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WTW Analyses and Mobility Scenarios with OPTIRESOURCE

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1 Overview

Today´s road transport is facing a number of challenges which will only be overcome if new sustainable and competitive solutions for fuels and powertrains can be realized. One issue is to take decisions for the choice of fuels and drive train technologies which have to be developed. The variety of options is huge: biodiesel, ethanol, DME, methanol, methane (either in natural gas or produced from biomass), hydrogen and electricity are only a portion of the alternative fuels. Hybrid electric vehicles, plug-in hybrids, electric vehicles with battery and and electric vehicles with fuel cell are the vehicle technologies which are currently being discussed. Not only maturity of the different technologies for fuel production and distribution as well as vehicle technologies are to be considered when selecting those technologies which should be promoted by politics and industry. Very important criteria like well-to-wheel energy consumption and green-house-gas emissions as well as production potentials of the fuels are of utmost importance. Daimler has used the software tool OPTIRESOURCE to investigate the impact of introduction of alternative drive trains and fuels on future energy consumption and GHG emission in different scenarios for the German car park. In the presentation detailed results of these scenario calculations will be shown. Emphasis is given to electric vehicles, such as battery electric vehicles and fuel cell electric vehicles.

2 Introduction

Security of fuel supply, air quality and climate change are the main reasons for the need of the introduction of alternative fuels and alternative drive trains for transport applications, especially road transport. A considerable number of options and solution is currently being developed, some are already on the road. Due to the variety of different fuel and drive train options it is not easy to asses the effects of these solutions on total energy consumption and the environment. Several studies concerning the energy consumption and green-house-gas (GHG) emissions of different transport options have been carried out and published. As the matter is very complex, only experts are able to interpret the results of such studies. Furthermore, results showing the benefit of a particular solution in terms of fuel consumption and GHG-emissions for a single car do not show the effect of the introduction of the technology in total. In order to enhance the understanding of such effects, Daimler decided to develop a software tool for the visualization of single energy chains for road transport applications and build up of scenarios for mobility. The software uses data for energy consumption and GHG-emissions from WTW-studies which already have been carried out. In the first version, most data were taken from the EUCAR/CONCAWE/JRC-WTW-study . As this study did not cover all possible options, data for some drive train options have been created by the Ludwig Bölkow System Technology GmbH and integrated in Optiresource®. The software can either be used to compare single energy chains in the query mode or to investigate the impact of new fuel and drive train options on total energy consumption and GHG-emissions. More information about Optiresource® can be found on http://www.optiresource.org. Furthermore, a public version of the Optirsource® query mode is located on the Daimler website on http://www.daimler.com/go/optiresource.

3 Software Description and Data Sources

The base philosophy of the Optiresource®-Car software is to use existing data implemented in a purpose-made database. The database plus the user interface constitute the Well-to-Wheel (WtW) system. All data from the study and these of the additional chains were incorporated in the database of the visualization software. This database contains the data defining the different energy paths from Well-to-Tank (WtT) and Tank-to-Wheel (TtW) in terms of energy efficiency, greenhouse gas emissions or any other available parameter. The users do a query to the database and get the results in terms of a visualization of the absolute or relative values of energy consumptions and GHG-emissions of each path. The way the query is done and the way the results are displayed depends on the kind of user. The data base stores and elaborates the data, the user interface manages how the query is done and how the results are displayed.

3.1 Query mode

The user chooses the quantities he likes to see (energy, GHG or both in the first version), the time period to which these quantities refer (2002, 2010 or both for the first version) and the energy chains. To select the energy chains, the user can select one or more primary energies and/or one or more processes, one or more fuels and/or one or more powertrains. It is possible to select all the chains with one single command. The selection can be done in a random way (the sequence of the choices is free). The system automatically pre-selects all the possible choices, according the selections made in the previous step. At the end of the query, the results are displayed in a bar diagram. The system is already designed to include the choice of various geographical contexts. A typical result of a query is shown in figure 1.

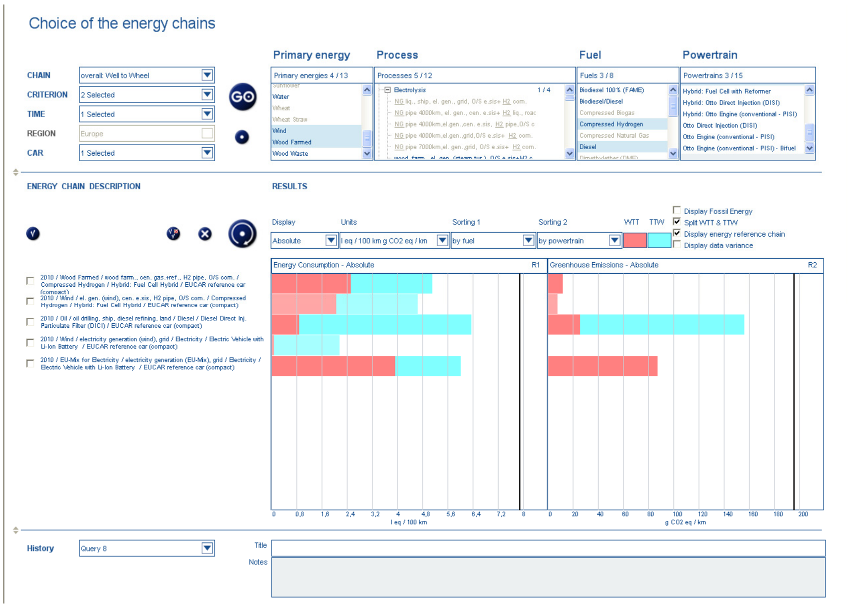

Figure 1: Example for the visualization of WTW-energy consumption and GHG-emissions in the query mode.

