Embedding LCA into automotive manufacturing & future vehicle policy

LowCVP/APC workshop

28 November 2019

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ADVANCED PROPULSION CENTRE UK

Philippa Oldham

Head of National Network Programmes

Ambition of the UK Government

- The target will require the UK to bring all greenhouse gas emissions to net zero by 2050, compared with the previous target of at least 80% reduction from 1990 levels.
- The UK has already reduced emissions by 42% while growing the economy by 72% and has put clean growth at the heart of our modern Industrial Strategy.
- UK the first major economy to pass new laws to reduce emissions to net zero by 2050 while remaining committed to growing the economy - putting clean growth at the heart of our modern Industrial Strategy.
- Ambition is that the UK is to lead other countries to follow in our footsteps driving prosperity by seizing the economic opportunities of becoming a greener economy.
- The UK's 2050 net zero target was recommended by the Committee on Climate Change, the UK's independent climate advisory body
- Net zero means any emissions would be balanced by schemes to offset an equivalent amount of greenhouse gases from the atmosphere, such as planting trees or using technology like carbon capture and storage

Life Cycle Assesment

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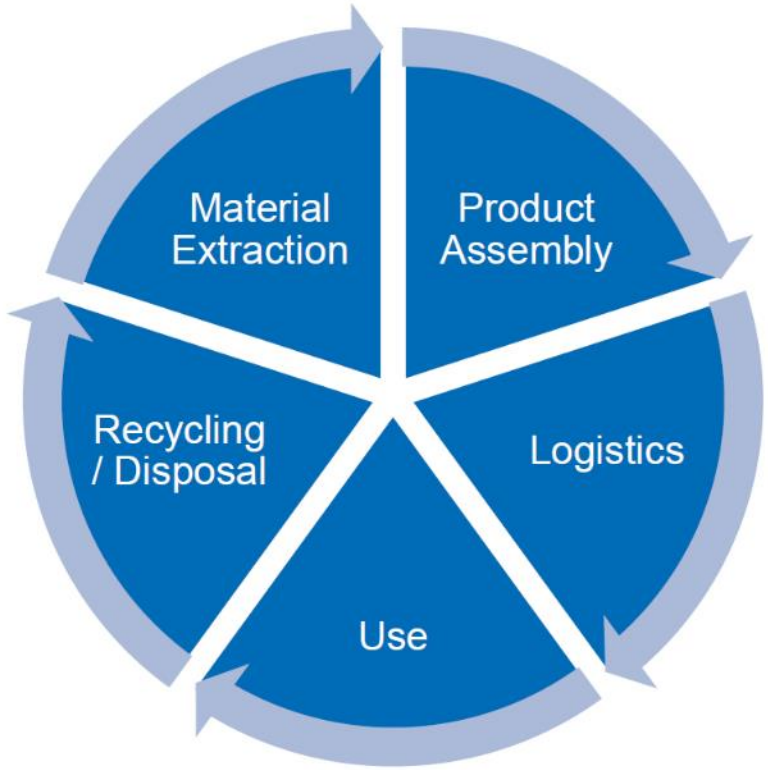
What is Life Cycle Assessment?

- All things have a **life cycle** of "birth", "use/service" and "death" in which they impact on their environment
- **Life Cycle Assessment (LCA)** is a technique for quantifying the environmental and human health impacts of a product over its life cycle
  - Other names include "life cycle analysis", "life cycle approach", "cradle-to-grave analysis", "ecobalance" or "environmental footprinting"
- **Life Cycle Thinking** is a way of thinking that includes the economic, environmental and social consequences of a product or process over its entire life cycle



