Concawe

Environmental Science for European Refining

Fleet & Fuels pathways for a carbon-neutral road transport in Europe by 2050: a review of possible options

Insights into requirements, feasibility and optimal solutions

5th April 2022

SAE World Congress - Keynote speech

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Outline

- About Concawe
- Setting the scene: The European Green Deal and the Fit-for-55 package at a glance
- ERTRAC carbon-neutral road transport 2050: A well-to-wheels perspective
- Biofuels: How much can be produced from available biomass?
- E-fuels: How much do they cost?
- Batteries: How to optimize the electrification of the fleet under constrained battery availability?
- Conclusions

Concawe

About Concawe

- Concawe is the scientific body of the European refining industry
- Concawe's mission is to perform scientific studies related to the refining industry, and to share the knowledge with our stakeholders and the public
  - *Our reports and papers are available in open-access on our website: www.concawe.eu*
- Concawe represents 40 Member Companies ≈ 95% of EU Refining capacity

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Setting the scene

The EU Green Deal and the Fit-for-55 package at a glance

- **The European Green Deal (EGD) sets the ambition toward a « clean » economy**
  - *A climate-neutral continent in 2050*
  - *With an intermediate target of -55% GHG emissions in 2030 (vs 1990)*
- **The Fit-for-55 package derives the EGD's ambition into several practical legislative texts, accross all the sectors of the economy**
  - *Main proposals for road transport*
    - -55% CO_2 emissions for new passenger cars in 2030 (vs 2020)
    - ICE ban in 2035 for new passenger cars
    - -43% CO_2 emissions for the overall emissions of road transport and buildings in 2030 (vs 2005), in a new ETS
    - -13% GHG intensity for transport fuels in 2030 (vs a fossil reference)

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ERTRAC

What is ERTRAC?

- **ERTRAC is the European Technology Platform (ETP) for Road Transport recognized and supported by th European Commission.**
- **Members gather all the stakeholders of Road Transport Research**

- **The tasks of ERTRAC are to:**
  - *Provide a strategic vision for road transport research and innovation in Europe.*
  - *Define strategies and roadmaps to achieve this vision through the definition and update of a Strategic Research Agenda (SRA) and implementation research roadmaps.*
  - *Stimulate effective public and private investment in road transport research and innovation.*
  - *Contribute to improving coordination between the European, national, regional public and private R&D activities on road transport.*
  - *Support the implementation of Horizon 2050, the European Framework Programme for Research and Innovation*

DISCLAIMER

- **The ERTRAC Carbon neutrality Study 2050 (WTW) analyses different "extreme" scenarios and compares effects**. It does not aim at giving a projection or at describing the way to achieve a carbon neutral road transport.
- It is a "Top-Down" theoretical approach where the **feasibility of the scenarios is not granted**
- The study only reflects the views of the contributing authors and is not an official European Commission position.
- **Results:**
  - This study explored different corner scenarios based on a static fuel and fleet modelling exercise.
  - The analysis does not include dynamic modelling or prediction; the results of the analysis should be considered as estimates for comparative purposes.
  - The analysis does not draw conclusions on fuel and electricity availability, competition with other sectors demand, economics, societal acceptance ...

INITIAL QUESTIONS

- Which technologies can support net **carbon-neutrality in road transport?**[1]
- How large is their **specific effect**?
- What could be the **fleet and fuel impact?**
- **How much energy** and **which energy** is needed for road transport? (electricity? hydrogen? synthetic fuels?)
- Which **energy paths** do we have and **how much electricity** is needed to produce the different energy carriers?

(1) Technical process which may locally have GHG emissions (CO2, CH4 and N2O emissions), but compensated on a life cycle basis by a GHG removal / offsetting mechanism (e.g. growth of biomass, Carbon Capture Use and Storage (CCUS, including from bioenergy), Direct Air Capture (DAC), etc.)

Concept of the study

48 scenarios!

TTW

Which powertrains could be used in in 2050?

3 Powertrain Scenarios

Which efficiency improvements are possible by 2050?

Optimistic – Pessimistic ranges

WTT

What will be the CO_2-footprint of electricity production in 2050?

2 Electricity Scenarios: 100% Renewable (RES) & 1.5 Tech

Which fuel production paths could be used in 2050?

4 Fuel Scenarios: Biofuels, e-fuels, Mixed fuels and Limited fossil

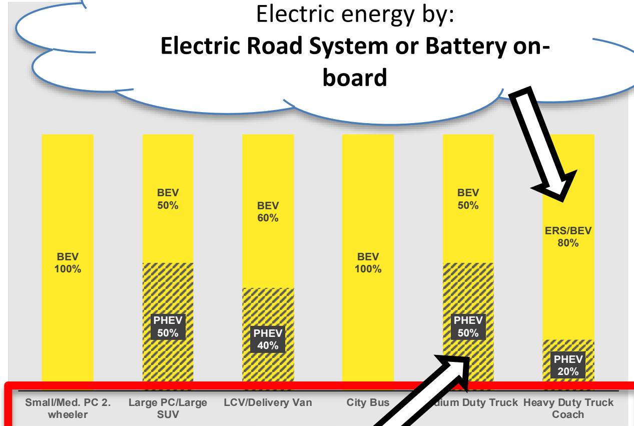
3 Powertrain Scenarios 2050

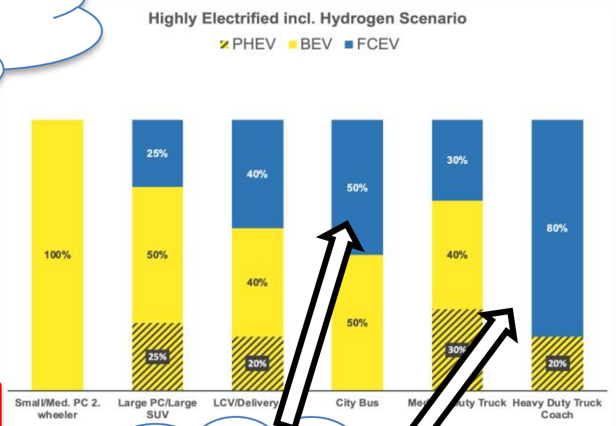
Scenarios assumptions as input for the study:

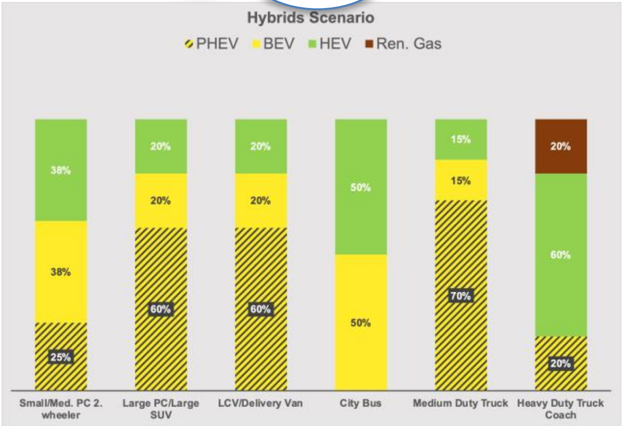
Hybrid Scenario, Why?

Maybe the infrastructure will not develop fully for Electric and Hydrogen

For Heavy duty trucks and Bus coaches: Electric energy by: **Electric Road System or Battery on-board**







PHEV = ability to run a significant distance pure electric

In this scenario the long distance electric vehicles operate with **Hydrogen energy**

...t powertrai... ...rner-points):

- Highly Electrifi... ...ystems (HE-ERS)
- Highly Electrified in... (HE-H)
- Hybrids Scenario (Hyb)

Fuel Scenarios 2050

Fuel-Scenario	Biofuel/waste	efuel	Fossil
	Fuel "family" (Feedstock / production technology)		
Advanced biofuels	90%	10%	-
Mixed	50%	50%	-
efuels	-	100%	-
Limited fossil	80%	10%	10%

✓ (BE)CCS

Note: BECCS refers to biofuel production routes coupled with CCS (allowing negative emissions)

Comparison of different fuel "family" shares being used in the different fuel scenarios (corner-points).

