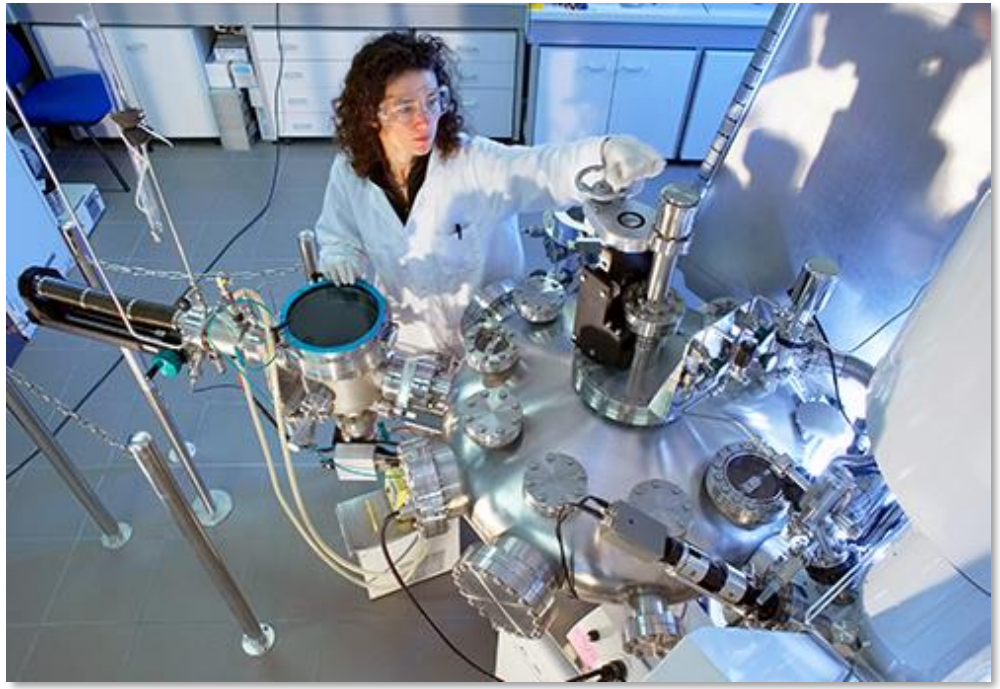
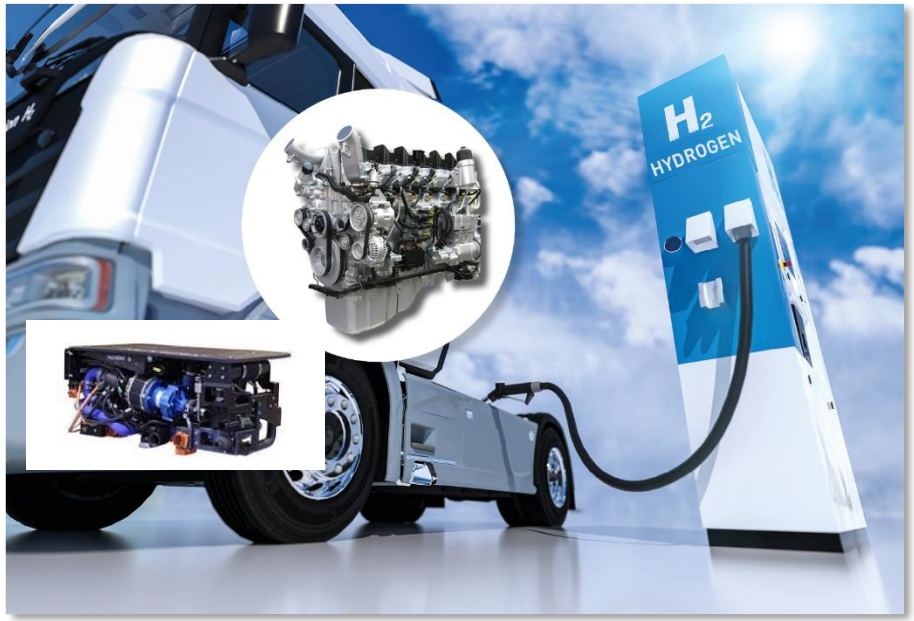




15th Concawe Symposium

Session2: Opportunities, how to make the low carbon transition successful?

LCA as a method and a tool (passenger cars and HDV)