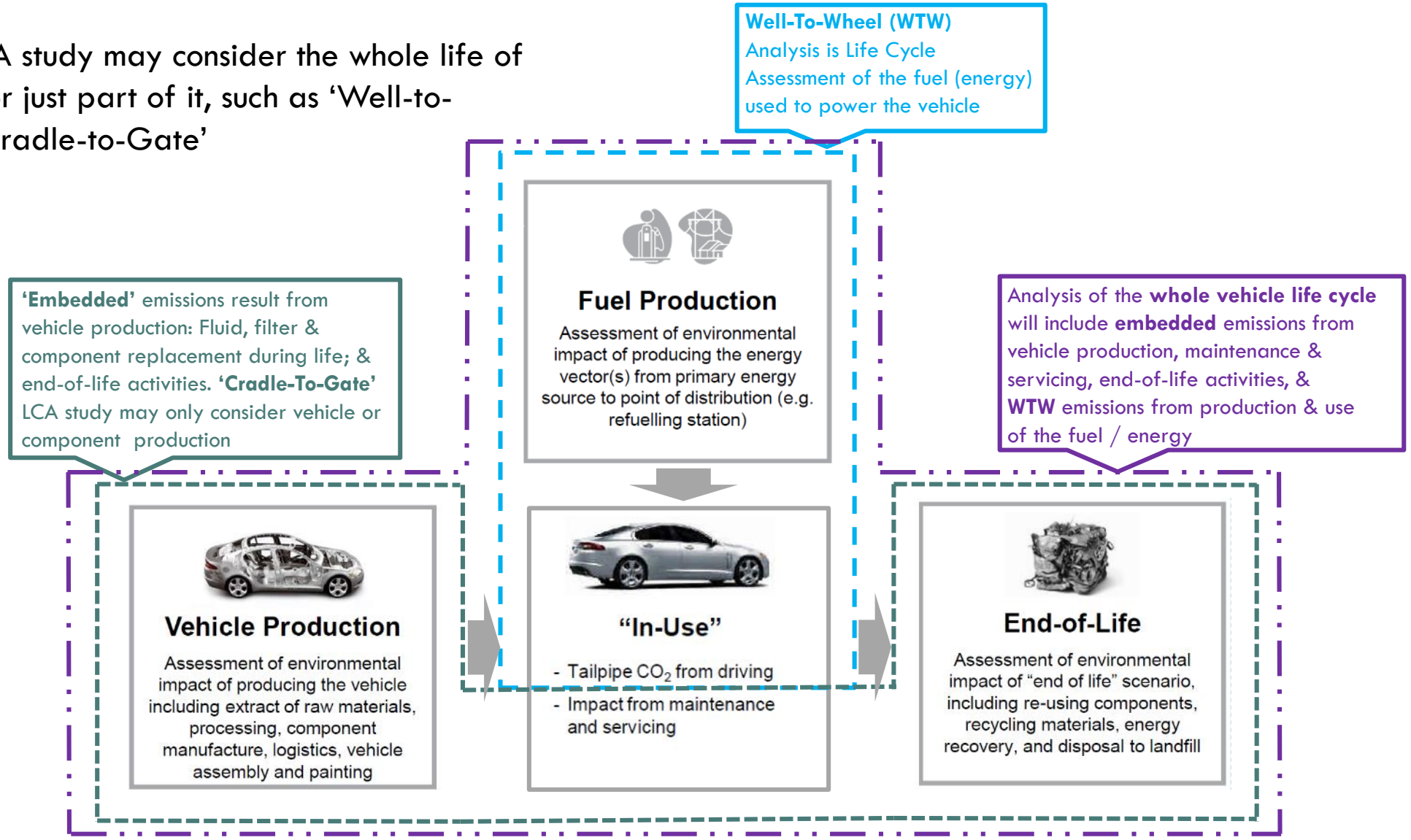
Formal Definition of Life Cycle Assessment

"It is a process to evaluate the environmental burdens associated with a product, process or activity by identifying and quantifying energy and materials used and wastes released to the environment. The assessment includes the entire life cycle of product, process or activity, encompassing extracting and processing raw materials, manufacturing, transport and distribution; use, re-use, maintenance; recycling, and final disposal"