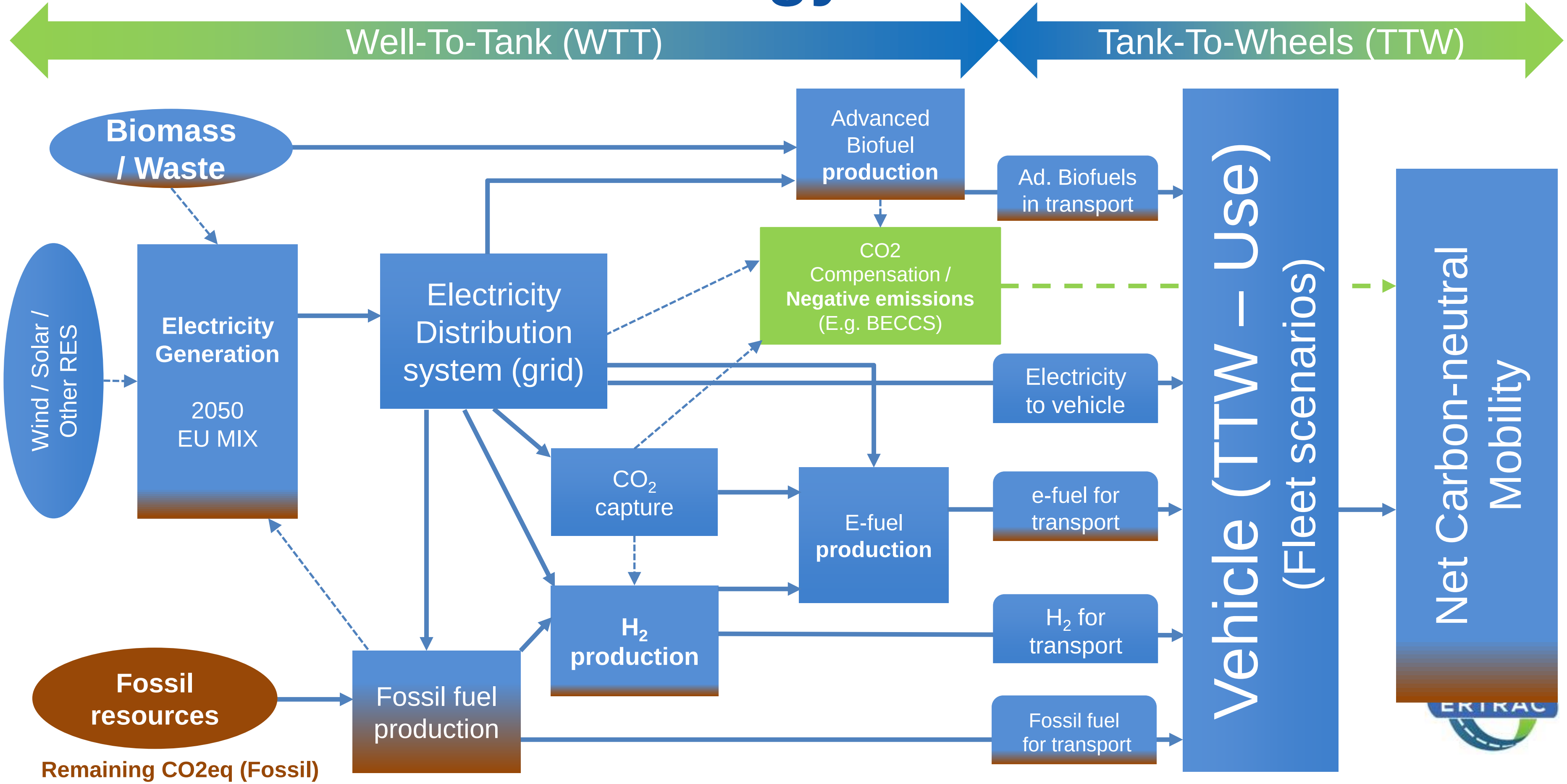
Fuel scenarios have been drafted independently from the powertrains scenarios.

The interactions between these two scenarios will be detailed in the WtW study.

Note:

- *Basis: JEC WTT v5 – 2030 extended towards 2050*
- *Drop-in fuels compatible with existing powertrains*

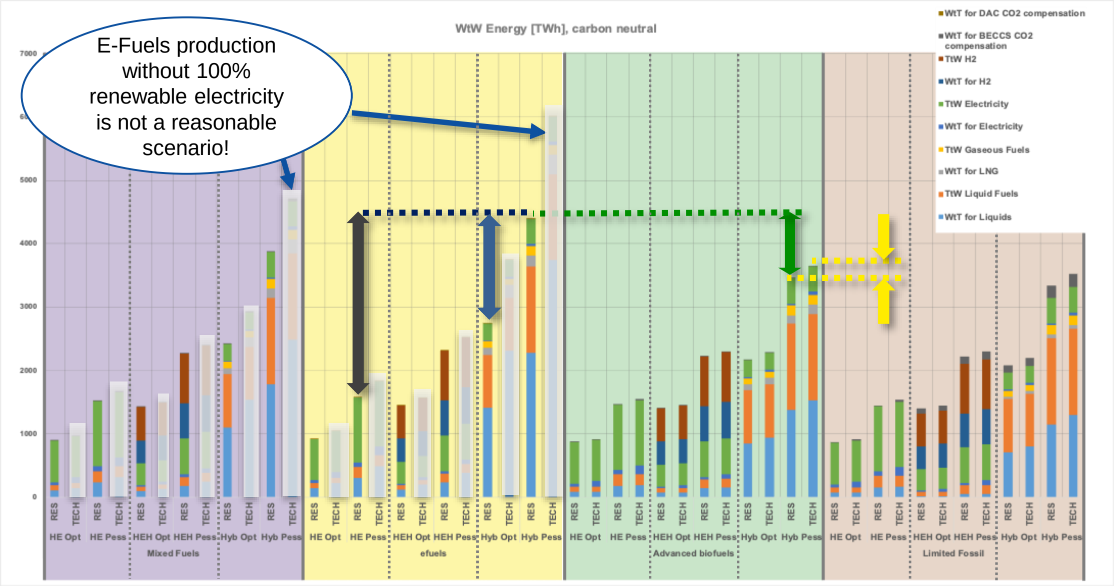
Results Fleet & Energy scenarios



Results Fleet & Energy scenarios

Question:

How much energy could be required to reach a net CO_{2eq} neutral road transport in Europe?
What leverage have the different scenarios? (WtW, TWh, CO_2 neutral)



The **variation in the WTW Energy** demand between

the fleet scenarios is up to	**~3000 TWh**
the optimistic–pessimistic case is up to	**~1500 TWh**
the fuel scenarios is about	**~1000 TWh**
electricity production scenarios up to	**~250 TWh**

Growing leverage

The share of TTW in the whole WTW energy consumption varies between **~50% up to 90%,** increasing with the level of fleet electrification.

DISCLAIMER
ERTRAC 2050 CO_2-Study
RESULTS

→E-Fuels production without 100% renewable electricity is not a resonable scenario!
→In the following slides we mainly focus on the 100% renewable electricity scenario (RES), combined with all fleet and fuel scenarios.

ERTRAC

Conclusions

- To achieve “carbon-neutral” road transport (WtW) in 2050, **drastic changes** are needed in all three areas:
  - Vehicle fleet and efficiency, powertrains and traffic technology,
  - Infrastructure
  - Energy Production (electricity, hydrogen and renewable fuels)
- **A mix of technologies ensures a more robust solution, where electrification** is the **key element** for the reduction of the CO_2 emissions.
  - BEV (possibly combined with Electrified Road System),
  - PHEV,
  - FCEV and Advanced Hybrid powertrains.
- The overall **WtW energy demand decreases drastically with fleet electrification**
- The **energy efficiency measures identified** (A, B and C) **reduce the energy / fuel consumption in all scenarios in a very significant way.**

Conclusions

- The **demand for fuels decreases massively in all scenarios**
  - **Reduction between 55%** (hybrids scenarios) **and 98%** (highly electrified scenarios)
  - Depending on the scenarios, the demand for **biofuels** ranges between **5 and 100 Mtoe**
- The total **demand for electricity** in road transport will **increase** (energy production + use in vehicle)
  - **20% - 160% of total EU28** el.cons. 2019 depending on the scenarios
  - Lowest increase (down to 20%) when heavily relying on biofuels
  - Intermediate increase (40-55%) when relying on highly electrified scenarios
  - Highest increase (up to 160%) when heavily relying on e-fuels
- The largely **Carbon-Neutral production of electricity** is a prerequisite for “carbon-neutral” road transport in all fleet and fuel scenarios.
- It impossible to tell which scenario is the best without a **systemic view**

