Fuels/Blends?

- **B5 according to EN 590:**  
all Diesel vehicles
- **> B5:**  
no release and no warranty for blends higher than 5 vol% Biodiesel (non-compliance with EN 590)
- **B100 (RME-Biodiesel according to EN 14214):**  
MYs 1996 – 2002 with RME-Biodiesel release  
from MY 2003: no general release

## Biodiesel: Why some Models cannot Use Certain Fuels?

- material incompatibilities (metals, elastomers, plastics)
  - softening, swelling or hardening and cracking of some elastomers including nitrile rubbers
  - corrosion of aluminium & zinc
- nonfulfilment of stringent exhaust gas legislation e.g. EU 4 using biodiesel in the diesel application
- no compatibility with Diesel particulate filters
- no compatibility with preheaters



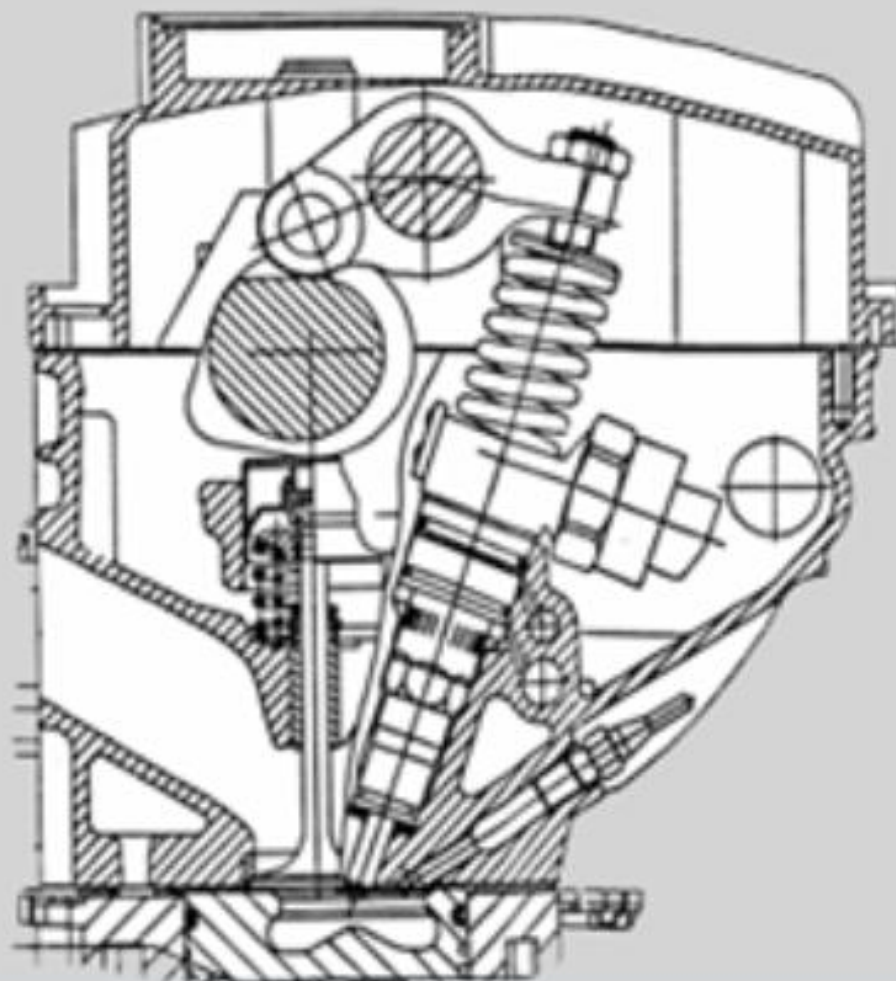
## Biodiesel: Position of the Fuel Injection Equipment (FIE) Manufacturers

### Common Position Statement on FAME (June 2004):

The currently agreed position of all FIE manufacturers is to **limit release of injection equipment for admixtures**

