



**STORHY**  
Train-IN 2006

## Session 1.4: Automotive Design Aspects and Requirements

### Well-to-Wheel Analysis

Energy consumption and Green-House-Gas emissions  
of future sustainable mobility options

Dr. J. Wind

25<sup>th</sup> – 29<sup>th</sup> September 2006  
Ingolstadt



## 1.4 Automotive Design Aspects and Requirements



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### CV – Dr. J. Wind

Address:

Dr. Jörg Wind, DaimlerChrysler AG, Neue Strasse 95,  
D-73230 Kirchheim/Teck-Nabern, Germany,  
Phone +49-7021 894614, Fax +49-711 3052 1432 93,  
e-mail:joerg.wind@daimlerchrysler.com



Dr. Jörg Wind, has studied physics at the Technical University of Munich (TUM). After doing his Ph.D. in the field of semiconductor physics and sensor technology at the TUM in 1992, he started working in the field of fuel cells and hydrogen. He was responsible for material development for high temperature fuel cells and for PEM stack development at DaimlerChrysler from 1992 until 2002. Since 2002, he is responsible for strategic energy projects, comprising hydrogen related projects (including energy systems analyses and WTW-analyses) and European projects in the field of hydrogen and fuel cells.



- Well-to-Wheel Analysis,  
Dr. J. Wind (DC), 20 min

## Abstract:

Reduction of energy consumption and emissions, especially GHG-emissions are the main drivers for alternative drive trains and fuels. Hydrogen and fuel cell vehicles are seen as the most promising options for a sustainable mobility of the future. To evaluate the best pathways for fuel (hydrogen) production and choice of drivetrains it is necessary to calculate the all relevant parameters from the source of primary energy (well) to the end use (wheel). The general principle of WTW-analyses is explained and the most relevant results of a recent study are shown and discussed in the presentation.



## Table of Content

- **Motivation: Energy supply, GHG-emissions**
- **Hydrogen supply pathways**
- **WTW-analysis and results**
- **Drive train strategies**

# Motivation for Alternative Fuels in Transport Applications

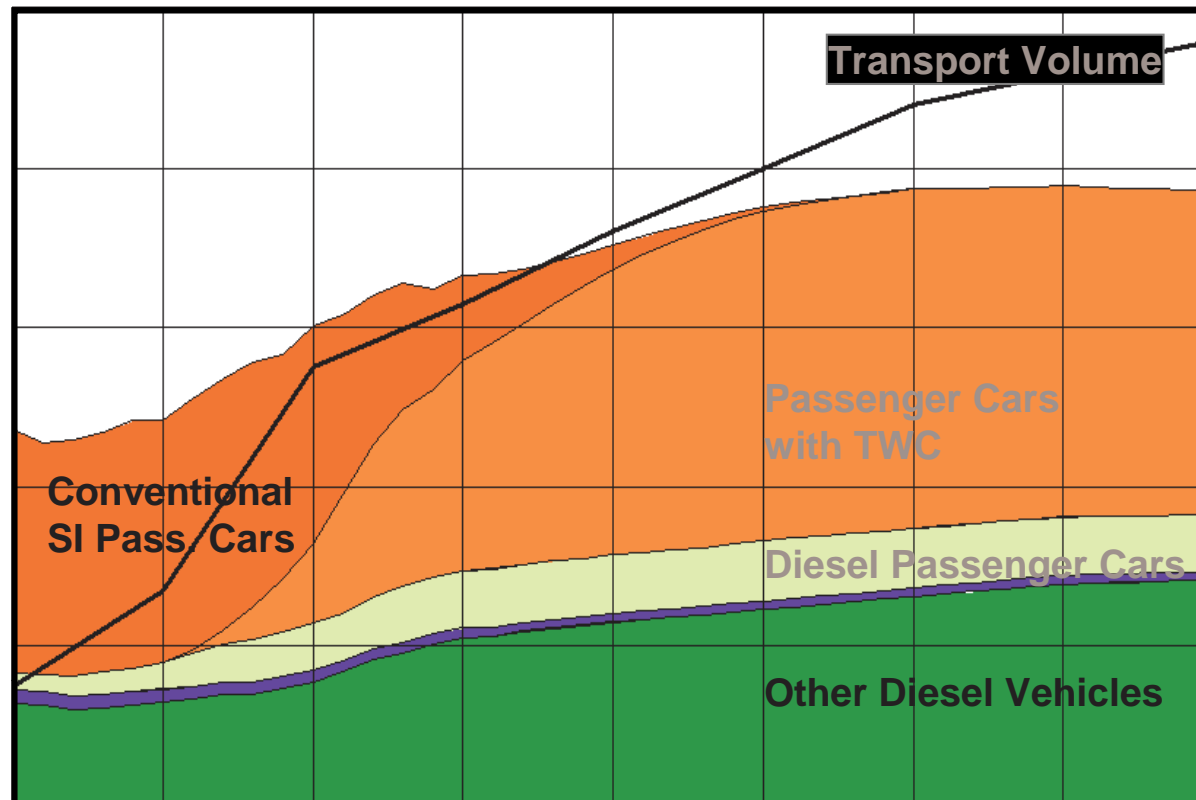


- **Individual mobility and efficient transport are an important basis of modern society and economy**
- **A cheap, reliable and environmental benign long term fuel supply is a prerequisite for unrestricted mobility**

## **Driving Forces**

- **Effective Reduction of CO<sub>2</sub> Emissions**
- **Securing of Energy Supply by Reducing the Dependence on Oil Imports from Politically Unstable Regions**
- **Reduction of the Consumption of Fossil Fuels, and**
- **Need for Cleaner Fuels to Support Emission Reductions**