3.2 Scenario mode

In this modality the user defines the energy mix, the composition of the vehicle fleet (type, km/year driven and quantities) and the technical improvements of a certain geographical area. As an alternative, pre-set scenarios can be up-loaded and modified. The results show what happens in that area in terms of quantities related to the technology (e.g. l/100km, MJ/100km, miles/gallon, GHG/km, GHG/mile) or any other available quantity in comparison with the present situation of that area. Figure 2 shows the result of a typical scenario produced with Optiresource.

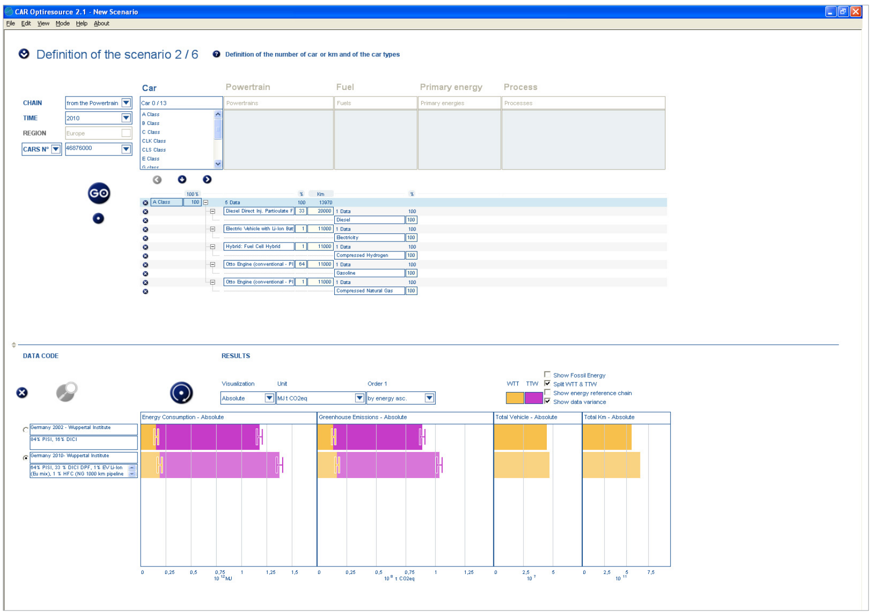

Figure 2: Example for the visualization of results from the scenario mode.

4 Description of Investigated Scenarios

4.1 Basic Scenario and Reality Check Scenario

Building scenarios for future road transport first needs a basic scenario in order to make reality checks and then compare results of the future scenarios with the basis. The base scenario consists of 50 million compact class cars, each of them driving 12,000 km per year. The driving pattern was also simplified: it has been assumed that the cars are always driven in the New European Drive Cycle. The share of diesel engines in the base scenario is 23%, the share of gasoline engines is 77%. All other drive trains are disregarded in the base scenario. Table 1 displays the parameters chosen for the base scenario.

For reality check we have also used Optiresource® to obtain the respective calculated energy consumption and GHG emissions for all passenger cars in Germany. The numbers used for this scenario were taken from a publication of the DIW and are shown in table 2.

Table 1: Parameter list for Base Scenario.

Car type	Mileage/car	Number of cars	Driving Pattern	Drive Train	Fuel
Compact class	12,000	38.5 Mio (77%)	NEDC	Otto engine (Port injection)	Gasoline from crude oil
Compact class	12,000	11.5 Mio (23%)	NEDC	Diesel engine (Direct Injection with particle filter)	Diesel from crude oil

Table 2: Parameter list for Reality Check Scenario.

Car type	Mileage/car	Number of cars	Driving Pattern	Drive Train	Fuel
Compact class	10,900	36.0 Mio (79%)	NEDC	Otto engine (Port injection)	Gasoline from crude oil
Compact class	19,500	9.6 Mio (21%)	NEDC	Diesel engine (Direct Injection)	Diesel from crude oil

4.2 Alternative scenarios

Currently, a number of different options for future mobility are in discussion, some of those being already on the road to some extent, some others being still in the development phase. We have investigated scenarios for four different future scenarios. Detailed description of the scenarios will be shown during the presentation.

5 Results

5.1 Energy use and GHG emissions for Reality Check Scenario

As already explained in the description of the basic scenario, we have used a simplified scenario. As simplification always causes uncertainties, we have checked the accuracy of the model results by comparison with real data for passenger cars in Germany in the year 2005. Table 3 shows the data obtained with Optiresource® as well as the published data.

Table 3: Comparison of Optiresource® results with data for Germany.

	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_{CO2eg}/km)
Data for German passenger cars in 2005	1.48×10^{12}	255	110×10^{6}	189
Results from Optiresource® for simplified scenario for Germany 2005	1.22×10^{12}	210	92×10^{6}	158

The comparison shows that both TTW energy consumption and TTW-GHG emissions of the Optiresource® scenario and real data differ in the range of 15%. Considering the simplification of the inputs for the scenario, using only one car type, deviation is rather small. The fact that the Optiresource® results are lower than real data can be explained with the different ages of the vehicles. In Optiresource® the data for the 2002 compact class reference vehicle were used, whereas the cars being actually on the road show a broad distribution of ages and are mostly equipped with older engines with somehow higher fuel consumption and CO_2-emissions. Other main reasons are the variety of vehicle types on the road and the real driving patterns which also differ from the NEDC. Taking all this into account, the results obtained with Optiresource® give a fairly good correlation with reality.

5.2 Alternative scenarios

The electrification of road transport is one of the major efforts taken in the automobile industry. It is expected that fuel cell electric vehicles (FCEV) and battery electric vehicles (BEV) will be introduced in the market within the next five years. The impact of different market introduction scenarios of FCEVs and BEVs will be shown during the presentation.