SETAC, 1991

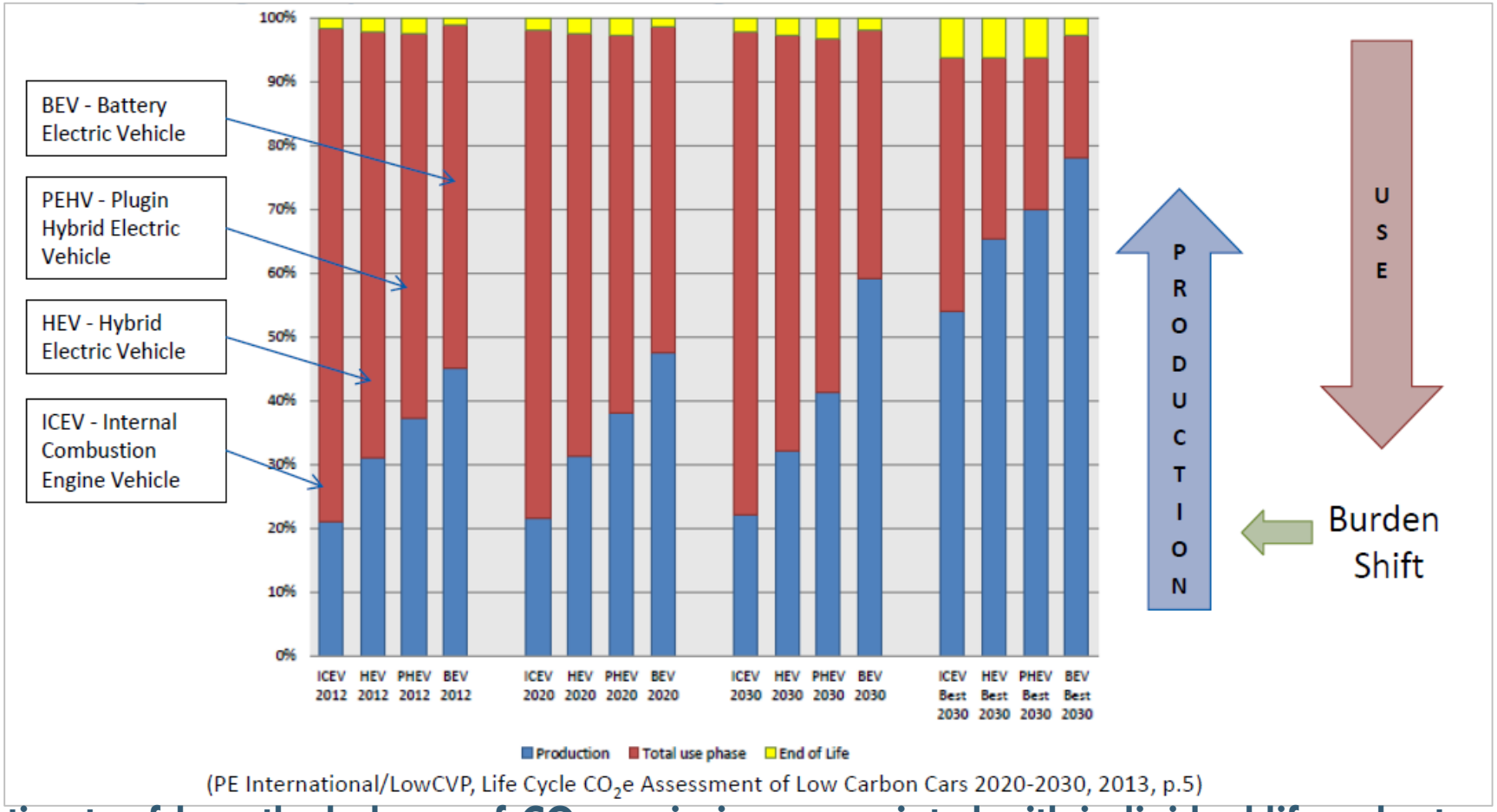
Understanding the LCA boundaries

A vehicle LCA study may consider the whole life of the vehicle, or just part of it, such as 'Well-to-Wheel' or 'Cradle-to-Gate'



The Journey to 2040

Why is introducing a lifecycle CO2e metric in policy important?



(PE International/LowCVP, Life Cycle CO_2e Assessment of Low Carbon Cars 2020-2030, 2013, p.5)

For EVs CO_{2e} burden will shift to vehicle production in the future

With climate change policy stronger focused on zero emission vehicles, a more robust approach to measuring and mitigating GHG emission required.

Future considerations for EVs will be reducing CO_2e in battery production, improving vehicle light weighting & battery density.

Estimate of how the balance of CO_{2e} emissions associated with individual lifecycle stages might vary for different technologies if the future.

