CLUB OF BOLOGNA

12th -13th November 2005

EIMA - Bologna

Utilisation of Biofuels (especially Biodiesel) on Internal Combustion Engines

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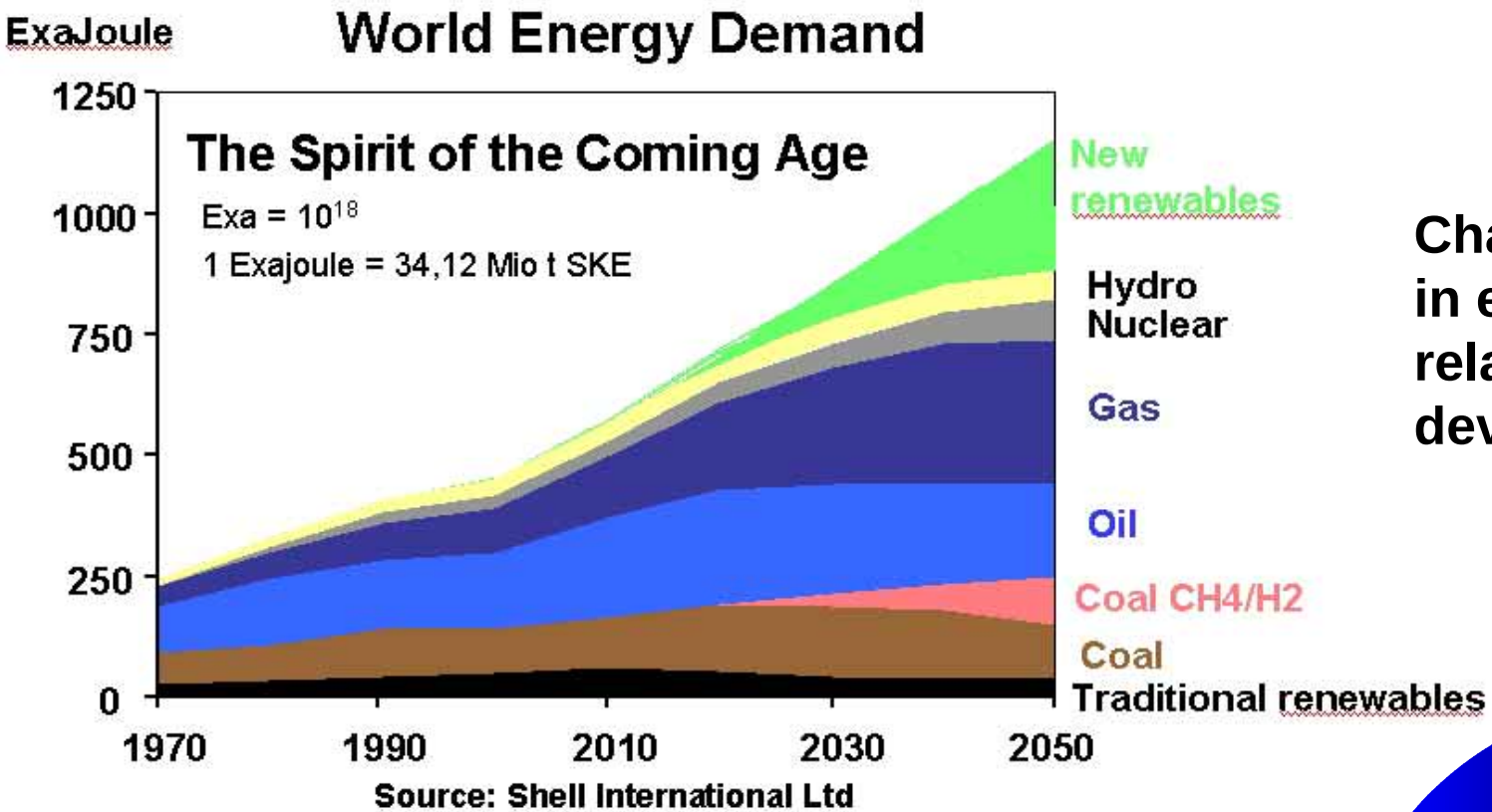
Group Research

