ORWeb Query Version

INTRODUCTION

Optiresource Car is a software package developed by Protoscar SA on behalf of DAIMLER AG to present and to perform comparative analyses of energy conversion chains including the fuel supply and consumption of current trucks. Since it is a web application, the user only needs a web browser, whatever the platform be (computer, tablet, etc.). The software allows the definition of various combinations of energy sources, fuels, and powertrains. Moreover, the energy chains include both the supply of primary energy sources (e. g. oil, rape oil, or wind energy) and the necessary energy conversion steps (e. g. oil refineries, natural gas reforming, hydrogen liquefaction) as well as the relevant transportation stages (e. g. pipelines, tanker trucks, electricity networks) – with the aim of supplying fuel or electricity at filling stations as well as operating passenger cars driven in the European driving cycle.
Based on studies relating to life-cycle assessments from the energy source to the powered wheel, the query mode allows the program user to create energy chains and to select the vehicle powertrain systems for which he needs more information or comparative analyses. Following the definition of the energy chains, the user may query, identify and display the results according to the various criteria determining these energy chains. Optiresource Car provides information about the primary energy requirements and the greenhouse gas emissions associated with the energy chain as well as the greenhouse gas reduction potential relative to the selected reference chain, but not about the availability of the selected energy sources. In addition, the user is also given information about the total cost of ownership and primary energy input, the land surface used, specific water consumption data as well as the biomass volume for selected fuels. The results achieved can be presented in a variety of dimensions in the form of Excel sheets.

The data used and displayed are based on the following two sources: (1) a study carried out by Concawe/Eucar/JRC latest release: *Prussi, M., Yugo, M., De Prada, L., Padella, M., Edwards. JEC Well-To-Wheels report v5. EUR 30284 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-20109-0, doi:10.2760/100379, JRC121213*, and (2) supplementary inputs provided by Ludwig-Bölkow-Systemtechnik GmbH (with particular reference to electricity generation on water and PV basis as well as electrolyzer technologies).
DOCUMENTATION-D-BASE.

CRITERIA

The criteria used to evaluate the user-defined energy chains are basically given in the following dimensions and abbreviations:

– MJ/100 km, kWh/100 km, leq gasoline/100km, Mpg *
– gCO_2eq/km (related to gasoline) *
– kg/100 km *
– $m^2/100$ km *
– l/100 km *
– $m^3/100$ km *
– WTW - Well to Wheel
– WTT - Well to Tank
– TTW - Tank to Wheel

* For the trucks the above units are given per 1t of payload.

Total amount of primary energy expended for the whole energy chain (WTW)

Presentation of energy-related results:

- Specific energy consumption (MJ/MJfuel), i.e. total amount of energy required for the delivery of 1 MJ of fuel to the filling station

$$\frac{WTT\ energy}{TTW\ energy} + 1$$

- Relative energy consumption (%)

$$\frac{WTW\ energy\ of\ the\ chain\ under\ consideration}{WTW\ of\ the\ reference\ chain} x\,100$$

- Reduction potential of energy consumption (%)

$$\frac{WTW\ of\ the\ reference\ chain\ -\ WTW\ of\ the\ chain\ under\ consideration}{WTW\ of\ the\ reference\ chain} x\,100$$

Positive results mean advantages for the chain under consideration compared with the reference chain.

- Shares of the total amount of primary energy coming from fossil, biomass, renewable (sun, water and wind) and nuclear sources.

Greenhouse gas (GHG) emissions for the whole energy chain (WTW)

Chains with negative emissions mean that the CO_2 credits (see below) are higher than the CO_2 emissions due to the combustion of fossil primary energies.

Presentation of energy-related results:

- Specific GHG-emissions (g/MJfuel)

$$\frac{WTT\ emissions + TTW\ emissions}{TTW\ energy}\ x\ 100$$

- Relative GHG-emissions (%)

$$\frac{WTW\ emissions\ of\ the\ chain\ under\ consideration}{WTW\ of\ the\ reference\ chain}\ x\ 100$$

- Reduction potential of the GHG-emissions (%)

$$\frac{WTW\ of\ the\ reference\ chain - WTW\ of\ the\ chain\ under\ consideration}{WTW\ of\ the\ reference\ chain}\ x\ 100$$

  Positive results mean advantages for the chain under consideration compared with the reference chain.

- CO_2 credits (gCO_2eq/km), i. e. due to the complete combustion of biomass-based fuels.