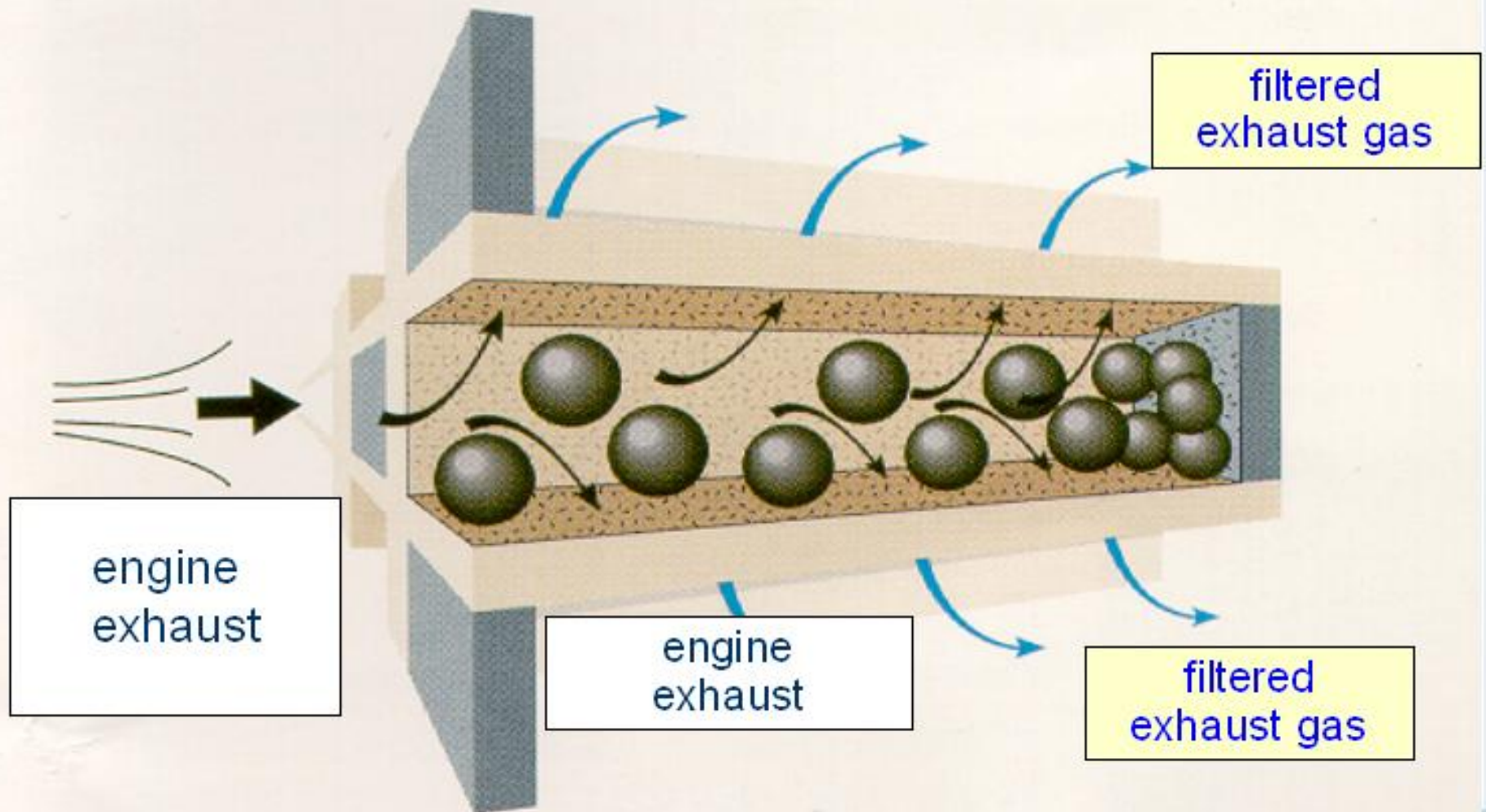
- **up to a maximum of 5% FAME** (meeting the EN14214 standard)
- with unadulterated diesel fuel (meeting the EN590 standard).

