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Impacts & opportunities from LCA and possible future policy

Nikolas Hill, Ricardo Energy & Environment

'Embedding life cycle CO_2e assessment into automotive manufacturing and future vehicle policy', LowCVP / APC, IMechE, 28 Nov 2019

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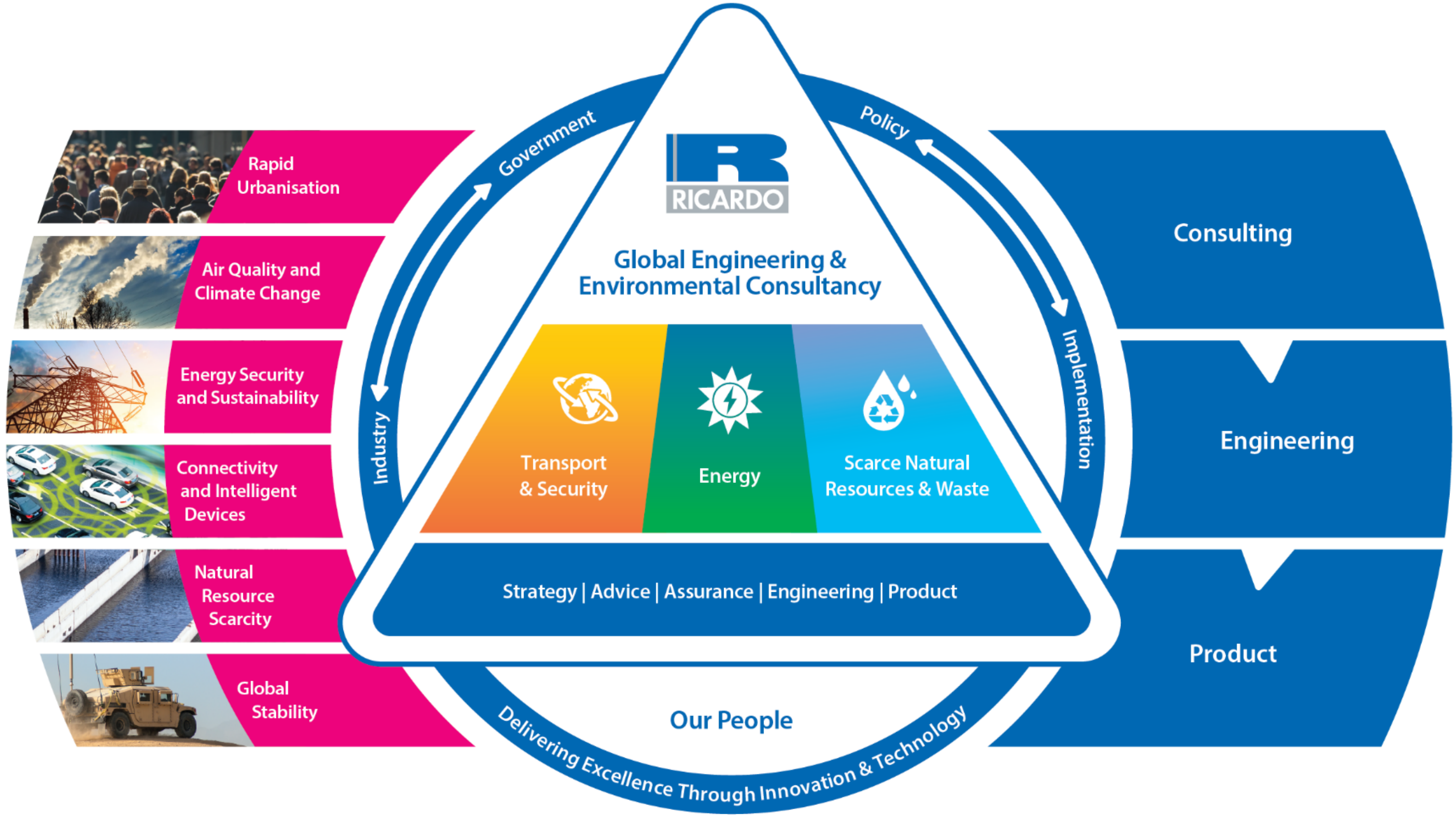
Overview

