UNDERSTANDING LIFE CYCLES FOR FUTURE POLICY

Andy Eastlake – LowCVP

Jane Patterson – Ricardo Strategic Consulting

FUTURE OF TECHNOLOGY SERIES

SHARING IDEAS

UNLOCKING OPPORTUNITIES

RICARDO

LowCVP Low Carbon Vehicle Partnership

OUR HISTORY OF SHAPING LCA UNDERSTANDING

LowCVP and its members supported by LCA experts – developing community consensus


RICARDO

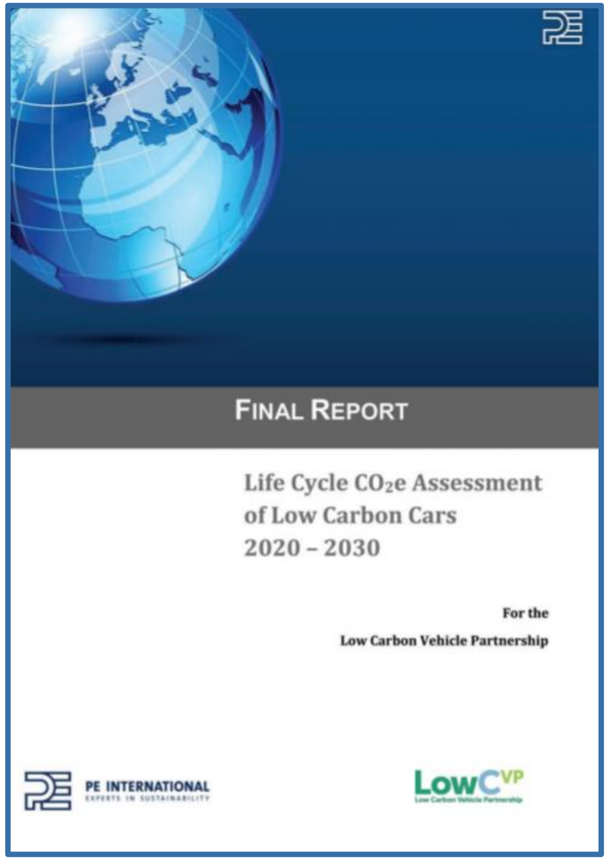
Preparing for a Life Cycle CO_2 Measure

A report to inform the debate by identifying and establishing the viability of assessing a vehicle's life cycle CO_2e footprint

Date	20 May 2011
Report	RD.11/124801.4
Project	Q57627
Confidential	Low Carbon Vehicle Partnership
Report by	Jane Patterson Marcus Alexander Adam Gurr
Approved	Dave Greenwood

LowCVP low carbon vehicle partnership

Accelerating the Shift to Low Carbon Vehicles and Fuels


FINAL REPORT

Life Cycle CO_2e Assessment of Low Carbon Cars 2020 – 2030

For the Low Carbon Vehicle Partnership

PE INTERNATIONAL

LowCVP

THE CHANGING FACE OF TRANSPORT

- Electrification and grid decarbonisation
- Increasing battery size and charging speeds
- Renewable and sustainable fuels and energy
- Light-weighting and material innovation
- Expanding range of vehicle categories and utility functions
- Mobility habits and transport demand

- The role of LCA can be ensuring there is a “whole life carbon conscience” to future trajectories
- Building community understanding and widespread awareness is a primary step, to ensuring the right questions can be asked.

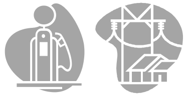
A VEHICLE LCA STUDY MAY CONSIDER THE WHOLE LIFE OF THE VEHICLE, OR JUST PART OF IT

Vehicle Life Cycle

Well-to-Wheel (WTW) Analysis

"Embedded" emissions

Whole vehicle life cycle
= embedded + WTW



Fuel Production

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

Vehicle Production

Assessment of environmental impact of producing the vehicle including extract of raw materials, processing, component manufacture, logistics, vehicle assembly and painting

Use

- Environmental impact of driving
- Impact from maintenance and servicing

End-of-Life

Assessment of environmental impact of "end of life" scenario, including re-using components, recycling materials, energy recovery, and disposal to landfill

Source: "Understanding the life cycle GHG emissions for different vehicle types and powertrain technologies", Ricardo report for LowCVP (2018) (RD18-001581-2)

FOR LOWCVP'S LCA STUDY WAS BASED ON A SELECTIVE REVIEW OF PUBLISHED LITERATURE

Study Methodology – Literature Review

Literature Searches

Searches of relevant LCA and related literature using a range of tools such as Ricardo Powerlink, Science Direct and Google. Also includes input from LowCVP members and Ricardo background information

Literature Scan & Categorisation

Identified documents entered into LCA Literature Database. Initial high-level review of all documents to categorise by vehicle type, powertrain technology, fuel / energy vector, vehicle components, life cycle stages, environmental impacts and LCA tools used