Joris Melgar

IFP Energies nouvelles

ABOUT US

A public sector **R&I** body

A **training** center

An industrial **group**

An international scope in the fields of energy, transport and the environment

1,635 people

1,190 engineers and technicians dedicated to research

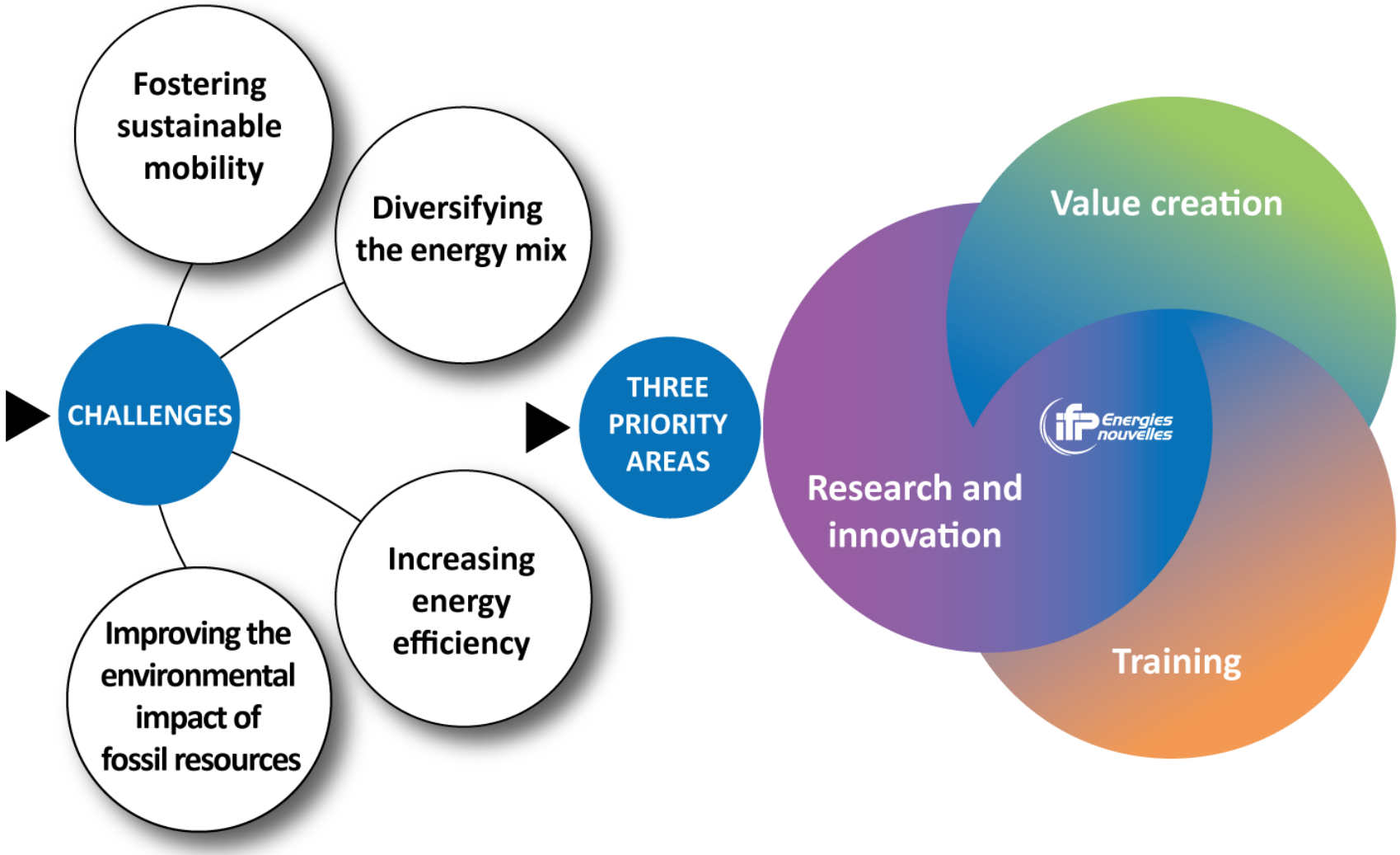
€120.5m budget allocation In 2020

€146.5m own resources In 2020

OUR MISSION

Context

Climate change and ecological transition



OUR R&I FOCUS AREAS

Sustainable mobility

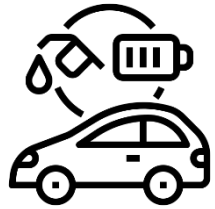
- Developing vehicle electrification
- Offering solutions for connected mobility
- Improving IC powertrains
- Optimizing the use of alternative fuels

LCA AS A METHOD AND A TOOL (PASSENGER CARS AND HDV)

Sustainable mobility

- Introduction to Life Cycle Assessment (LCA)

- **Concawe's light passenger vehicle CO_2 emissions comparator**
  - Purpose : Evaluation of PHEVs in real-world conditions
  - Methodology : experimental data and simulation results



Concawe
Environmental Science for European Refining

- **Concawe's heavy duty vehicle CO_2 emissions comparator**
  - Purpose : Comparison of CO2eq emissions over HDVs applications
  - Methodology : Simulation calibration and extrapolation