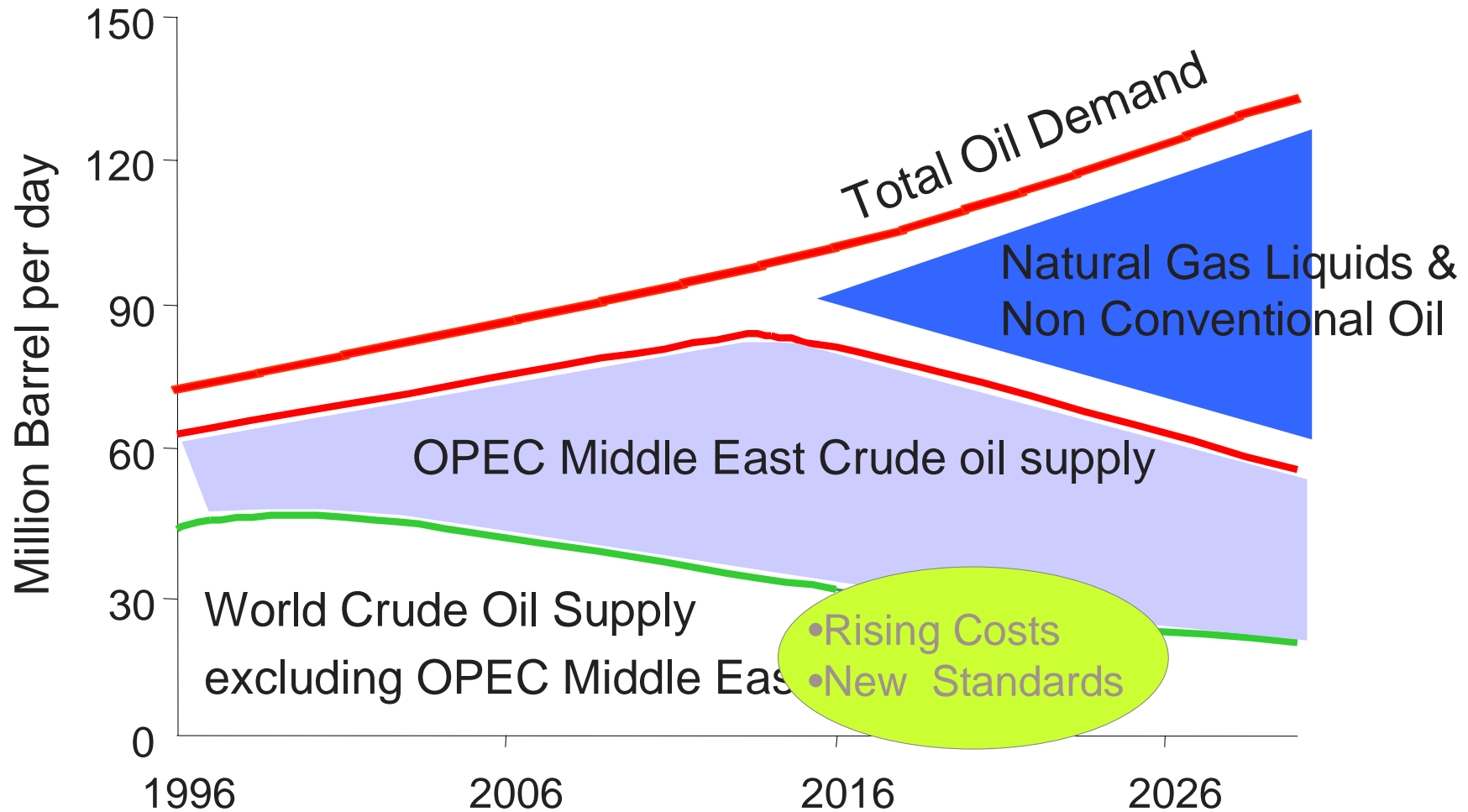
## Motivation: CO<sub>2</sub> Road Emissions (Example for Germany)

