



An introduction to Concawe's vehicle life-cycle CO₂ emissions comparator

8th November 2022

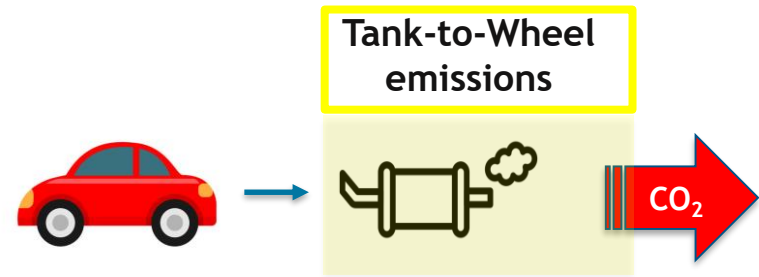
Roland Dauphin, Science Executive Fuels Quality & Emissions

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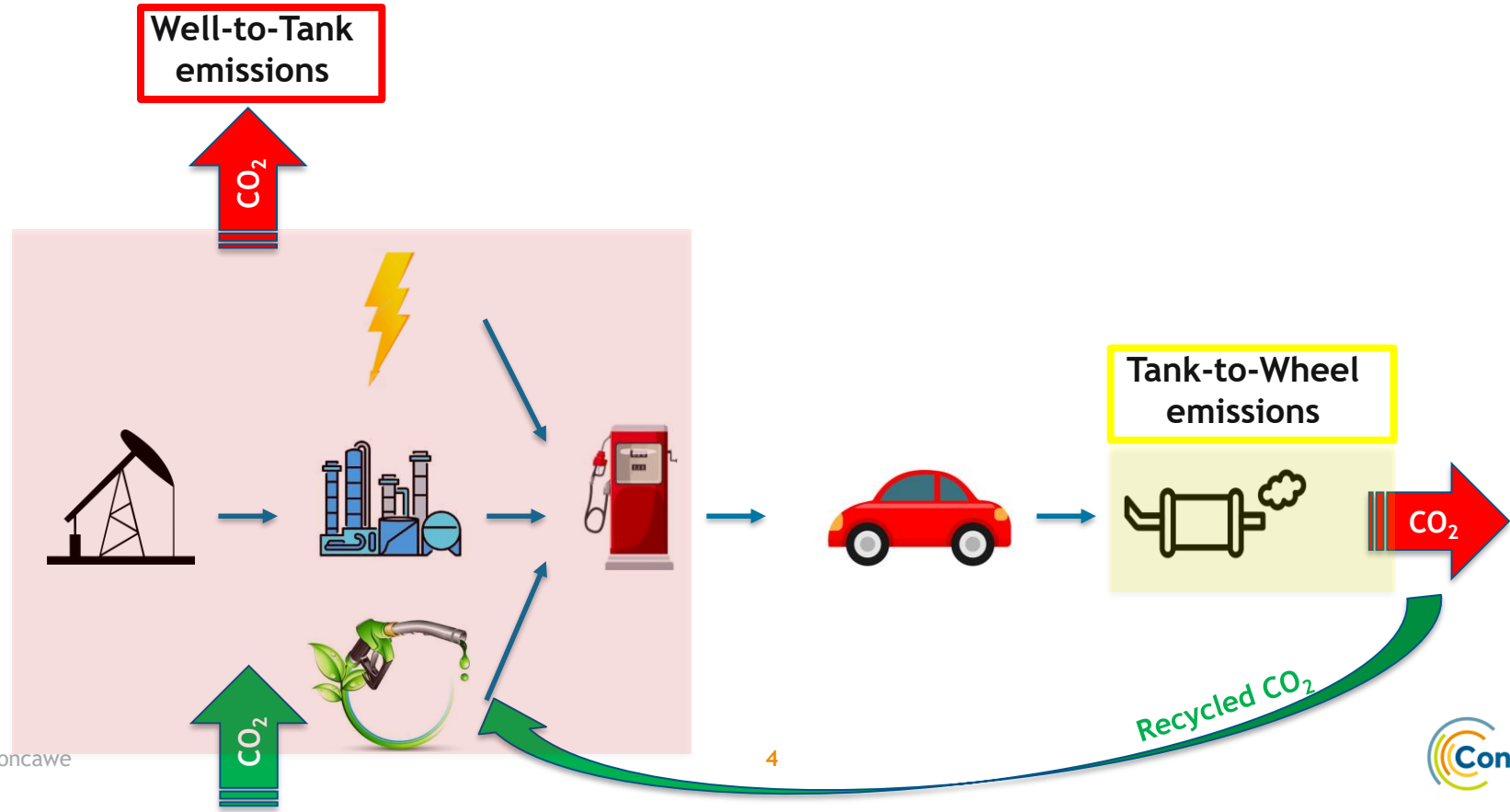
Outline

- **Introduction to life-cycle assessment (LCA)**
 - *Purpose of life-cycle assessment*
 - *Why life-cycle assessment matters*
 - *What is challenging about life-cycle assessment?*
- **Concawe's vehicle life-cycle CO₂ emissions comparator**
 - *Purpose of the CO₂ comparator*
 - *How does it work?*
 - *Demonstration of the CO₂ comparator*
- **Limits to the selected approach**