**The final product B5 must also comply with EN 590.**



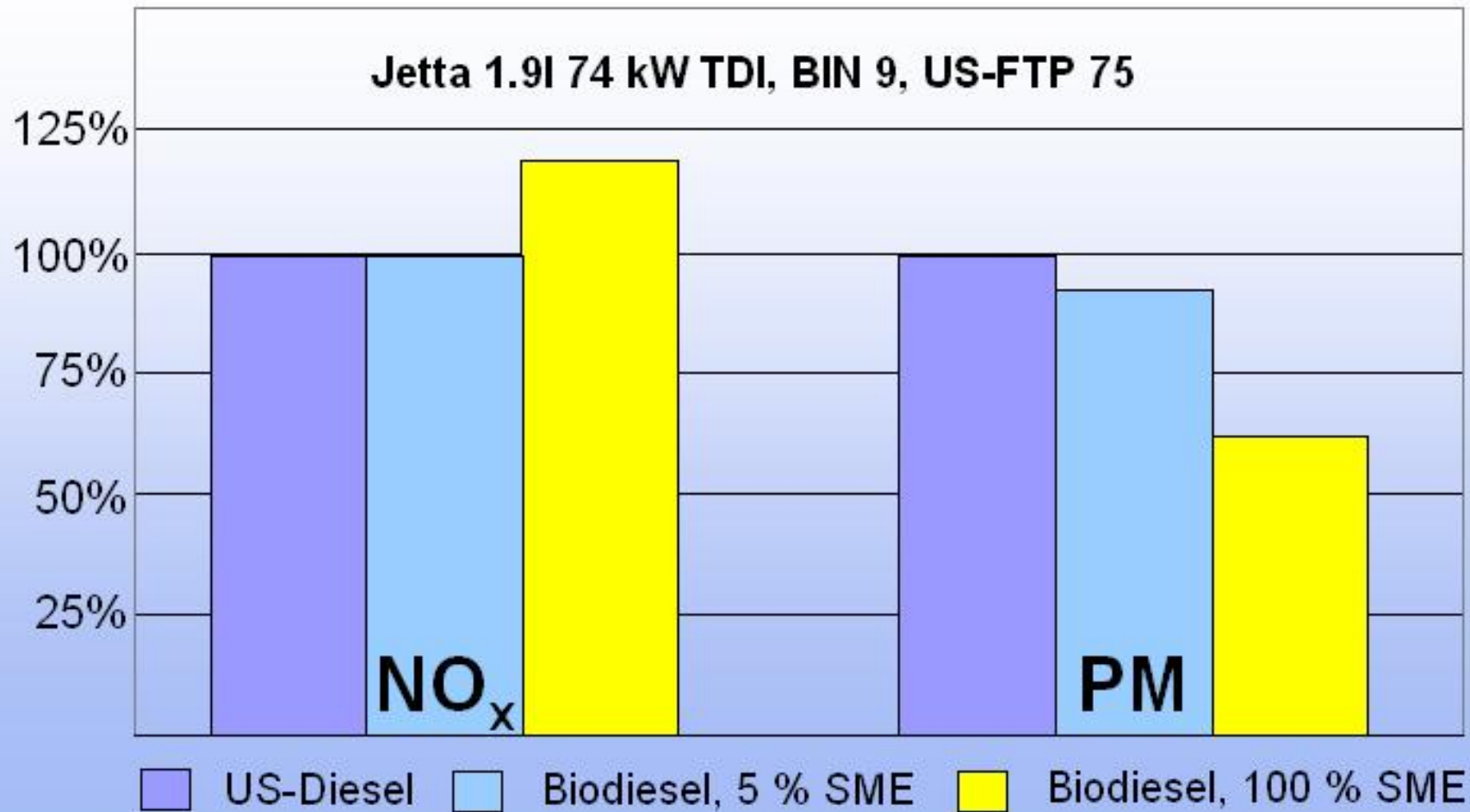


# Ceramic Particulate Trap

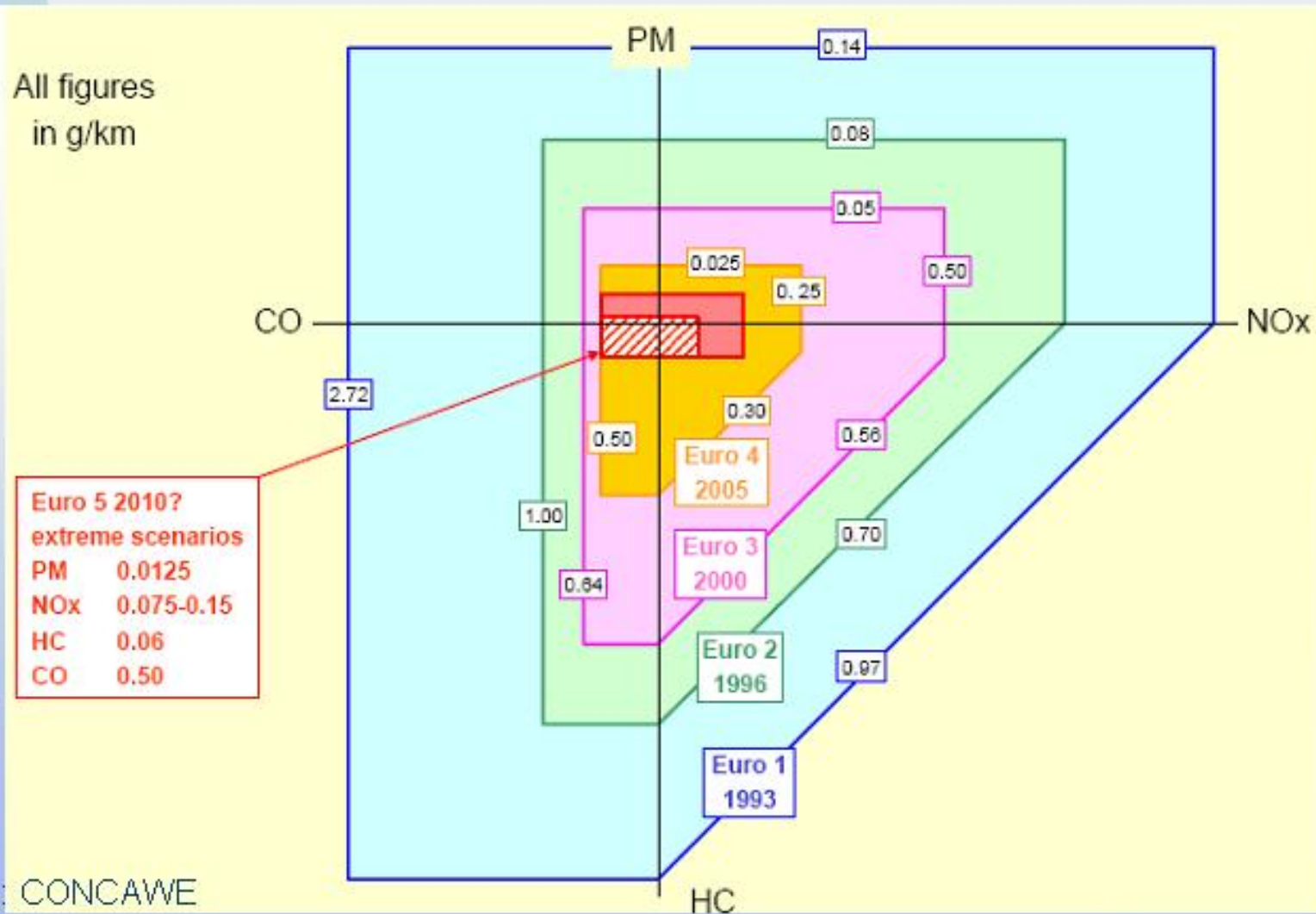


# Soybeanmethylester: NOx- and PM- Emissions

Dr. Hans-Joachim Lohmeyer, 02.11.2015



# EU-Emission Standards for Light Duty Diesel Vehicles



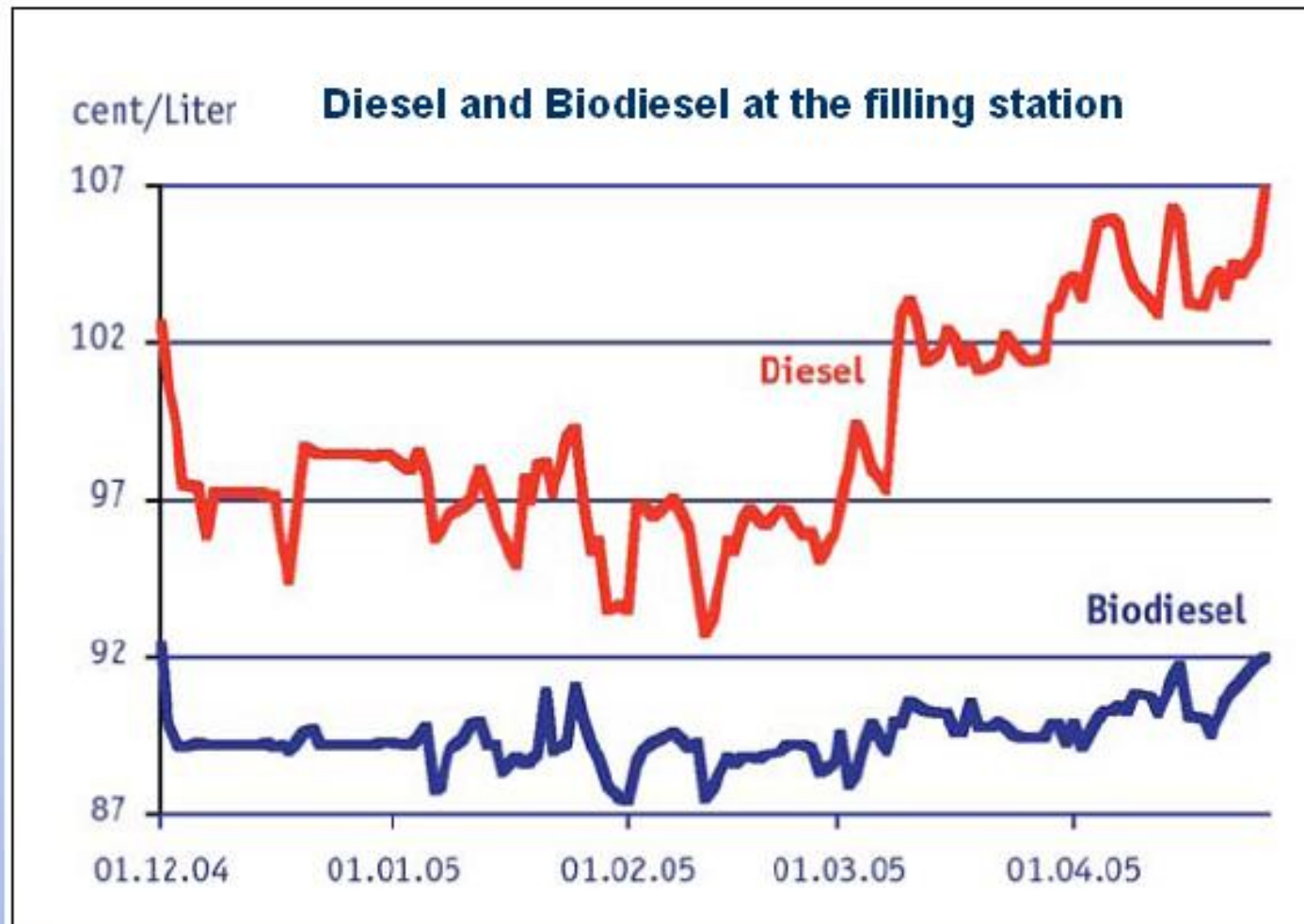
Source: CONCAWE



# Biodiesel: Position of the Automotive Industry

- **blending of biodiesel to diesel fuel (according to EN 590)**
  - 1. priority: 5% biodiesel (EN 14214) under the responsibility of the mineral oil industry ⇒ quality guarantee ( 5% blend is a requirement of the fuel injection equipment manufacturers.)
  - 2. priority: automotive industry is open for 10% blending (B10) if all diesel fuel in EU is blended to the limit of 5%. It is difficult to justify changing the fuel specification based on the demands of a few countries. But this case has to be examined in cooperation with all parties:
    - approval of the fuel injection equipment manufacturers
    - new specification within CEN for diesel fuel B10
    - review of the existing 100% biodiesel (B 100) specification
- **B 100 is rejected by the automotive industry due to**
  - nonfulfilment of EU 4 with neat biodiesel and Diesel related application
  - noncompliance with diesel particulate filters
  - customers complaints about engine failures caused by insufficient fuel quality