- Limits and perspectives

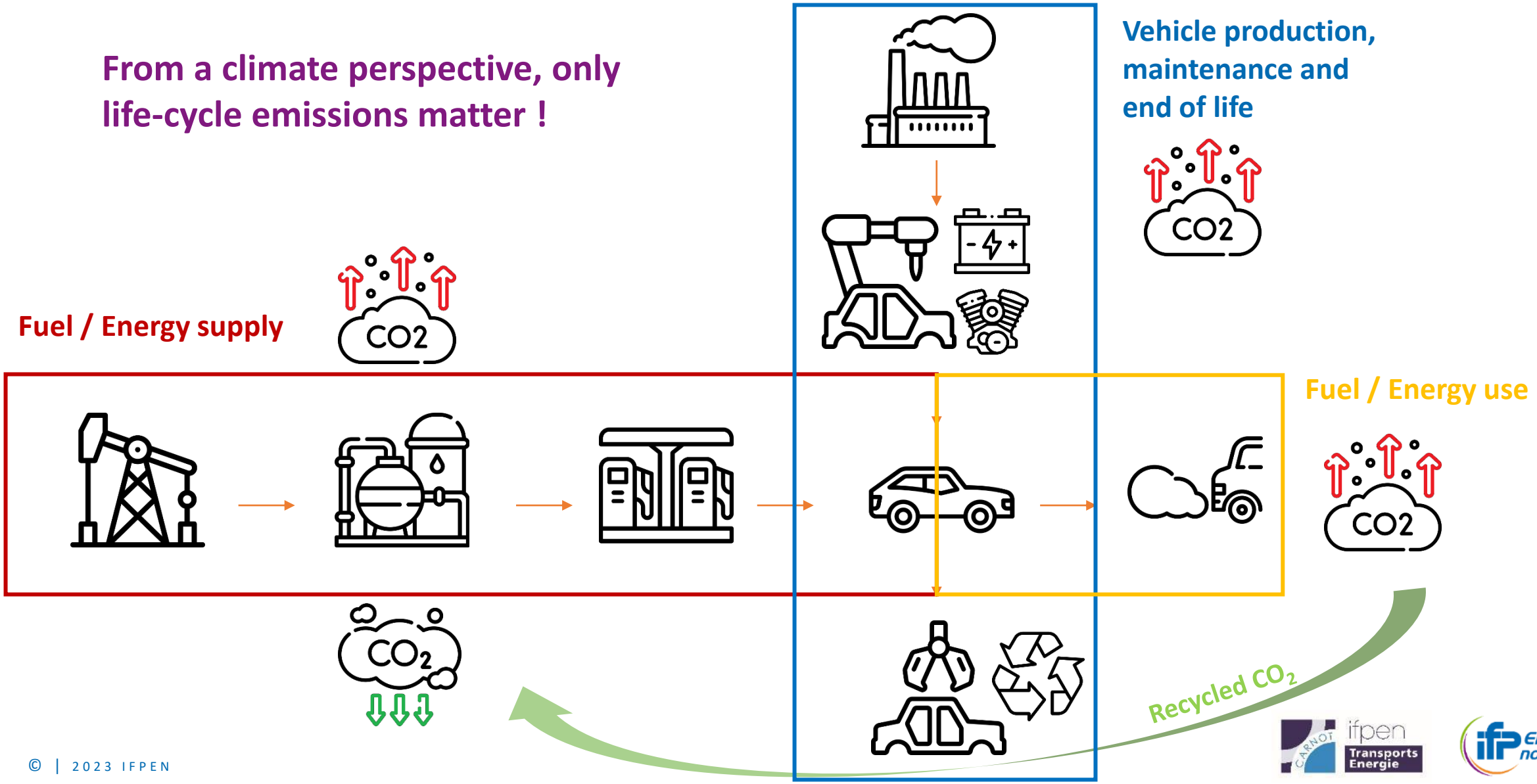
ifpen Transports Energie

ifp Energies nouvelles

INTRODUCTION TO LIFE CYCLE ASSESSMENT (LCA)

Sustainable mobility

From a climate perspective, only life-cycle emissions matter !



CONCAWE'S LIGHT PASSENGER VEHICLE CO2 EMISSIONS COMPARATOR

Sustainable mobility

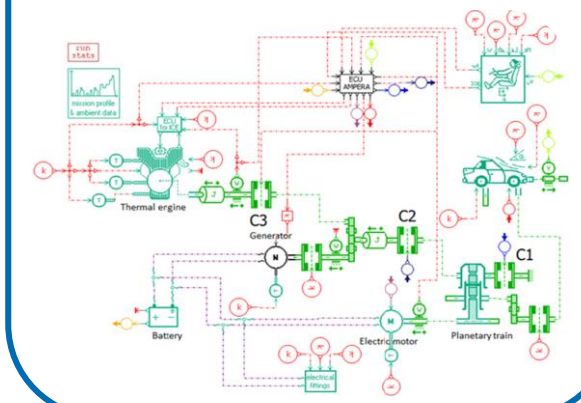
2020-2022 Concawe/IFPEN collaboration : ***"Evaluation of Plug-in Hybrid Electric Vehicles in real-world conditions"***

- **Experimental** campaign on 2 tested PHEVs :
  - In-lab and on-road
  - Between -2°C and +35°C
  - Gasoline, Diesel and renewable fuels
  - Recharged and uncharged conditions
  - Various driving profiles
- Calibration of a **simulation platform** for vehicle energy assessment
- Integration of **CO2 emission factors** linked to use and manufacture
- Development of an emissions **comparison tool**

