Comparison of Energy Consumption and Green-House-Gas emissions of different mobility scenarios with Optiresource<sup>®</sup>

The "Well-to-Wheel" Optimizer used at Daimler

Dr. J. Wind, <u>P. Froeschle</u> Electrical Vehicle Symposium 23, Anaheim, December 3, 2007

#### What are the reasons for the current debate?



#### Al Gore: An inconvenient truth



#### – UNO Climate report, Feb. 2007 –





## The recent $CO_2$ - debate takes on different shapes throughout the world



Caption of presentation / Department / Date (year-month-day)

Optiresource is a tool for quick and reliable decisions Different Optiresource versions for different target groups

#### Web/Exhibition version



Caption of presentation / Department / Date (year-month-day)

## The Web version is designed for easy use by non-experts



### The expert version has a wide variety of funcionalities

#### The user can

- compare different energy chains in terms of energy consumption, GHG emissions etc.
- detect the chains allowing for the optimization of the consumptions and emissions.
- identify the impact of different energy scenarios.

#### **Different modes**

- "Query mode": the user selects the chains according to certain criteria, the results are visualized (almost 1000 chains available)
- "Scenario Mode": the user defines scenarios in terms of energy supply and energy demand and then visualizes and compares them

### **Optiresource Query Mode**

			Prima	ry energy	/	rocess Fuel Powertrain		
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## Example for WTW results in the Query Mode





## Example for WTW results in the Query Mode





The Optiresource findings for the example query are clearly in favor or renewable hydrogen as a fuel

- By far the lowest GHG emissions and very low energy consumption are achieved by a **Fuel Cell vehicle** powered by H2 from wind energy.
- Hydrogen from NG shows even lower energy consumption but clearly higher GHG emissions than  $H_2$  from wind. However GHG emissions of this pathway are already lower than those from conventional ICEs.
- An **H2 ICE** powered by hydrogen from NG is the worst of all shown both in terms of energy consumption and GHG emissions.

Both in terms of energy consumption and GHG emissions, the **Fuel Cell vehicle** is the best of all alternatives shown

# The Scenario mode lets one compare different scenarios in terms of energy consumption and GHG emissions

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## Very good agreement between Optiresource data and real values

	Total energy consumption for passenger cars tank-to-wheel (TTW) (MJ)	Energy consumption per 100 km TTW (MJ/100km)	Total GHG emissions from passenger cars TTW (tons)	GHG emissions per km TTW (g <sub>CO2eg</sub> /km)
Data for German passenger cars in 2005	1.48 x 10 <sup>12</sup>	255	110 x 10 <sup>6</sup>	189
Results from Optiresource <sup>®</sup> for simplified scenario for Germany 2005	1.22 x 10 <sup>12</sup>	210	92 x 10 <sup>6</sup>	158

Optiresource figures are slightly lower that real values because

- 2002 compact class reference vehicle was used while actual car fleet is older with higher fuel consumption and GHG emissions.
- Compact class reference vehicle does not represent the variety within car fleet.
- Real driving patterns differ from NEDC.

### Definition of example scenarios

		Szenarios (Share of driv e trains)						
Drive Train	Fuel	Base scenario	20% Hybrid Electric Vehicles	20% Biodiesel Vehicles	20% Fuel Cell Vehicles, Wind	20% Battery Electric Vehicles, Wind		
Otto engine (Port injection)	Gasoline from crude oil	77%	67%	67%	67%	67%		
Diesel engine (Direct Injection with particle filter)	Diesel from crude oil	23%	13%	13%	13%	13%		
Diesel engine (Direct Injection with particle filter)	Biodiesel from rapeseed	-	-	20%	-	-		
Parallel Hybrid with Otto engine	Gasoline from crude oil	-	10%	-	-	-		
Parallel hybrid with Diesel engine	Diesel from crude oil	-	10%	-	-	-		
Hybridized Fuel Cell Drive Train	Hydrogen from Wind energy (by electrolysis)	-	-	-	20%	-		
Li-Ion Battery and Electric Motor	Electricity from Wind energy	-	-	-	-	20%		

# Comparion of the scenarios in terms of energy consumption and GHG-emissions

Scenario Title	Energy Consumption - Absolute	GHG Emissions - Absolute				
Base Scenario						
20% Hybrid Electric Vehicles						
20% Biodiesel Vehicles						
20% Fuel Cell Vehicle Hydrogen from Windenergy						
20% Battery Electric Vehicles Electricity from Windenergy						
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The Optiresource analysis of the example scenarios shows FCV to be the only real alternative for the future

- In terms of GHG emissions every alternative scenario is better than the reference scenario
- However, only the introduction of Fuel Cell vehicles or battery electric vehicles lead to a significant reduction of GHG emissions as well as energy use
- **BEV** show a very similar effect on GHG emissions as **FCV** with even lower energy consumption

Due to still significant difficulties of battery electric vehicles, **Fuel Cell vehicles** are the only mid term alternative for sustainable mobility

## Thank you!