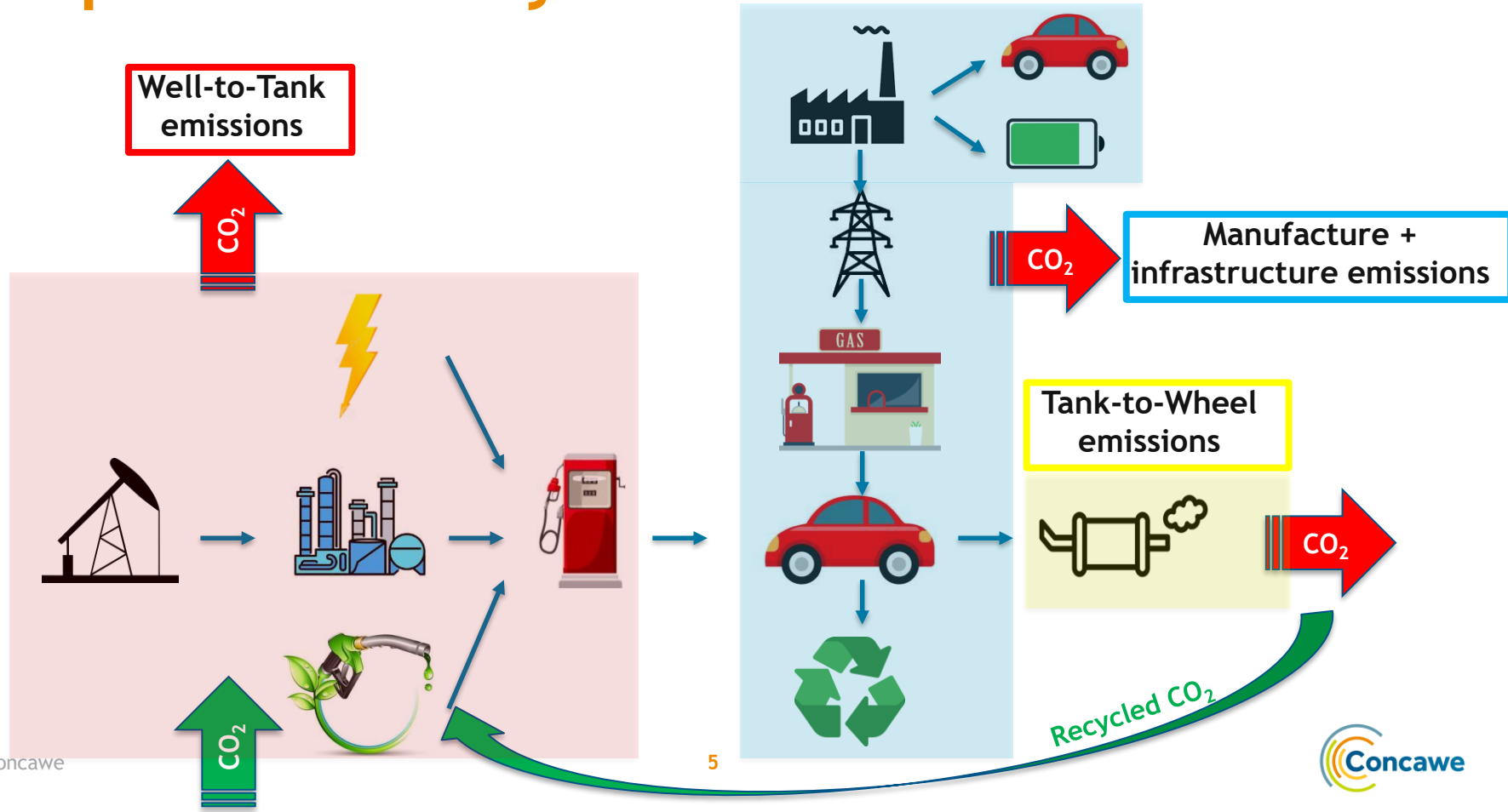
Purpose of life-cycle assessment



Purpose of life-cycle assessment

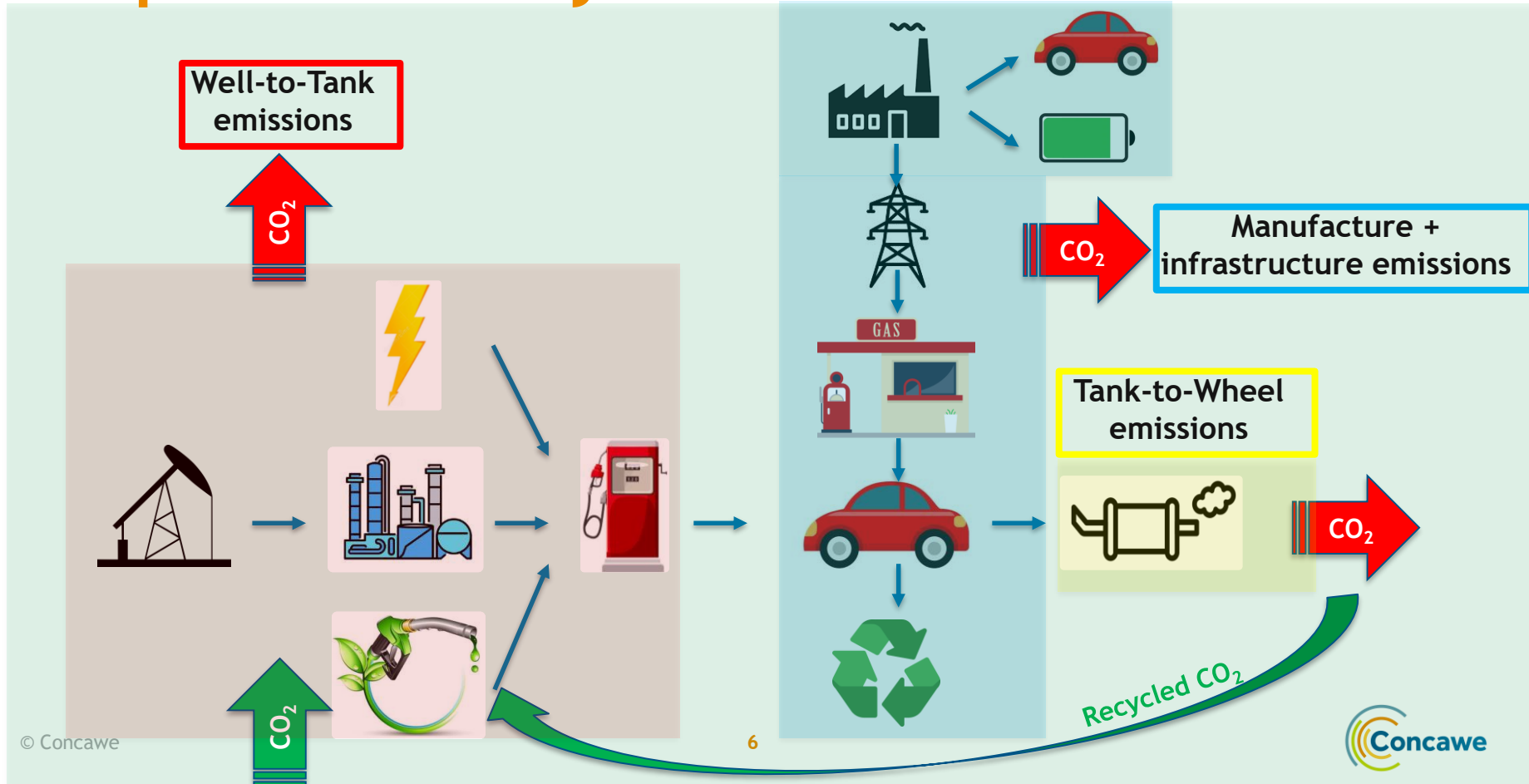


Purpose of life-cycle assessment



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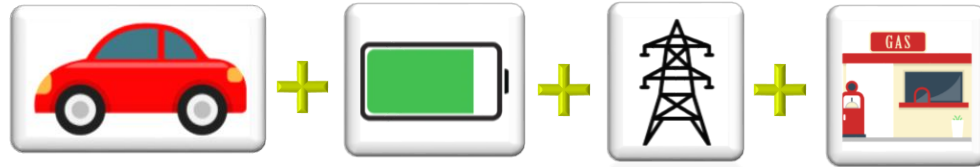
Life-cycle emissions



Why life-cycle assessment matters

- From a climate perspective, it does not matter whether the greenhouse gases are emitted

- *During the production of the car and infrastructure*



- *During the production of the energy carrier*











- *Or at the tailpipe*














From a climate perspective, only life-cycle emissions matter

What is challenging about life-cycle assessment?