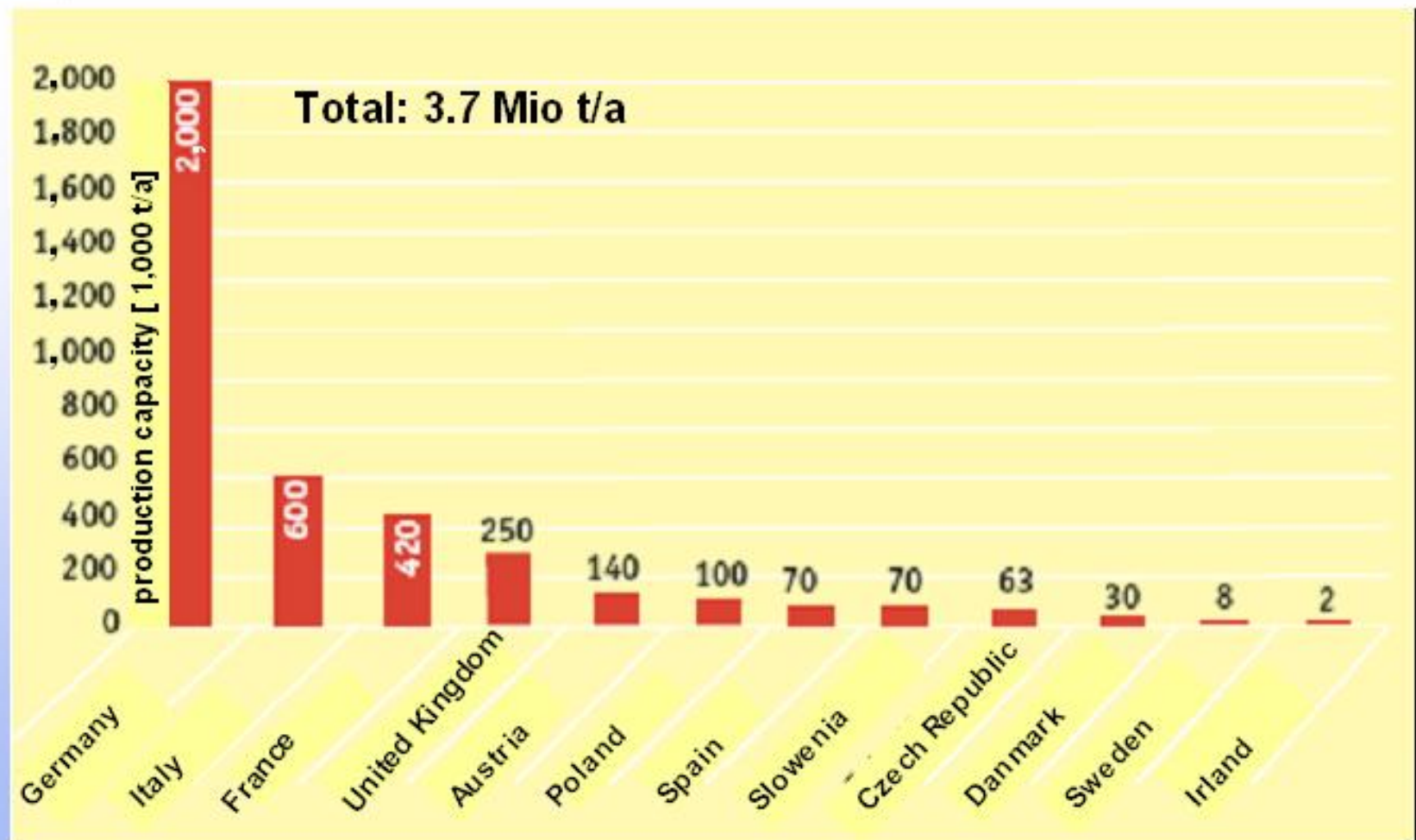
# Biodiesel: Price on German Market



Source: UFOP



## European Production Capacity of Biodiesel (2005/2006)



Source: UFOP



# Biodiesel Demand in the EU

## Germany

**Diesel Fuel Demand [ Mio t]**

**2005**

**2010**

**30.2**

**31.3**

Source: MWV 05.2005

**Biodiesel Demand [ Mio t]**

- EN 590: 5 vol%
- Biofuels-Directive
  - 2 % (energetic)
  - 5,75 % (energetic)

**1.51**

**1.565**

**0.7**

**2.1**

## EU 25

**Diesel Fuel Demand [ Mio t]**

**169.0**

**197.0**

Source: EUCAR/CONCAWE 07.2005