The Journey to 2040

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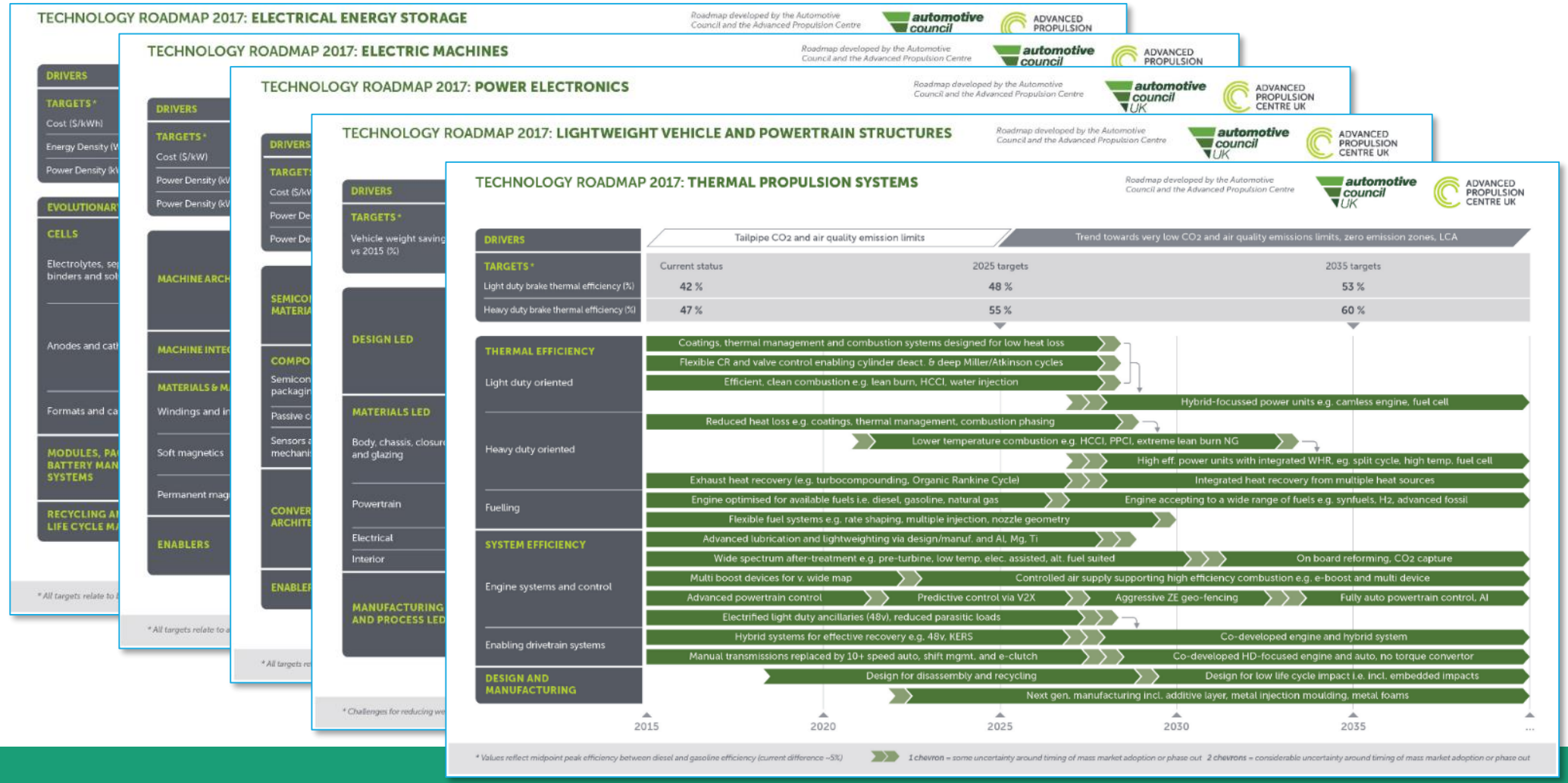
APC Product & Technology roadmaps set out the ambition to move towards an LCA approach



Life Cycle impact for Future Transport policy

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28 November 2019

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Andy Eastlake

Managing Director

The Guardian - Monday & Tuesday

Newspaper led policy is not often useful - Confused consumers stall progress

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Are electric vehicles really so climate friendly?