Emissions	Measurable?	Regulated?
Tank-to-Wheel (tailpipe)		
Well-to-Tank		
Manufacture, infrastructure and recycling		
Life-cycle		

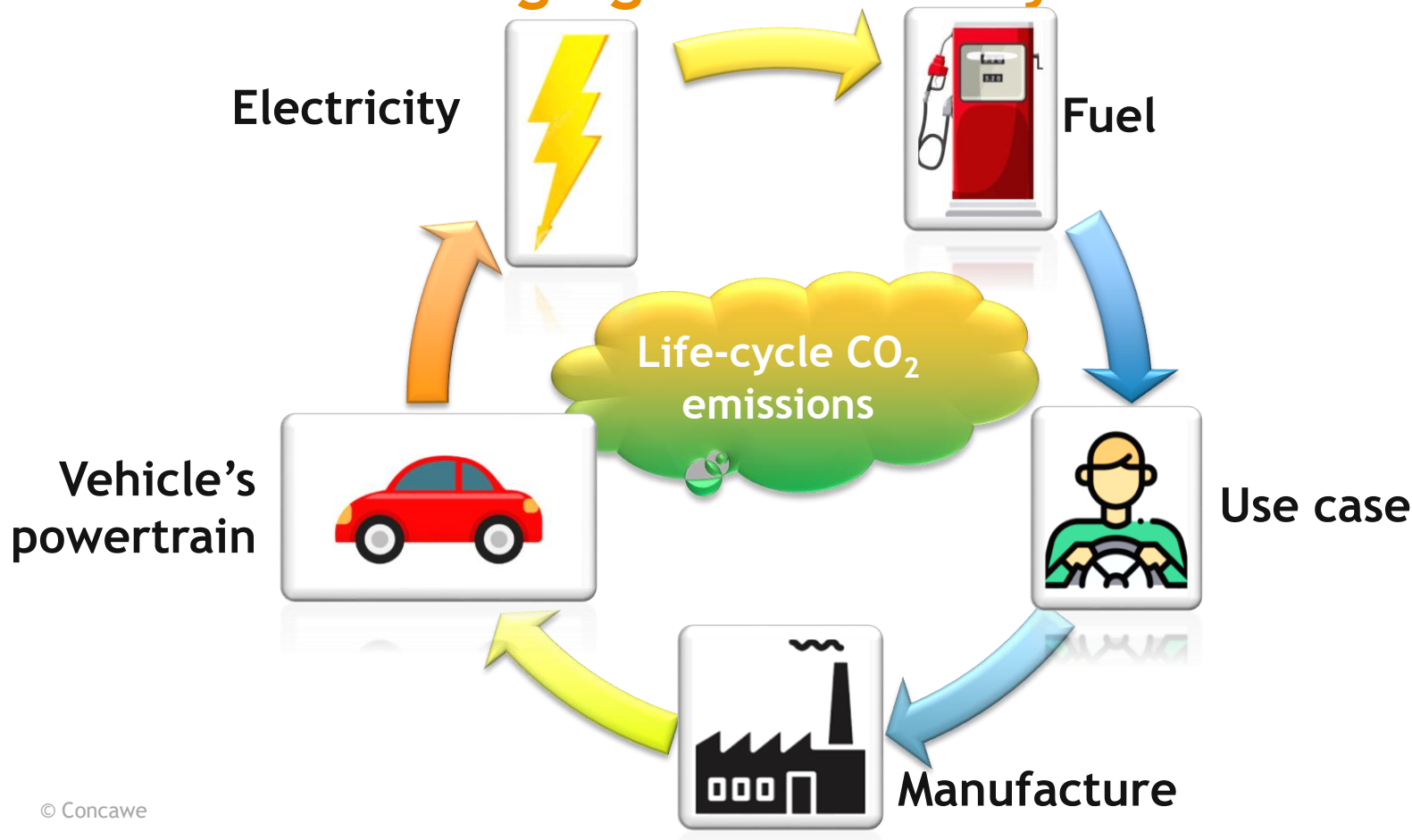
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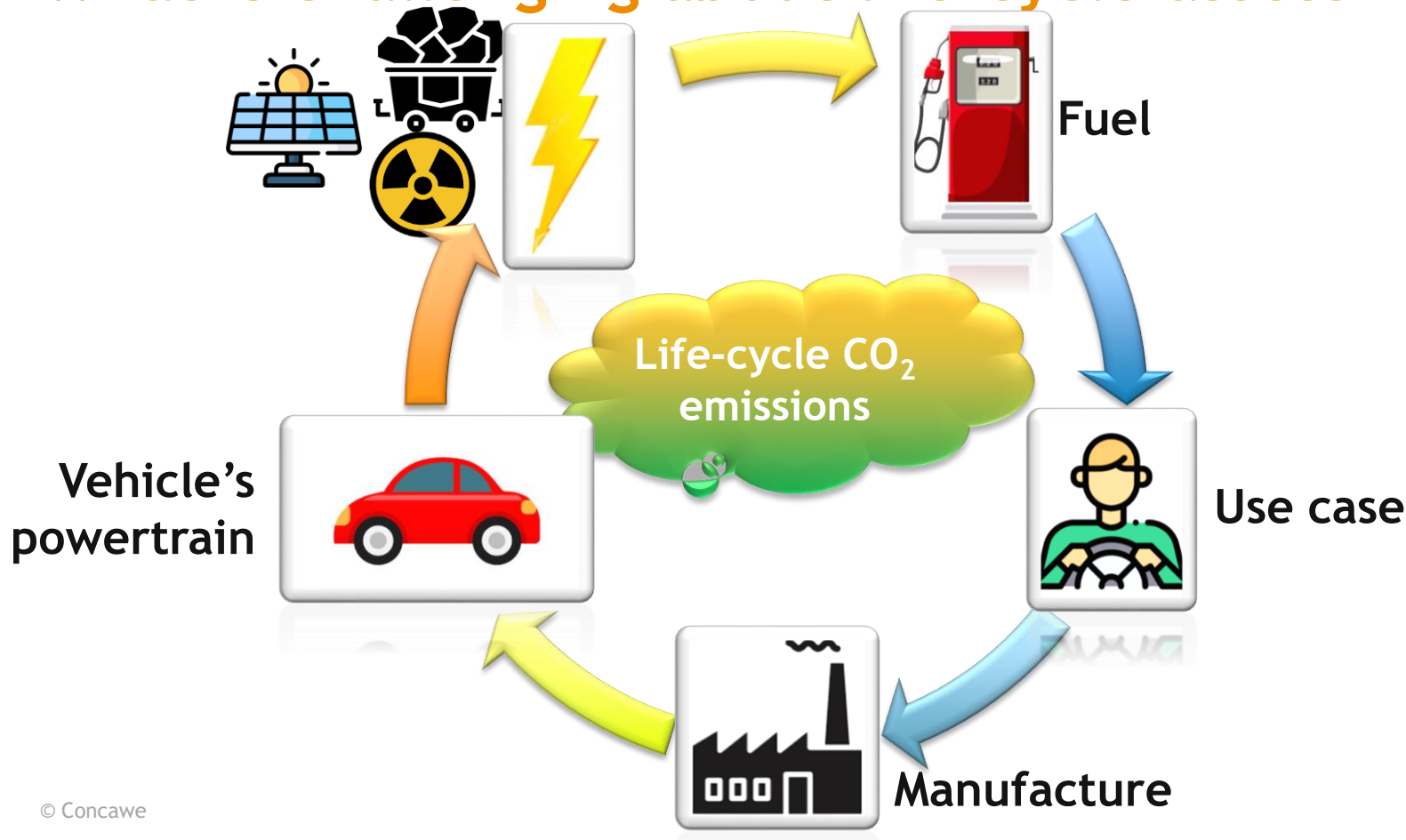
Evaluation means:

- Assumptions
- Scenarios
- Use cases
- Etc.