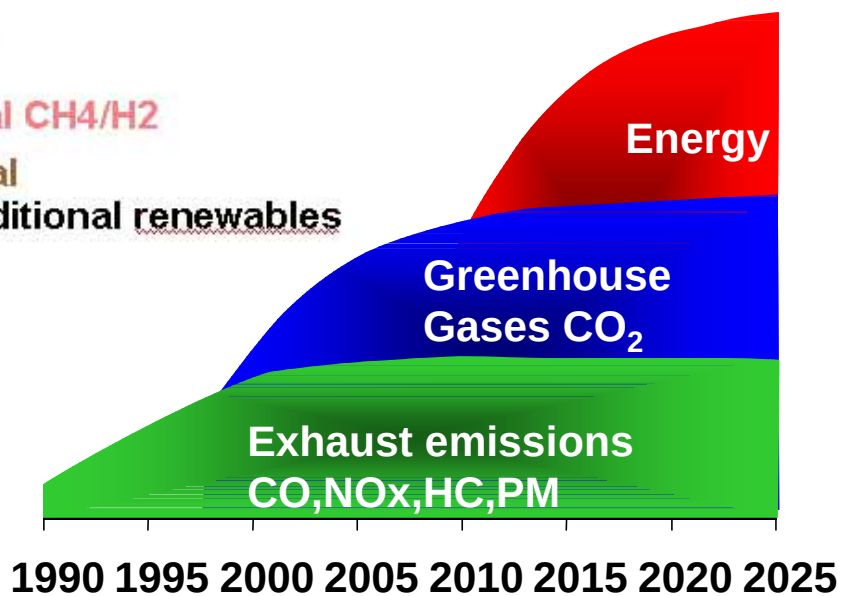
Powertrain, Fuels and Lubrificants

VOLKSWAGEN AG

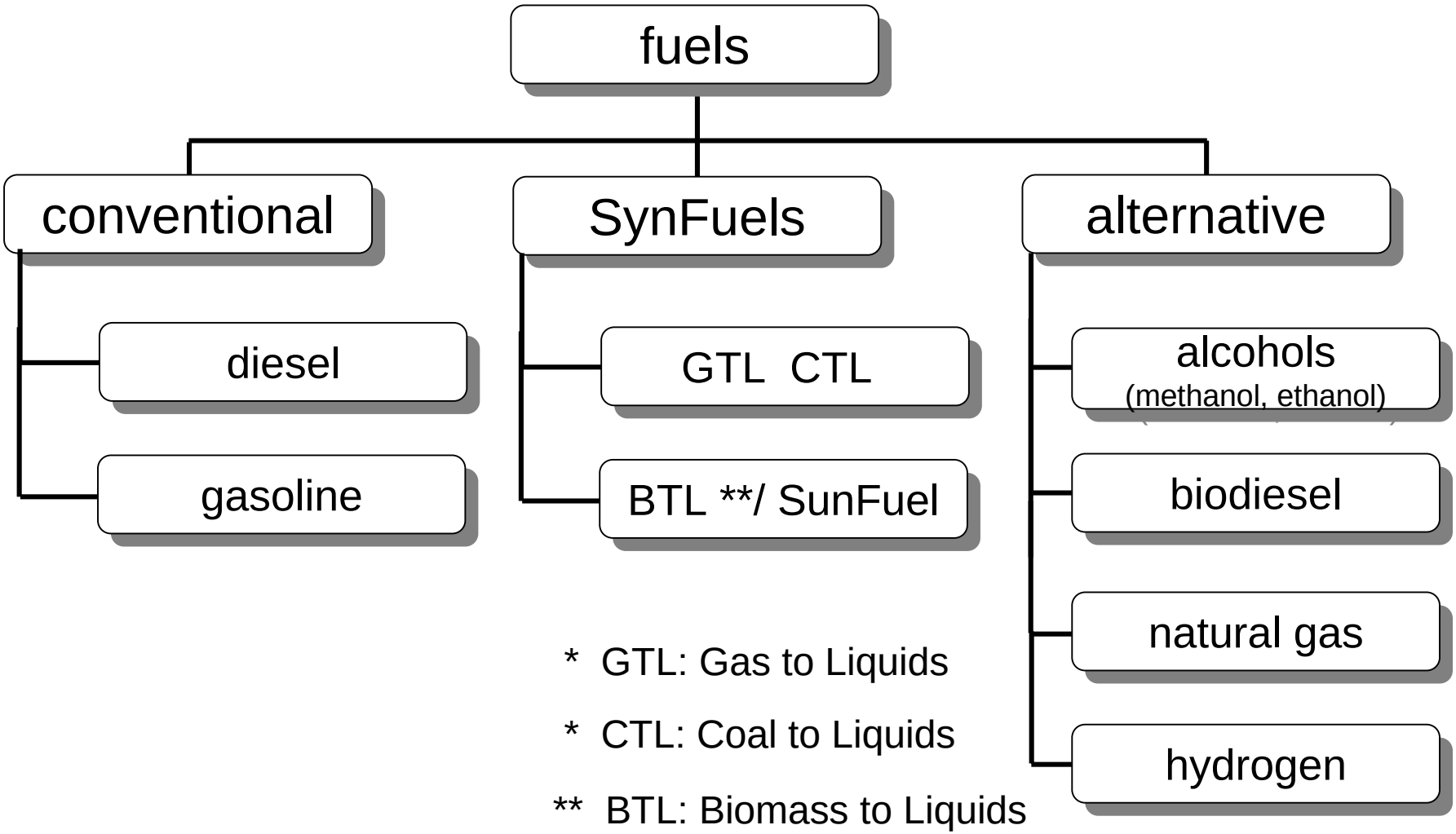
Main Topics



Change in environment related development topics



Fuels



* GTL: Gas to Liquids

* CTL: Coal to Liquids

** BTL: Biomass to Liquids

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_x, PM)
- low CO_2- emissions

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**

but

- **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

	Synthetic Fuels			Conventional Biofuels
Process	GTL (Gas to Liquid)	BTL (Biomass to Liquid)	CTL* (Coal to Liquid)	z.B. FAME*, Ethanol
Group	SynFuel	SunFuel	SynFuel	
Product	Diesel	Diesel	Diesel	
	= 2nd generation of advanced biofuels			= 1st generation of biofuels

* FAME: Fatty Acid Methyl Ester

* with sequestration

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

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)

- **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**
- **blendung of EtOH to diesel fuel is strongly rejected on account of both safety and mechanical incompatibility**

Neat Vegetable Oil

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

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

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 unsufficient 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)

Bio Oil → **Feed tank**

↓

Acid
Caustic
Water → **Pretreatment**
Impurities removal → **Sludge**

↓

Hydrogen → **NExBTL-Process**
Conversion of Fatty Acids to Parafins and Isoparafins
→ **Fuel gas**
→ **Sour water**

Stabilation

↓

Component tank → **Diesel tank** → **NExBTL component sales**

Mineral oil diesel ↓

Diesel + biodiesel blends →

Source: Fortum

Biodiesel: Volkswagen‘s Investigations in the 80‘s

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

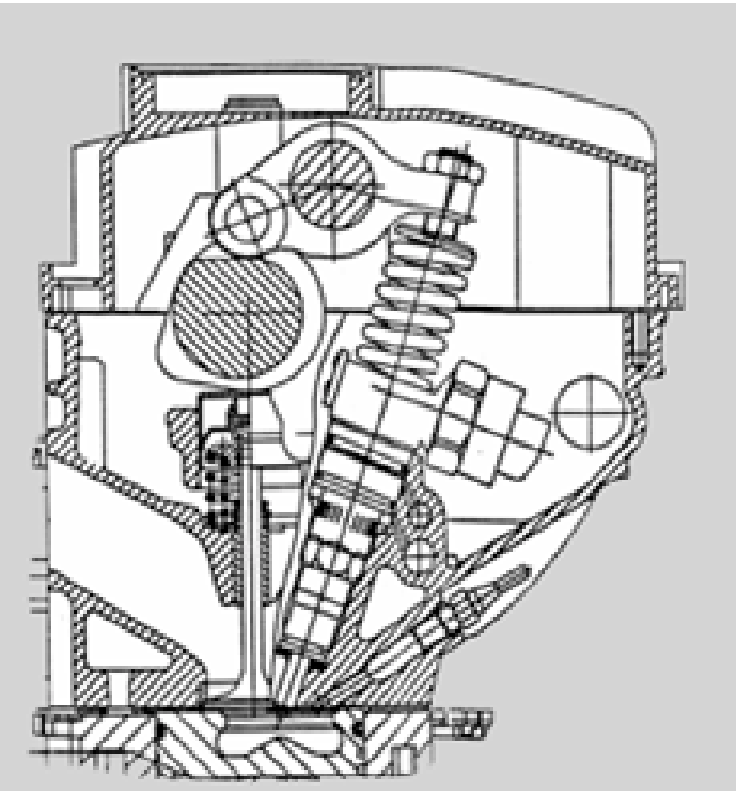
Biodiesel: Which VW Models can Use which Fuels/Blends?