**Biodiesel Demand [ Mio t]**

- EN 590: 5 vol%
- Biofuels-Directive
  - 2 % (energetic)
  - 5,75 % (energetic)

**8.45**

**9.85**

**4.5**

**13.0**

# Liquid Biofuels

litres per year and hectare



**1,653 l gasoline equivalent**



**3,101 l diesel equivalent**



**1,183 l diesel equivalent**

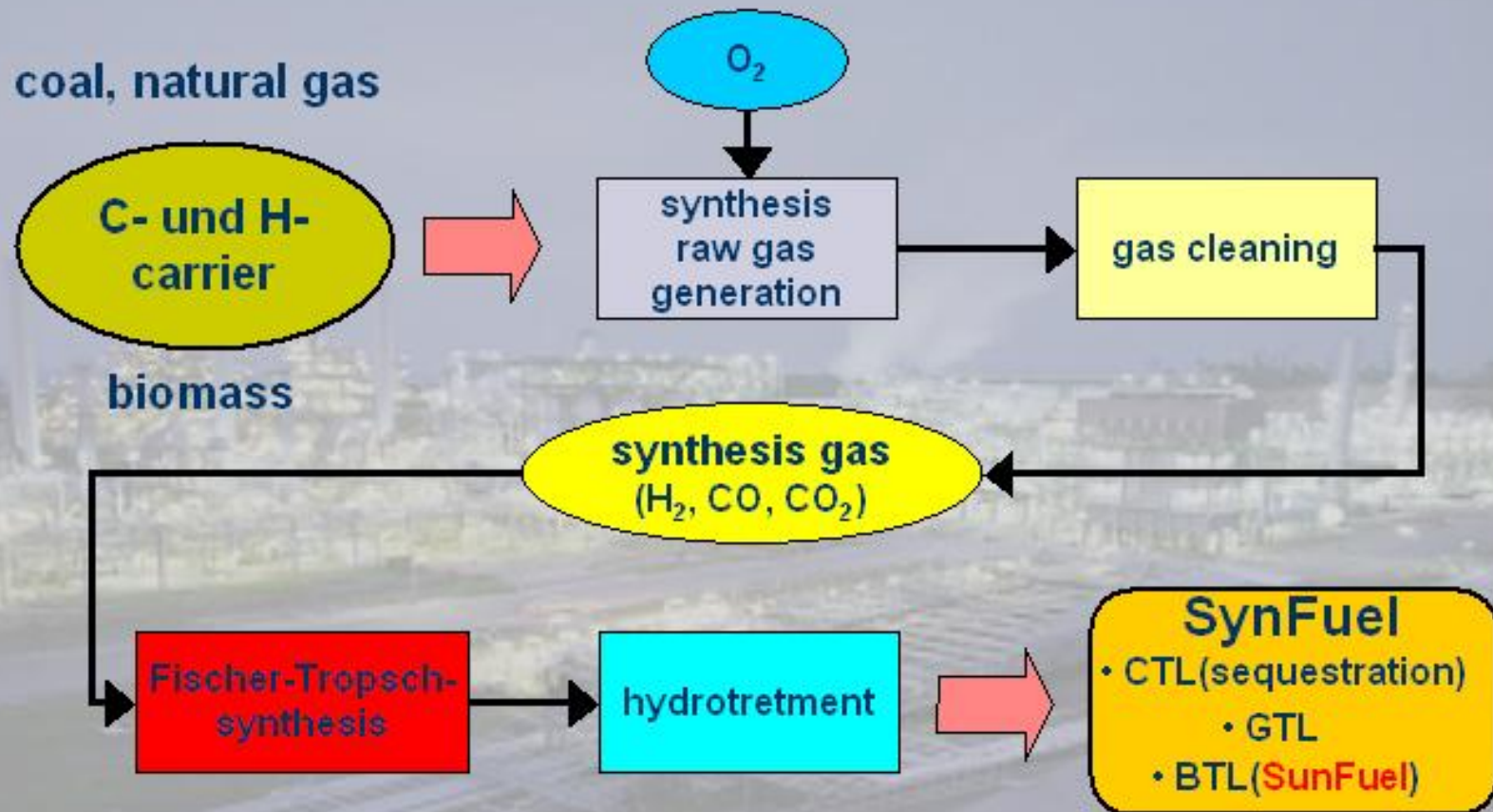


**1,254 l diesel equivalent**

Source: FNR (Fachagentur Nachwachsende Rohstoffe, Germany)