Prioritisation

Papers ranked according to relevance to this study (more recent papers and European context considered most relevant), and usefulness of data recorded. Highly ranked papers selected for next-level Literature Review

Literature Review of "Top 50"

Review of papers by vehicle type (and batteries) to extract relevant information such as application, key assumptions, life cycle impact results

L-Category | **Passenger Car** | **Trucks** | **Buses** | **Batteries**

Discussion & Critique

Recording of Literature Review outputs to provide understanding of life cycle GHG emissions for different vehicle types and powertrain technologies. Also, highlighting areas of commonality or convergence, and reasons for variation

Source: "Understanding the life cycle GHG emissions for different vehicle types and powertrain technologies", Ricardo report for LowCVP (2018) (RD18-001581-2)

OVER 150 RELEVANT DOCUMENTS WERE IDENTIFIED, THE TOP 50 WERE INCLUDED IN THE LITERATURE REVIEW

Literature Review Dashboard

136
papers & reports identified

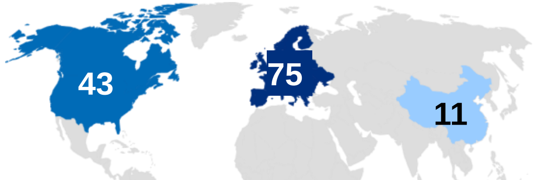
15+
Literature Searches completed

Including c.25 documents submitted by LowCVP members

>100
papers scan read or reviewed

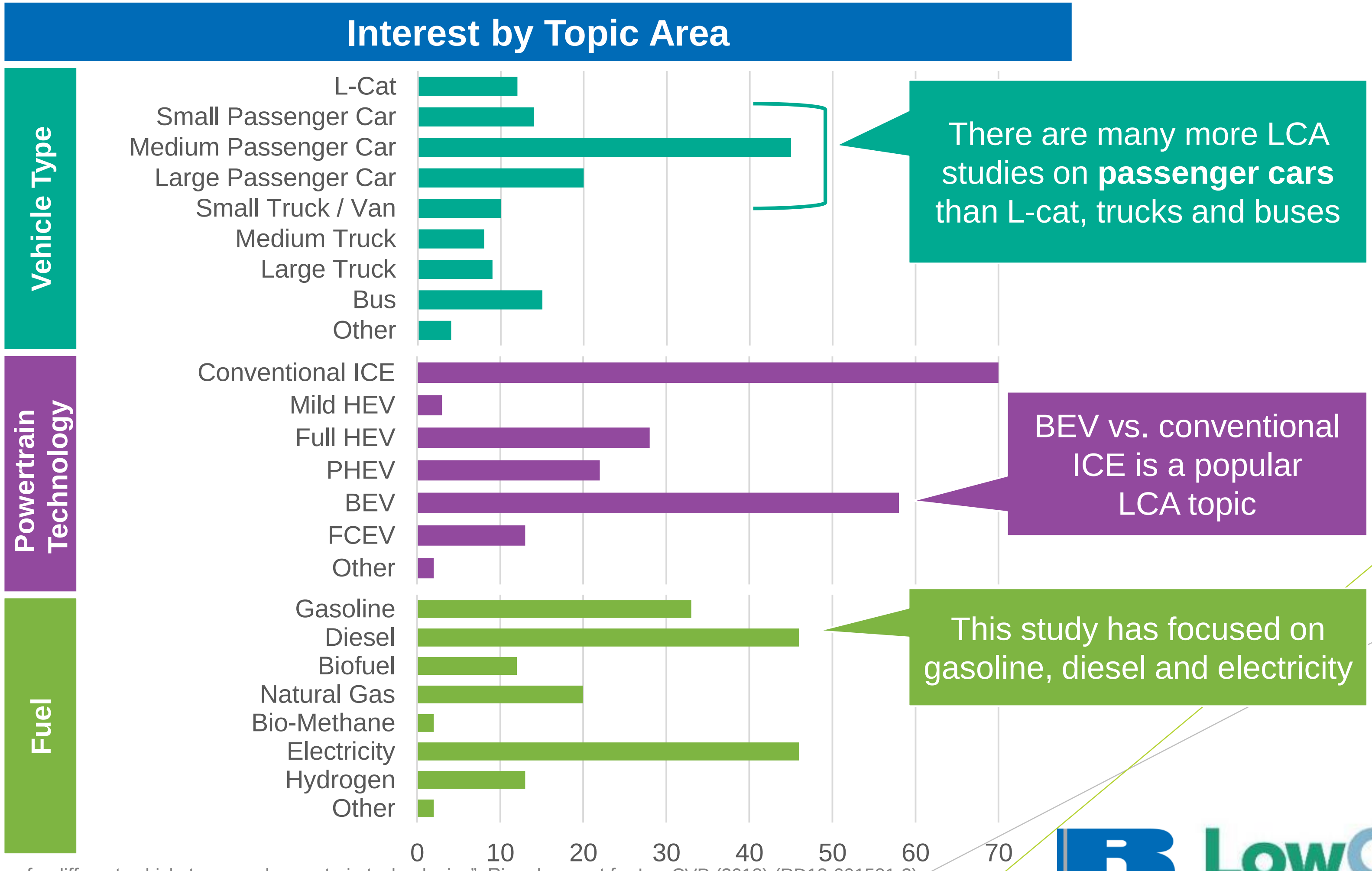
In addition **30** News Articles and **c.20** OEM and Supplier Sustainability & Environmental reports also considered