- 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



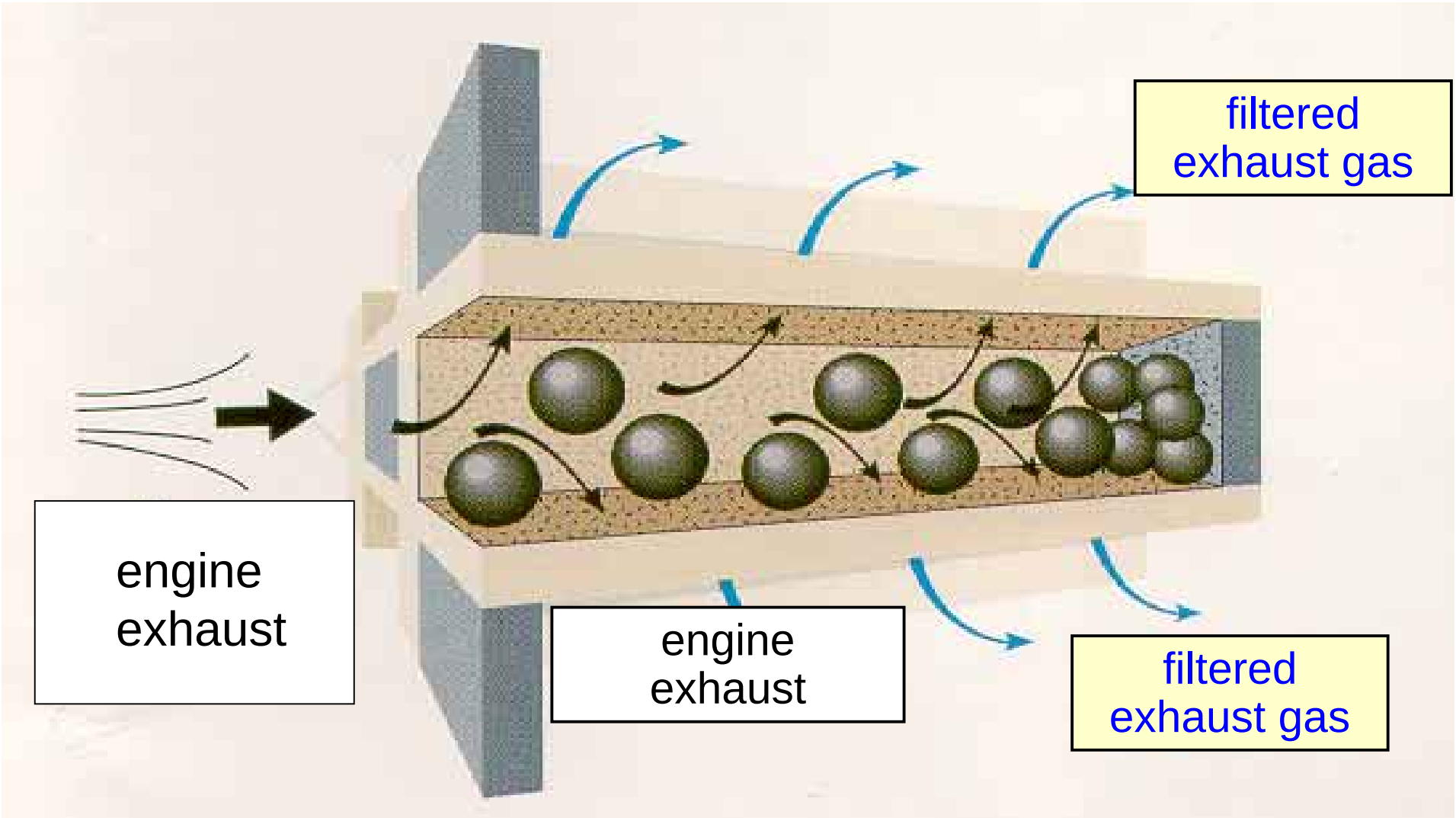
Common Position Statement on FAME (June 2004):