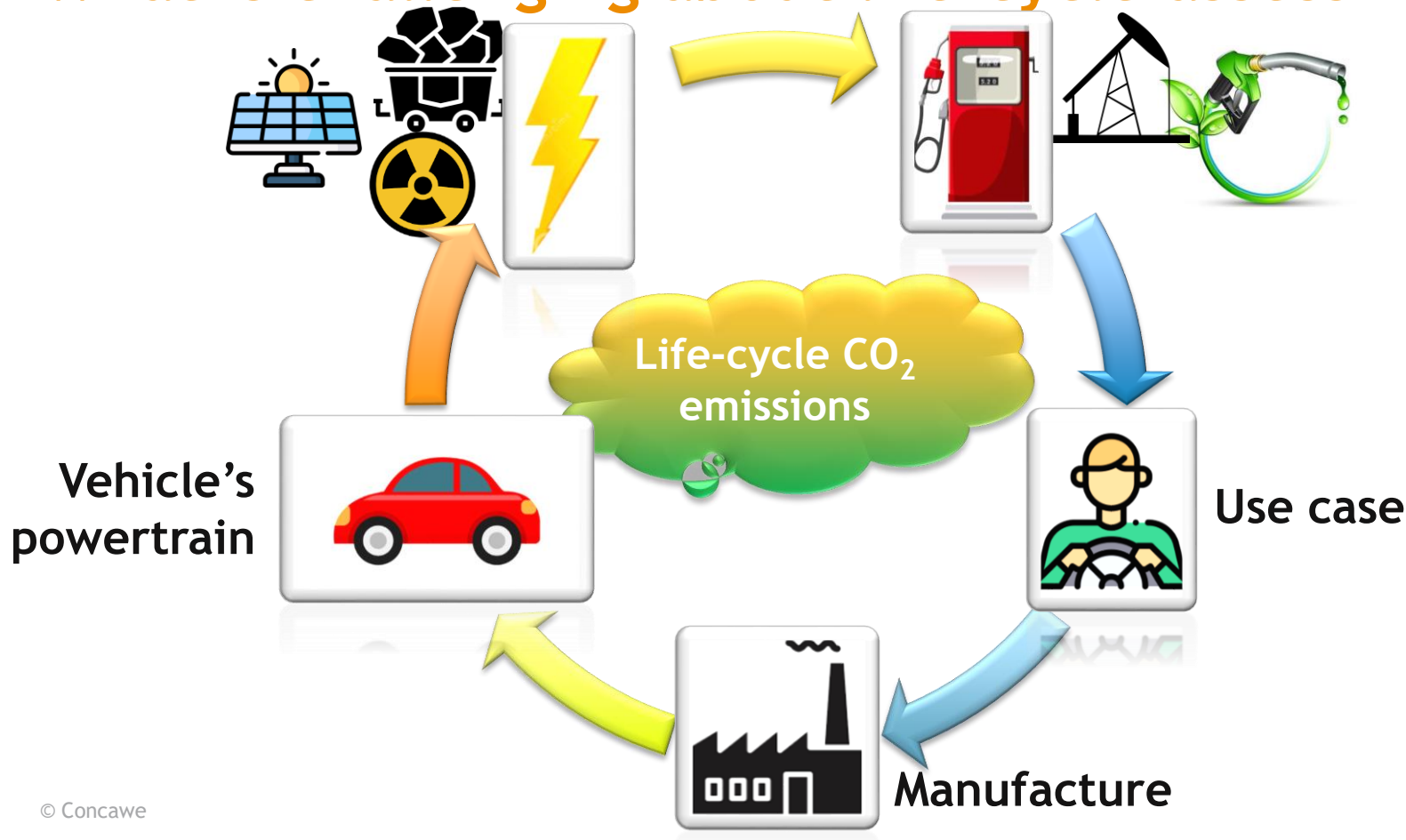
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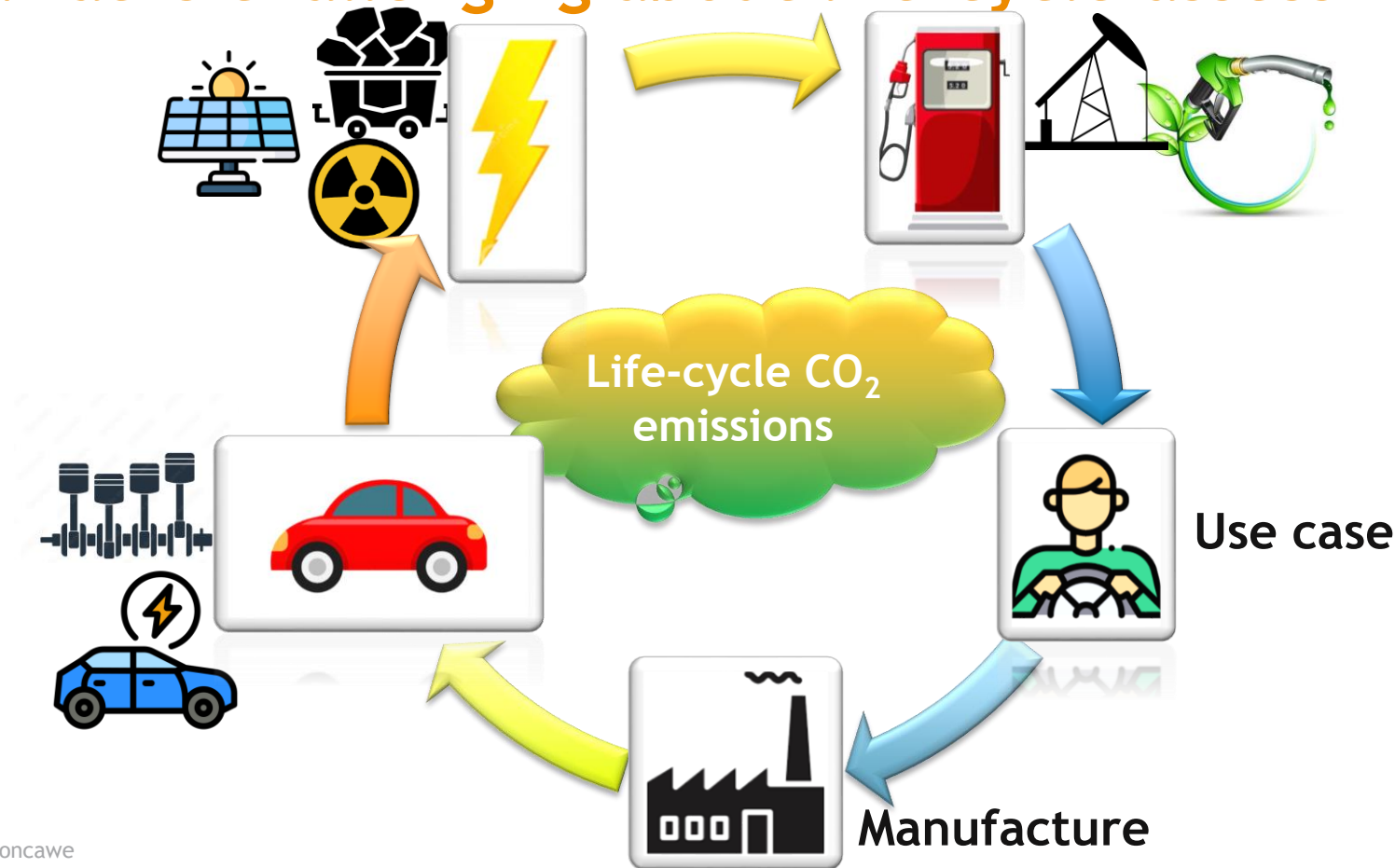
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