CONCAWE'S LIGHT PASSENGER VEHICLE CO2 EMISSIONS COMPARATOR

Sustainable mobility

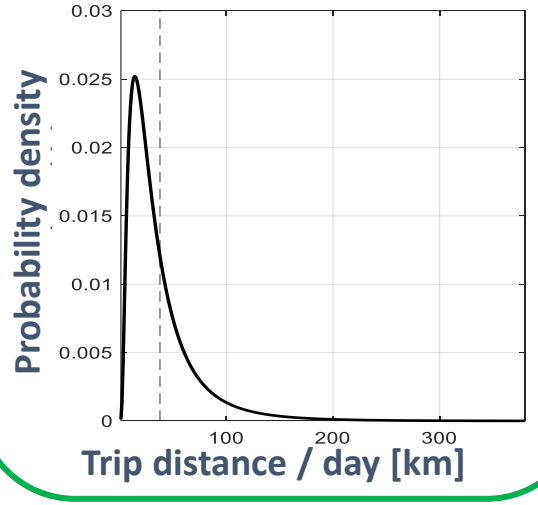
PHEV simulator



Calibrated on experimental data

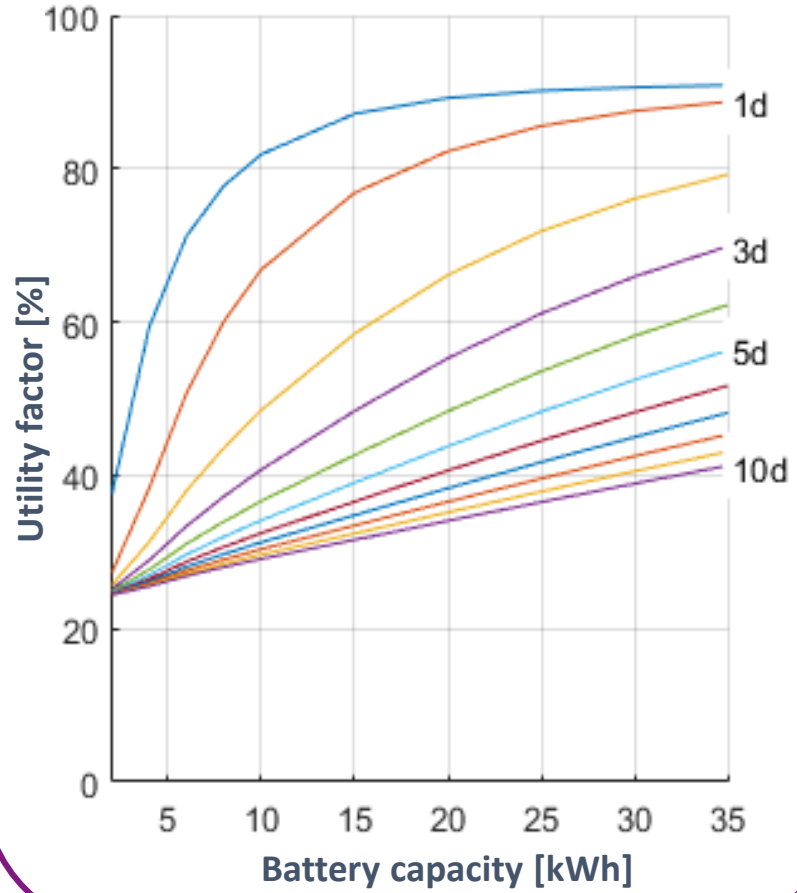
+50'000 simulations!

Use cases



Statistical model

Real-world performance

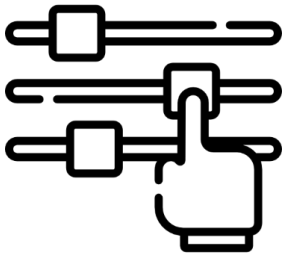


CONCAWE'S LIGHT PASSENGER VEHICLE CO2 EMISSIONS COMPARATOR

Sustainable mobility

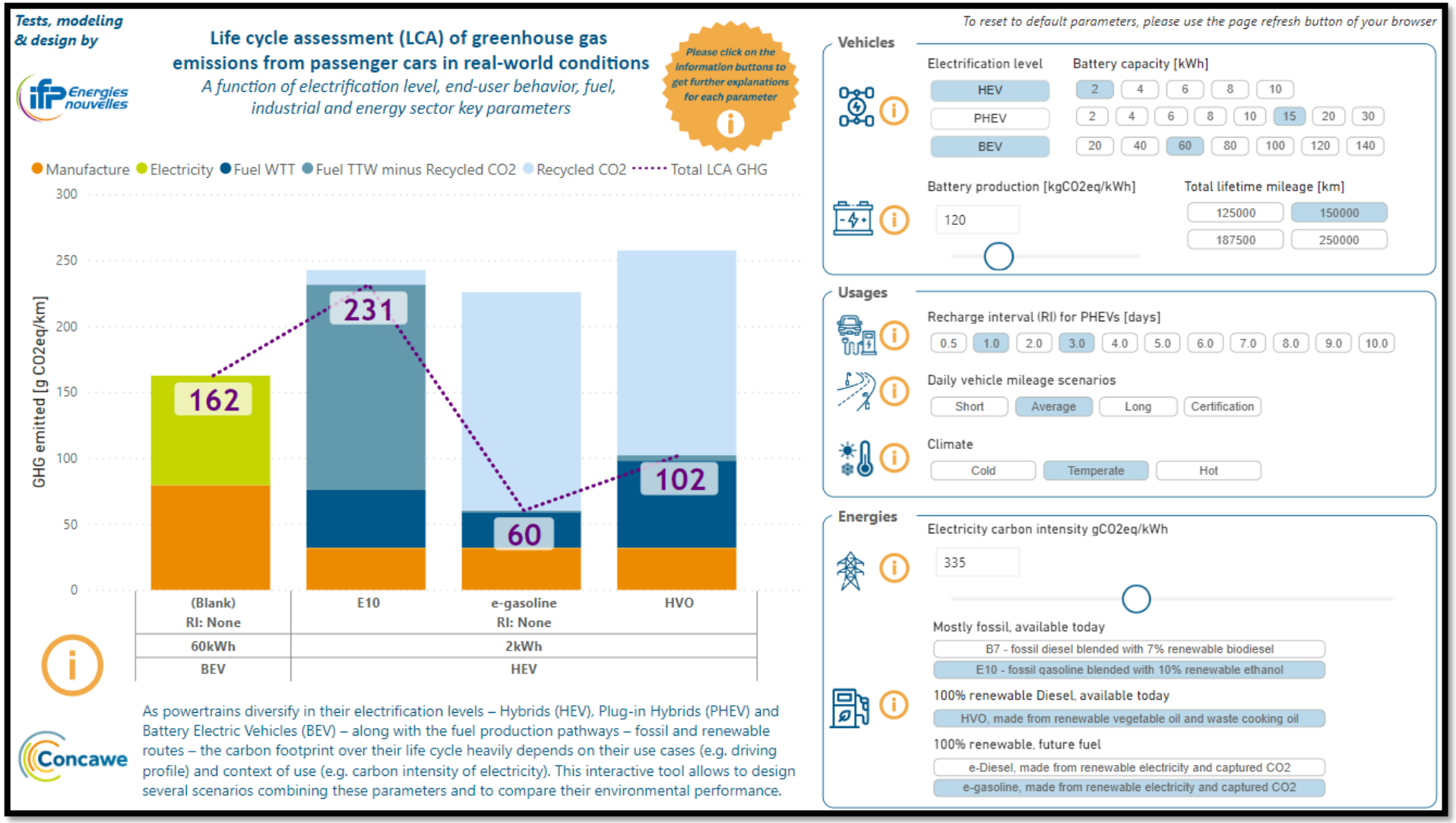
An interactive tool, with guided scenarios, allowing to compare life-cycle CO2 emissions from passenger cars, function of your own use case and own sensitivities according to parameters :