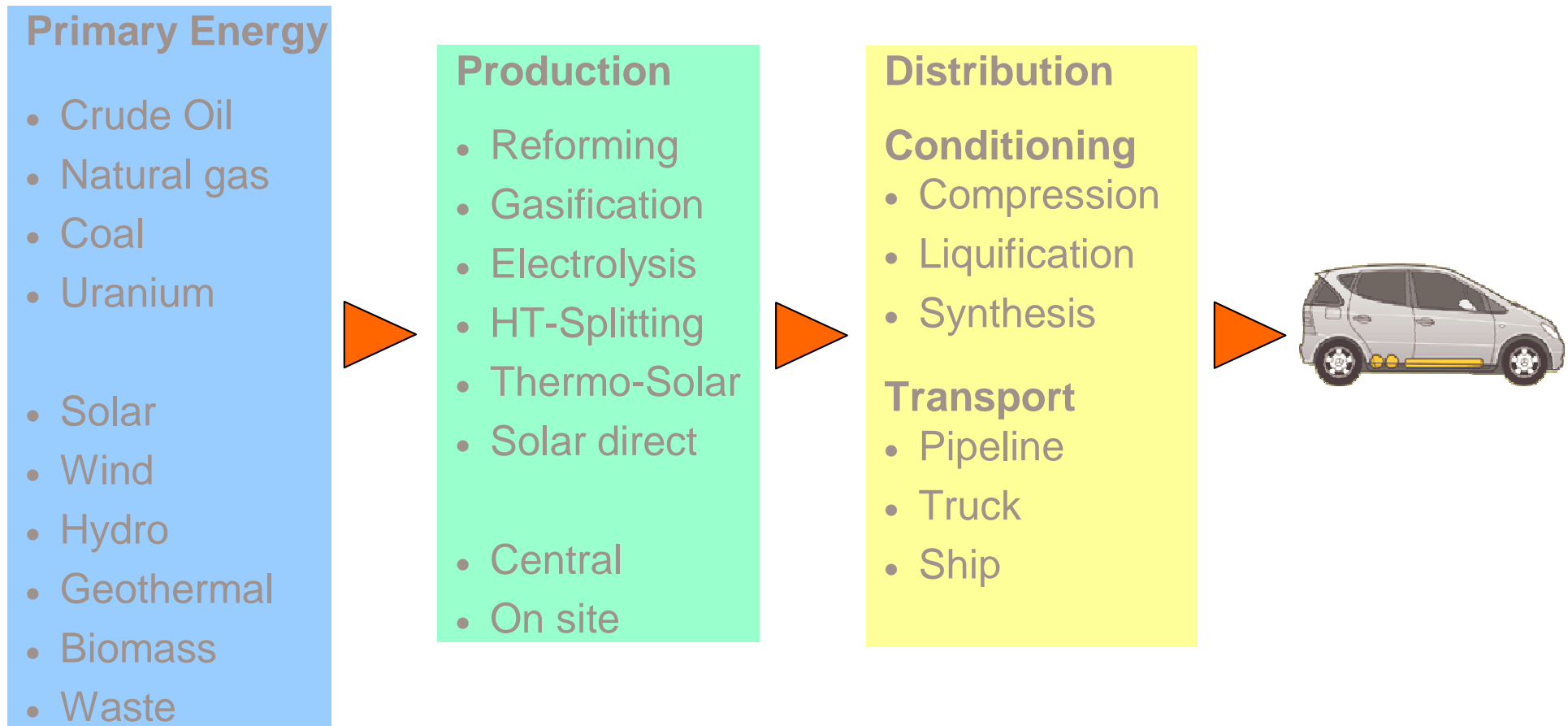


Motivation: Crude Oil Demand 1996 - 2026



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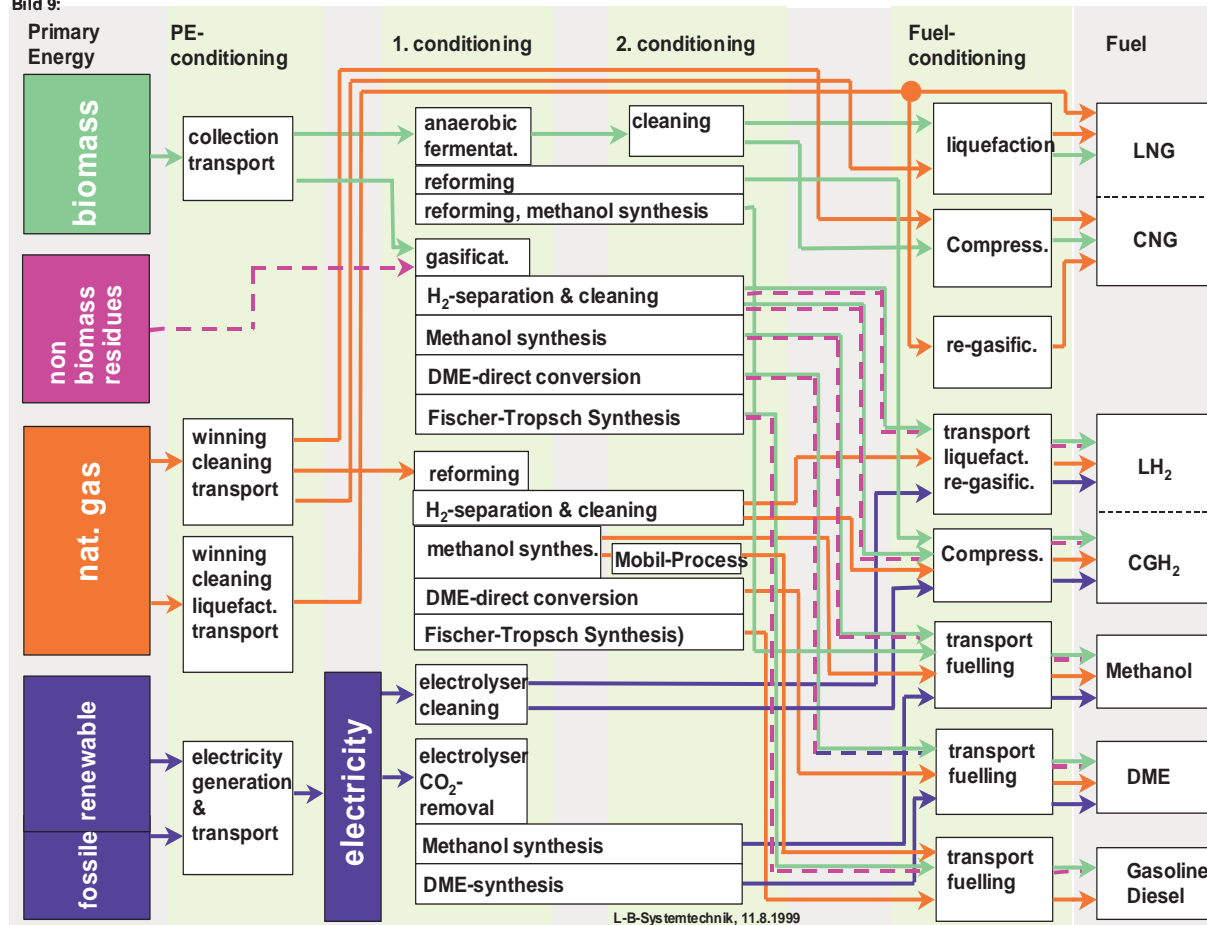




# Production pathways for vehicle fuels

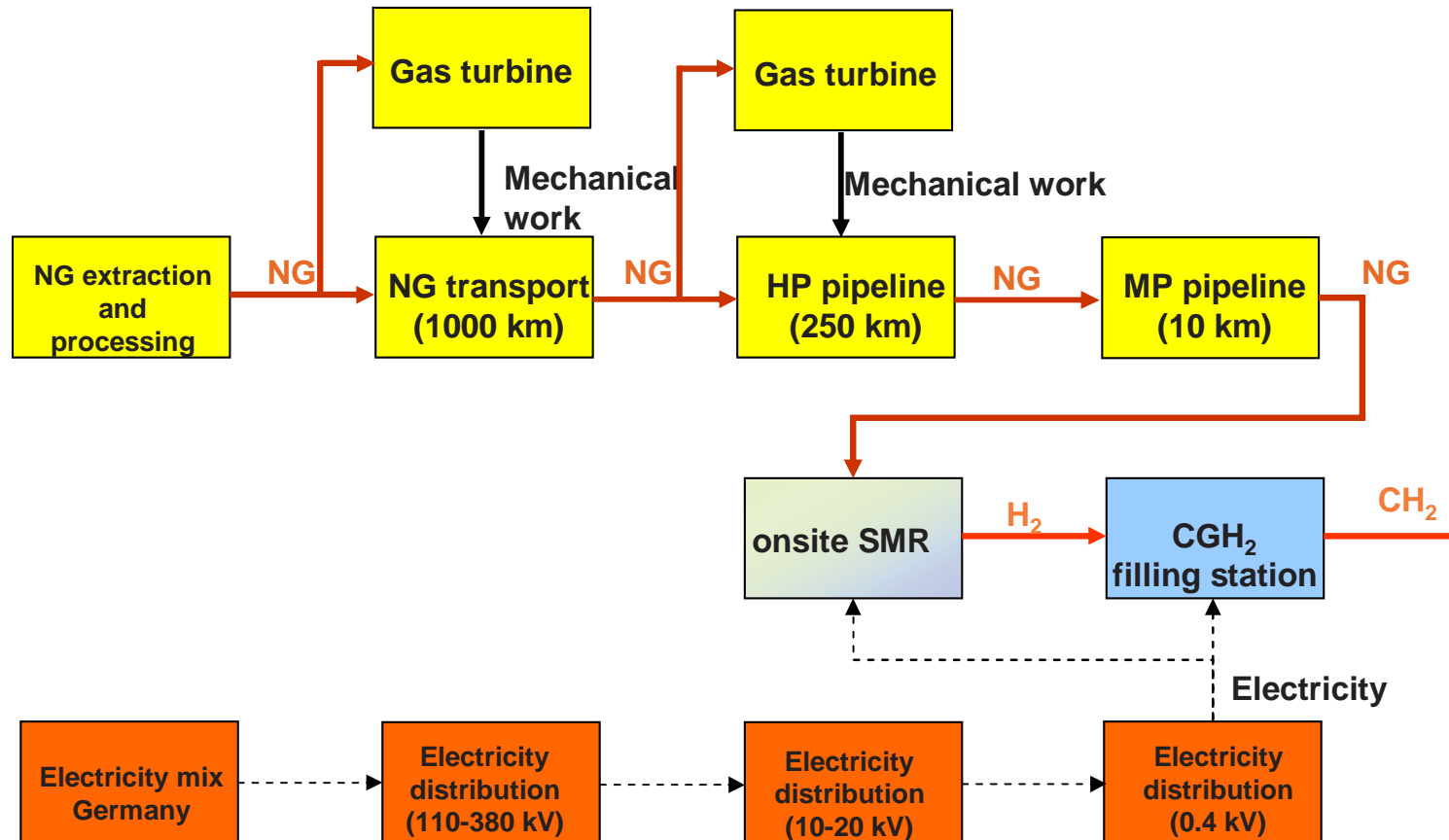


Bild 9:



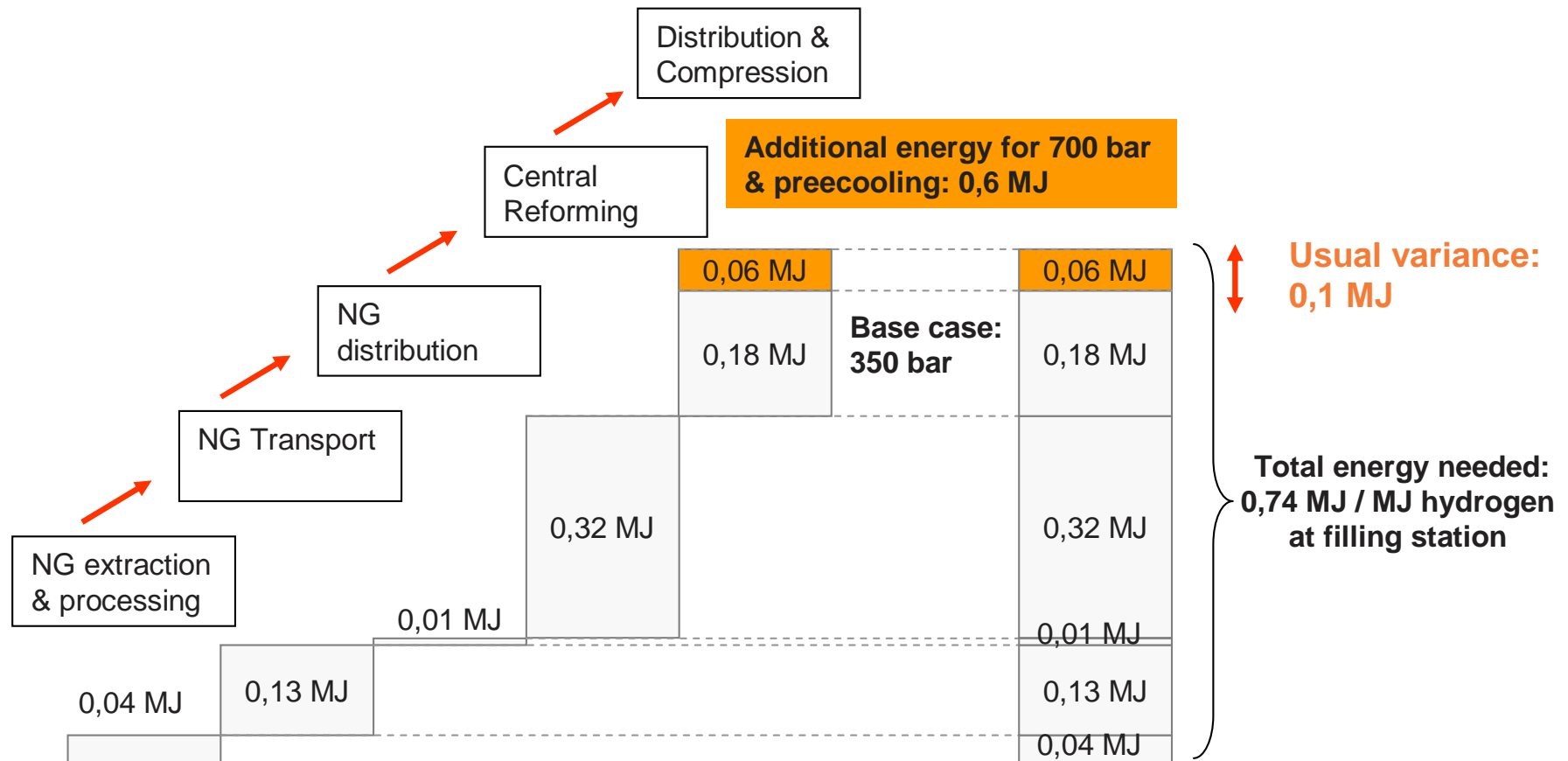
High Complexity affords detailed knowledge of correlations and processes as well as powerful calculation methods (e.g. E3-database from LBST)

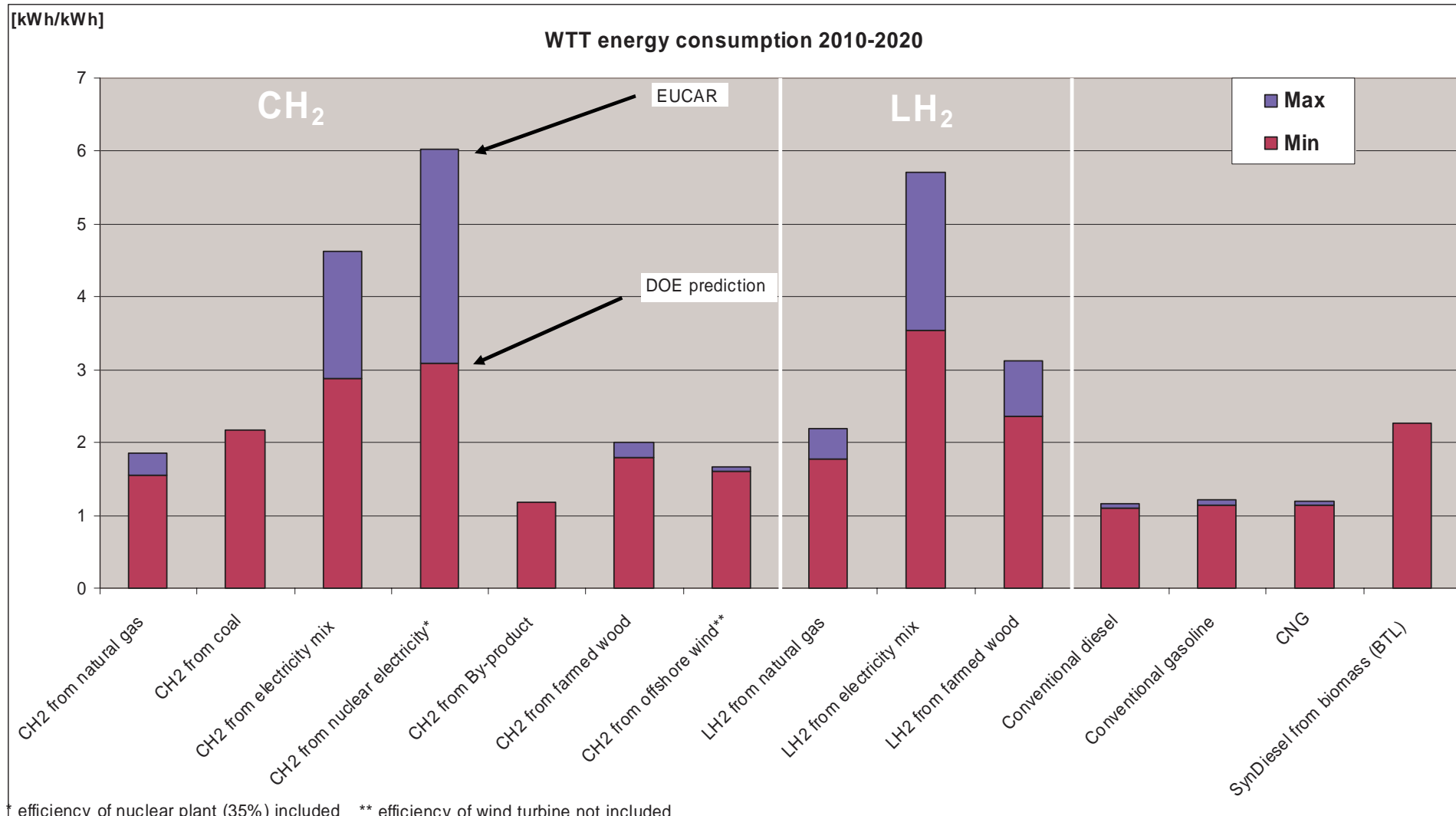
## Example for a H<sub>2</sub>-supply chain: CH<sub>2</sub> from on site reforming of natural gas





Example for energy need for H<sub>2</sub>- supply to filling station: Central reforming of natural gas





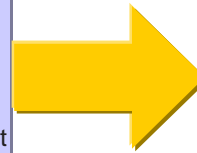
# Hydrogen Fuel Cell Vehicles: Tank to Wheel (TTW) Efficiency