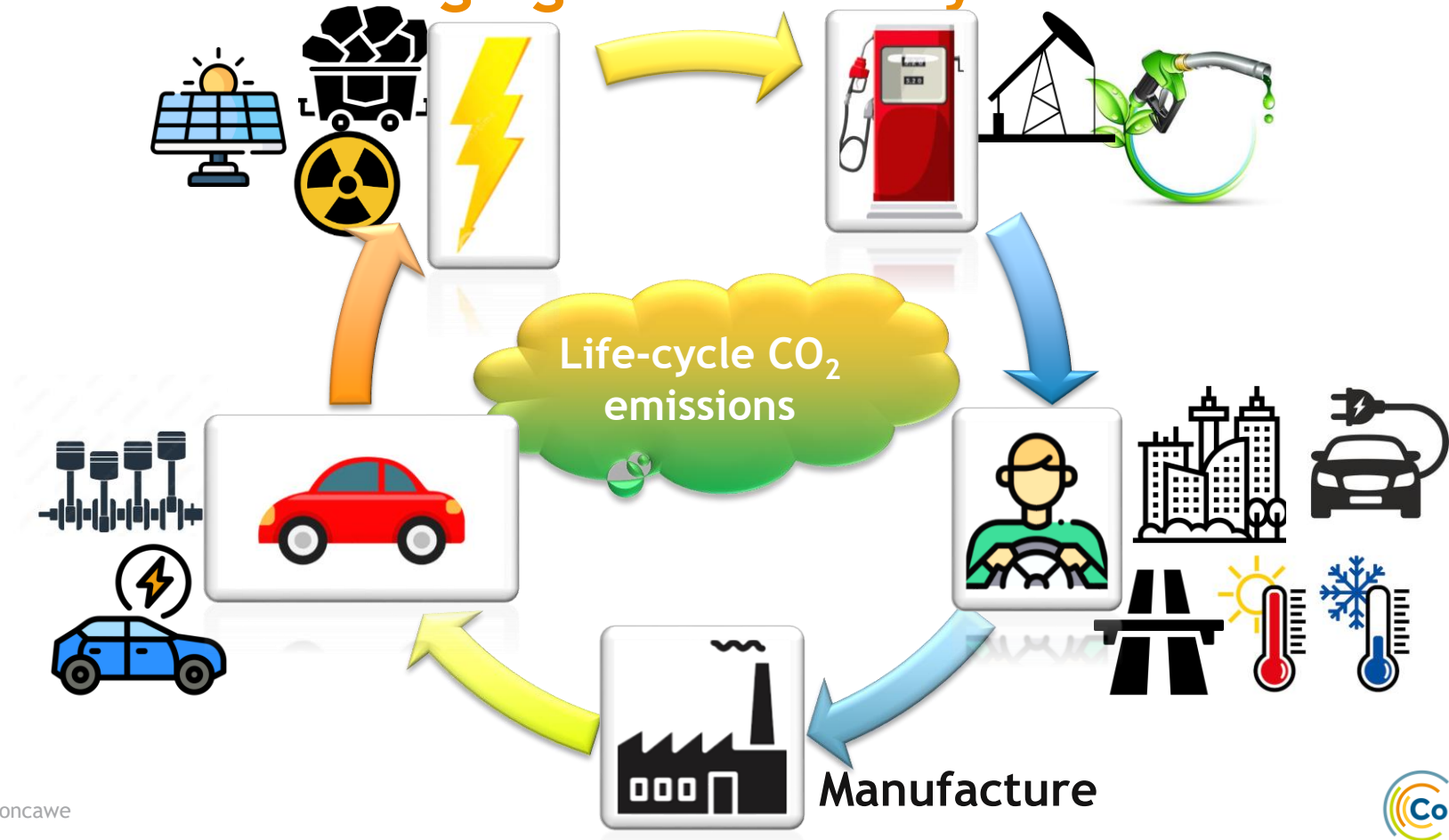
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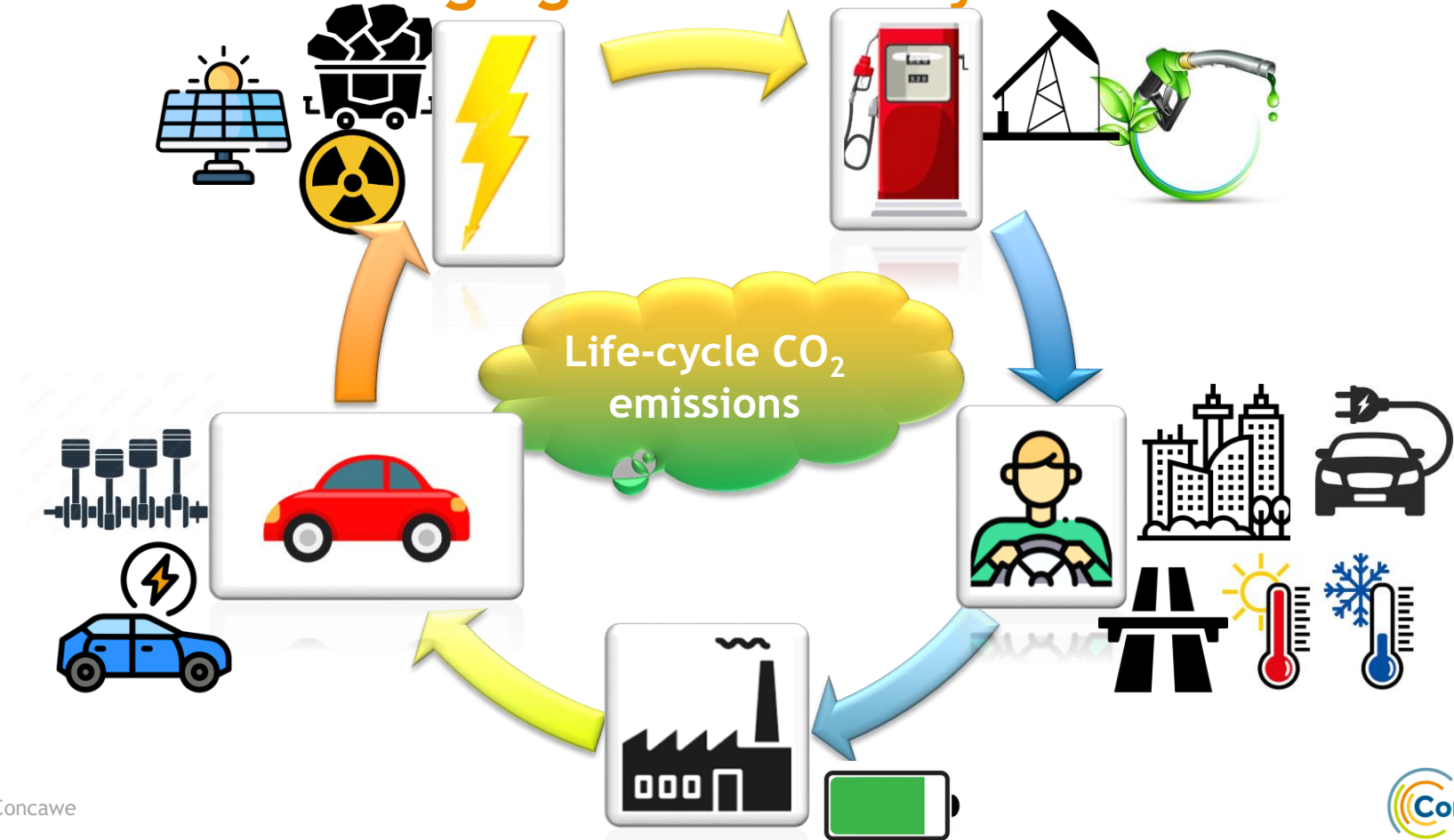
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