- **Overview of Ricardo**
- Key considerations and questions for life cycle assessment:
  - Why are we interested?
  - How are LCA studies used by the automotive industry and others?
  - What impact does kind of LCA being considered have?
  - How do we define the vehicle lifecycle?
  - What are the key parameters that should be considered?
  - How might key design decisions influence the outcome?
  - What are the dangers of focusing only on Greenhouse Gases?
- Summary – What are the key take-aways and how might EU LCA policy develop?

Ricardo is a Global Engineering & Environmental Consultancy with over 3000 employees: engineers, scientists and consultants in all major regions

Sectors

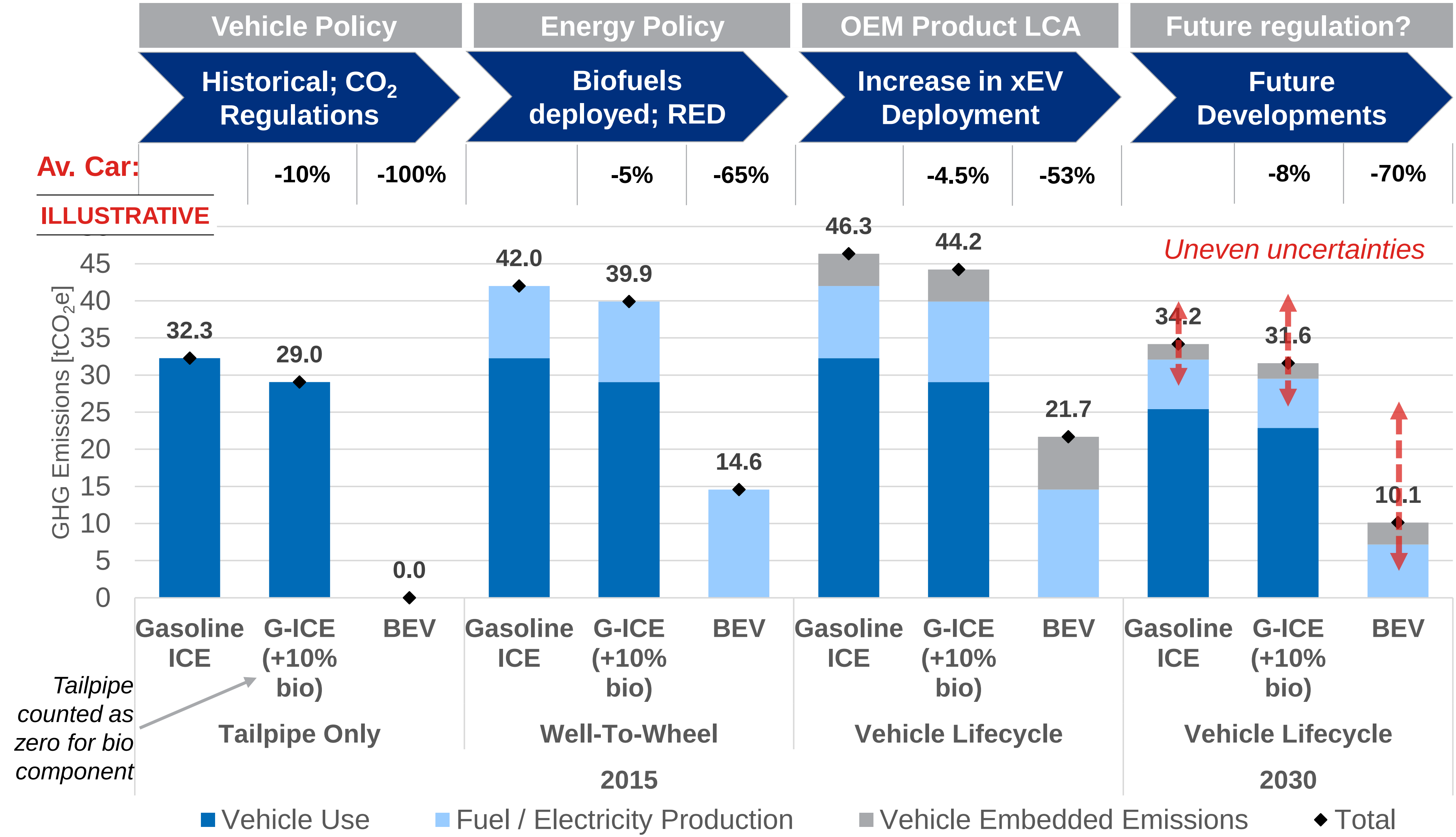
- Automotive
- Commercial Vehicles
- Defence
- Energy & Environment
- Motorsport
- Motorcycle
- Off-Highway Vehicles
- Rail