- **Configuration and design of the vehicles**
  - Hybrids, Plug-in hybrids and Electric cars
  - Battery capacity and emission related to its manufacture
  - Lifetime mileage
- **Usage of the vehicles**
  - Recharge frequency for the plug-in hybrids
  - Typical trip profiles
  - Climate conditions
- **Energy carriers**
  - Carbon intensity of electricity used
  - Fuels, with fossil and renewable options



CONCAWE'S LIGHT PASSENGER VEHICLE CO2 EMISSIONS COMPARATOR

Sustainable mobility



https://www.carsco2comparator.eu/

CONCAWE'S HEAVY DUTY VEHICLE CO_2 EMISSIONS COMPARATOR

Sustainable mobility

2023 Concawe/IFPEN collaboration "A life-cycle assessment tool for heavy-duty vehicles"

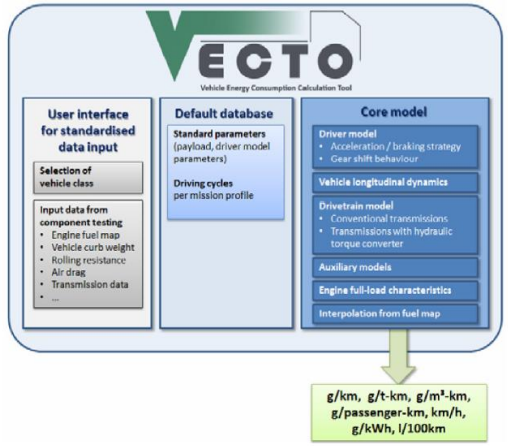
- Calibration of a **simulation platform** for vehicle energy assessment
- Integration of **CO2 emission factors** linked to use and manufacture
- Development of an emissions **comparison tool**

https://hdvco2comparator.eu/

CONCAWE'S HEAVY DUTY VEHICLE CO_2 EMISSIONS COMPARATOR

Sustainable mobility

Simcenter Amesim simulation platform



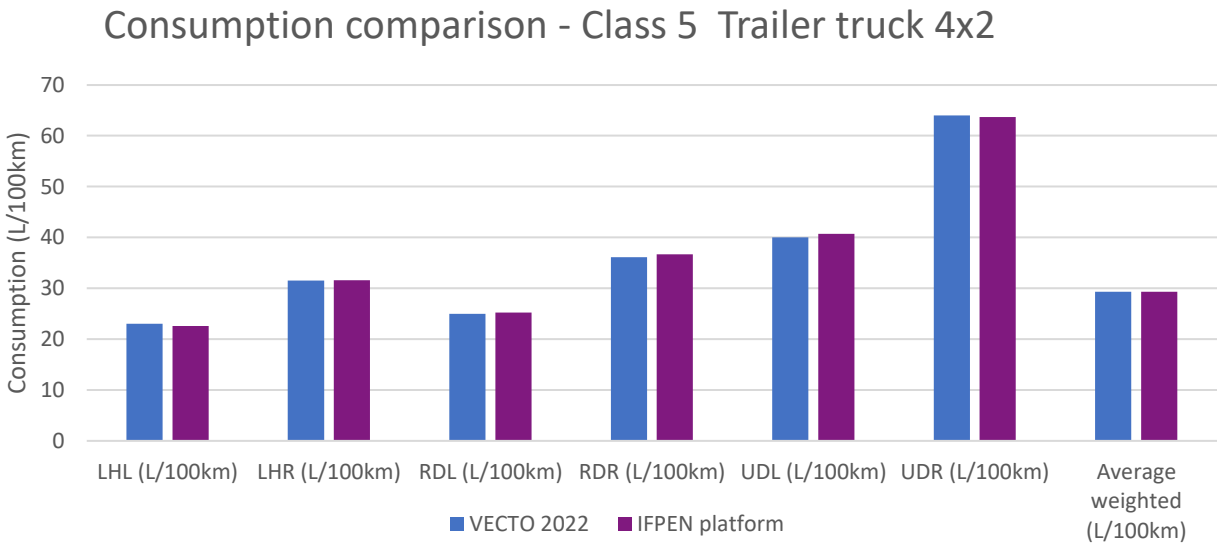
→ **Calibration of ICEVs models on VECTO tool and data** (*developed on behalf of European Commission-JRC by TU-Graz*)