Geography



Rest of World – 15 papers

Note: Some papers considered >1 geographical region



FUTURE OF TECHNOLOGY SERIES

Source: "Understanding the life cycle GHG emissions for different vehicle types and powertrain technologies", Ricardo report for LowCVP (2018) (RD18-001581-2)

RICARDO

LowCVP Low Carbon Vehicle Partnership

RESULTS: THE RELATIVE CONTRIBUTION OF EACH VEHICLE LIFE CYCLE STAGE IS HIGHLY DEPENDENT ON THE VEHICLE TYPE AND POWERTRAIN TECHNOLOGY

Relative Contributions of each Life Cycle Stage by Vehicle Type and Powertrain Technology

Vehicle Type	Conventional ICE Powertrain Technology				BEV Powertrain Technology			
	Vehicle Production	WTT	TTW	EoL	Vehicle Production	WTT	TTW	EoL
L-Category	c.10-30%	c.10-15%	c.60-75%	<5%	c.45-75%	c.25-55%	-	<5%
Passenger Car	c.15-30%	c.10-15%	c.60-70%	<3%	c.20-60%	c.40-60%	-	<3%
Heavy Duty Truck	c.1-3%	>95%		<1%				
Bus	c.15%	>80%		<5%	c.30-40%	c.60-70%	-	<5%

The relative contribution of embedded emissions (from vehicle production and EoL) to in-use (WTW) is highly dependent on the **vehicle type, lifetime mileage and duty cycle**

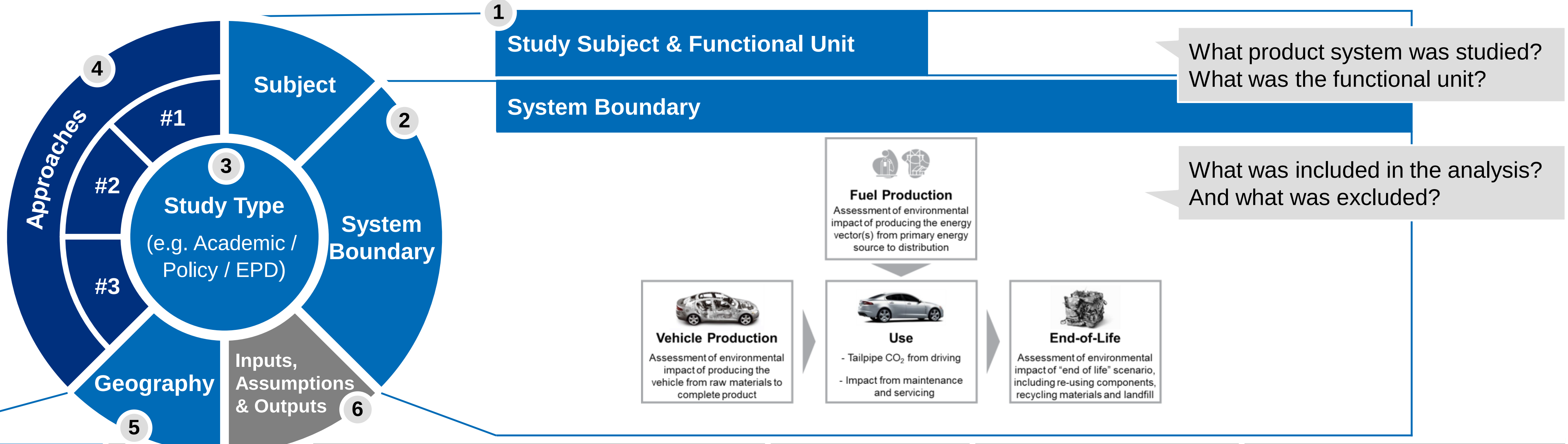
The contribution of End-of-Life is difficult to quantify since most studies assume high recycle rates, and some apply “credits” for producing recycled material. However, the general consensus is that the portion to overall life cycle emissions is relatively low (<5%)