3,000+ staff
73 nationalities
48 sites in **20** countries

The objective throughout our over 100-year history has been to maximise efficiency and eliminate waste in everything we do

Why are we interested? Combination of changes in the regulatory environment, as well as the uptake of new fuels and powertrains



Source: Ricardo life cycle analysis (2018) for average EU passenger car. Assumes lifetime 210,000 km, uplift of NEDC to real-world fuel consumption (~35%/40% for ICE/EV). GHG from fuel/electricity consumption is based on the 2015 average fuel/grid electricity factor; Literature average 15.3 kgCO2e/kg battery. Avoided burden approach – including credits for recycling.

How are LCA studies used by the automotive industry and others? Studies are formulated based on a complex range of criteria, data…

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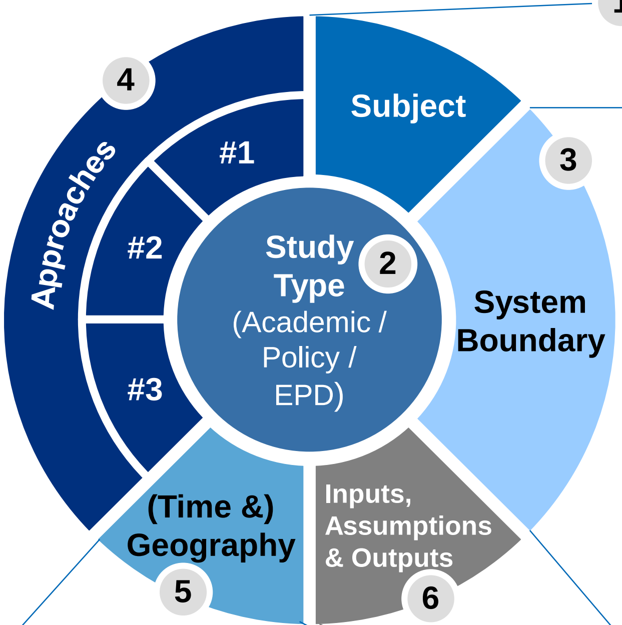
Overview key LCA considerations



1 **Study Subject & Functional Unit** — E.g. specific vehicle, or generic example? total impacts, or impact per vkm or tkm?

System Boundary

Fuel Production
Assessment of environmental impact of producing the energy vector(s) from primary energy source to distribution

It is also good to note what has been excluded from the analysis

Vehicle Production
Assessment of environmental impact of producing the vehicle from raw materials to complete product

Use
- Tailpipe CO_2 from driving
- Impact from maintenance and servicing

End-of-Life
Assessment of environmental impact of "end of life" scenario, including re-using components, recycling materials and landfill

(Time &) Geography	Input Data	Key Assumptions	LCI Datasets	Environmental Impact Factors
 2020 → 2030 → 2050	Primary vs. Secondary	Lifetime Mileage [km] Low Carbon Fuel use and Electricity GHG intensity [kgCO_2e/kWh] Battery embedded GHG factor [kgCO_2e/kWh or kg CO_2e/kg]	E.g. EcoInvent *(also many choices within these…)*	E.g. Global Warming Potential (GWP) [tCO2e], Cumulative Energy Demand (CED), Human Toxicity, etc.