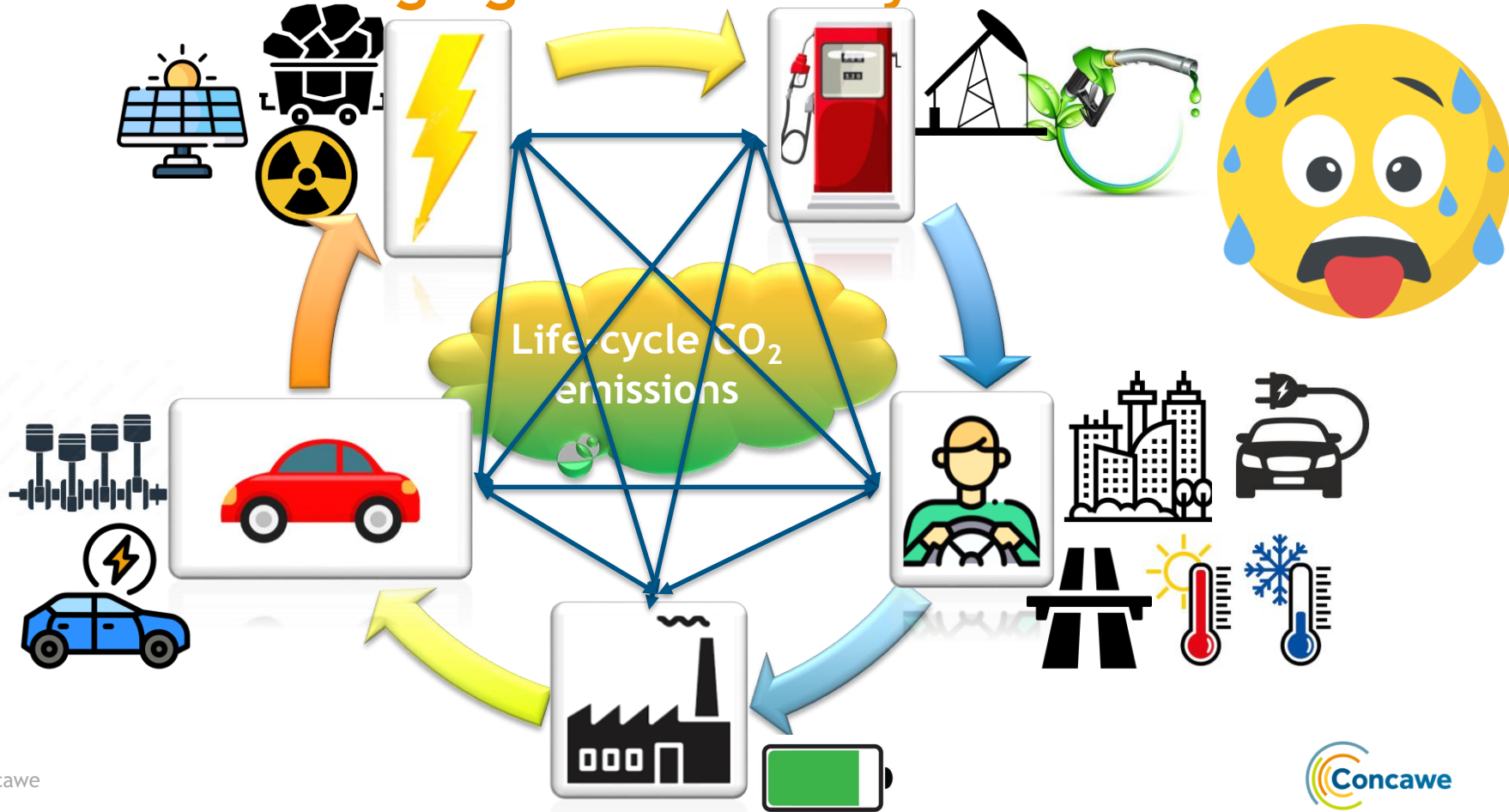
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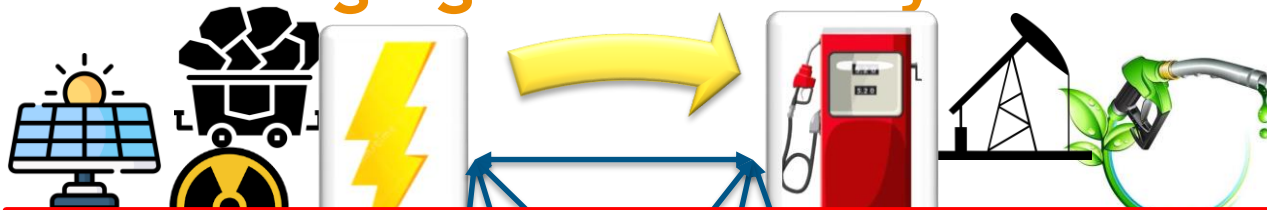
What is challenging about life-cycle assessment?