VECTO : Expert tool to simulates CO2 emissions and fuel consumption based on vehicle longitudinal dynamics. It is developed on behalf of European Commission-JRC by TU-Graz

Used for :

- CO2 certification of HDV in the EU
- CO2 emissions definition of the European heavy duty vehicle fleet

Electrified powertrains not covered by current version !



CONCAWE'S HEAVY DUTY VEHICLE CO_2 EMISSIONS COMPARATOR

Sustainable mobility

Simcenter Amesim simulation platform

- **Literature review to define powertrains sizing**
- Creation of **dedicated Simcenter Amesim sketches for each powertrain archicture** (ICEV, HEV, BEV and FCEV)

Powertrain	Energy carrier	Class 5 Long haul	Class 2 delivery	City bus 12m	Coach	Refuse truck
ICE	Diesel	12.8L / 400kW /2700Nm / 12gears	7.1L / 225kW /1130Nm / 12gears	7.1L / 225kW /2700Nm / 6 gears	7.7L / 250kW / 1400Nm / 6 gears	7.1L / 225kW /2700Nm / 6 gears
	CNG	12.9L / 340kW/ 2000Nm / 12gears	9L / 225kW/ 1150Nm / 12gears	9L / 225kW/ 1150Nm / 6 gears	9L / 225kW/ 1150Nm / 6 gears	9L / 225kW/ 1150Nm / 6 gears
	H2	15.2L / 410kW/ 1950Nm / 12gears	9.3L / 220kW /1100Nm / 12gears	9.3L / 220kW/ 1100Nm / 6 gears	9.3L / 220kW/ 1100Nm / 6 gears	9.3L / 220kW/ 1100Nm / 6 gears
HEV	Diesel	12.8L / 400kW /2700Nm / batt 20kWh/ e-motor 150kW / 12gears	7.1L / 225kW /1130Nm / batt 30kWh/ e-motor 100kW / 12gears	7.1L / 225kW /1130Nm / batt 10kWh/ e-motor 35kW -250Nm / 6 gears	7.7L / 250kW /1400Nm / batt 10kWh/ e-motor 35kW – 250Nm / 6 gears	7.1L / 225kW /1130Nm / batt 10kWh/ e-motor 35kW - 250Nm / 6 gears
PHEV	Diesel / Electricity	12.8L / 400kW /2700Nm / batt 130kWh/ e-motor 250kW -1100Nm / 12gears	7.1L / 225kW /1130Nm / batt 100kWh/ e-motor 250kW -1100Nm / 12gears	7.1L / 225kW /1130Nm / batt 100kWh/ e-motor 160kW-400Nm / 6gears	7.1L / 225kW /1130Nm / batt 35kWh/ e-motor 160kW-400Nm / 6gears	7.1L / 225kW /1130Nm / batt 35kWh/ e-motor 160kW - 400Nm / 6gears
BEV	Electricity	batt 400kWh / e-motor 350kW-2000Nm-5krpm / 2gears	batt 300kWh / e-motor 250kW-1100Nm / 2gears	batt 400kWh / e-motor 250kW-1100Nm / 2gears	batt 500kWh / e-motor 300kW -1500Nm / 2gears	batt 300kWh / e-motor 250kW-1100Nm / 2gears
FCEV	H2	FC 225kW / H2 50kg / batt 100kWh / e-motor 350kW-2000Nm-5krpm / 2gears	#1 :FC 225kW / H2 30kg / batt 20kWh / e-motor 250kW-1100Nm / 2gears #2 :FC 75kW / H2 15kg / batt 100kWh / e-motor 250kW-1100Nm / 2gears	FC 75kW / H2 35kg / batt 75kWh / e-motor 250kW-1100Nm / 2gears	FC 75kW / H2 35kg / batt 75kWh / e-motor 300kW - 1500Nm / 2gears	FC 75kW / H2 25kg / batt 75kWh / e-motor 250kW - 1100Nm/ 2gears

→ IFPEN Simcenter Amesim platform allows for **extending energy comparisons** (other than conventional diesel)

→ A **vehicle / powertrain sizing matrix** is proposed for consumption and LCA analysis

CONCAWE'S HEAVY DUTY VEHICLE CO_2 EMISSIONS COMPARATOR

Sustainable mobility

Total vehicle CO2eq emissions

Energy supply (WtT) : data related to fuels and electricity carbon intensity

Variable WtT emission factors :

- *Electric carbon intensity*
- *H2 production (blue/green/grey)*
- *Fuel (biofuel, e-fuel, renewable gas etc..)*

Sources :

