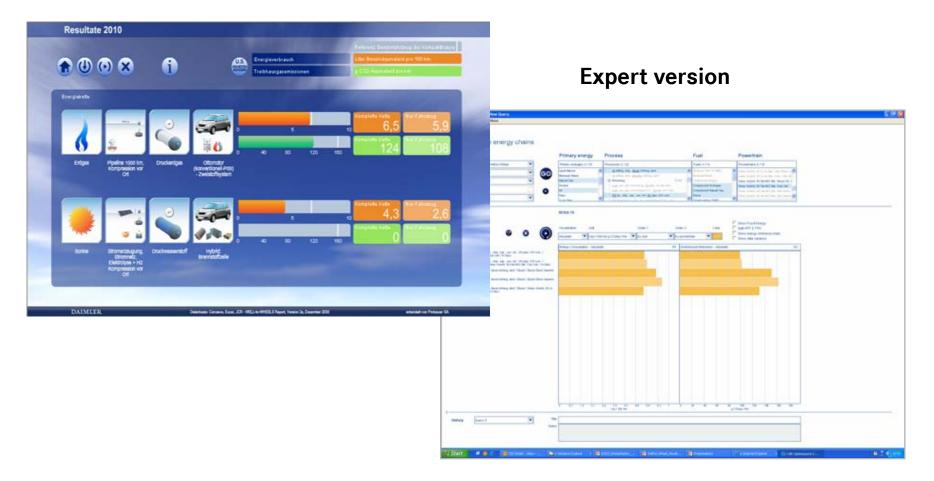
#### **Optiresource – Daimler's "Well-to-Wheel"- Optimizer**

Comparison of Energy Consumption and Green-House-Gas emissions of different mobility scenarios with Optiresource

Dr. J. Wind, <u>P. Froeschle</u>, Daimler AG NHA Annual Hydrogen Conference 2008, Sacramento, April 2nd, 2008

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



#### Web/Exhibition version

#### The Web version is designed for easy use by nonexperts



# 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.

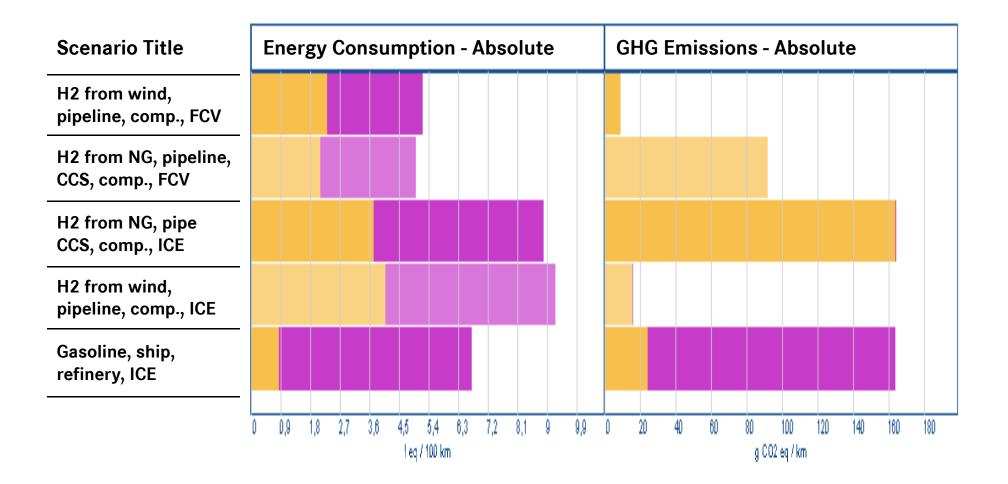
#### Different modes

- "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**



#### **Example for WTW results in the Query Mode**



# The Optiresource findings for the example query are clearly in favor of 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<sub>2</sub> 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 alternatives 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 to compare different scenarios in terms of energy consumption and GHG emissions