## Current TTW Efficiency\*:

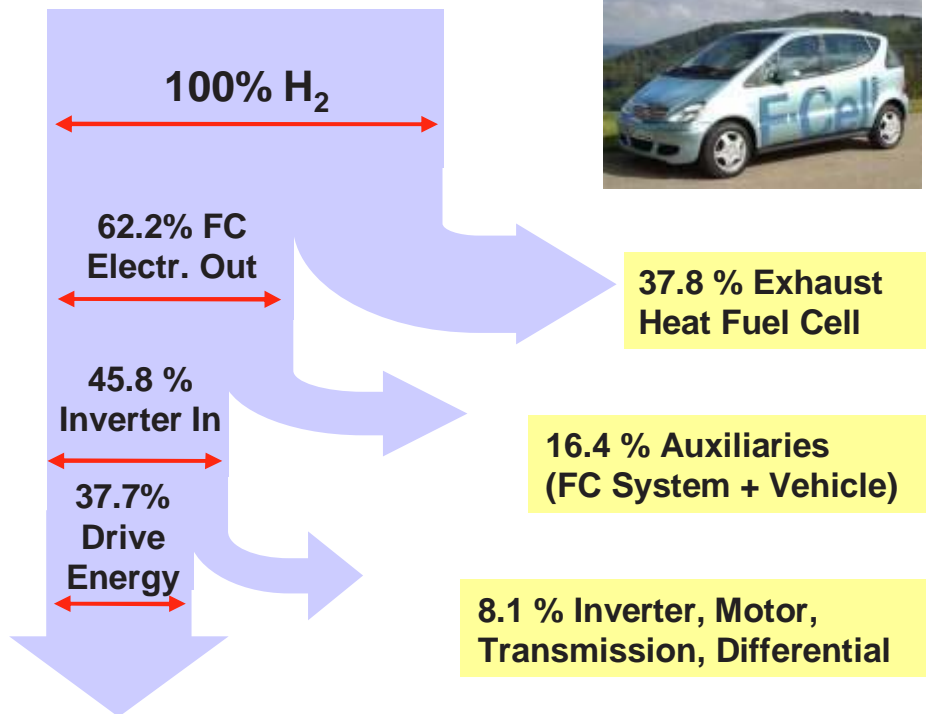
Fuel Cell Vehicle:	37 %
Diesel Vehicle:	24%
Gasoline Vehicle:	20%

\* NEDC, warm start  
Source: DC



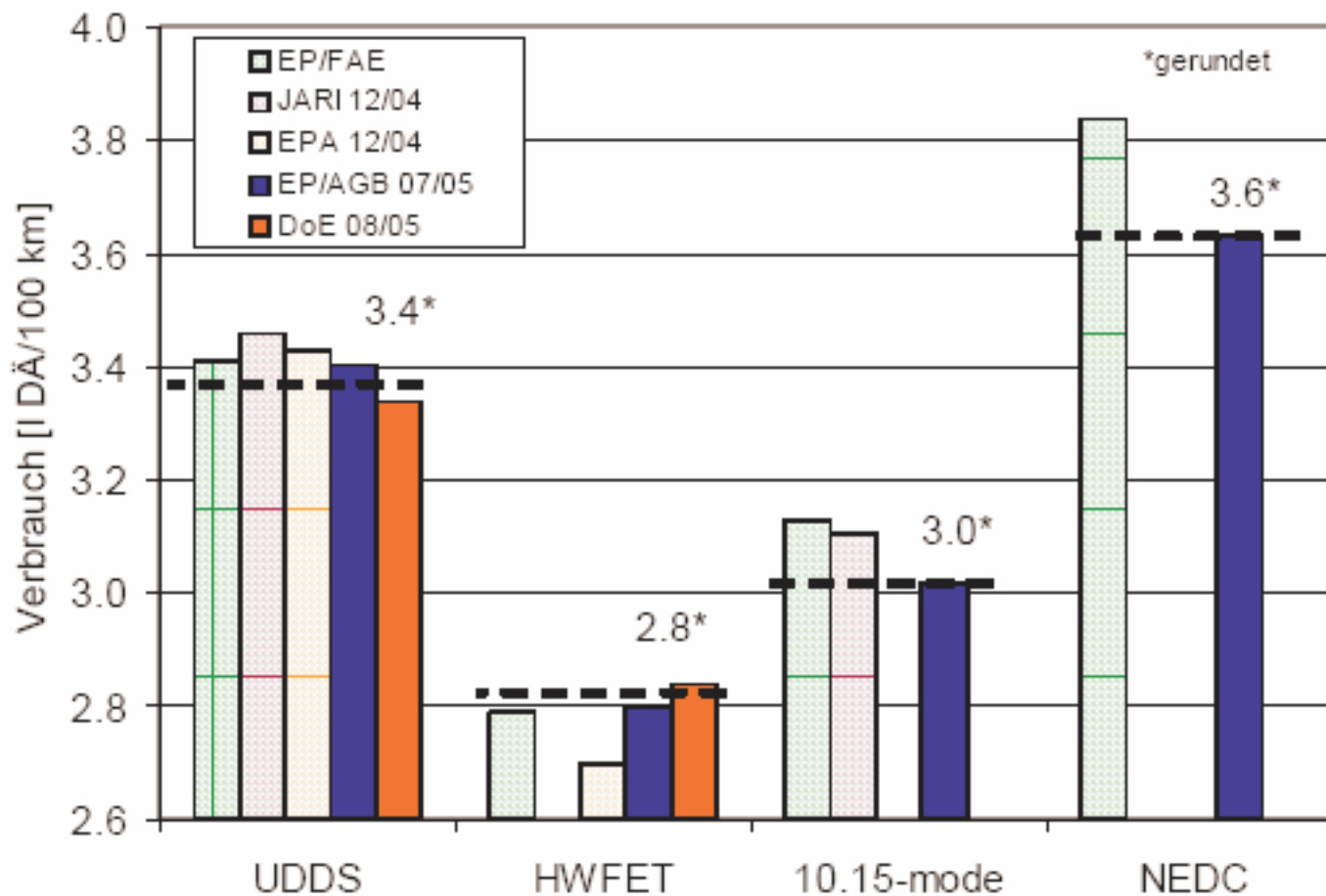
## Potential future TTW Efficiency\*:

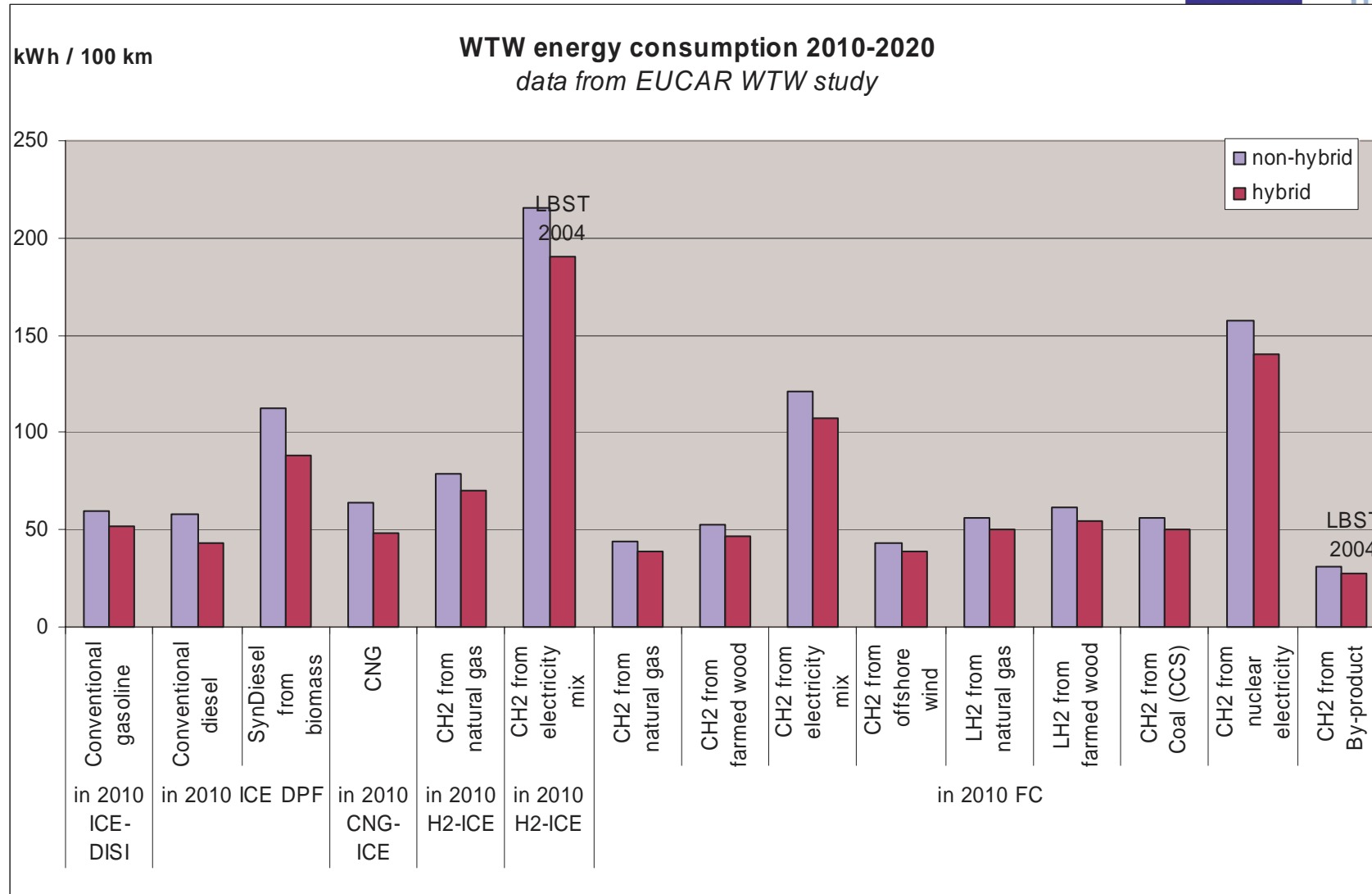
Fuel Cell Vehicle:	>45 %
Diesel Vehicle:	27%
Gasoline Vehicle:	23%



FCVs of Generation 2 have an efficiency, which is twice as high as vehicles with conventional combustion engines. Still there are potentials for more.

## TTW-fuel consumption of the DC F-Cell in different driving cycles



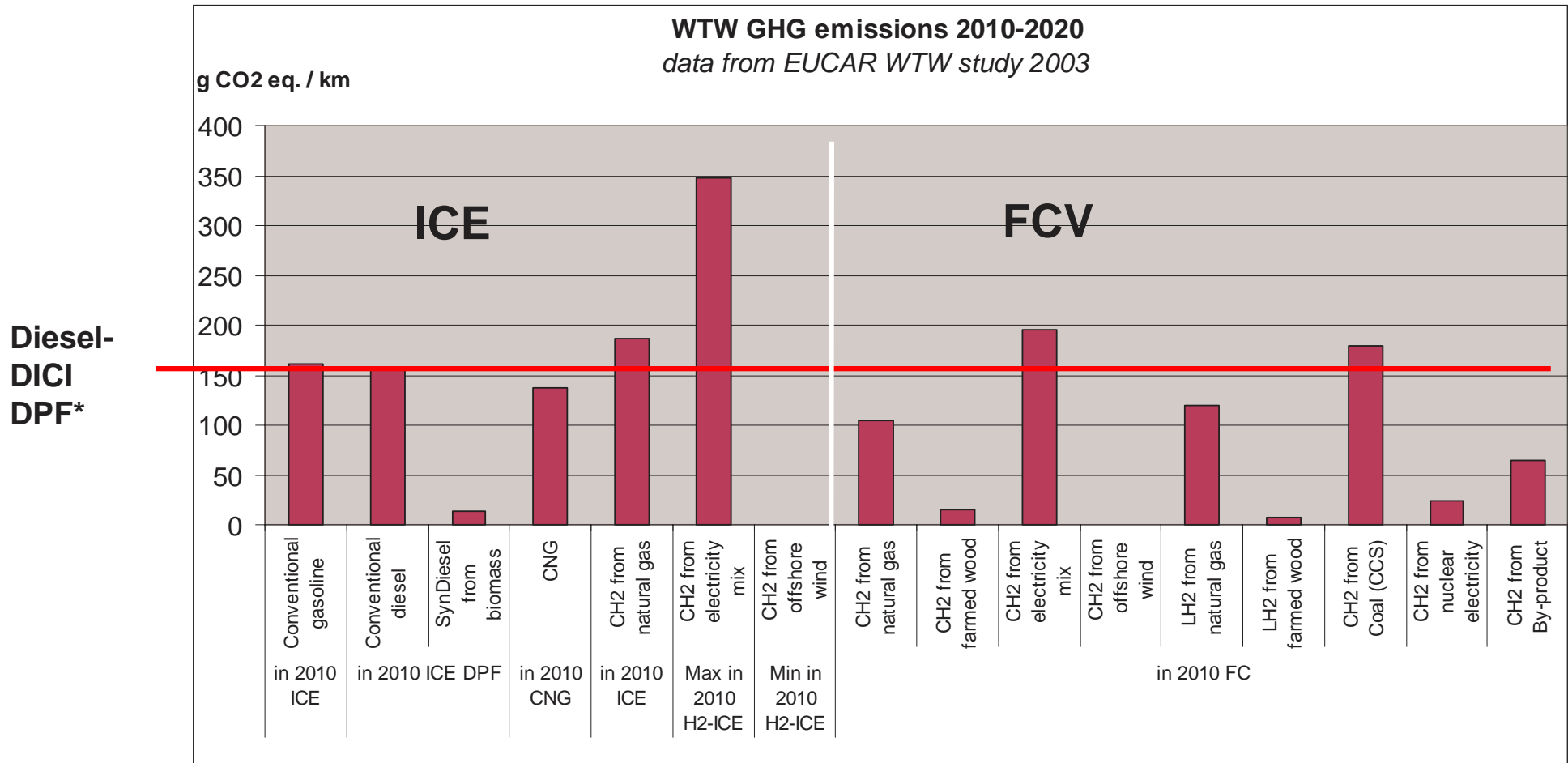


## GHG -Emissions WTW

(Sum of all GHG-semissions in CO<sub>2</sub>-equivalent)



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\* = Diesel mit Partikelfilter