Hans-Werner Sinn

EVs produce more CO_2 than say diesel – it's just they emit via the power plant not the exhaust pipe

- Response: Yes, electric vehicles really are better than fossil fuel burners

▲ A parking sign for electric vehicles in Grüheide, Germany. Photograph: Hannibal Hanschke/Reuters

Electric, hybrid and low-emission cars

Yes, electric vehicles really are better than fossil fuel burners

Hans-Werner Sinn's opinion piece on whether electric cars are as climate friendly as they seem generated a good deal of controversy. William Todts, executive director of Transport & Environment, gives his response

William Todts

Tue 26 Nov 2019 11.28 GMT

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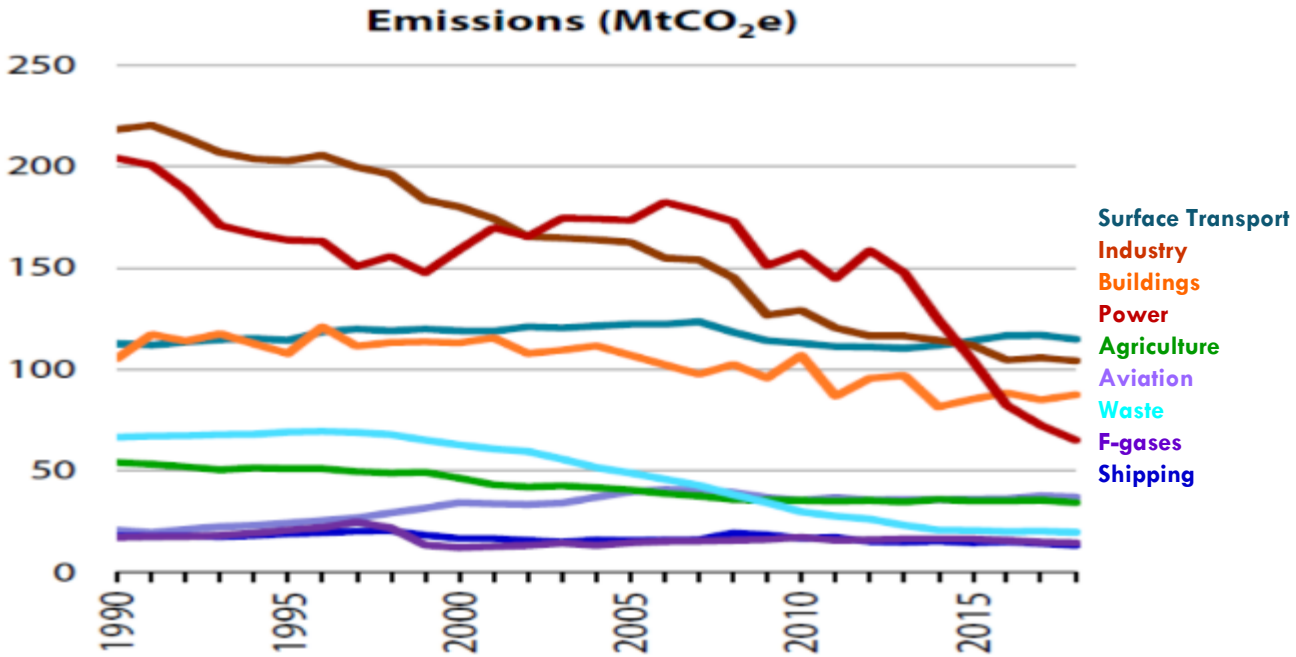
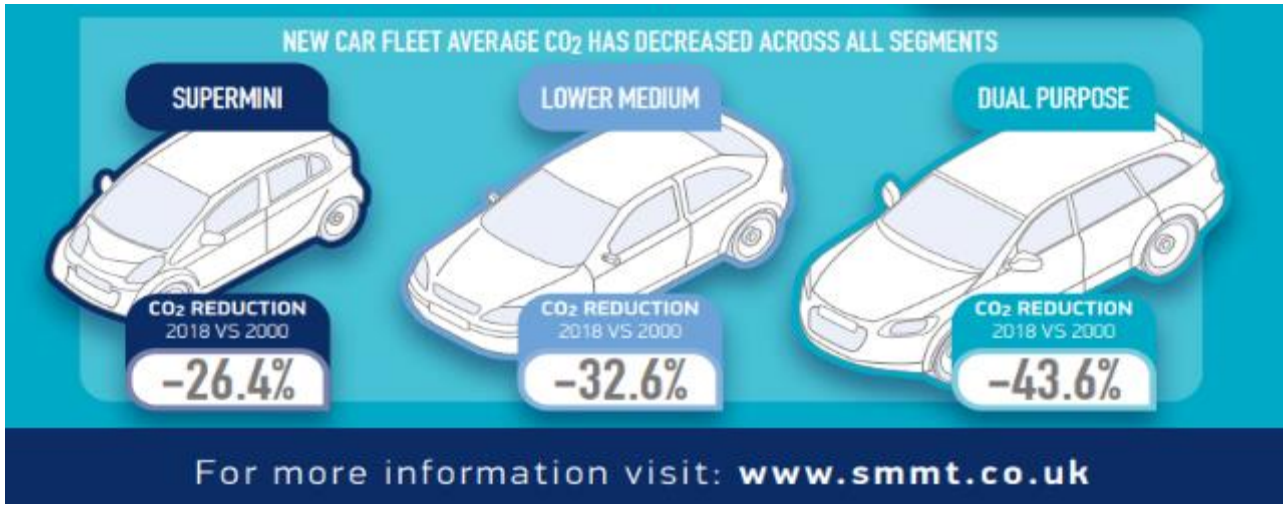
Climate change, CO_2 and Transport