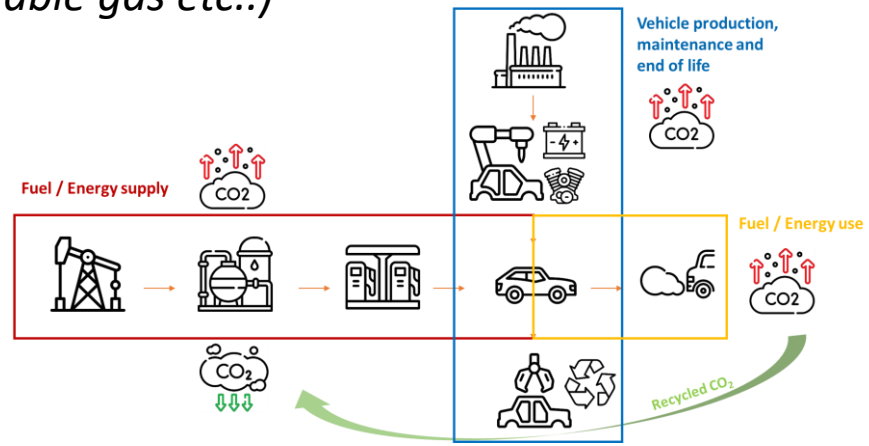
- *JEC v5 2020*
- *Concawe 17/22 report*
- *JRC Scarlat 2022 report*

Vehicle life cycle :

Performed using SimaPro® version 9.2.0.2 + Ecoinvent v.3.7.1 LCA database + Environmental Footprint reference packages 3.0 (European commission)

Variable production emission factors :

- *Battery*
- *Fuel cell*
- *H2 tank*



Energy use (TtW) :

Energy and fuel consumptions from simulations

Variable parameters for vehicle energy consumptions :

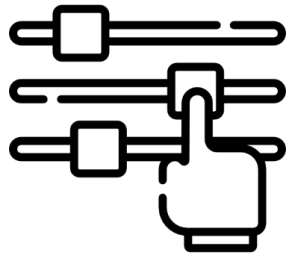
- *Powertrain sizing and efficiency*
- *Usage*

CONCAWE'S HEAVY DUTY VEHICLE CO_2 EMISSIONS COMPARATOR

Sustainable mobility

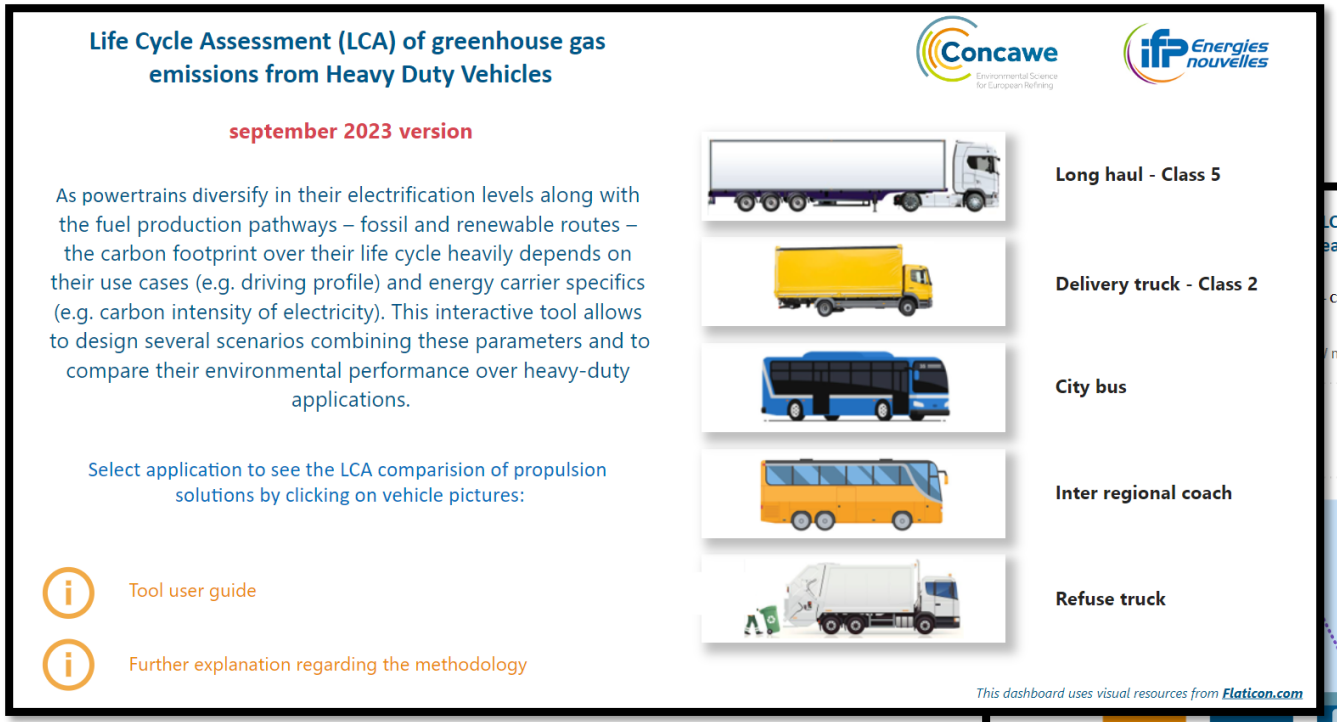
An interactive tool, with guided scenarios, allowing to compare life-cycle CO2 emissions from heavy-duty applications (trucks and buses) :