What kind of LCA are we considering? The type of LCA considered can have significant impacts on scope, datasets and methodology…

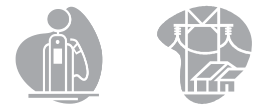
	Academic	• **Intended audience:** wider academic and research community. • **Primary interest:** the creation of knowledge. • Results **may be published** in technical journals • Subject may be **real or hypothetical/generic**
	Policy Analysis	• **Intended audience** is policy makers and academics • **Purpose** is to aid understanding of potential implications for policy development • **Impact** of product/service **within wider social system** • Subject may be **real or hypothetical/generic**
Changes needed	**Environmental Reporting** **(& possible future regulation)**	• **Intended audience** is customers and general public • **Purpose** is the quantification of impacts of manufacturer's specific products • **Certified** to conform to LCA standards, e.g. ISO 14025 • Results usually in Environmental Product Declarations (EPDs) or Corporate Responsibility Reports

How do we define the vehicle lifecycle? Vehicle LCA studies vary in their system boundaries and in particular treatment of EoL…

Vehicle Life Cycle

Well-to-Wheel (WTW) Analysis: Life Cycle Assessment of the fuel or electricity used to power the vehicle

Vehicle cycle "Embedded" emissions: result from from vehicle production; fluid, filter and component replacement during life; and end-of-life activities. A **"cradle-to-gate"** LCA study may only consider vehicle or component production



Fuel & Electricity Production

Assessment of (WTT) environmental impact of producing the energy vector(s) from primary energy source to point of distribution (e.g. refuelling station)

Whole Vehicle Life Cycle:

Analysis of the **whole vehicle life lifecycle** will include embedded emissions from vehicle production, maintenance and servicing, and end-of-life activities, and WTW (WTT+TTW) emissions from production and use of the fuel / energy in operating the vehicle, and non-fuel emissions

Vehicle Production

Assessment of **'Cradle-to-Gate'** environmental impact of producing the vehicle including extract of raw materials, processing, component manufacture, logistics, vehicle assembly and painting