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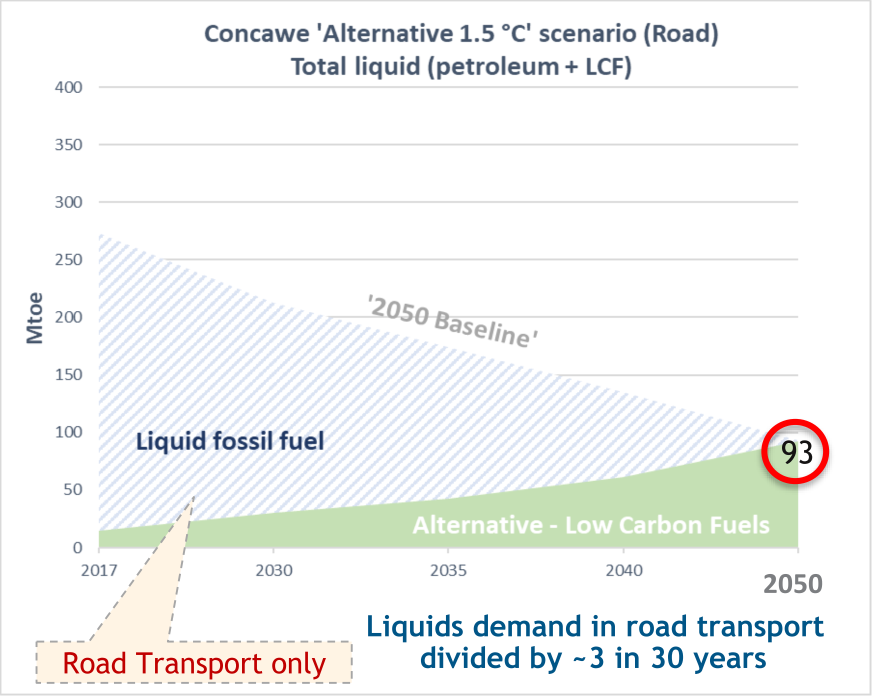
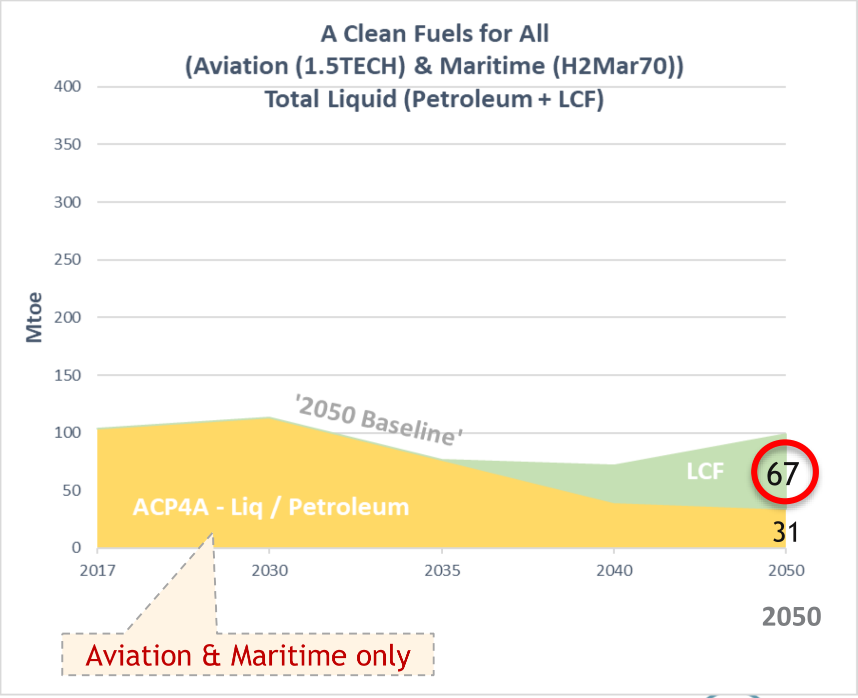
Concawe Alternative 1,5°C Scenario - Refining contribution to EU Climate Ambition

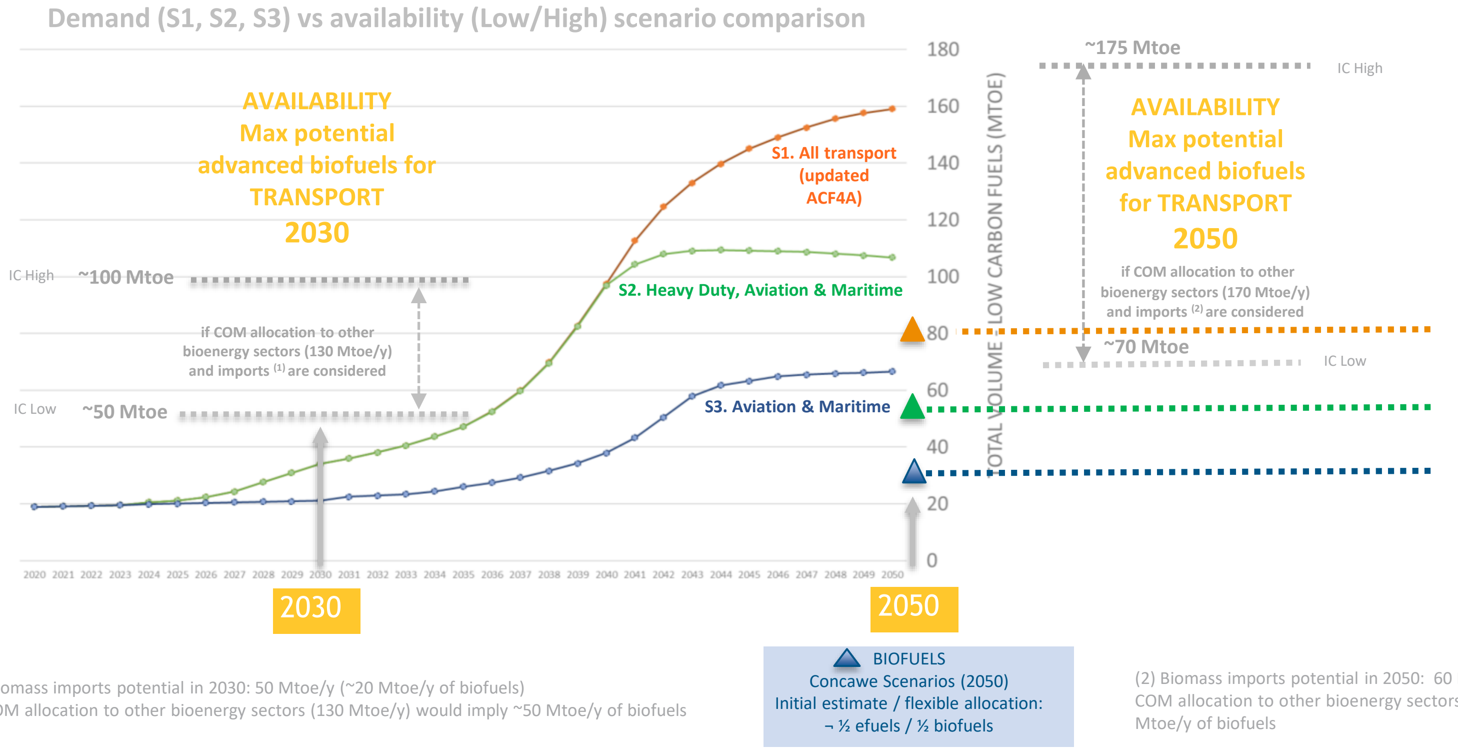
"BASELINE "scenario ("A clean Planet for All", EU Commission, 2018), but covered by Low Carbon Liquid fuels





Sustainable Biomass Availability vs LCF demand

Enough sustainable biomass for road, aviation and marine biofuels



(1): Biomass imports potential in 2030: 50 Mtoe/y (~20 Mtoe/y of biofuels)
COM allocation to other bioenergy sectors (130 Mtoe/y) would imply ~50 Mtoe/y of biofuels

(2) Biomass imports potential in 2050: 60 Mtoe/y (~40 Mtoe/y of biofuels)
COM allocation to other bioenergy sectors (170 Mtoe/y) would imply ~120 Mtoe/y of biofuels

Conclusions

- **According to Concawe scenarios, there is enough biomass to feed the road transport, maritime and aviation sectors with low-carbon fuels (160 Mtoe) providing that**
  - *A mix of ~50%/50% biofuels/e-fuels is used for low-carbon fuels*
  - *Substantial efficiency gains are made (e.g. parallel electrification in the road transport sector)*
- **The ERTRAC scenario resulting in the highest biofuel demand (100 Mtoe)…**
  - *90% biofuel*
  - *Mixed powertrains (more ICEs)*
  - *Pessimistic ranges for efficiency and traffic management*
- **… seems possible at first sight, but would compete with the biomass demand from other sectors (maritime, aviation, power sector)**
  - *A mixed low-carbon fuel scenario (50%/50% biofuels/e-fuels) seems more reasonable to ensure feasibility*
- **Next steps**
  - *Evaluation of biomass mobilisation and impact on biodiversity*

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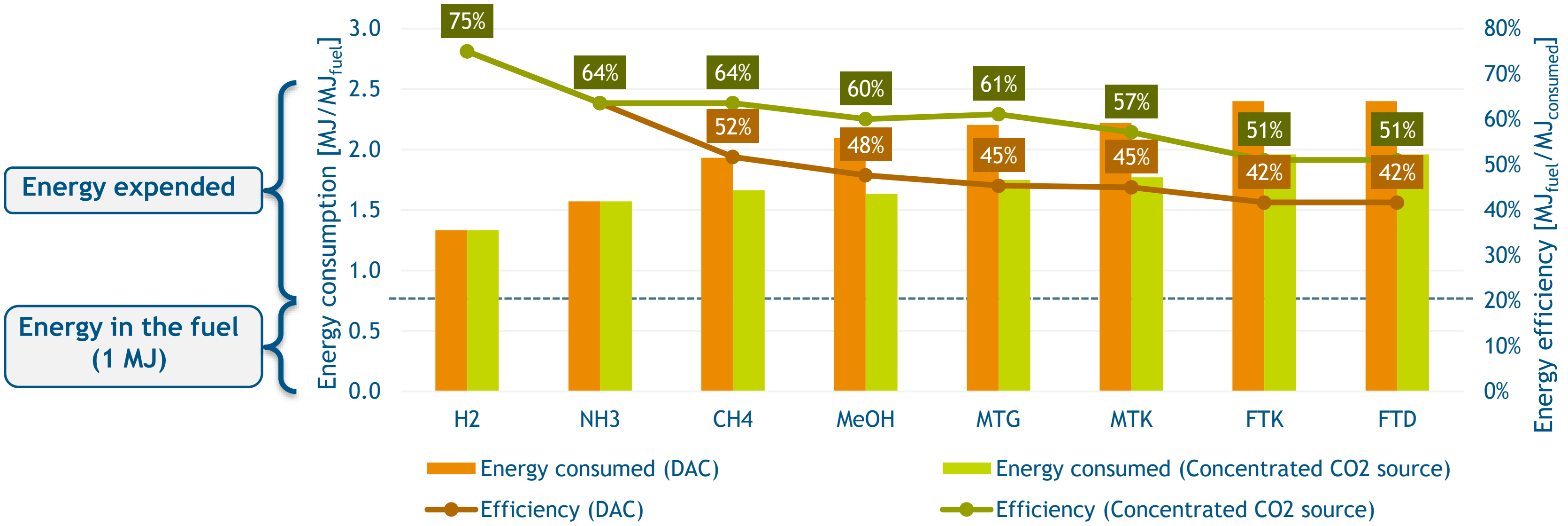
Technical assessment