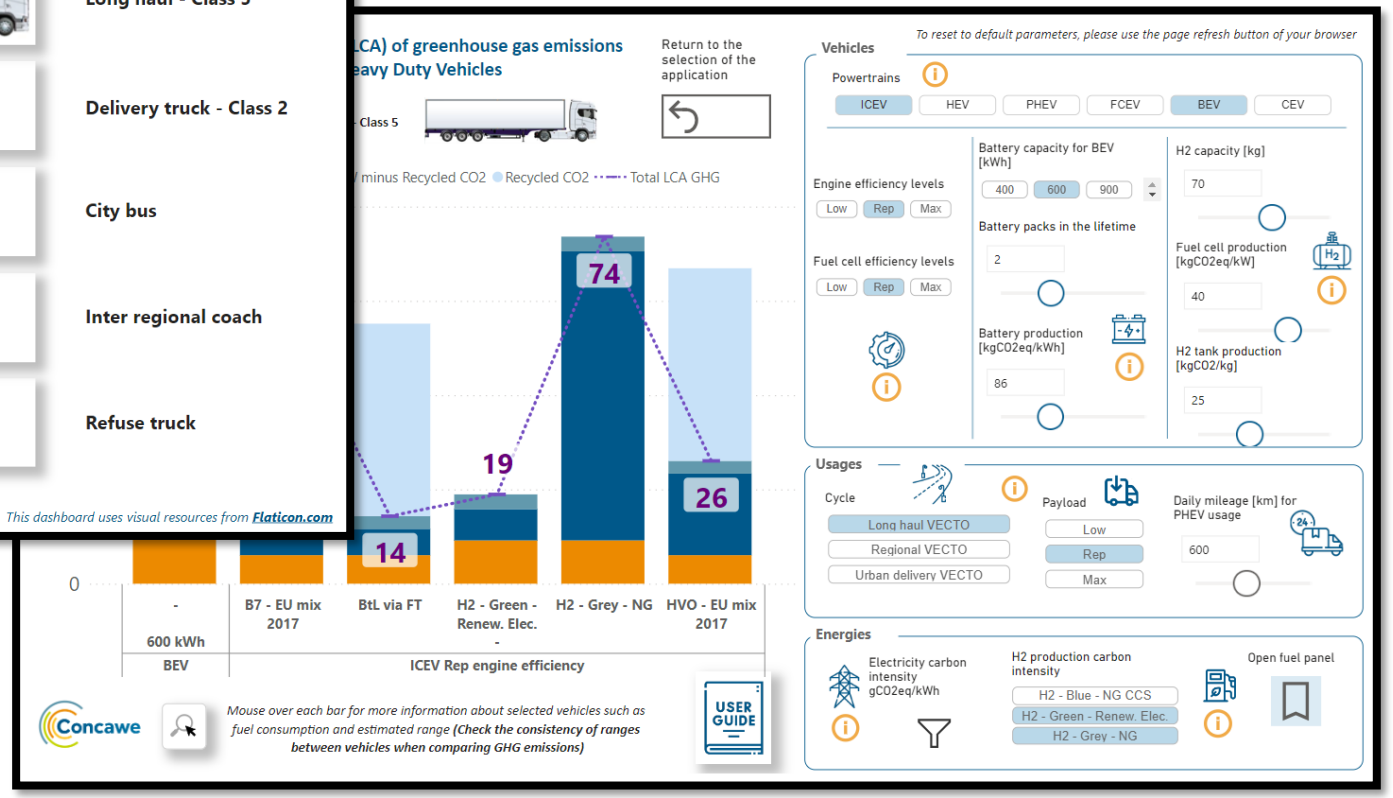
- **Configuration and design of the vehicles**
  - ICEVs, HEVs, PHEVs, Electric and Fuel Cell vehicles
  - Battery capacity and emission related to its manufacture
  - H2 capacity and emission related to carbon fiber tank manufacture
  - Powertrain efficiencies
- **Usage of the vehicles**
  - Payloads
  - Typical trip profiles
- **Energy carriers**
  - Carbon intensity of electricity used
  - Diesel-like, Gas and H2 with fossil and renewable options



CONCAWE'S HEAVY DUTY VEHICLE CO_2 EMISSIONS COMPARATOR

Sustainable mobility





https://hdvco2comparator.eu/

→ live demo !

CONCLUSIONS

Sustainable mobility

→**The tools created by Concawe and IFPEN utilize energetic simulation results and emission factors derived from LCA to assess and contrast the CO2eq emissions of various propulsion options for both passenger cars and heavy-duty vehicles**

→**These tools are designed to guide the public and decision-makers in identifying solutions for decarbonising the road transport sector**

A peer-reviewed scientific paper outlining the first study's methodology

Evaluation of plug-in hybrid vehicles in real-world conditions by simulation

→**The tools do a lot but do not answer all questions :**

❑**The environmental analysis only focuses on CO2eq emissions**

Other environmental impacts such as consumption of water and raw materials and emissions of local pollutants should not be overlooked

❑ **Economic considerations would be relevant to complete the comparison of technologies**

❑ **Periodic updates are essential to incorporate the ongoing energy and technological advancements within the transport sector**