Primary energy quantity (PEQ) given in mass units for the whole energy chain,
i. e. total amount of energy expended divided by its lower heating value (LHV).

This computation is only possible for primary energies that can be weighed in kg.

- LHV for the biomasses is given on a dry matter basis; the moisture content is taken into account in computing the PEQ quantity.
- Typical LHV and moisture content data are to be found on page 9 of the **WTT APPENDIX 1**.
- PEQ can also be given as a specific value (kg/MJ)

$$\frac{PEQ}{TTW}$$

Land use demand (LU) given in area units for the whole energy chain,
i.e. the primary energy quantity (PEQ) divided by its yield per unit of area (kg/m^2).

The yield values are supplied by Ludwig-Bölkow-Systemtechnik GmbH.

- LU is also computed for chains based on sun and wind. In this case, LU is defined as a PEQ value expressed in energy (MJ/100km) divided by its energetic yield per unit of area (MJ/m^2). Energetic yield data are supplied by Ludwig-Bölkow-Systemtechnik GmbH.
- LU can also be given as a specific value (m^2/MJ), i.e. the land use demand (LU) for the delivery of 1 MJ of fuel to the filling station

$$\frac{LU}{TTW}$$

Water consumption (WU) given in volume units for the whole energy chain (l/100 km),
i.e. the specific water consumption for the process (l/MJfuel) multiplied by the TTW energy of the chain (MJ/100km).

The values of the specific water consumption are supplied by Ludwig-Bölkow-Systemtechnik GmbH.

- Negative results mean that the quantity of water received during the process as a byproduct is higher than the water consumption.
- This value can be also given as a specific value (l/MJ), i.e. the water consumption (WU) for the delivery of 1 MJ of fuel to the filling station

$$\frac{WU}{TTW}$$

The criteria are visualized as mean values. The values in the d-base are based both on statistics on current production methods and on technologies that are largely not yet fit for series production today. Therefore, some values are affected by a significant uncertainty. The software is able to visualize the uncertainty ranges of the values (Energy and GHG).

For further information about the method, see **WTW REPORT**.

TCO (Total Cost of Ownership)

OR computes the TCO with 4 approaches, according the values of depreciation rate (dr) and interest rate (ir) the users input.

Case	*Example*	*dr*	*ir*
A	• The car is purchased by the owner using her or his own money • It has not any residual value at the end of the ownership period	= 0	= 0
B	• The car is purchased by the owner using her or his own money, • It retains a residual value at the end of the ownership period	≠ 0	= 0
C	• The car is purchased by the owner using a loan (partial or full) • It has not any residual value at the end of the ownership period	= 0	≠ 0
D	• The car is purchased by the owner using a loan (partial or full) • It retains a residual value at the end of the ownership period	≠ 0	≠ 0

Two options can be applied to each approach, according the value of the DiscountRate:

1. *DiscountRate* = 0, the costs are not actualized;
2. *DiscountRate* ≠ 0, the costs are actualized (with Net Present Value method)

The total TCO, over the entire life of the car, is given by:

$$TotalAbsoluteTCO = VehicleCost + FixedCost + EnergyCost + OtherVariableCost$$

The TCO per km is:

$$TotalSpecificTCO = \frac{VehicleCost}{TotalMileage} + \frac{FixedCost}{TotalMileage} + \frac{EnergyCost}{TotalMileage} + \frac{OtherVariableCosts}{TotalMileage}$$

where

$$TotalMileage = AnnualMileage \cdot OwnershipYears$$

Initial cost

Approach A:

$$VehicleCost = InitialCost = UpfrontCost - CashBonus - DealerDiscount + HomeFuelStation + PurchaseTax$$

Approach B (InitialCost computed as in case A):

$$VehicleCost = VehicleValueLost = InitialCost\left[1-\left(1-dr\right)^{OwnershipYear}\right]$$

depreciation rate can be input either as a value or as a result of the following computation:

$$dr = 1 - MileageFactor^{TotalMileage} \cdot LifeFactor^{OwnershipYears}$$

Approach C (InitialCost computed as in case A):

- *DiscountRate* = 0

$$VehicleCost = CapitalCost = lf \cdot InitialCost \cdot \frac{ir}{1-(1+ir)^{-LoanYears}} \cdot LoanYears$$

- *DiscountRate* ≠ 0

$$VehicleCost = CapitalCost = lf \cdot InitialCost \cdot \frac{ir}{1-(1+ir)^{-LoanYears}} \cdot \sum_{i=1}^{OwnershipYears} \frac{1}{\left(1-DiscountRate\right)^{i}}$$

Approach D (InitialCost computed as in case A):

$$VehicleCost = CapitalCost - ResidualValue = CapitalCost - \left(VehicleValueLost - InitialCost\right)$$

where VehicleValueLost is computed as case B and CapitalCost is computed as case C.