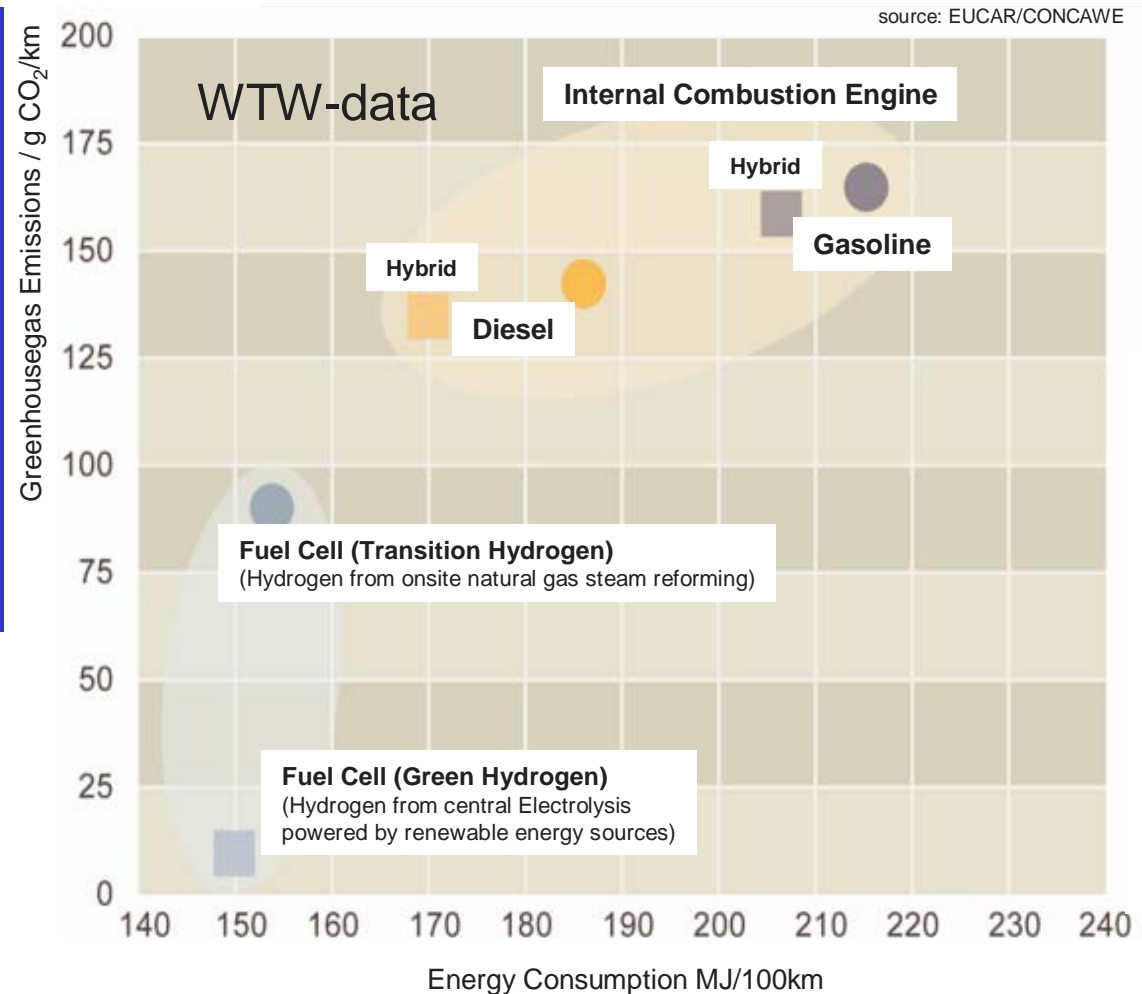


## Advantages of Fuel Cell Vehicles

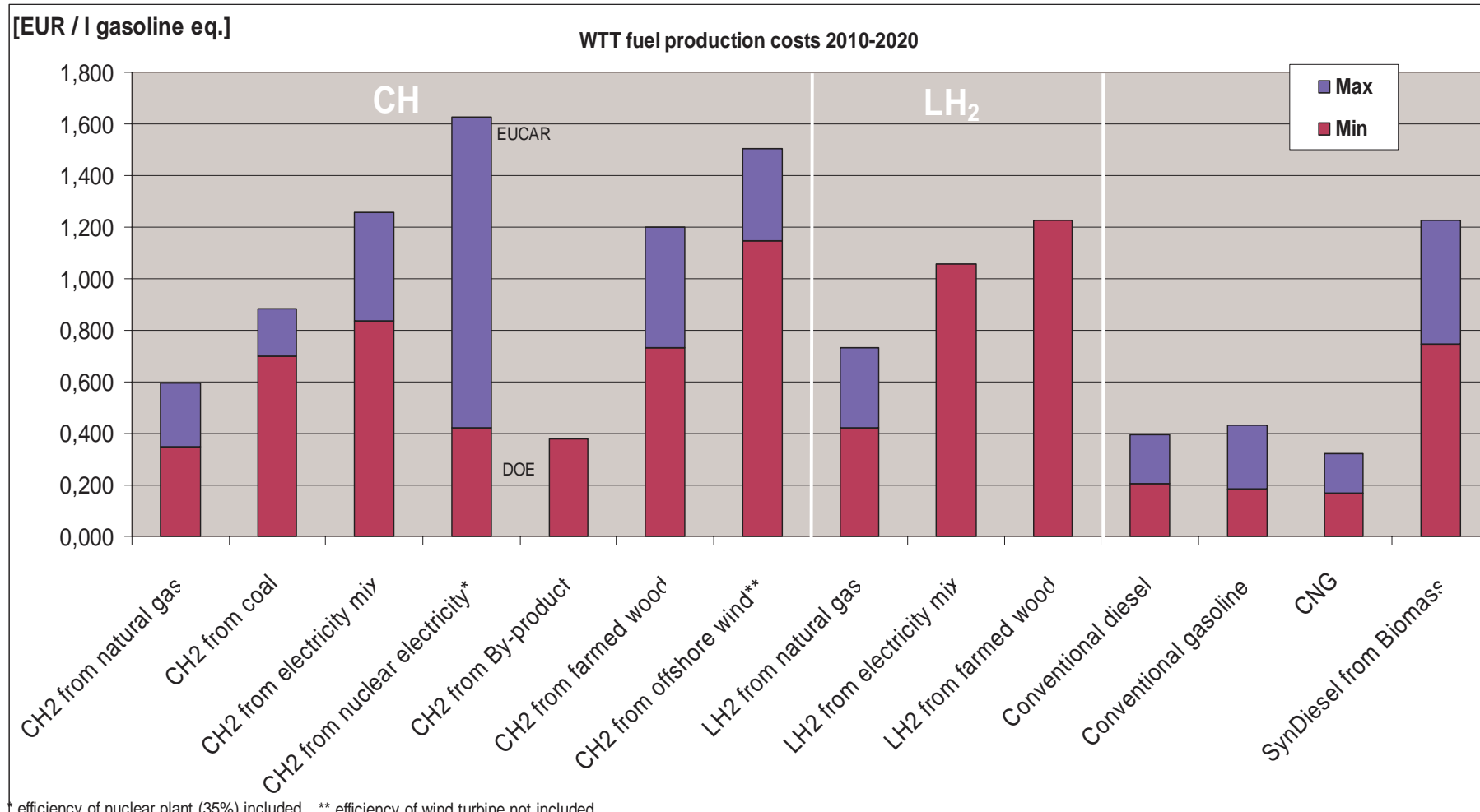
- Reduction of greenhouse gas emissions: no emissions
- Efficient use of energy: efficiency twice as high compared to conventional combustion engines
- Diversification of energy resources for our mobility: independent from crude oil