Use/Operation

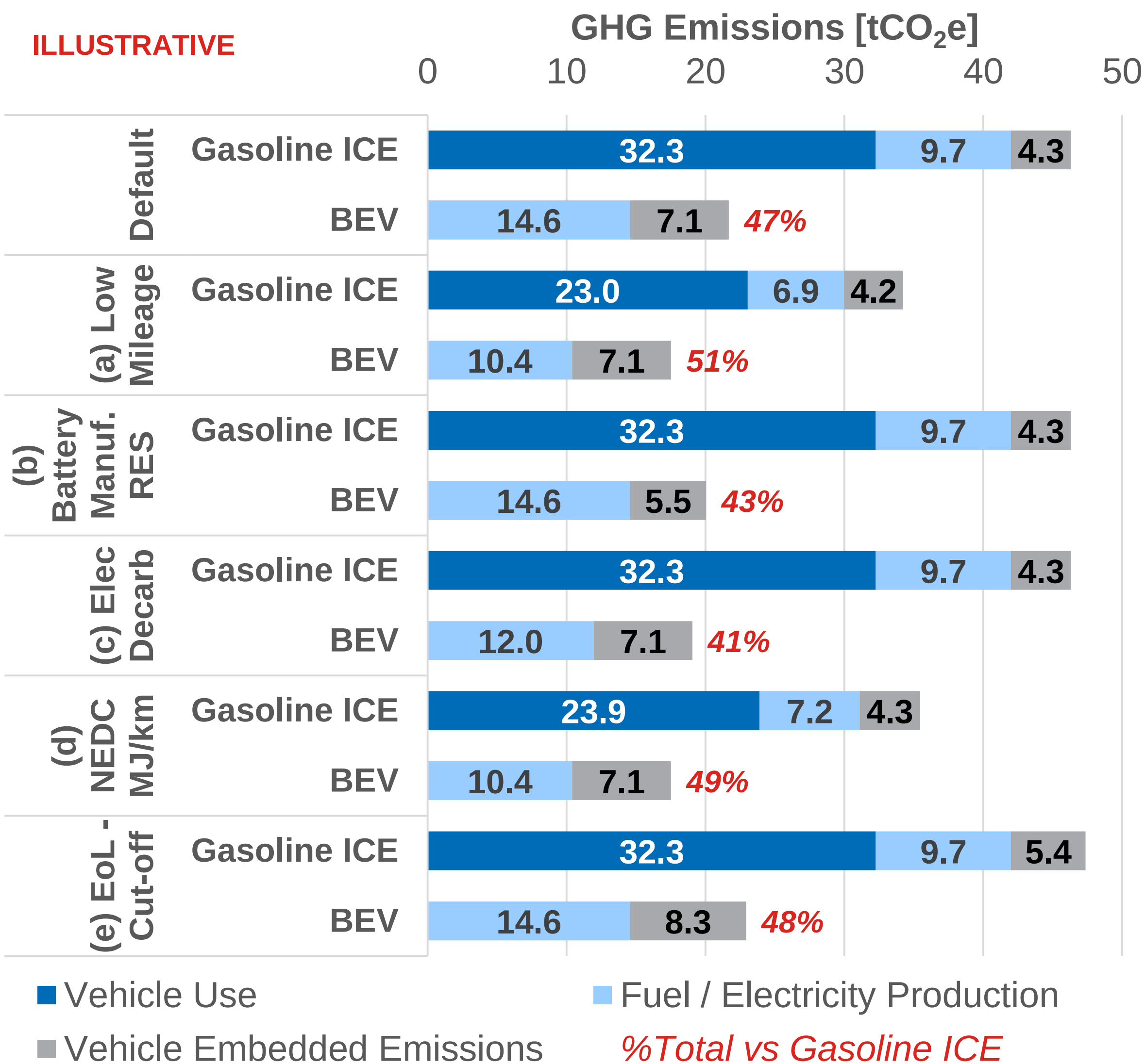
- Environmental impact of driving (TTW emissions)
- Impact from maintenance and servicing

End-of-Life

Adds assessment of environmental impact of "end-of-life" scenario (i.e. -to-Grave). Can include: **re-using** or **re-purposing** components, **recycling** materials, energy recovery, and disposal to landfill

Mobility System Life Cycle … adds **Infrastructure**

What are the key parameters that should be considered? Key assumptions commonly made in LCA can have a profound impact…



Av. Car - Default

- 210,000 km lifetime (EU Av.)
- Battery cell manuf. KR / JP
- Electricity EU av. 2015
- ‘Real-world’ MJ/km
- EoL: recycling credits