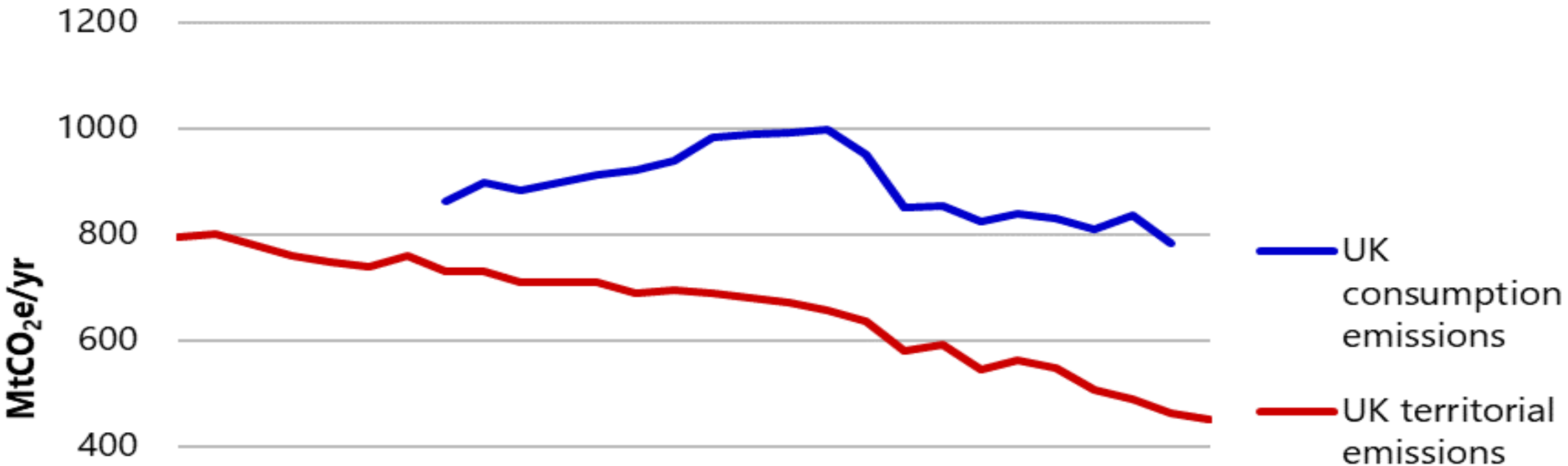


Electric cars and the end of gas boilers will help the UK reach zero emissions target