	Car	Powertra	ain	Fuel	Primary energy	Process		
from the Powertrain 💌	Car 0 / 13	Powertrains		Fuels	Primary energies	Processes		
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N Europe	C Class CLK Class							
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	0	Hybrid: Fuel Ce		000 1 Data Compressed Hydrogen	100			
	0	E Otto Engine (cor	nventional - PI 64 110	000 1 Data	100			
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		Otto Engine (cor	inventional - Pi 1 110		100 100 100			
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ø	0	RESULTS Visuelization Absolute	Unit MJ1 CO2eq	Oscillea  Oscillea  Oscillea  Compressed Natural Gas  Compressed Natural Gas  Order 1	100 100	WTT TTW V Split W	IT & TTW energy reference chain	
any 2002 - Wuppertal Institute	•	RESULTS Visuelization Absolute	Unit MJ1 CO2eq	Oscillate  Ocillate  Compressed Natural Osc  Compressed Natural Osc  Order 1  Order 1  V  Dy energy a	100 100	WTT TTW V Split WT Show e	rT & TTW energy reference chain lata variance	
any 2002 - Wappertal Institute PISI, 10% DICI	•	RESULTS Visuelization Absolute	Unit MJ1 CO2eq	Oscillate  Ocillate  Compressed Natural Osc  Compressed Natural Osc  Order 1  Order 1  V  Dy energy a	100 100	WTT TTW V Split WT Show e	rT & TTW energy reference chain lata variance	7
avy 2002 - Wappertal Institute PISI, 16% DICI any 2010- Wappertal Institute PISI, 33 & DICI OPE, 11% EVULon	•	RESULTS Visuelization Absolute	Unit MJ1 CO2eq	Oscillate  Ocillate  Compressed Natural Osc  Compressed Natural Osc  Order 1  Order 1  V  Dy energy a	100 100	WTT TTW V Split WT Show e	rT & TTW energy reference chain lata variance	7
avy 2002 - Wappertal Institute PISI, 16% DICI any 2010- Wappertal Institute PISI, 33 & DICI OPE, 11% EVULon	•	RESULTS Visuelization Absolute	Unit MJ1 CO2eq	Oscillate  Ocillate  Compressed Natural Osc  Compressed Natural Osc  Order 1  Order 1  V  Dy energy a	100 100	WTT TTW V Split WT Show e	rT & TTW energy reference chain lata variance	
avy 2002 - Wappertal Institute PISI, 16% DICI any 2010- Wappertal Institute PISI, 33 & DICI OPE, 11% EVULon	•	RESULTS Visuelization Absolute	Unit MJ1 CO2eq	Oscillate  Ocillate  Compressed Natural Osc  Compressed Natural Osc  Order 1  Order 1  V  Dy energy a	100 100	WTT TTW V Split WT Show e	rT & TTW energy reference chain lata variance	
any 2002 - Wappertal Institute PHSI, 16% DTCI any 2016- Wappertal Institute PSI:33 33 DTCI OPF, 11% EVUI-ben	•	RESULTS Visuelization Absolute	Unit MJ1 CO2eq	Oscillate  Ocillate  Compressed Natural Osc  Compressed Natural Osc  Order 1  Order 1  V  Dy energy a	100 100	WTT TTW V Split WT Show e	rT & TTW energy reference chain lata variance	
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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

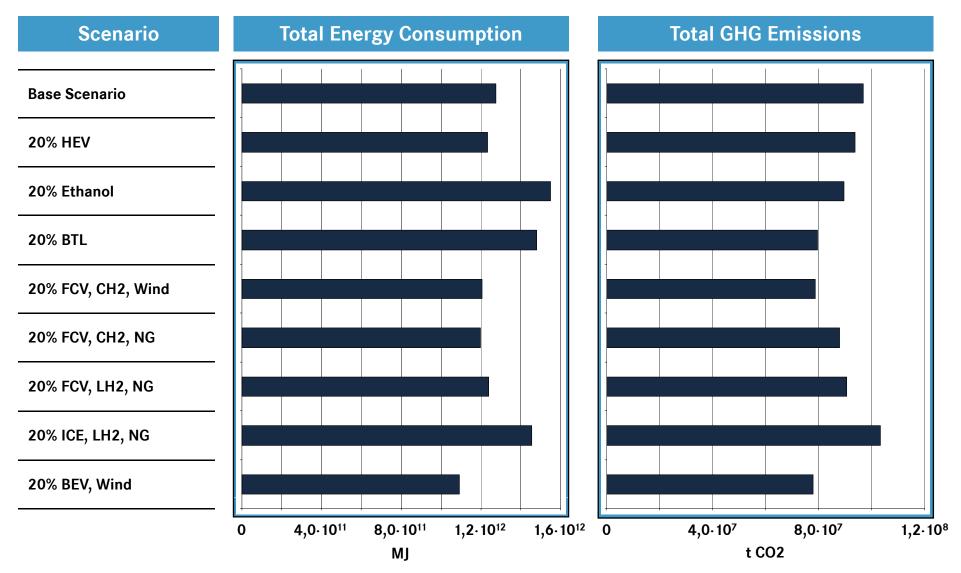
#### Optiresource figures are slightly lower that real values because

- 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**

Powertrain	Fuel	Scenarios (Proportion of different drive trains and fuels)								
		Base Scenario	20% HEV	20% Ethanol	20% BTL	20% FCV CH2, Wind	20% FCV CH2, NG	20% FCV LH2, NG	20% ICE LH2, NG	20% BEV Wind
Otto Engine	Gasoline (Crude Oil)	77%	67%	67%	67%	67%	67%	67%	67%	67%
Diesel	Diesel (Crude Oil)	23%	13%	13%	13%	13%	13%	13%	13%	13%
Otto Engine Hybrid	Gasoline (Crude Oil)	-	10%	-	-	-	-	-	-	-
Diesel Hybrid	Diesel (Crude Oil)	-	10%	-	-	-	-	-	-	-
Otto Engine	Ethanol (Wheat)	-	-	20%	-	-	-	-	-	-
Diesel	BTL (Wood)	-	-	-	20%	-	-	-	-	-
Fuel Cell Hybrid	H2 (Wind)	-	-	-	-	20%	-	-	-	-
Fuel Cell Hybrid	CH2 (NG)	-	-	-	-	-	20%	-	-	-
Fuel Cell Hybrid	LH2 (NG)	-	-	-	-	-	-	20%	-	-
Otto engine	LH2 (NG)	-	-	-	-	-	-	-	20%	-
Electric Motor and Li-Ion Battery	Electricity (Wind)	-	-	-	-	-	-	-	-	20%

#### **Results of the scenario calculation**



# 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 except the H2 ICE is better than the base 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 viable mid term alternative for sustainable mobility

## Thank you!