What is challenging about life-cycle assessment?



What is challenging about life-cycle assessment?



Life-cycle assessment requires to design scenarios among numerous options and use cases, which leads to countless possible combinations



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- Limits to the selected approach

Purpose of Concawe's vehicle life-cycle CO₂ emissions comparator

What is the best combination of electrification options and energy carriers to decarbonize passenger cars?

- 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 profile
 - Climate conditions
 - *Energy carriers*
 - Carbon intensity of electricity used
 - Fuels, with fossil and renewable options



How does it work?

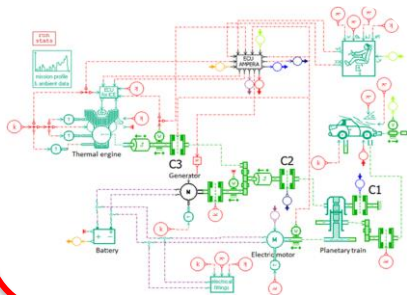
- Tested cars: 2 PHEVs, extensively tested to generate experimental data
 - *In-lab and on-road*
 - *Between -2°C and +35°C*
 - *Gasoline, Diesel and renewable fuels*
 - *Recharged and uncharged*
 - *Various driving profiles*
- Experimental results used as inputs to the creation and calibration of a simulation platform



Simulation platform workflow

Developed by  ifp Energies nouvelles

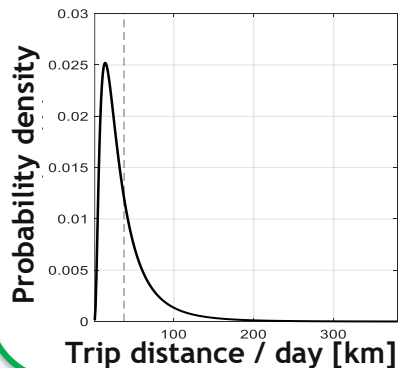
PHEV simulator



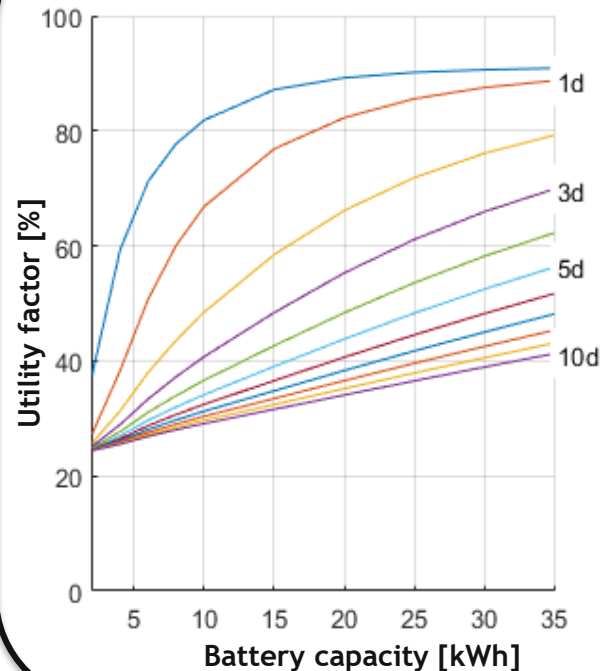
+50'000 simulations!

Statistical model

Use cases



Real-world performance

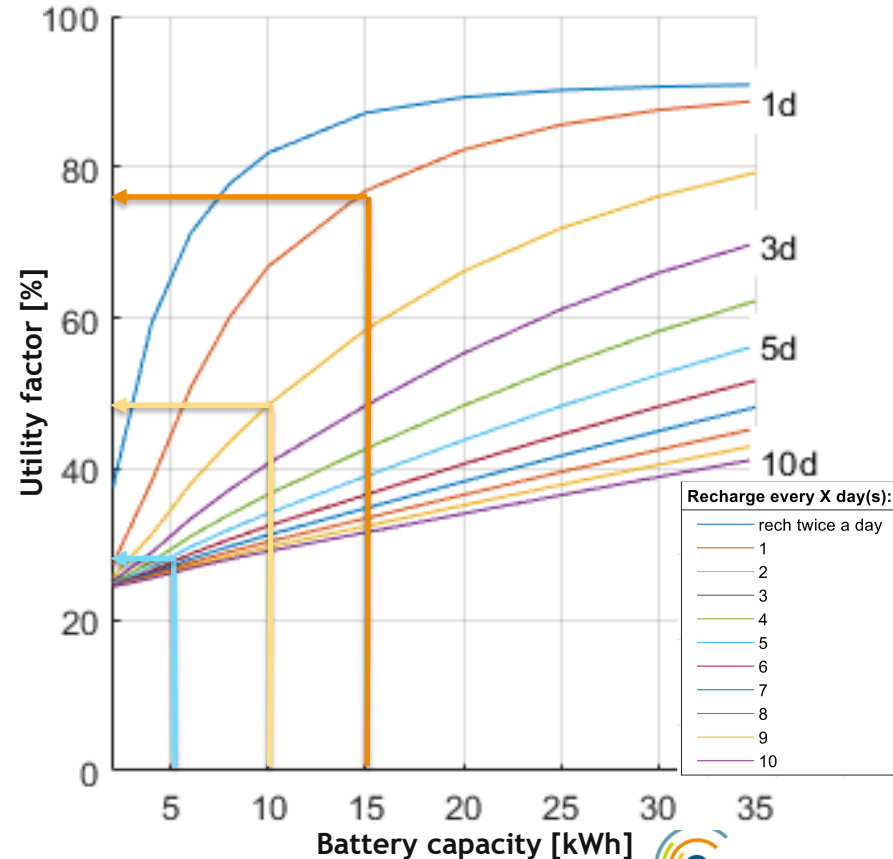


Assessment of Utility Factor under real-world conditions, using simulations

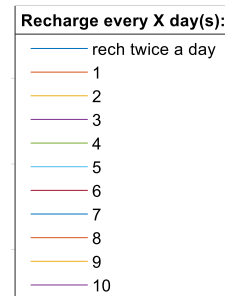
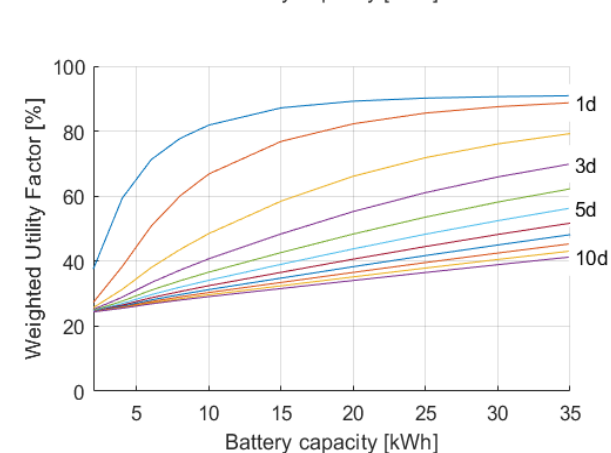
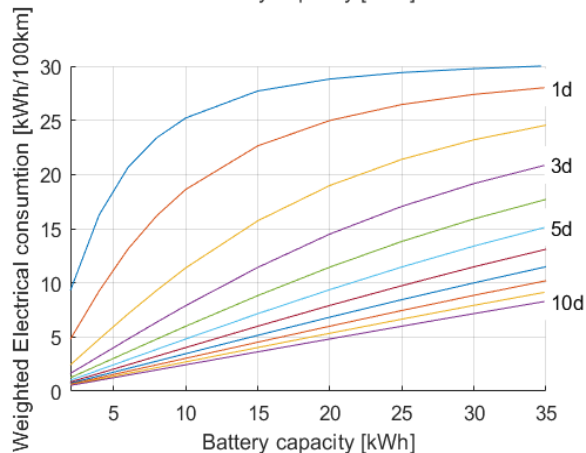
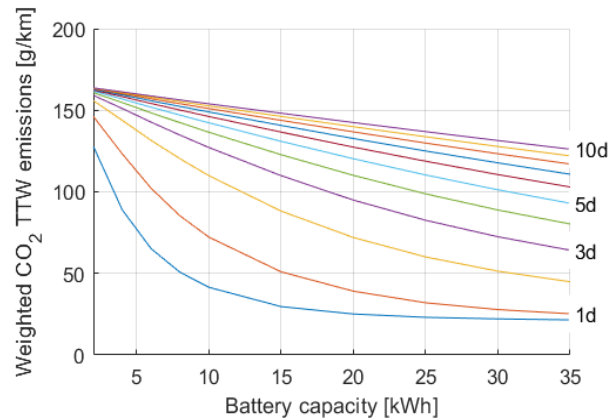
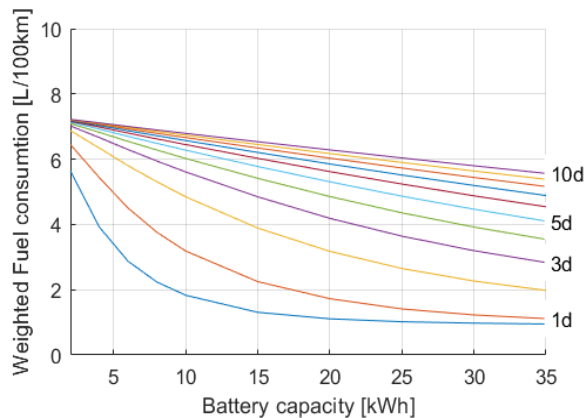
A gasoline PHEV with a **15 kWh** battery capacity **recharged every day** has an average utility factor of **77%**