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

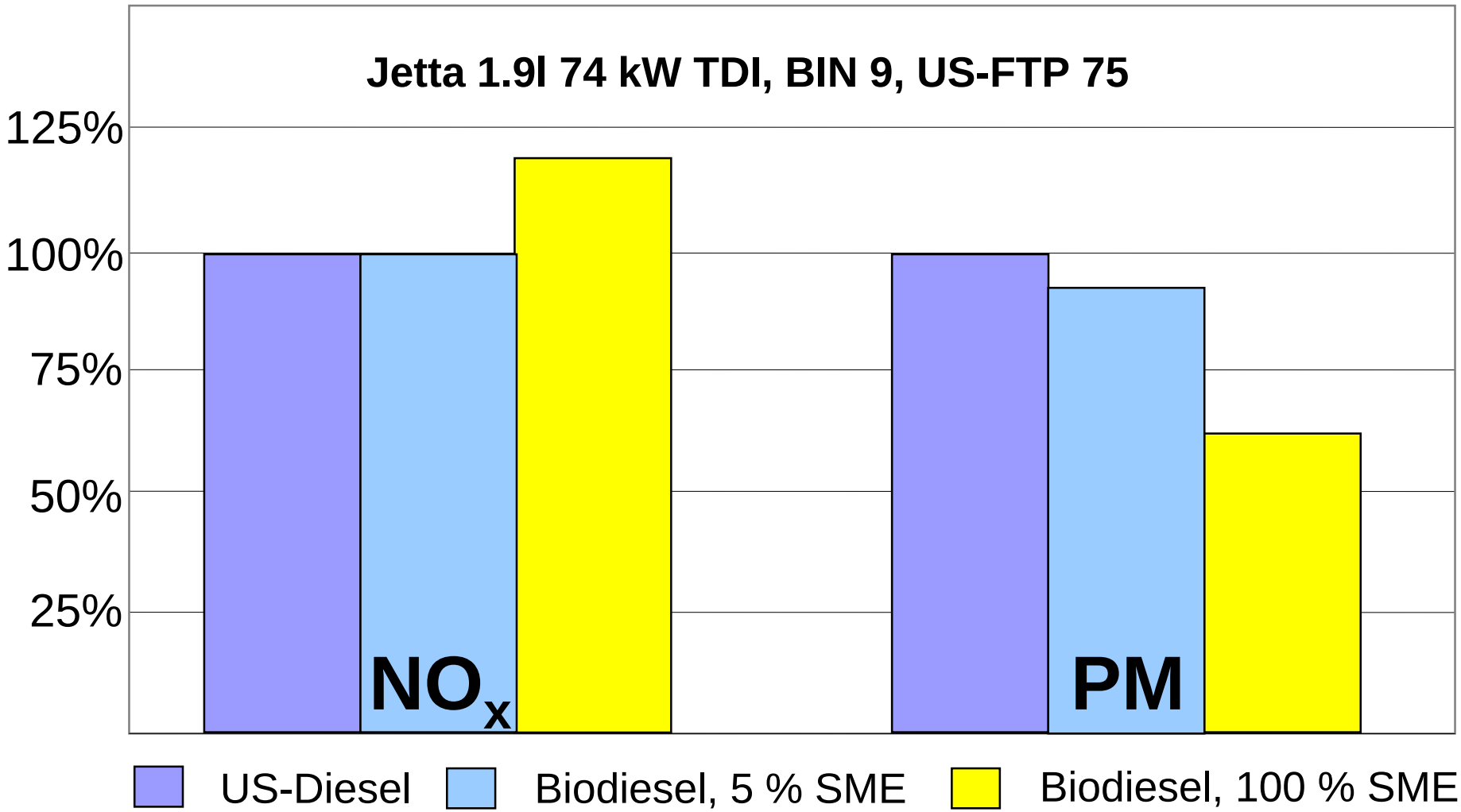
- **up to a maximum of 5 % FAME** (meeting the EN14214 standard)
- with unadulterated diesel fuel (meeting the EN590 standard).

The final product B5 must also comply with EN 590.