Results: Energy balance - North EU, 2050

Lower energy efficiency linked to higher processing fuel routes: routes with higher drop-in fossil replacement in existing fleet

Increase of ~10% points in efficiency if concentrated CO_2 source vs DAC



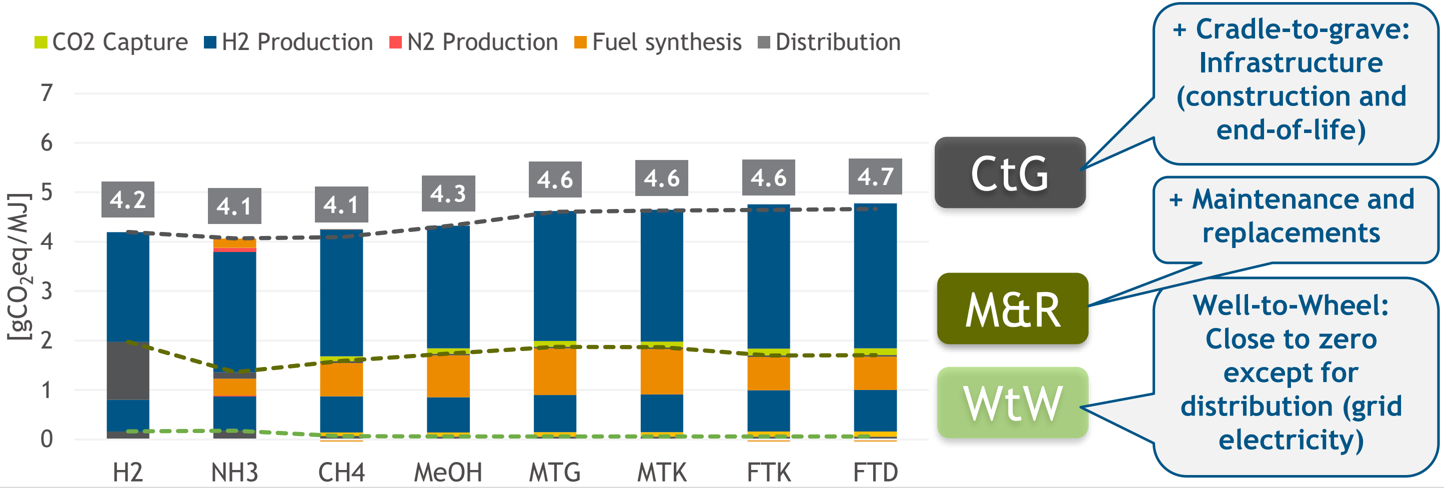
Legend:
MTG: Methanol-to-gasoline
MTK: Methanol-to-kero
FTK: Fischer-Tropsch kero
FTD: Fischer-Tropsch diesel

Not shown is e-OMEx with 34% (DAC) and 28% (concentrated source) efficiency due to high processing needs

Technical assessment

Results: GHG emissions - North EU, 2050

Cradle-to-Grave (CtG) emissions are similar for all the pathways: The ones less energy-intensive to produce are more energy-intensive to transport



	H2	NH3	CH4	MeOH	MTG	MTK	FTK	FTD
Fossil reference* →	113.0	121.4	67.6	100.6	90.4	83.0	83.0	92.1
Reduction vs fossil →	-96%	-97%	-94%	-96%	-95% **	-94% **	-94% **	-95% **

*Source: JEC WtT Study v5, GaBi Database

**Additional reduction if RED II fossil fuel comparator (94 gCO_2eq/MJ) is used

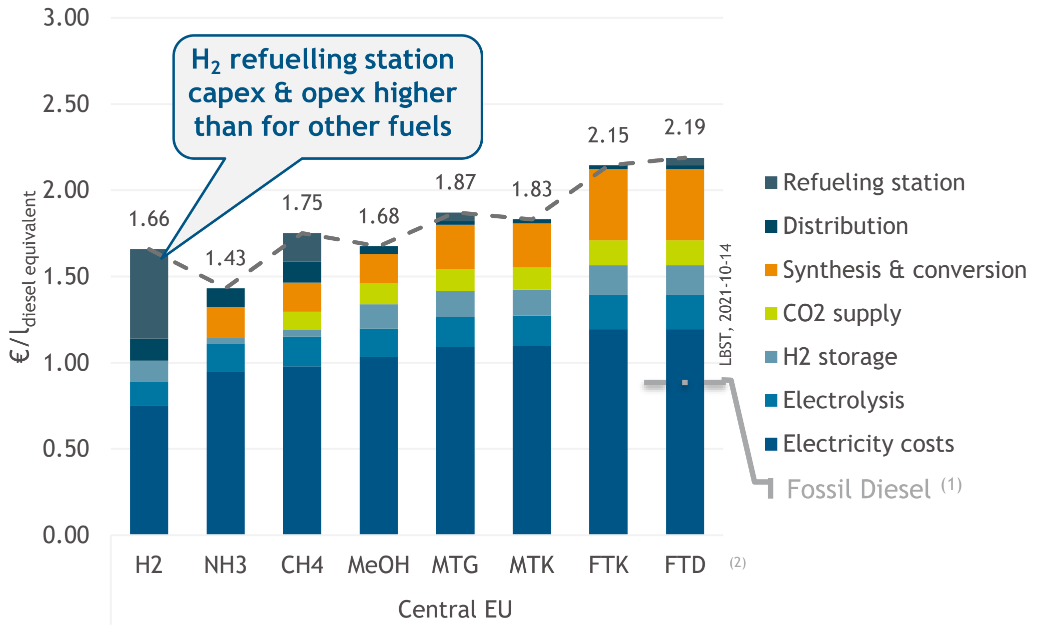
E-fuels achieve up to 94-97% GHG reduction vs fossil alternatives

Excluding e-OMEx with 10.6 g CO_2eq/MJ due to the higher processing due to the complexity of the molecule

Economic assessment

Results: Costs of fuel supply - Example (EU Central, 2050)

E-fuels that are less energy-intensive generally lead to lower costs of fuel supply