**Fuel Cell Vehicles realize highly efficient and emission-free mobility.**



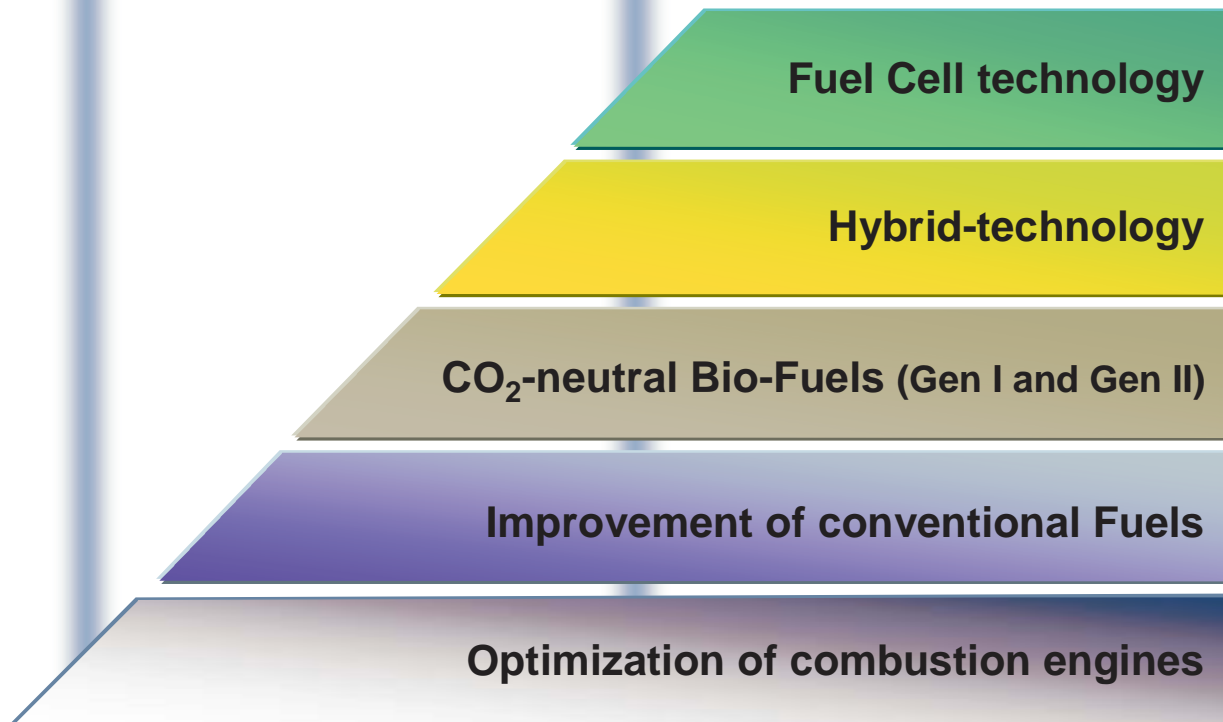
# Hydrogen supply costs for selected pathways

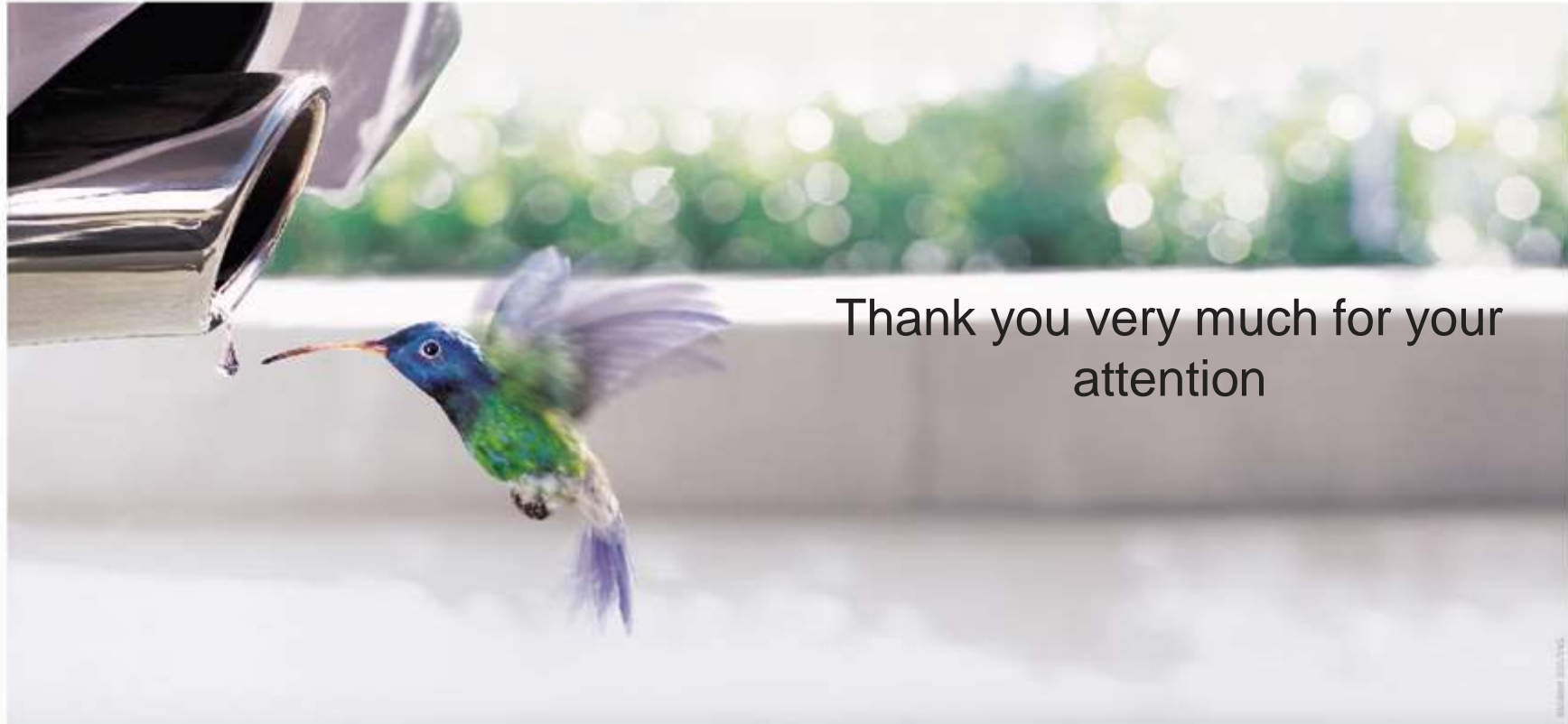




today

tomorrow





Thank you very much for your attention

## Just what the environment needs from a car. Water.

If nature had one wish, what do you think it would be? A car that doesn't produce exhaust? We thought so too. That's why our hydrogen powered Fuel Cell vehicles only emit water. In fact, as they've proven in recent road tests, they may well be the alternative drive systems of the future. At DaimlerChrysler Research, we're developing these intelligent technologies today. For the automobiles of tomorrow.

To find out more about 'Energy for the Future' visit [www.daimlerchrysler.com](http://www.daimlerchrysler.com).



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