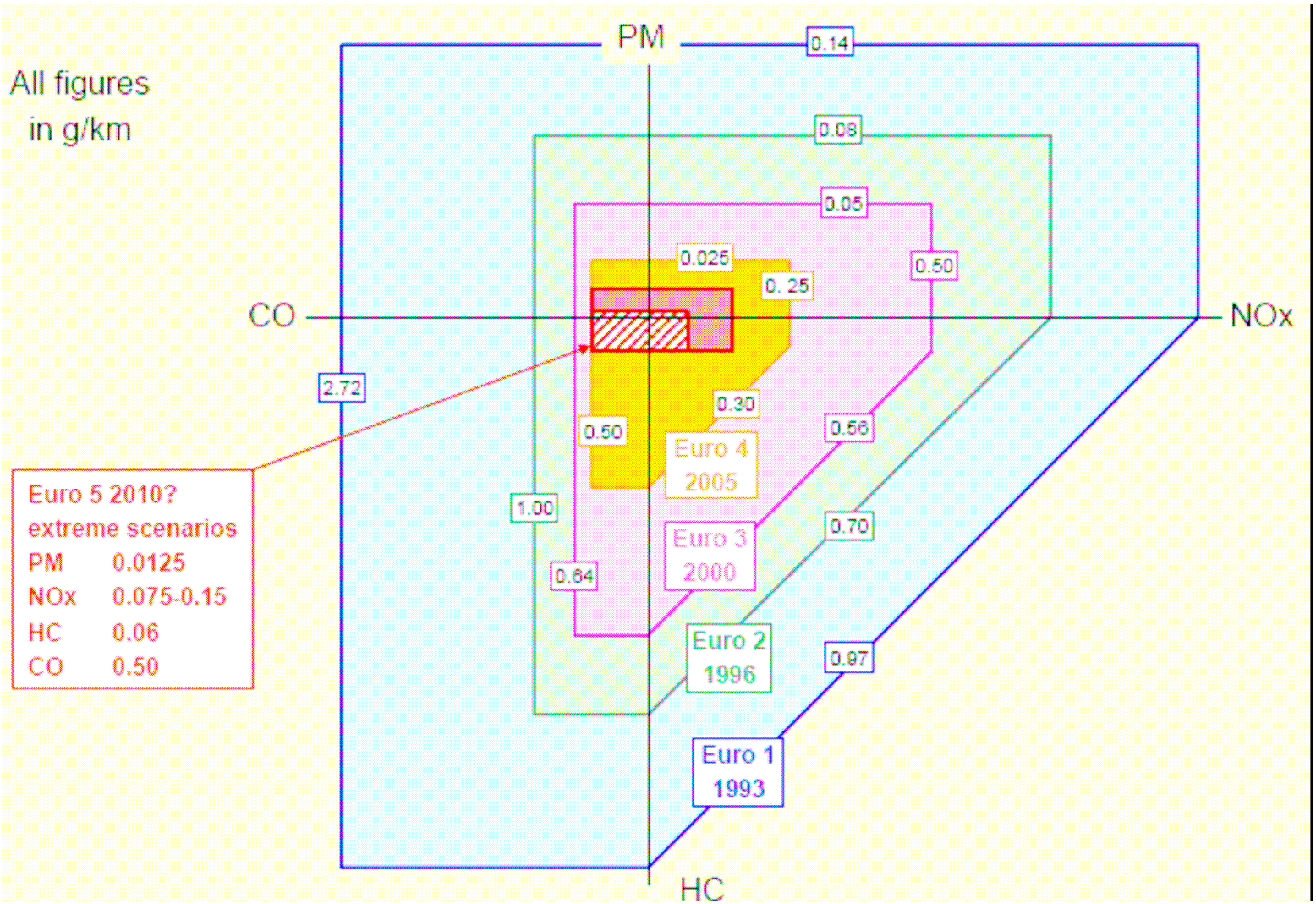
Ceramic Particulate Trap



Soybeanmethylester: NOx- and PM- Emissions



EU-Emission Standards for Light Duty Diesel Vehicles

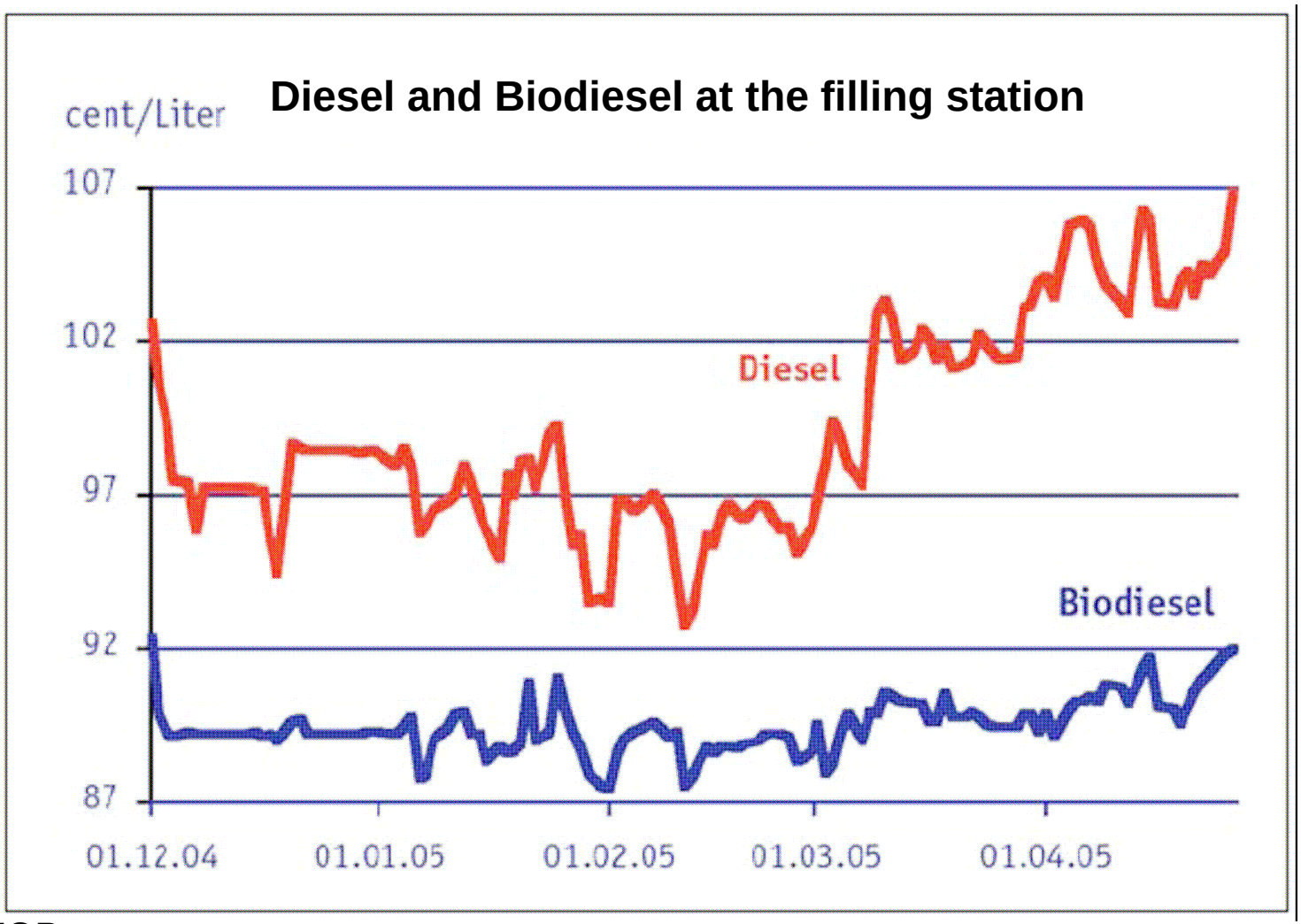


Source: CONCAWE

Biodiesel: Position of the Automotive Industry

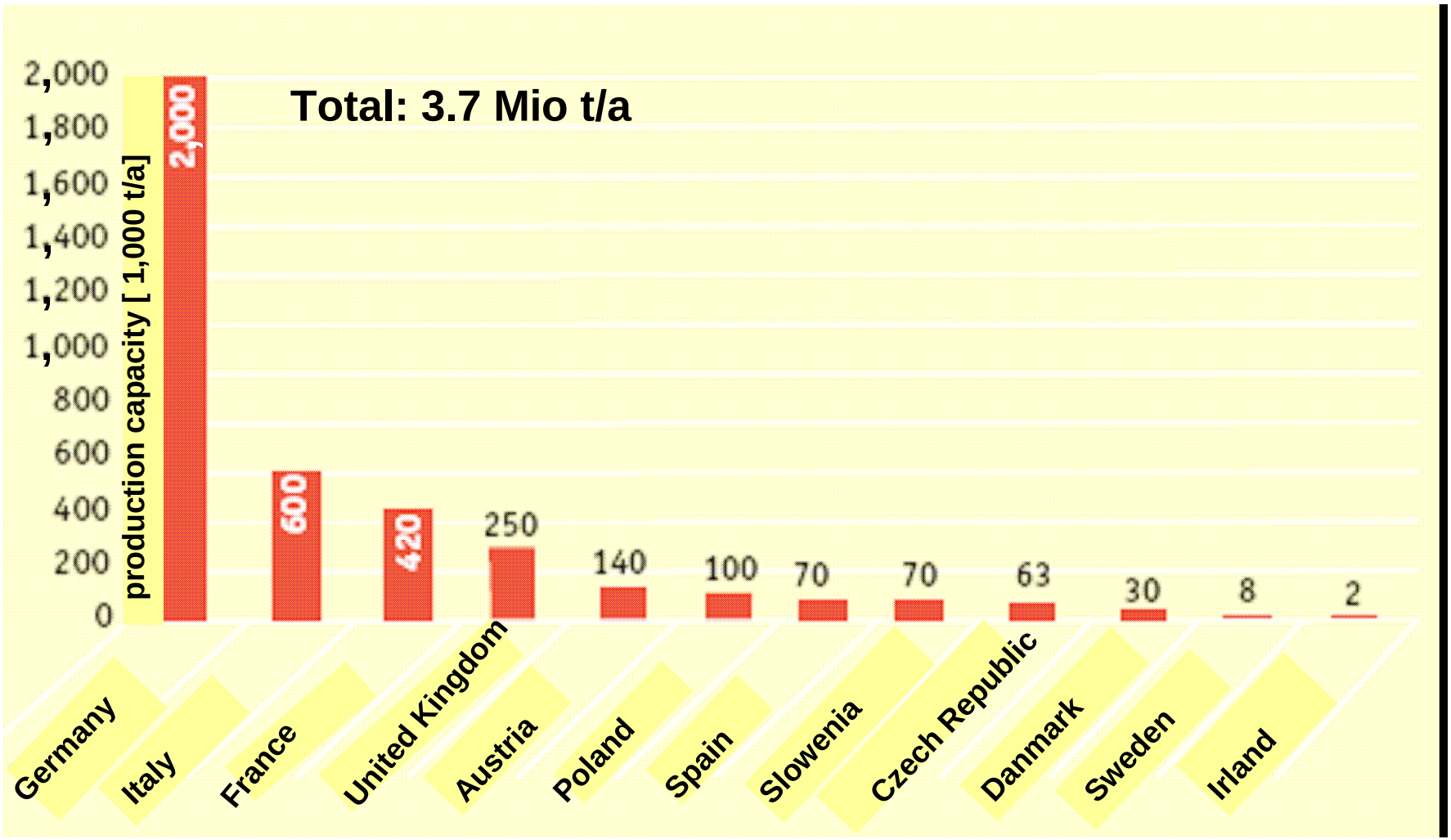
- **blending of biodiesel to diesel fuel (according to EN 590)**
  - 1. priority: 5 % biodiesel (EN 14214) under the responsibility of the mineral oil industry ⇨ quality gurantee (5 % blend is a requirement of the fuel injection equipment manufacturers.)