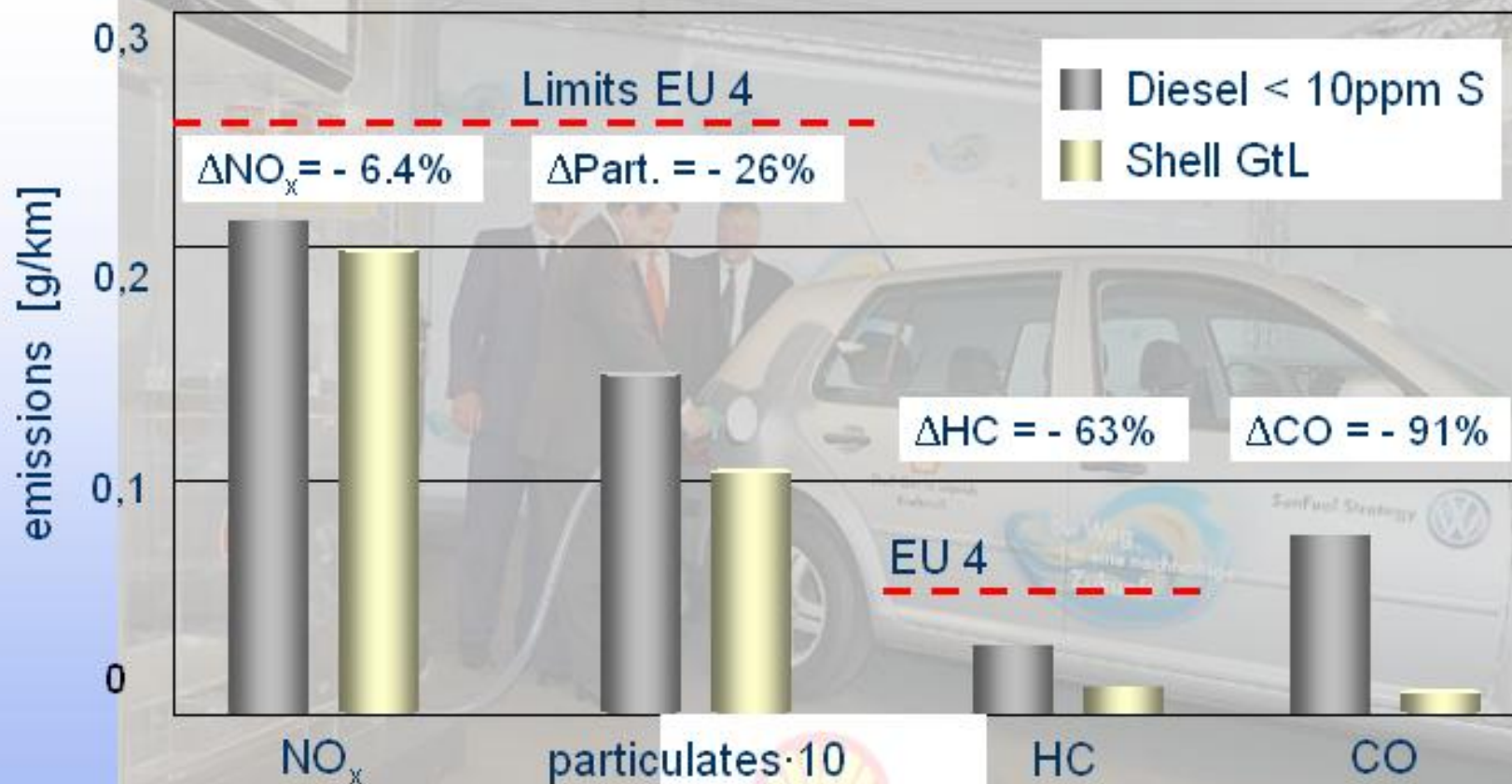
# Simplified Synthetic Fuel Production Process