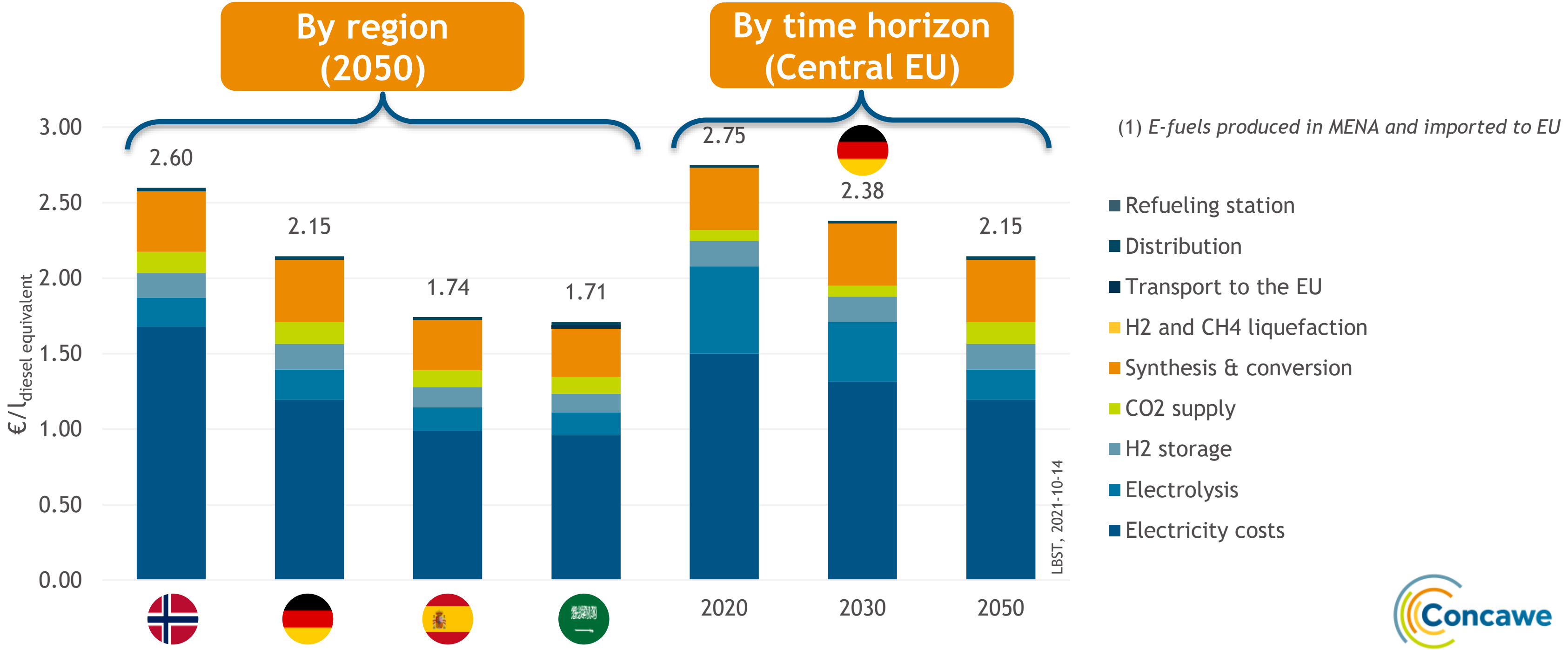


Note
(1) Diesel price: 0.3 €/l (2020) - 0.8 €/l (2050), with crude-oil prices (40 €/bbl (2020)-110 €/bbl (2050) taken from the EU Commission Impact Assessment
(2) e-OME$_x$ production cost: 2.67 €/l

Economic assessment

Results: Impact of geography & time (example: e-kerosene)

E-fuels produced in MENA and South EU show the lowest fuel costs, followed by Central and North EU
E-fuels costs are reduced with time (22%) due to decreasing CAPEX for wind & PV plants, electrolysis, and improvement of electrolysis efficiency despite lower availability of CO_2 concentrated sources



Conclusions

Key results

- E-fuels efficiency
  - Lower energy efficiency of drop-in routes (e.g. e-diesel) due to more demanding processes compared to non-drop-in routes (e.g. H2, NH3)
  - Increase of ~10% points in efficiency if concentrated CO_2 source vs DAC

- E-fuels GHG emissions
  - E-fuels CtG emissions are similar for all the pathways analysed and achieve reductions up to 93-96% vs fossil alternatives (North EU 2050)

- E-fuels production costs
  - Fuel supply costs of 1.5 - 4.1 €/l of diesel-equiv. in 2020 and 1.0 - 2.6 €/l in 2050[(2)], mainly influenced by electricity costs assumptions
  - E-fuels produced in MENA show the lowest fuel costs, followed by South, Central and North EU
  - Key sensitivities: electricity costs and discount rate

[2] Across geographies, excluding outlier OMEx with 2.6-5.4 and 1.9-3.5 €/l respectively

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Context

- **EU ambition to accelerate the electrification of road transport (Light Duty) and at the same time, becoming a global leader in sustainable battery production by developing its own production capacity [1]**

- **Large uncertainties associated with the battery production/supply capacities to meet the growing demand in EU beyond transport sector (e.g. stationary applications)**
  - **Global concerns on availability of critical minerals [2, 3, 4, 5]**
  - **2030 forecasts: Concawe's literature review on battery production capacity in the EU [6, 7]**
    - *Extreme ranges between 0.3 TWh/y and 0.95 TWh/y*
  - **Situation today (2020), for the sake of comparison [7]**
    - *Global battery capacity deployed amounted to 0.475 TWh/y, out of which 0.06 TWh/y were installed in Europe*

[1] 'European Battery Alliance' (European Commission website). https://ec.europa.eu/growth/industry/policy/european-battery-alliance_en
[2] 'The Role of Critical Minerals in Clean Energy Transitions', IEA report, 2021. https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions
[3] Sustainable Fuels for the Energy Transition of Transport – Part IV. Transformation of Mobility to the GHG Neutral Post Fossil Age. https://www.fvv-net.de/fileadmin/user_upload/FVV_1378_Fuels_Study_IV_2021-10-01_presentation_final_web.pdf
[4] 'COP26: Why battery raw materials are a highly-charged topic', Wood Mackenzie, 2021 https://www.woodmac.com/news/opinion/cop26-why-battery-raw-materials-are-a-highly-charged-topic/
[5] Zeng, A., Chen, W., Rasmussen, K.D. et al. Battery technology and recycling alone will not save the electric mobility transition from future cobalt shortages. Nat Commun 13, 1341 (2022). https://doi.org/10.1038/s41467-022-29022-z
[6] PV Europe, 2020. Battery manufacturing is coming to Europe. Article published on the PV Europe website on 22 November 2020.
[7] Ultima Media, 2021. INSIGHT: Electric Vehicle Battery Supply Chain Report: How Battery Demand and Production Are Reshaping the Automotive Industry.

Context

"In a scenario consistent with climate goals, expected supply from existing mines and projects under construction is estimated to meet only half of projected lithium and cobalt requirements and 80% of copper needs by 2030"

"The cobalt supply shortage appears inevitable in the short- to medium-term (during 2028-2033), even under the most technologically optimistic scenario"

ARTICLE

https://doi.org/10.1038/s41467-022-29022-z OPEN

Check for updates

Battery technology and recycling alone will not save the electric mobility transition from future cobalt shortages

Anqi Zeng[1,2,3,8], Wu Chen[2,8], Kasper Dalgas Rasmussen[2], Xuehong Zhu[1,3]✉, Maren Lundhaug[4], Daniel B. Müller[4], Juan Tan[5], Jakob K. Keiding[5], Litao Liu[6], Tao Dai[7]✉, Anjian Wang[7] & Gang Liu[2]✉

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Context

COP26 briefing: 13 October 2021

Metals: A big battery-shaped barrier to rapid electrification?

Gavin Montgomery and Max Reid

Wood Mackenzie

"Planned battery production capacity is grossly insufficient to meet projected demand [under a 2°C scenario]. We estimate an additional 4.6 TWh would be needed by 2030, at a cost of $350 billion. But cost isn't the only barrier — timescales are also a challenge. Given mine development cycles, producing sufficient volumes of cathode materials in the time appears insurmountable"

FVV
Research Association for Combustion Engines

"Temporary Lithium and Cobalt bottlenecks are expected in a worldwide 100% BEV ramp-up"

frontier economics | ifeu | FVV

FVV FUEL STUDY IV

Sustainable Fuels for the Energy Transition of Transport – Part IV
Transformation of Mobility to the GHG Neutral Post Fossil Age
October 1st, 2021

Objectives

- **Concawe's assessment aims to investigate the following key questions:**
  - **How to make the best use of a certain level of battery production/supply towards a minimized GHG emissions of EU-wide newly registered cars towards 2030?**
    - ***Putting the question of « feasibility » at the core of the issue***
    - ***Shifting from a back-to-back comparison to a systemic approach***
    - ***Starting the mitigation of transport-related GHG "now" without waiting for the full rollout of the gigafactories.***
  - **Is there a role for PHEVs? How much the Utility Factor could impact the results?**
  - **Open a debate with the road transport industry on**
    - ***Likelihood to live in a battery-constrained environment by 2030+?***
    - ***Impact of aspects not considered in this work (e.g. production costs, costumer acceptance) on the optimal vehicles sales mix?***

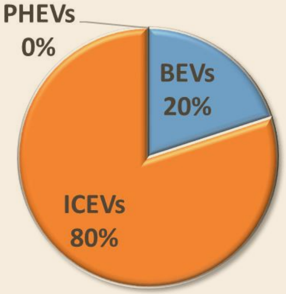
What is better?

- **Objective: Minimize WtW CO_2 emissions of 10 new passenger cars**
  - *Under a constraint of 100 kWh of batteries to produce them*

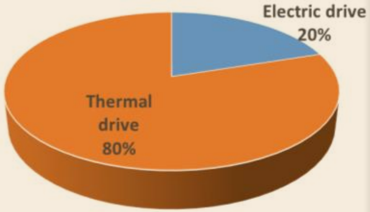
2 pathways

- **Batteries allocated to BEVs (50 kWh each)**
  - *2 BEVs*
  - *8 ICEVs*
  - *0 PHEVs*

Sales composition

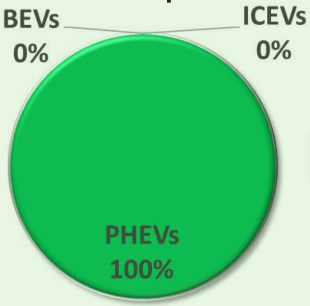


Electrified mileage: 20%

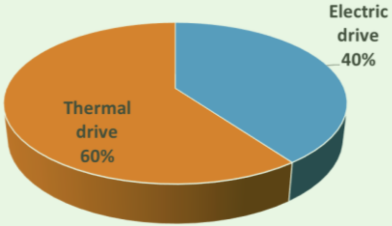


- **Batteries allocated to PHEVs (10 kWh each)**
  - *0 BEVs*
  - *0 ICEVs*
  - *10 PHEVs, assuming 40% electric drive (Utility Factor)*

Sales composition



Electrified mileage: 40%



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What is better?