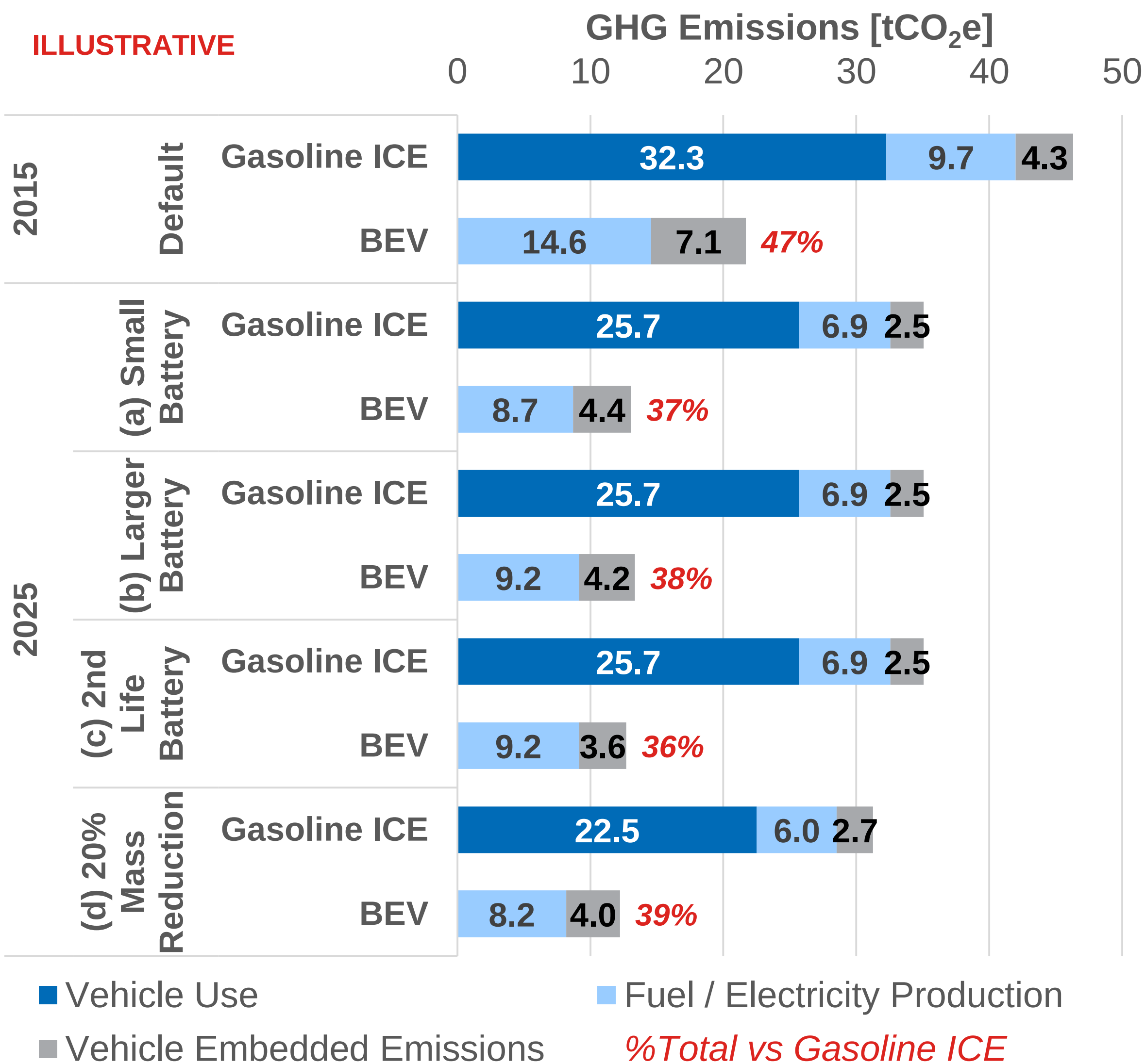
Av. Car - Alternative

a) 150,000 km (Common LCA)
b) Battery manuf. 100% RES
c) Electricity EU av. 2015-2030
d) NEDC MJ/km
e) EoL: no recycling credits

→ Careful consideration of these parameters / their variability will also influence vehicle design

Source: Ricardo life cycle analysis, December 2018. Assumes NEDC to Real-World uplift of 35% for Gasoline ICE, and 40% for BEV. BEV battery capacity ~24 kWh.

How might key design decisions influence the outcome? Important decisions on battery sizing, mass reduction and planning for EoL…



Av. Car - Default

- 210,000 km lifetime (EU Av.)
- Battery cell manuf. KR / JP
- Electricity EU av. 2015/2025
- ‘Real-world’ MJ/km
- EoL: recycling credits

Av. Car - 2025 Alternative

a) Small battery, with replacement (cycle life)*
b) Larger (by 80%) battery, no replacement needed**
c) Credit for 2nd Life Battery (displacing a new battery)
d) 20% Mass Reduction

* Emissions for replacement battery are included within the overall Vehicle Embedded Emissions total.
** For a larger battery pack, fewer charge-discharge cycles are required for the same overall mileage.