Notes:

- *UpfrontCost*: the official selling price.
- *CashBonus*: cash subsidy for the car purchase.
- *DealerDiscount*: dealer's discount.
- *HomeFuelStation*: the cost of the charging station, if any.
- *PurchaseTax*: tax payed at the car purchase.
- *MileageFactor*: defines how the value lost depends on the total mileage.
- *LifeFactor*: defines how the value lost depends on the car age.
- *lf*: the % of initial cost which is covered by a loan

EnergyCosts

They can be computed either with a constant price during the OwnershipYears or with a linear variable price. The energy cost can be variable year by year, therefore the total cost is

- *DiscountRate* = 0

$$EnergyCost = \sum_{i=1}^{OwnershipYears} EnergyCost_i$$

- *DiscountRate* ≠ 0

$$EnergyCost = \sum_{i=1}^{OwnershipYears} \frac{EnergyCost_i}{\left(1+DiscountRate\right)^i}$$

For non-plug-in powertrains, the energy cost for the generic year i, is:

$$EnergyCost_i = TTWEn \cdot FuelCost \cdot \left(1+cf\right)^i \cdot AnnualMileage$$

For pure electric vehicles, the electricity cost can be different if the car is charged at home or at a public charging station. If the index 1 and 2 represents the two charging options, then the energy cost in the generic year i, is

$$EnergyCost_i = TTWEn \cdot \left[kfo \cdot FuelCost_1 \cdot \left(1+cf_1\right)^i + \left(1-kfo\right) \cdot FuelCost_2 \left(1+cf_2\right)^i\right] AnnualMileage$$

For PHEVs and REEVs the two above formulas are used to compute the fuel cost and the electricity cost.

Notes:

- *TTWEn*: TTW energy consumption
- *kfo*: the ratio between the energy charged with the charging option 1 to the whole charged energy. For instance if 1 represents home charging and 2 public charging, kfo = 0.9 means that 90% of charging is done at home.
- *FuelCost*: fuel (energy) cost
- *cf*: a factor giving the annual variation of fuel cost

OtherVariableCosts

The costs depending on the yearly mileage.

- *DiscountRate* = 0

$$OtherVariableCosts = \left(Tires + Maintenance + BatteryLease + CO_2SocialCost\right) \cdot AnnualMileage \cdot OwnershipYears$$

- *DiscountRate* ≠ 0

$$OtherVariableCosts = \left(Tires + Maintenance + BatteryLease + CO_2SocialCost\right) \cdot AnnualMileage \cdot \sum_{i=1}^{OwnershipYears} \frac{1}{\left(1+DiscountRate\right)^i}$$

Notes:

- *Tires*: cost of tires
- *Maintenance*: maintenance cost
- *BatteryLease*: battery lease per km
- *CO_2SocialCost*: the environmental cost due to the GHG emissions of the whole chain (WTWGHGEmissions), given by

$$CO_2SocialCost = CO_2Cost \cdot WTWGHGEmissions$$

- *CO_2Cost*: the environmental cost for of each gram of emitted GHG.

FixedCosts

The costs paid on yearly base.

- *DiscountRate* = 0

$$FixedCosts = \left(Tax + Insurance + Repair + CareCost + UseCost - ParticipationGridRegulation\right) \cdot OwnershipYears + DisposalCost$$

- *DiscountRate* ≠ 0

$$FixedCosts = \left(Tax + Insurance + Repair + CareCost + UseCost - ParticipationGridRegulation\right) \cdot \sum_{i=1}^{OwnershipYears} \frac{1}{\left(1 + DiscountRate\right)^{i}} + DisposalCost$$

Notes:

- *Tax*: total amount of taxes paid on yearly base.
- *Insurance*: total amount of insurance fees on yearly base
- *Repair*: repair cost
- *UseCost*: cost related to the fees like parking, highways, road pricing and similar.
- *ParticipationGridRegulation*: income that plug-in vehicles could get from the grid operators to allow them to use the car battery for grid regulation purposes.
- *DisposalCost*: cost related to the car scrapping and recycling at the end of life.

For any question or suggestion about the software developement, please contact:

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