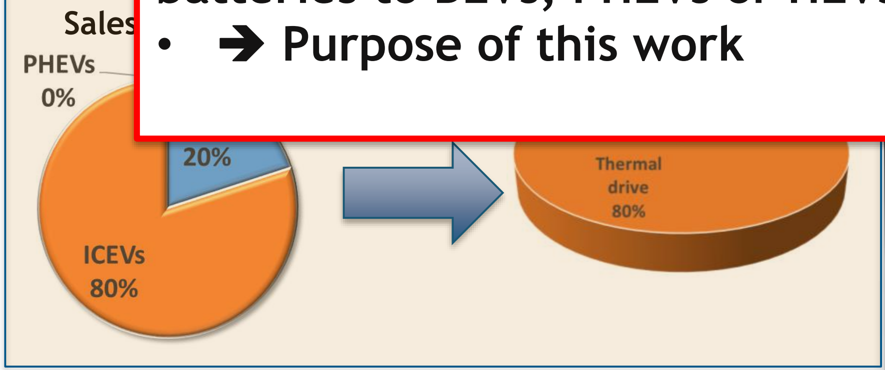
- **Objective: Minimize WtW CO2 emissions of 10 new passenger cars**
  - *Under a constraint of 100 kWh of batteries to produce them*

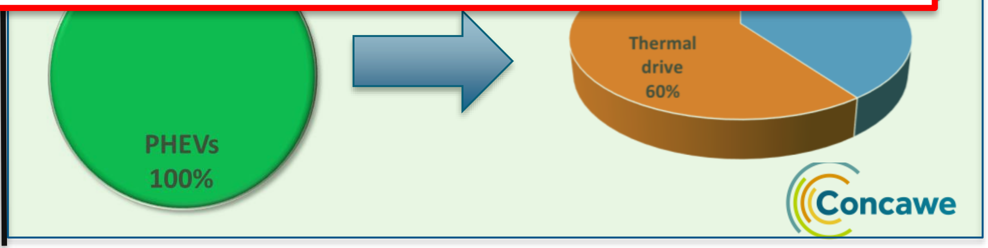
Depending on the systemic constraints, allocating batteries to PHEVs can

- Maximize the share of electric drive
- Minimize the WtW CO2 emissions

What is the extent of the systemic conditions leading to allocate batteries to BEVs, PHEVs or HEVs when minimizing WtW CO2 emissions?

- ➔ Purpose of this work





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Simultaneous optimisation of sales mix & battery size of PHEV

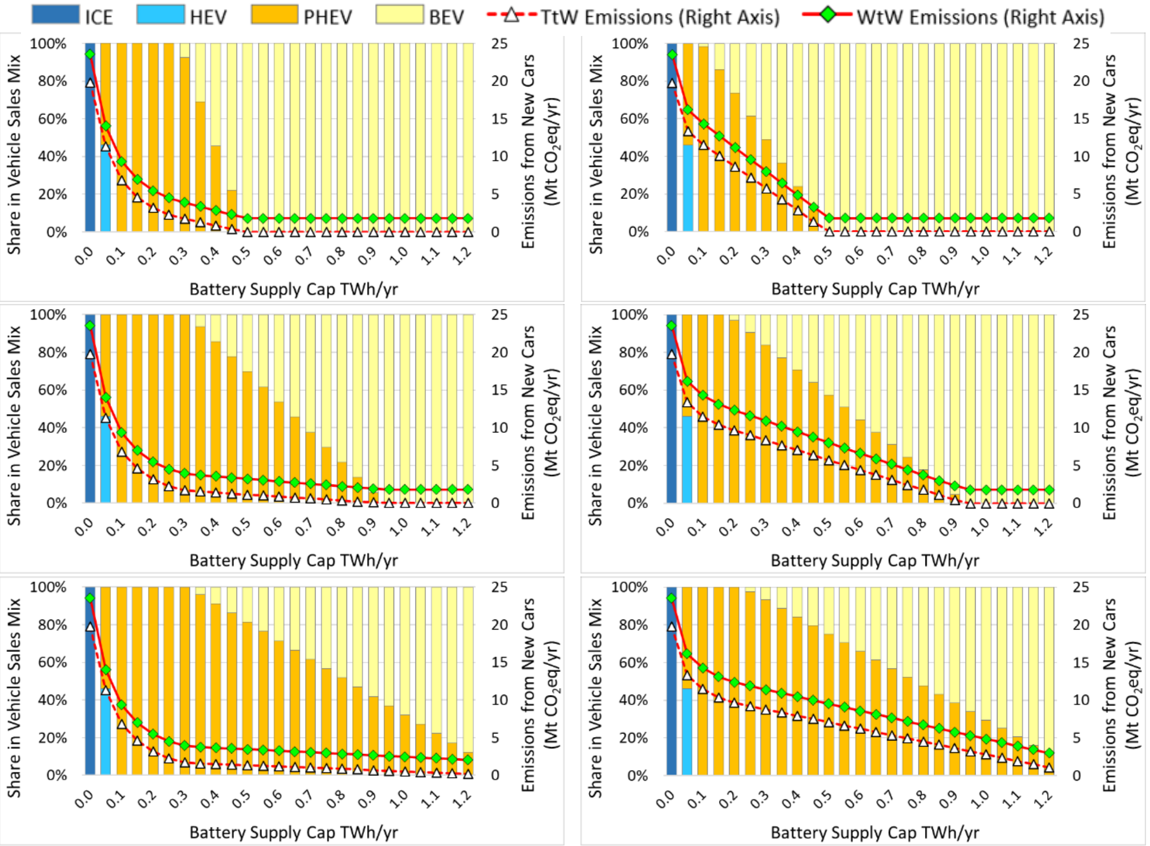
Optimal vehicle sales mix minimizing WtW CO2 emissions

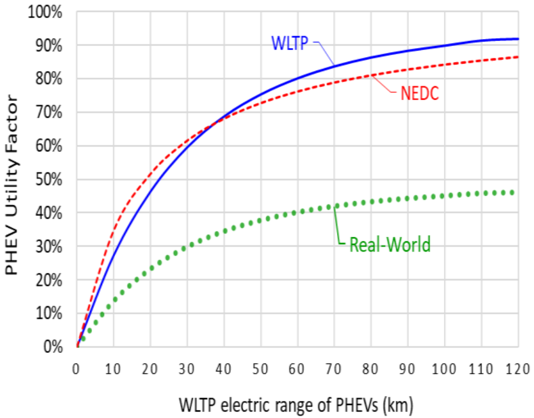
WLTP Utility Factor | Real-World Utility Factor

BEV-200

BEV-400

BEV-600





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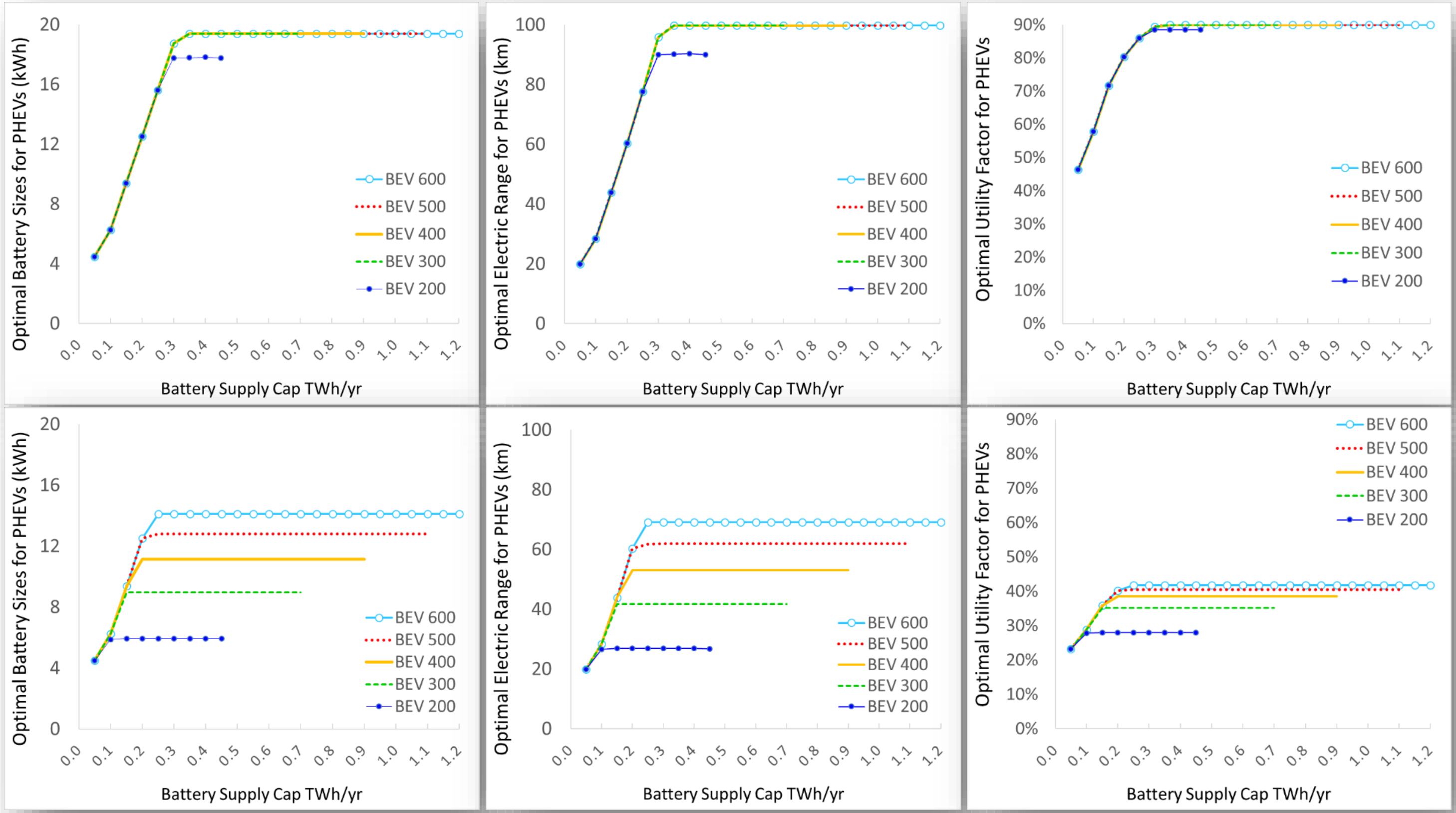
Simultaneous optimisation of sales mix & battery size of PHEV