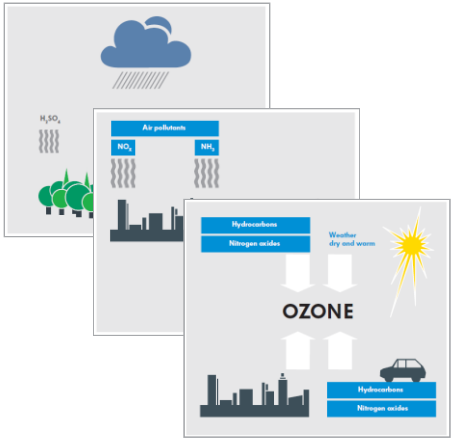
Source: Ricardo life cycle analysis, Dec’ 2018. Assumes NEDC to Real-World uplift of 35% for Gasoline ICE, and 40% for BEV. 2015 BEV battery capacity ~24 kWh; 2025 ‘smaller/larger’ = 30 / 54 kWh.

Is it all about Greenhouse Gases? Other impacts and factors also influence the overall comparisons of impacts…for example:

Primary Energy

- How much / what types of source?
- What is the most efficient use of renewables?
  - BEV = 1x
  - FCEV = ~3x
  - eFuel = ~5x

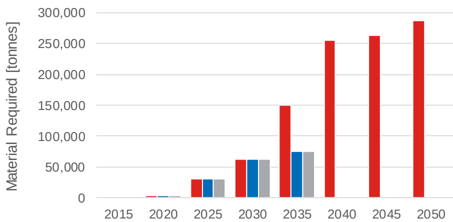
Air Quality Pollutants



- Emissions impacts vary by:
  - Powertrain
  - Lifecycle stage
  - Location
- Can influence conclusions

Resources

3 Li Lithium	27 Co Cobalt	28 Ni Nickel



- Availability of key materials for batteries, motors
- Biomass supply for bioenergy *and* other uses
- Water consumption

[Lifecycle Costs, i.e. TCO]

- Total Cost of Ownership ≈ LCA for money
- Environmental externalities (costs) added for societal analysis

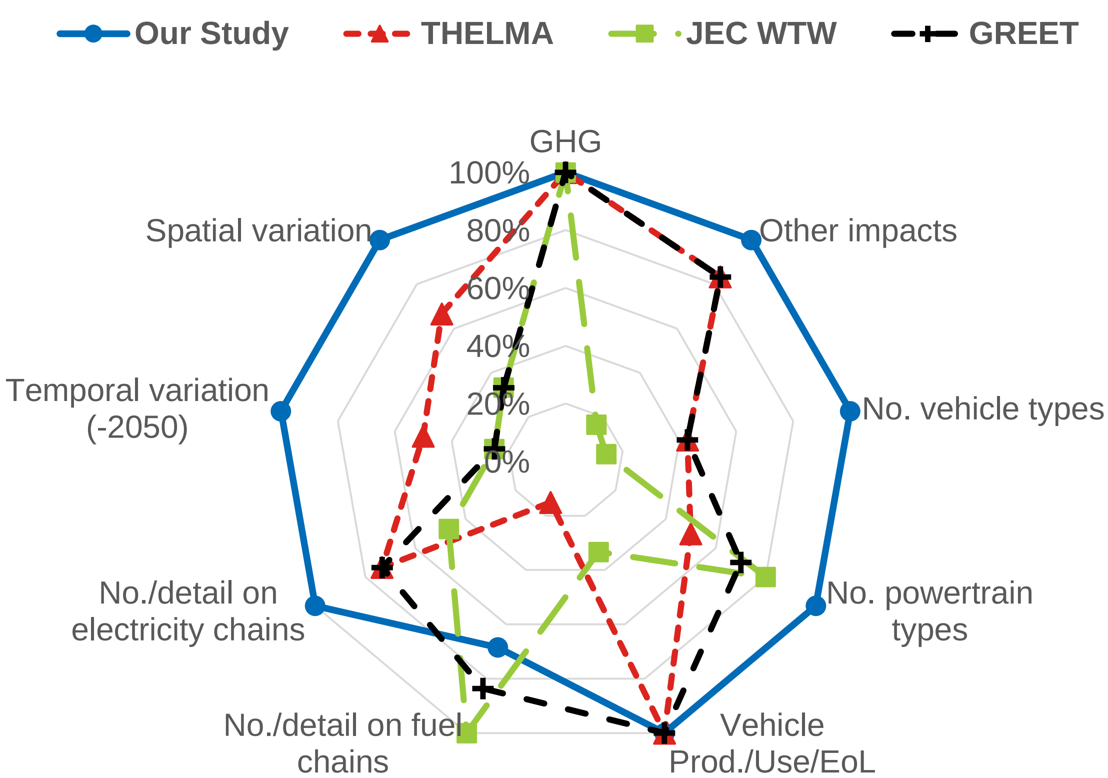
Summary –
What are the key take-aways and how might EU LCA policy develop?