# Fleet Test Trial in Berlin 2003

25 vehicles, 5 months



Shell Gas to Liquids

# Shell GTL Retail-Worldwide



**Thailand**

**Shell Pura Diesel**

● 2002

● blend of standard diesel, Shell GTL and an additive

● emissions benefits, better engine performance

Source: Shell Global Solutions



**Greece**

**Shell Diesel 2004**

● 2003

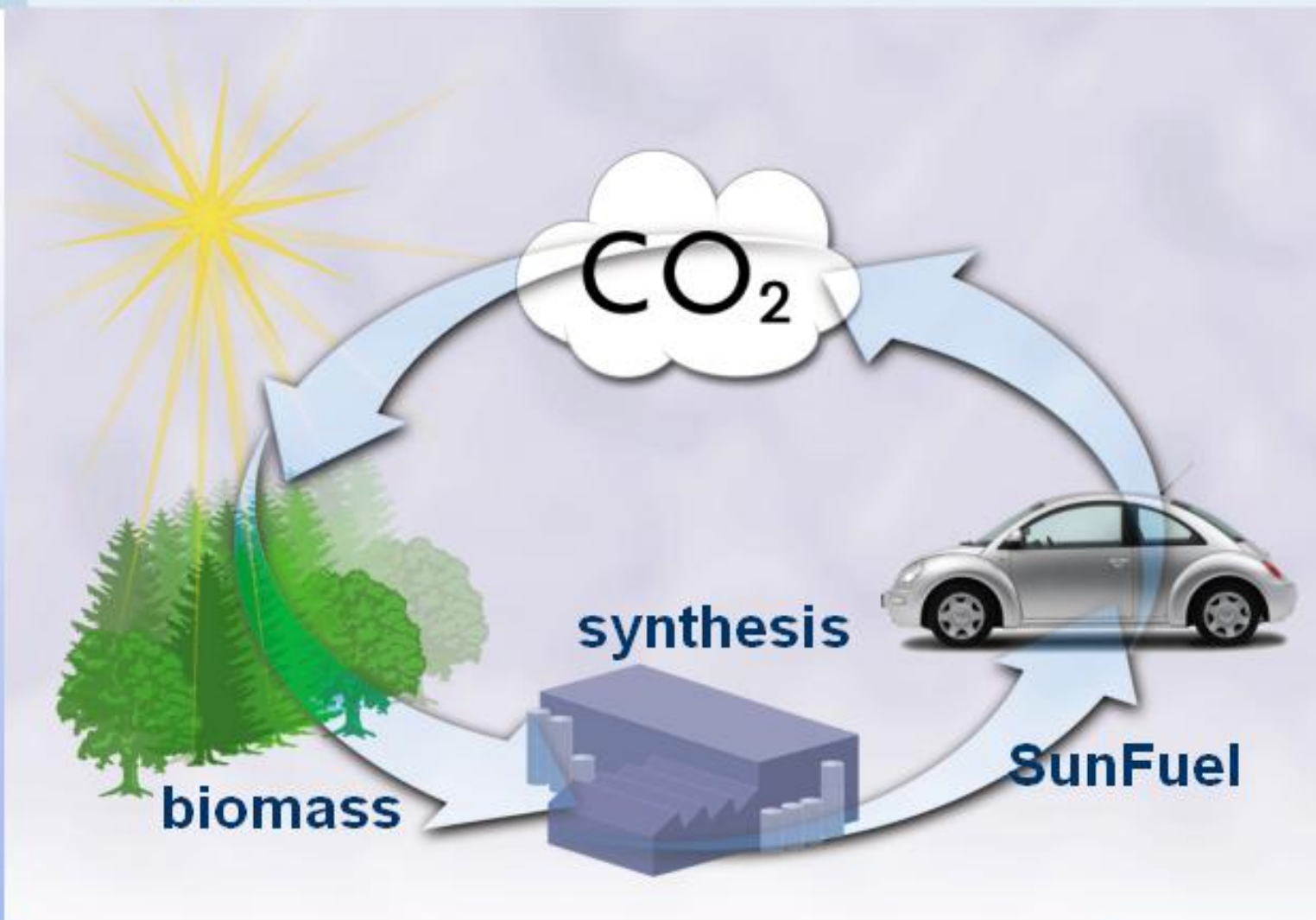


**Germany /  
Netherlands /  
Austria / Italy**

**Shell V- Power Diesel**

● beginning in 2004

## CO<sub>2</sub> – Cycle with SunFuel





# Volkswagen's Activities on SunFuel



Cooperation with the countries Niedersachsen, Brandenburg and Hessen for development of a biomass infrastructure for SunFuels.

Target: investigation of the availability of energy plants in that region



Cooperation with **CHOREN Industries GmbH (SunFuel producer) and Daimler-Chrysler**

Target: production and testing of **BTL-Fuel / plants**



Operation of an experimental farmland (5 ha) with the University of Kassel near Wolfsburg with different energy plants

Target: demonstration of an environment friendly culture of high yields of biomass

# SunFuel – Demonstration Plant by Shell/Choren



**Capacity:** 50 MW thermal  
15.000 t/a

**Input:** wood  
straw  
energy plants

**Products:** SunFuel

**Status:**  
- 1.10.2003: gasification is running  
- 1.8.2005: contract Shell/Choren  
- today: FT-part under construction

**Start of Production:** 2007



# SunFuel: The Route into a Sustainable Future



## Thank You For Your Attention