Optimal Battery Sizes

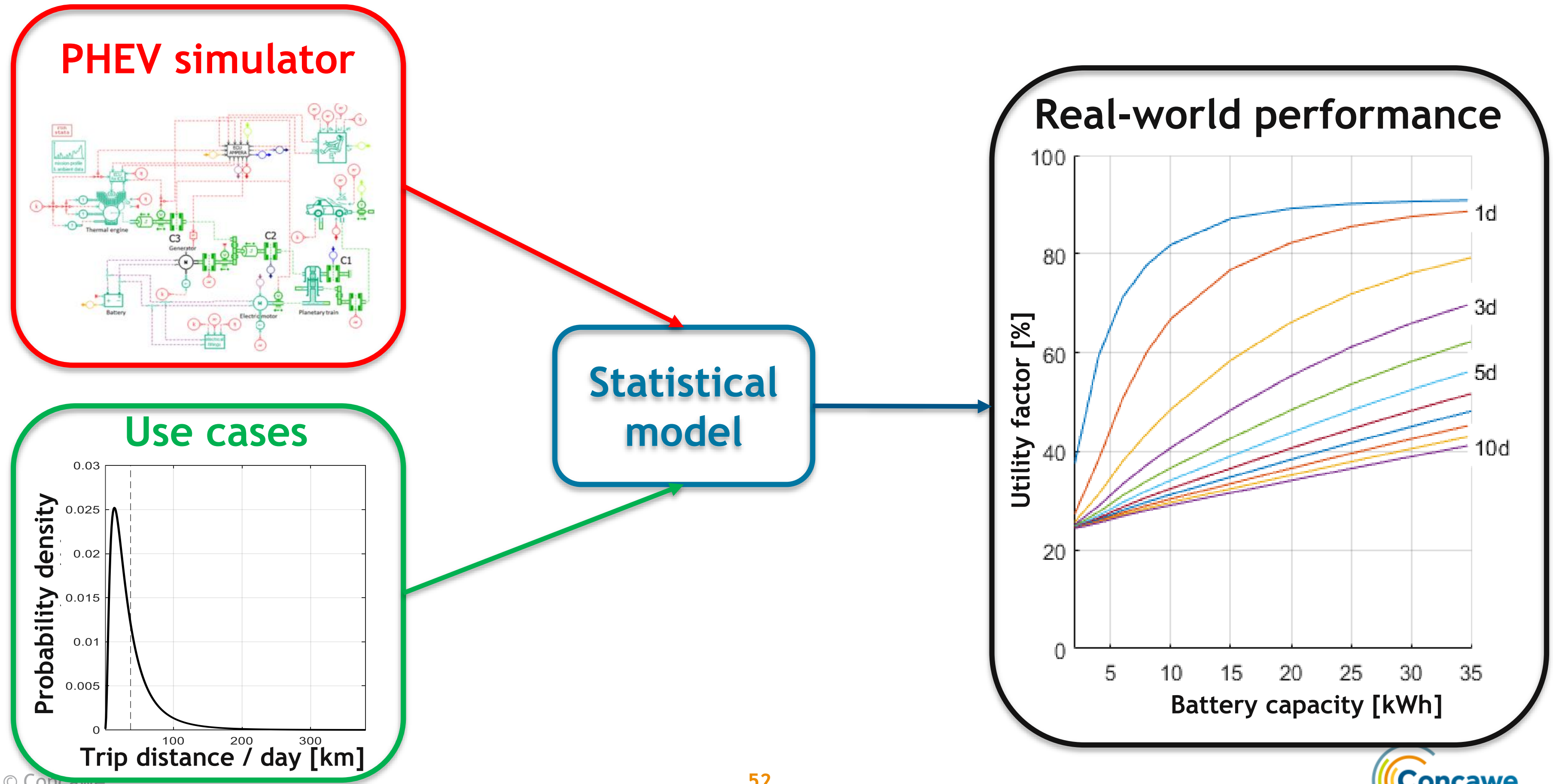
WLTP Utility Factor

Real-World Utility Factor



Role of lower-range PHEVs to efficient use of the limited battery resources

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

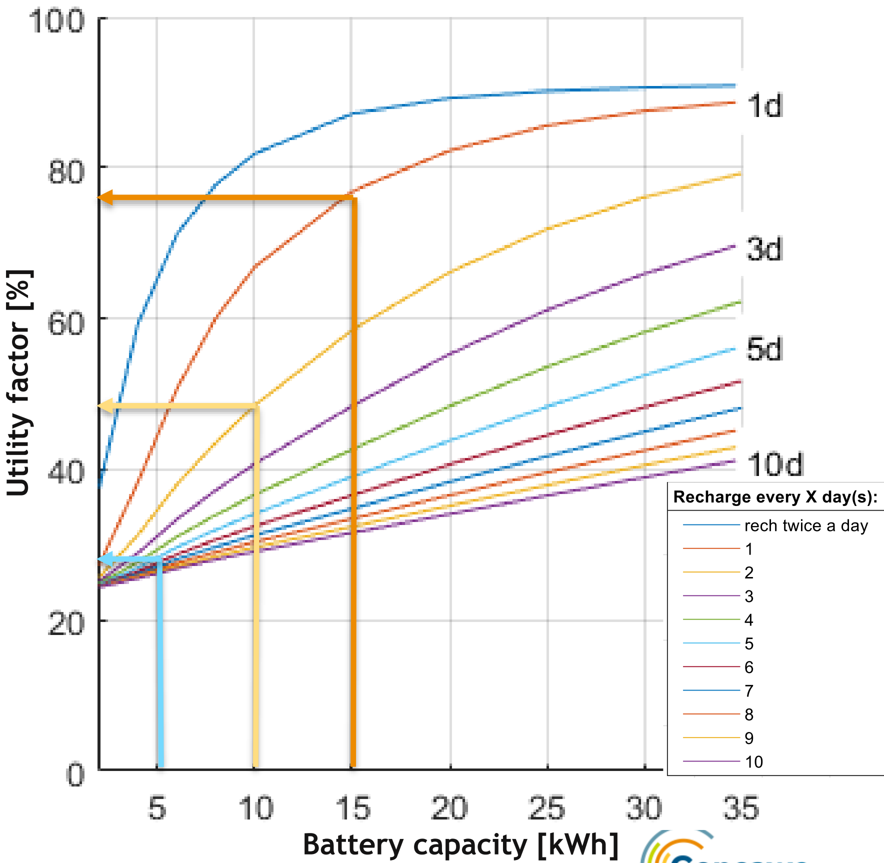


Assessment of Utility Factor under real-world conditions, using simulations

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%

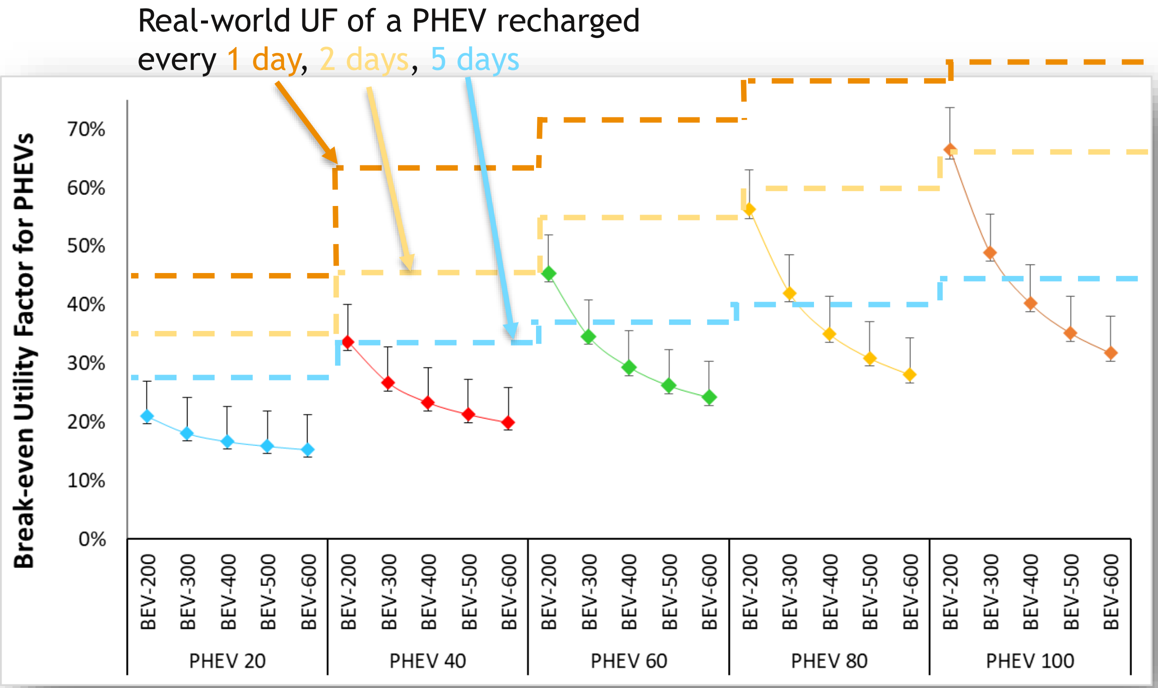
A gasoline PHEV with a 5 kWh battery capacity recharged every 5 days has an average utility factor of 28%