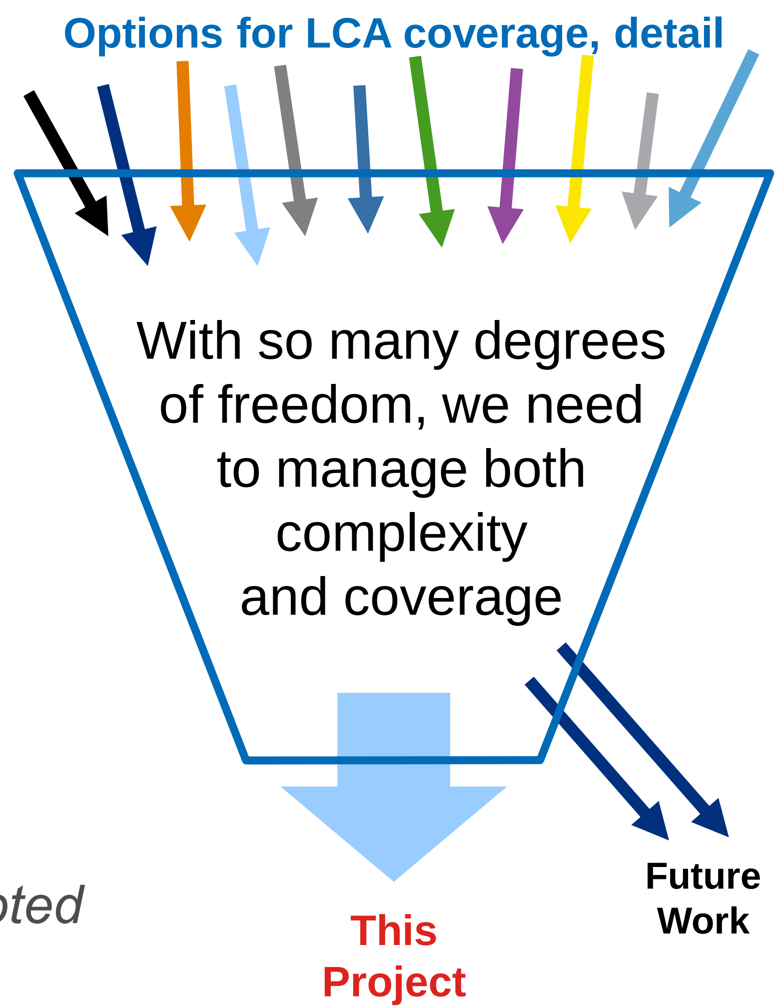
- For policy analysis it is particularly important for LCA to look forwards and understand also what might change in 10+ years, which can have a significant impact
  - This can help inform policy decisions, but regulatory-based approaches would need important methodological differences
- Clear definition of the goal and scope are critical
- Key assumptions must be clearly defined, based on real-world application, and consistent with the goal and scope
- Consider consequences of design / use – rightsizing batteries, factoring in balance of priorities across the entire lifecycle to avoid making decisions that have adverse net impacts
- It is important not to just look at GHG – a holistic view considering other impacts is also important to identify potential hotspots and avoid creating new issues elsewhere

Ricardo Energy & Environment and its partners ifeu, E4Tech and ZHAW have been appointed by DG CLIMA to investigate the environmental impacts of vehicles through Life Cycle Assessment

Scope of our study vis-à-vis reference studies

Level of coverage and detail





This study's broad scope has rarely been attempted before, requiring a streamlined approach

Thank you!

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