  - 2. priority: automotive industry is open for 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)



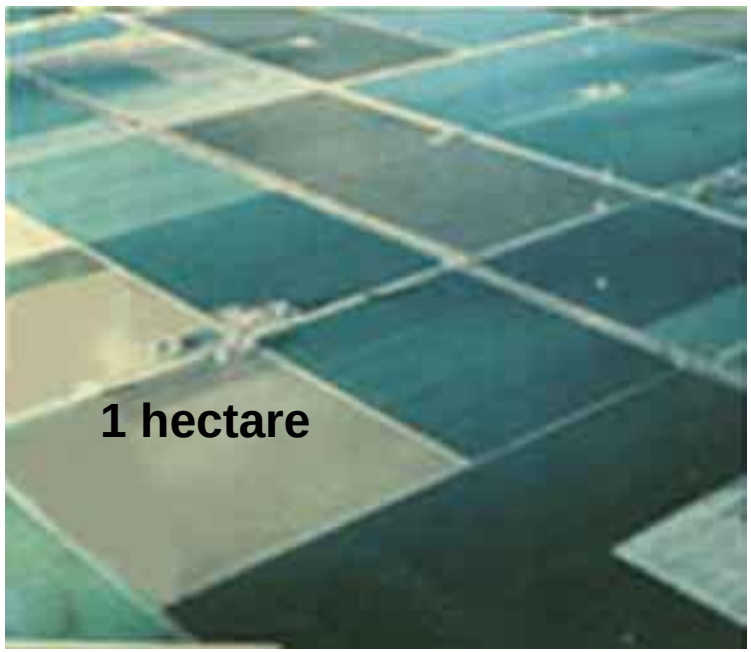
Source: UFOP

Biodiesel Demand in the EU

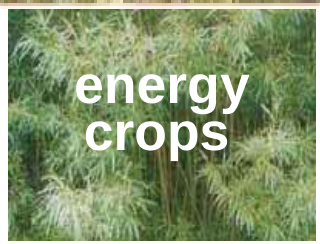
Germany	2005	2010
Diesel Fuel Demand [Mio t]	30.2	31.3
Biodiesel Demand [Mio t]	Source: MWV 05.2005	
• EN 590: 5 vol %	1.51	1.565
• Biofuels-Directive		
- 2 % (energetic)	0.7	
- 5.75 % (energetic)		2.1
EU 25		
Diesel Fuel Demand [Mio t]	169.0	197.0
Biodiesel Demand [Mio t]	Source: EUCAR/CONCAWE 07.2005	
• EN 590: 5 vol %	8.45	9.85
• Biofuels-Directive		
- 2 % (energetic)	4.5	
- 5.75 % (energetic)		13.0