Carbon intensity for electricity could be nearly zero if renewable, sustainable electricity is used in the vehicle. This should shift all life cycle environmental burdens to vehicle production and end-of-life

Source: “Understanding the life cycle GHG emissions for different vehicle types and powertrain technologies”, Ricardo report for LowCVP (2018) (RD18-001581-2)

LOWCVP PROPOSE A “GUIDANCE FRAMEWORK” TO HELP THE WIDER AUTOMOTIVE COMMUNITY & POLICY MAKERS UNDERSTAND LCA

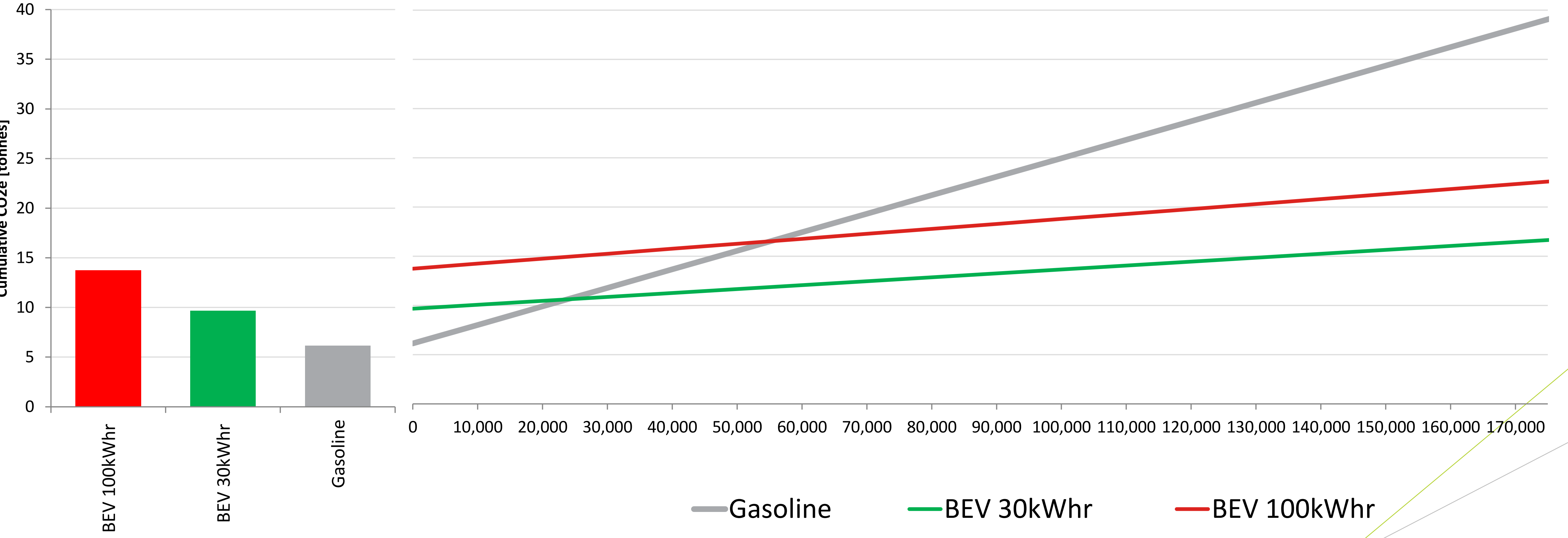
Understanding LCA Studies – “Guidance Framework” Overview



Geography	Input Data	Key Assumptions	LCI Datasets	Environmental Impact Factors	Time Horizon
	Primary vs. Secondary data	Vehicle duty cycle; Lifetime Mileage [km]; Electricity carbon intensity [kgCO_2e/kWh]; Battery embedded carbon factor [kgCO_2e/kWh or kgCO_2e/kg] , etc.	E.g. EcoInvent How old is this data?	E.g. Global Warming Potential (GWP) [tCO2e], Human Toxicity, etc.	Model Year (current / historic / future); Vehicle Lifetime; Allowance for temporal effects, etc.

Source: “Understanding the life cycle GHG emissions for different vehicle types and powertrain technologies”, Ricardo report for LowCVP (2018) (RD18-001581-2)

THE EFFECT OF BATTERY SIZE ON CARBON SAVINGS (HYPOTHETICAL EXAMPLE ONLY)



ECONOMY AND ENVIRONMENT – THE TOTAL COST APPROACH

- In the same way as the costs of EVs require a whole life approach. Carbon impact needs similar.
- If infrastructure is incorporated the picture is more complex
- In applications where embedded carbon is high, reuse and recycling become highly influential aspects
- Ultra-high energy use applications (truck) may be best served by hybrid solutions
- Demand for larger batteries and Ultra power chargers could undermine GHG benefits
- Right-sized batteries combined with high energy density range extenders may be beneficial for some applications

- **Bigger isn't always better!**