A gasoline PHEV with a **10 kWh** battery capacity **recharged every 2 days** has an average utility factor of **48%**

A gasoline PHEV with a **5 kWh** battery capacity **recharged every 5 days** has an average utility factor of **28%**



Similar methodology to generate assessment of CO₂ emissions, fuel and electricity consumption



Demonstration of the CO₂ comparator

Access the tool at www.carsCO2comparator.eu

Tests, modeling
& design by

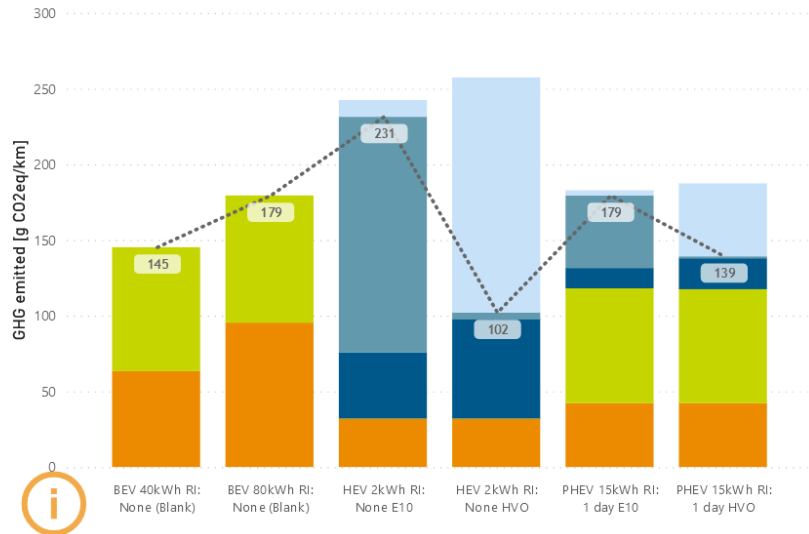


Life cycle assessment (LCA) of greenhouse gas emissions from passenger cars in real-world conditions

A function of electrification level, end-user behavior, fuel, industrial and energy sector key parameters



● Manufacture ● Electricity ● Fuel WTT ● Fuel TTW minus Recycled CO₂ ● Recycled CO₂ Total LCA GHG



As powertrains diversify in their electrification levels – Hybrids (HEV), Plug-in Hybrids (PHEV) and Battery Electric Vehicles (BEV) – along with the fuel production pathways – fossil and renewable routes – the carbon footprint over their life cycle heavily depends on their use cases (e.g. driving profile) and context of use (e.g. carbon intensity of electricity). This interactive tool allows to design several scenarios combining these parameters and to compare their environmental performance.

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To reset to default parameters, please use the page refresh button of your browser

Vehicles

Electrification level

HEV ☐ PHEV ☐ BEV ☐

Battery capacity [kWh]

2 4 6 8 10 15 20 30 40 60 80 100 120 140

Battery production [kgCO₂eq/kWh]

120

Total lifetime mileage [km]

125000 150000 187500 250000

Usages

Recharge interval (RI) for PHEVs [days]

0.5 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10...

Daily vehicle mileage scenarios

Short Average Long Certification

Climate

Cold Temperate Hot

Energies

Electricity carbon intensity gCO₂eq/kWh

335

Mostly fossil, available today

B7 - fossil diesel blended with 7% renewable biodiesel
E10 - fossil gasoline blended with 10% renewable ethanol

100% renewable, available today

HVO, made from renewable vegetable oil and waste cooking oil

100% renewable, available today

e-Diesel, made from renewable electricity and captured CO₂
e-gasoline, made from renewable electricity and captured CO₂



Outline

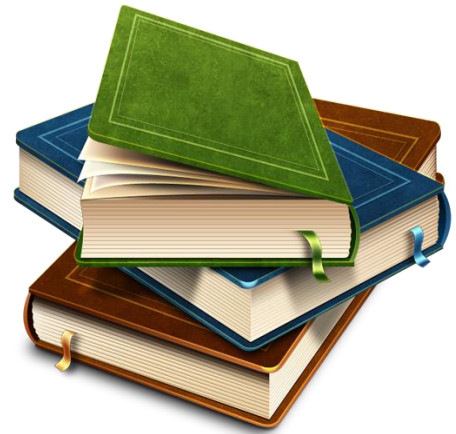
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Limits to the selected approach



- **Simulation options limited by initial experimental data**
 - *Vehicle: C-segment vehicle only*
 - *Powertrain: no "ICE-only" vehicle, no fuel cell*
 - *Fuel: no E85, no B100, no CNG/LNG, no H₂*
- **The simulator does not address the issue of the availability of the considered options**
 - *E.g. Is there enough battery to build only electric car for everyone within the decade?*
 - *E.g. Is there enough renewable fuels for everyone within the decade?*
 - *Etc.*
- **The simulator only provides a back-to-back comparison and does not provide an optimal solution with a system perspective**
 - *E.g. what is the optimal vehicles sales mix to minimize CO₂ emissions under simultaneous limited availability of batteries and low-carbon fuels?*
 - Other Concawe work demonstrates that PHEVs are the masterpiece of passenger cars decarbonization, making an optimal use of batteries and low-carbon fuels

References



- CO₂ comparator user guide
 - <https://www.carsco2comparator.eu/user-guide/>
- Evaluation of plug-in hybrid vehicles in real-world conditions
 - <https://www.concawe.eu/wp-content/uploads/Rpt-10-22.pdf>
- Evaluation of plug-in hybrid vehicles in real-world conditions by simulation
 - <https://www.carsco2comparator.eu/wp-content/uploads/2022/10/Evaluation-of-PHEV-in-real-world-conditions-Draft-v2-with-appendix.pdf>
- Fuel and Recharging Effects on Regulated and Unregulated Emissions from a Gasoline and a Diesel Plug-In Hybrid Electric Vehicle
 - <https://www.sae.org/publications/technical-papers/content/2022-01-1125/>
- Optimal electrification level of passenger cars in Europe in a battery-constrained future
 - <https://www.concawe.eu/wp-content/uploads/Optimal-electrification-battery-constrained.pdf>



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**Thank you for
your attention**

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