Liquid Biofuels

litres per year and hectare



1,653 l gasoline equivalent



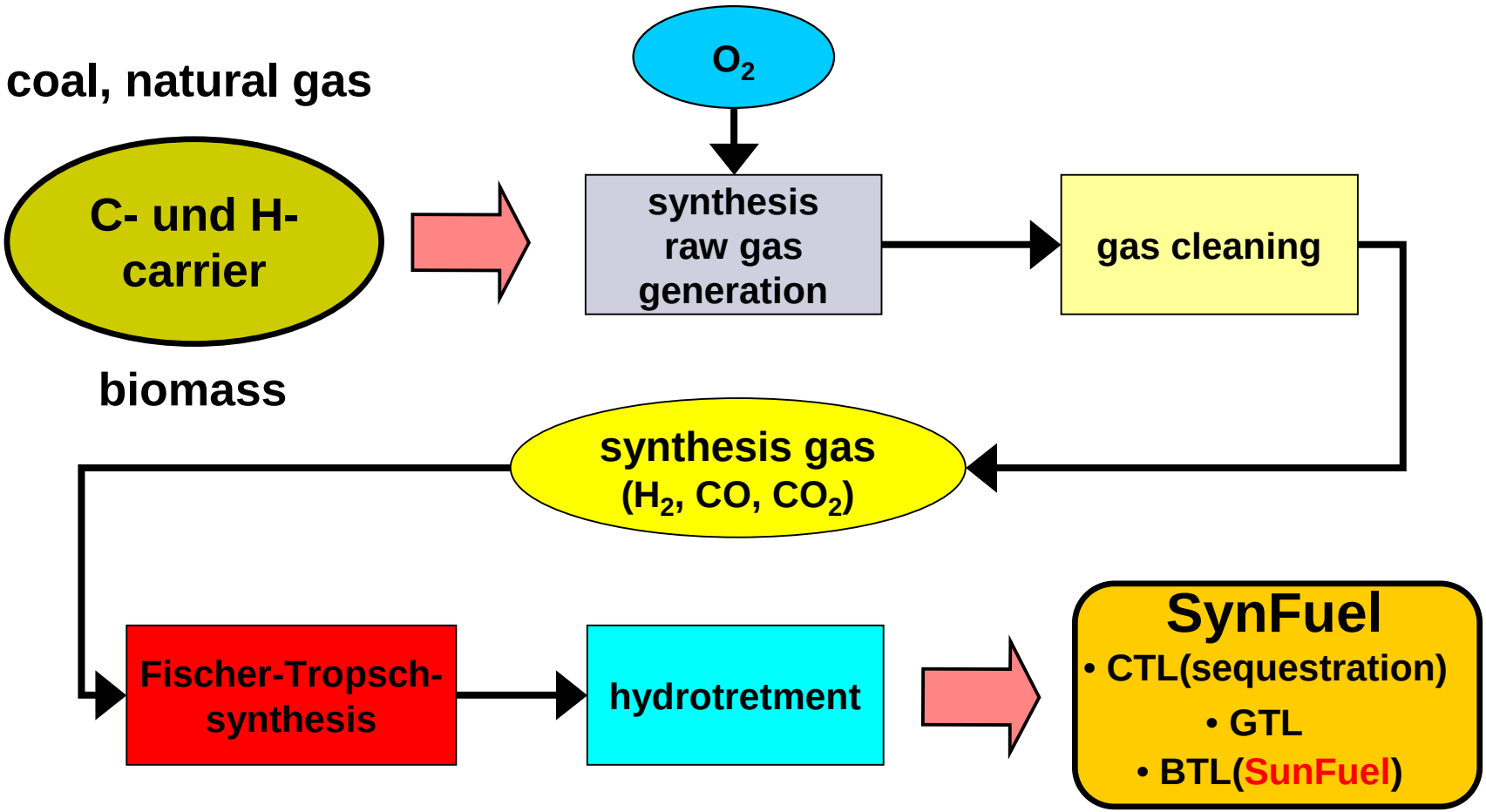
3,101 l diesel equivalent

1,183 l diesel equivalent

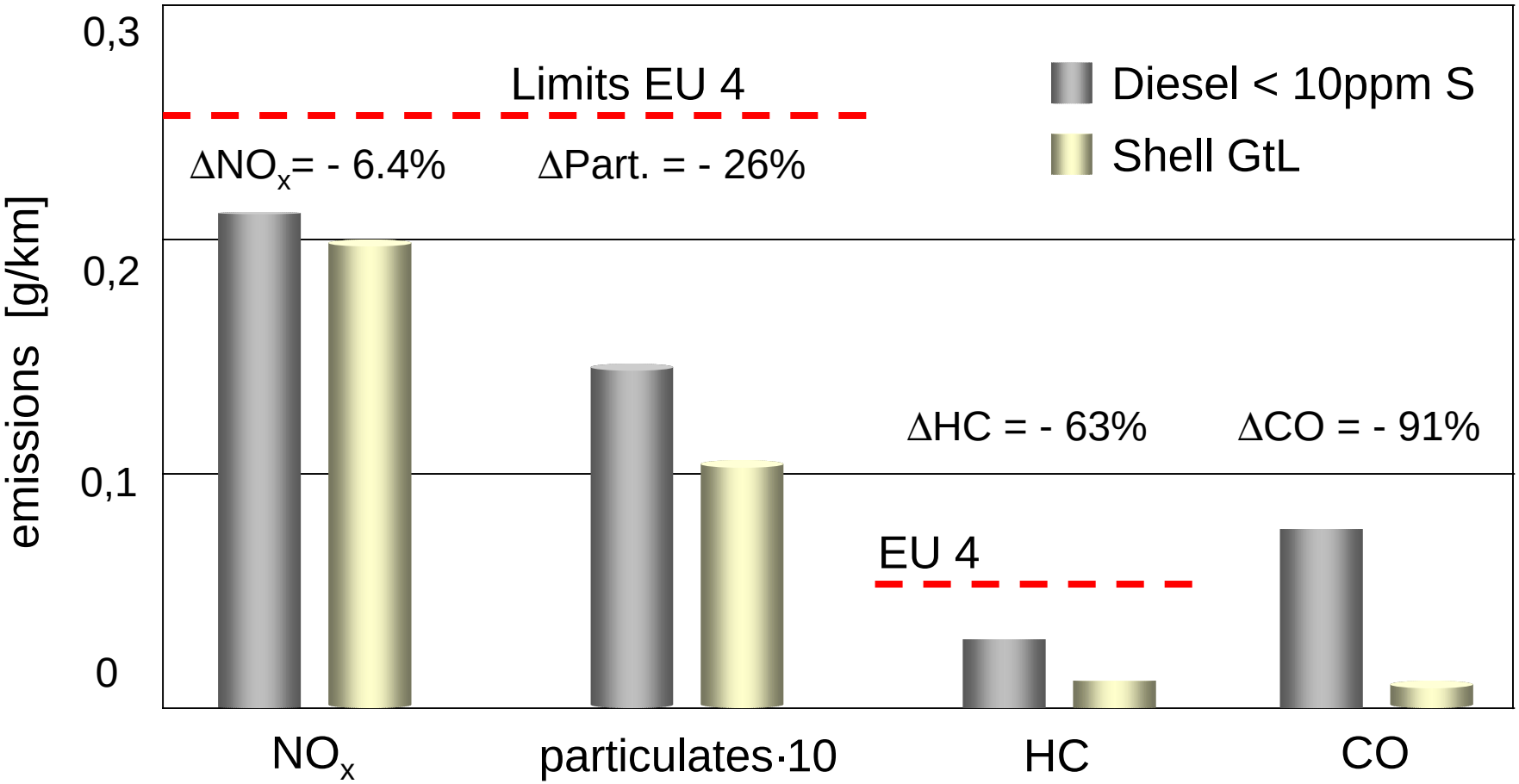
1,254 l diesel equivalent

Source: FNR (Fachagentur Nachwachsende Rohstoffe, Germany)

Simplified Synthetic Fuel Production Process



Fleet Test Trial in Berlin 2003
25 vehicles, 5 months



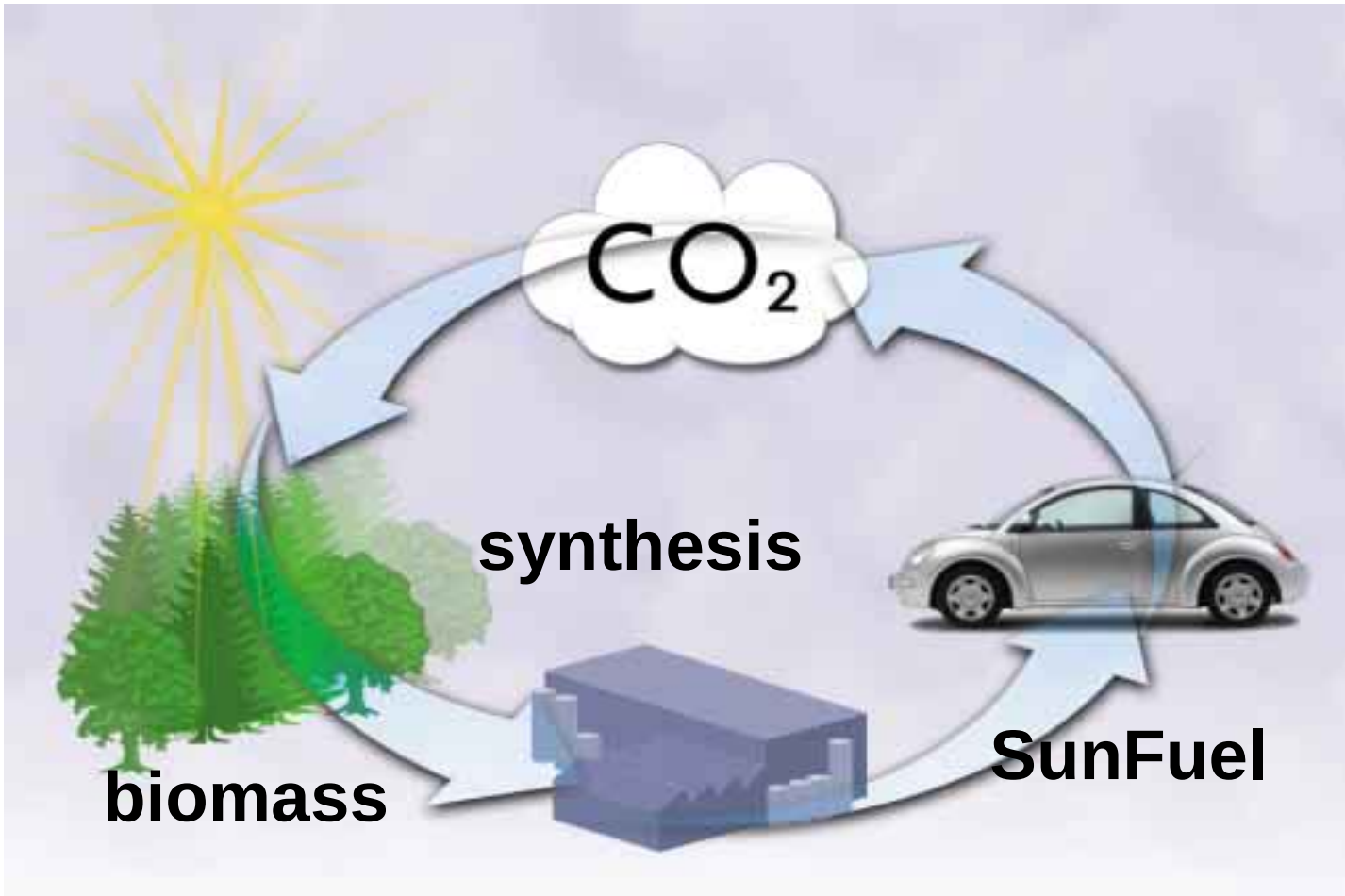
Shell GTL Retail-Worldwide

Thailand	Greece	Germany / Netherlands / Austria / Italy
Shell Pura Diesel	Shell Diesel 2004	Shell V- Power Diesel
● 2002	● 2003	● beginning in 2004

- **blend of standard diesel, Shell GTL and an additive**
- **emissions benefits, better engine performance**

Source: Shell Global Solutions

CO_2 – Cycle with SunFuel



Volkswagen‘s Activities on SunFuel

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

<u>Target:</u> investigation of the availibility of energy plants in that region

Cooperation with CHOREN Industries GmbH (SunFuel producer) and Daim-ler-Chrysler

<u>Target:</u> production and testing of BTL-Fuel / plants

Operation of an experimen-mental farmland (5 ha) with the University of Kassel near Wolfsburg with differ-ent energy plants

<u>Target:</u> 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