Break-even utility factor

Minimum level of utility factor required to bring PHEVs to the optimal sales mix

- Break-even utility factor increases with the battery size of PHEVs.
- Increasing the battery size of BEVs reduces the break-even utility factor.
- Real-world utility factor of a PHEV recharged every day is always bigger than the break-even utility factor, no matter the battery capacity
- Real-world utility factor of a small PHEV (20-40 km battery range) recharged every 5 days is still bigger than the break-even utility factor. For bigger PHEVs, it depends on the battery capacity of BEVs



Error bars show the sensitivities with respect to the carbon intensity of electricity supply mix ranging from 0 to 76.4 gCO_2eq/MJ

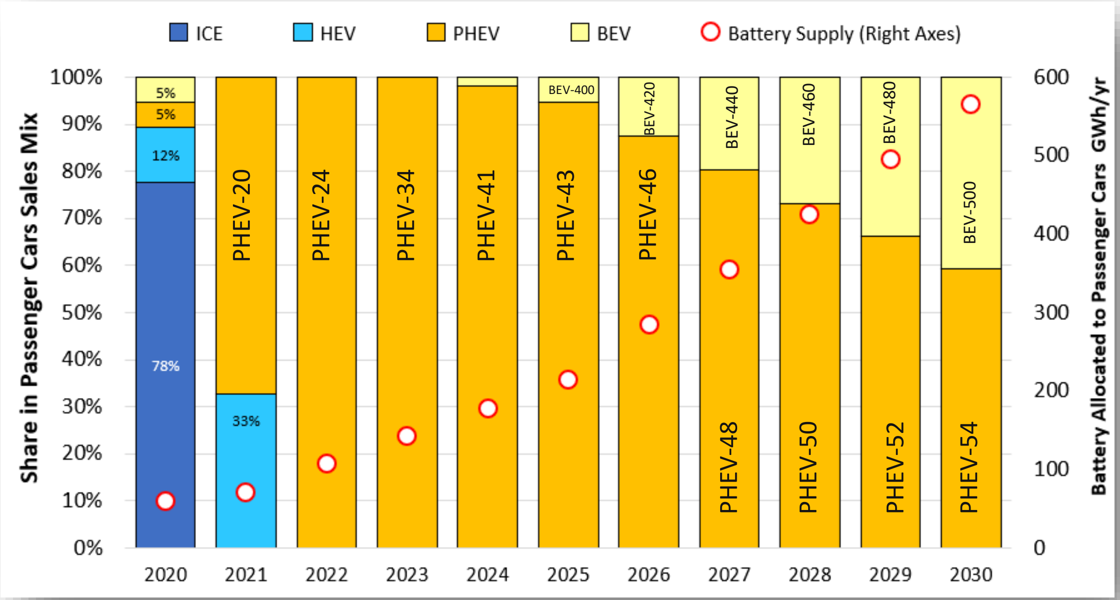
Optimal sales mix subject to battery supply constraint

Minimizing life-cycle GHG emissions: Full EV Penetration Scenario

Key Assumptions:

- Total numbers of annual sales: 16M cars/yr
- Max share of EVs (BEV+PHEV) in new sales: 100% during 2021-2030 (subject to optimisation)
- Real-World Utility Factor – Conservative
- Battery range (size) for BEVs: Linear increase 400 km (58 kWh) in 2020 → 500 km (71 kWh) in 2030
- Net zero battery trade
- E10eq as the proxy for biofuel for combustion engines (No additional low-carbon fuel)
- Electricity LCA carbon intensity (gCO2eq/MJ) Linear decrease: 122 (2020) → 69 (2030)
- Battery carbon intensity (kg CO2eq/kWh): Linear decrease:
  BEV: 96 (2020) → 65 (2030)
  PHEV: 108 (2020) → 73 (2030)
- Vehicle energy use MJ/km (WLTP): Linear decrease JEC 2015 data (2020) → JEC 2025+ data (2030)

Conservative Real-World Utility Factor for PHEVs: 23% (PHEV-20) → 39% (PHEV-54)



Notes:

2020 sales mix represents the historical data (not optimised)

Battery ranges (sizes) of PHEVs are optimised subject to battery resource constraints

Conclusions

❑ Battery Supply & Demand:

- Uncertainties about reliable battery imports due to growing demand worldwide, and critical minerals availability

❑ Optimal electrification level:

- PHEVs would be the main component of the optimal sales mix towards 2030 even under conservative utility factors.
- To ensure the best utilisation of the limited battery resources while taking the advantage of more efficient powertrains, PHEVs recharged every 1 or 2 days would be preferable over HEVs and BEVs in reducing GHG emissions, whatever their battery capacity (20 – 100 km all electric range).
- Even if recharged only every 5 days, lower-range PHEVs (20-40 km all electric range) would still be preferable over HEVs and BEVs in reducing GHG emissions in a battery-constrained environment.
- Longer-range BEVs are not deemed as the optimal choice in terms of a systemic GHG emissions reduction. Assuming the larger battery sizes for BEVs (>400 km) under a battery-constrained condition would lead to the higher contribution of PHEVs.

❑ Impact of using low carbon fuels:

- Increasing the contribution of low-carbon fuels in the fuel mix and decreasing the carbon intensity of the electricity mix would not change the optimal sales mix significantly. However, they will offer significant additional WTW GHG emissions savings.

Outline

- About Concawe
- Setting the scene: The European Green Deal and the Fit-for-55 package at a glance
- ERTRAC carbon-neutral road transport 2050: A well-to-wheels perspective
- Biofuels: How much can be produced from available biomass?
- E-fuels: How much do they cost?
- Batteries: How to optimize the electrification of the fleet under constrained battery availability?
- **Conclusions**

Conclusions

- To change a system, it is needed to think at a system level
- Developing a "carbon-neutral" road transport is highly complex, beyond WtW evaluations
  - *Scalability must be granted: availability of critical minerals, biomass, water supply, land, etc.*
  - *Energy supply must be secured, in spite of intermittent RES*
  - *Customer acceptance is key: ease of use, cost etc.*
  - *Systemic evaluation is needed to ensure that the whole system is viable ➔ source of uncertainty*
- By many aspects, electrification is desired, but the feasibility of 100% electrified road transport can be genuinely questioned, at least during the transition
  - *What can be electrified? How to electrify?*
- Optimization under systemic constraints show that PHEVs could be the masterpiece of road transport decarbonization during the transition
  - *PHEVs accelerate mileage electrification, even with conservative utility factors*
- Biomass is available in sufficient volumes to produce biofuels when it goes along with e-fuels and electrification
- E-fuels
  - *Flexible process which can provide drop-in and non-drop-in components*
  - *Thermodynamically inefficient and requires a lot of renewable electricity*
  - *Expected to remain more expensive than fossil fuels*
- ➔ No silver bullet

References

All materials available in open access on Concawe's website

- **Carbon-neutral road transport 2050 – A technical study from a well-to-wheels perspective**
  - *https://www.concawe.eu/wp-content/uploads/ERTRAC-PPT-Carbon-Neutral-Road-Transport-2050_Workshop_April_29.pdf*
  - *Peer-reviewed paper being drafted*
- **Sustainable biomass availability in the EU, to 2050**

Imperial College London Consultants
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  - *https://www.concawe.eu/wp-content/uploads/Sustainable-Biomass-Availability-in-the-EU-Part-I-and-II-final-version.pdf*
- **E-Fuels: A techno-economic assessment of EU domestic production and imports towards 2050**
  - *https://www.concawe.eu/wp-content/uploads/Session-2-Presentation-3-Alba-Soler-and-Patrick-Schmidt.pdf*
  - *Full report available soon*
- **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*
- **Evaluation of plug-in hybrid vehicles in real-world conditions**

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  - *Peer-reviewed papers being drafted*
  - *Full report available soon*

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Thank you for your attention

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