share

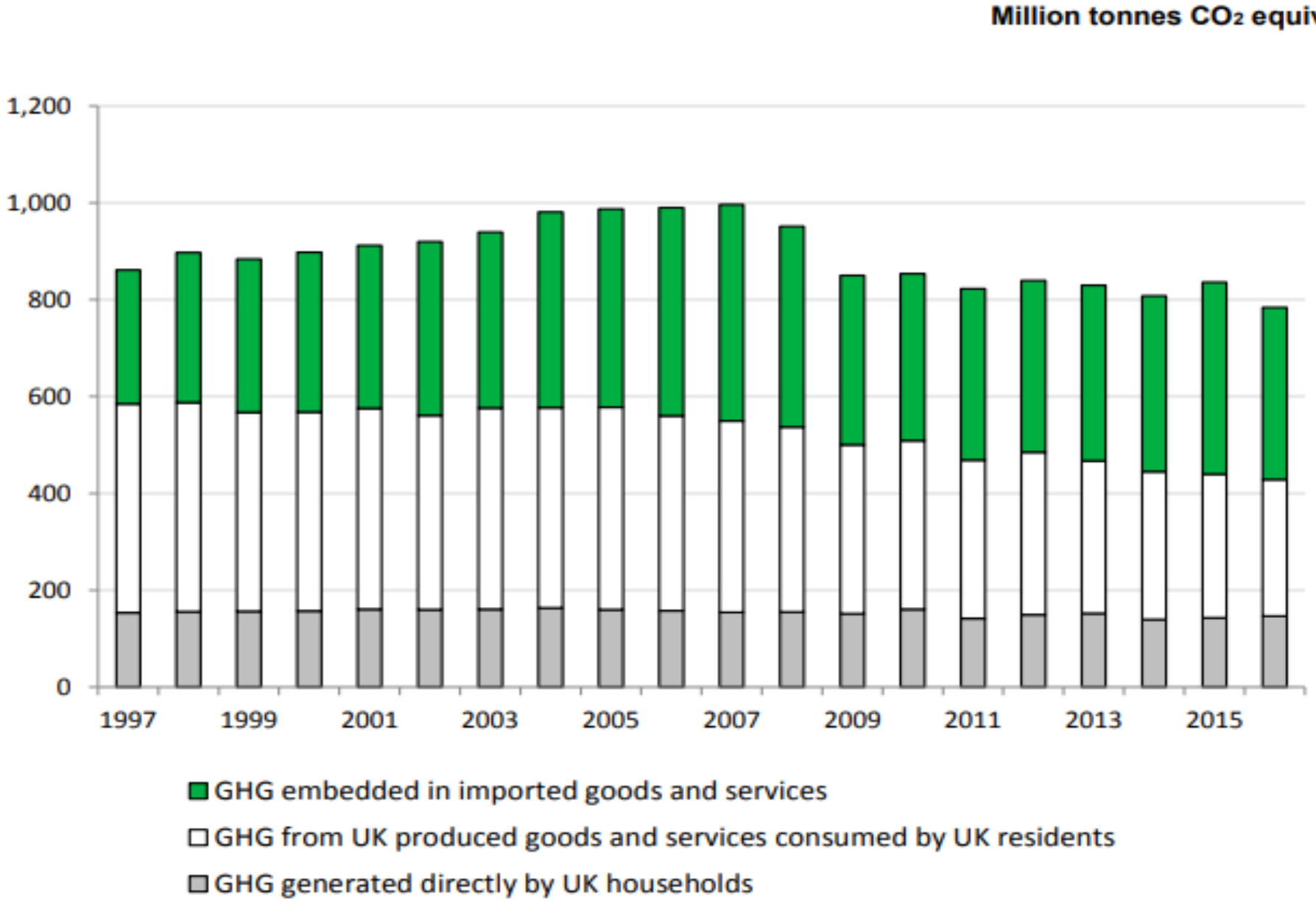
Save 19

Our “imported” emissions are growing

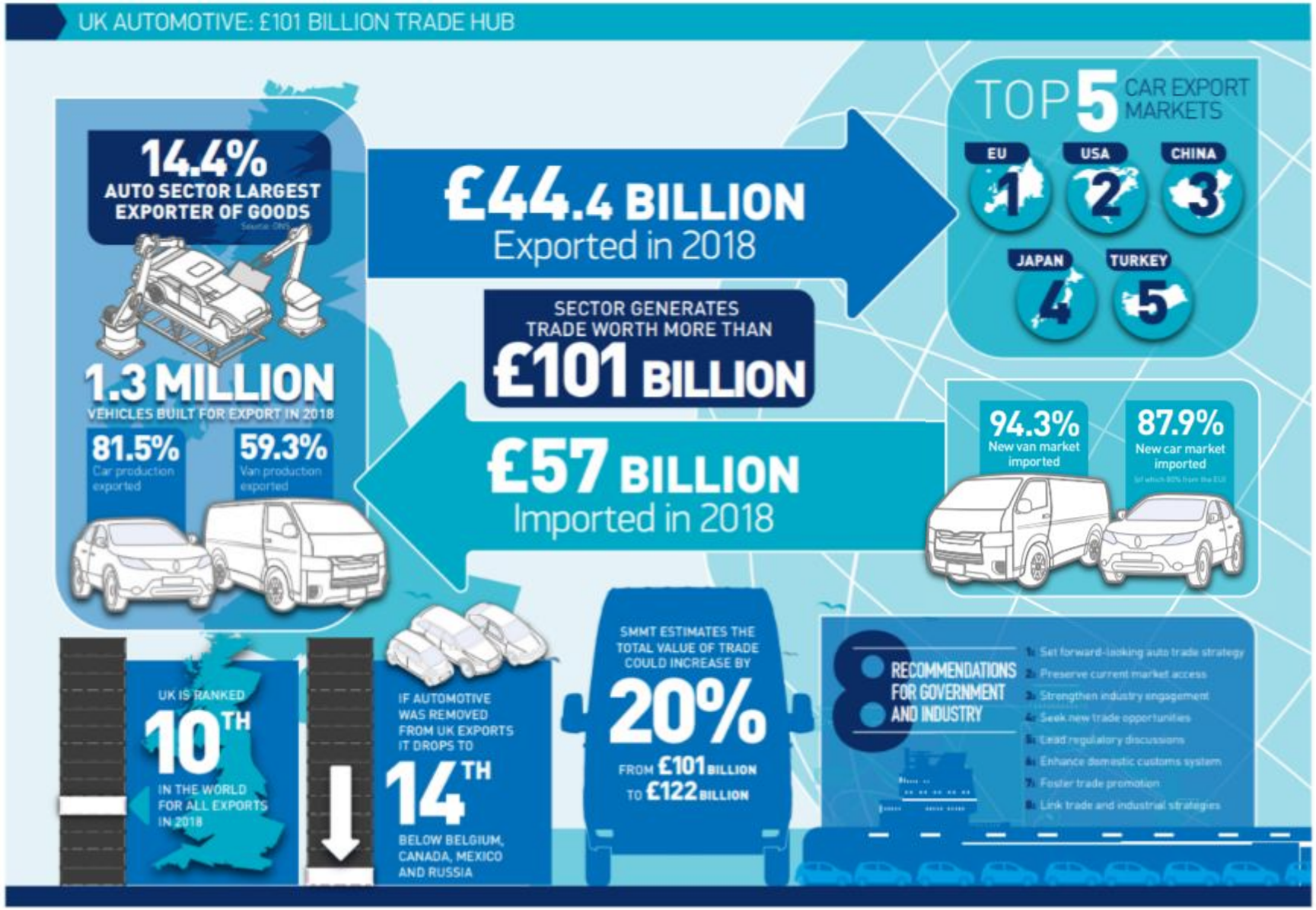


In pursuing a net-zero emissions target, it is important that the actions to reduce UK territorial emissions do not simply off-shore these emissions to other parts of the world. Furthermore, actions that the UK can take to reduce its consumption emissions could be as effective in tackling climate change as actions to reduce territorial emissions. We reflect that in our scenarios in Chapter 5, which for example include resource efficiency and waste reduction, and identify actions that will reduce both UK territorial and imported emissions.

Figure 1 Greenhouse gas emissions associated with UK consumption 1997 to 2016



UK's carbon footprint
DEFRA April 2019



Page 4 | 2019 UK AUTOMOTIVE TRADE REPORT THE SOCIETY OF MOTOR MANUFACTURERS AND TRADERS

THE SOCIETY OF MOTOR MANUFACTURERS AND TRADERS 2019 UK AUTOMOTIVE TRADE REPORT | Page 5

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Automotive is important

UK imports vast majority of vehicles sold

Exports are significant but do not compensate

Understanding life cycle GHG impacts

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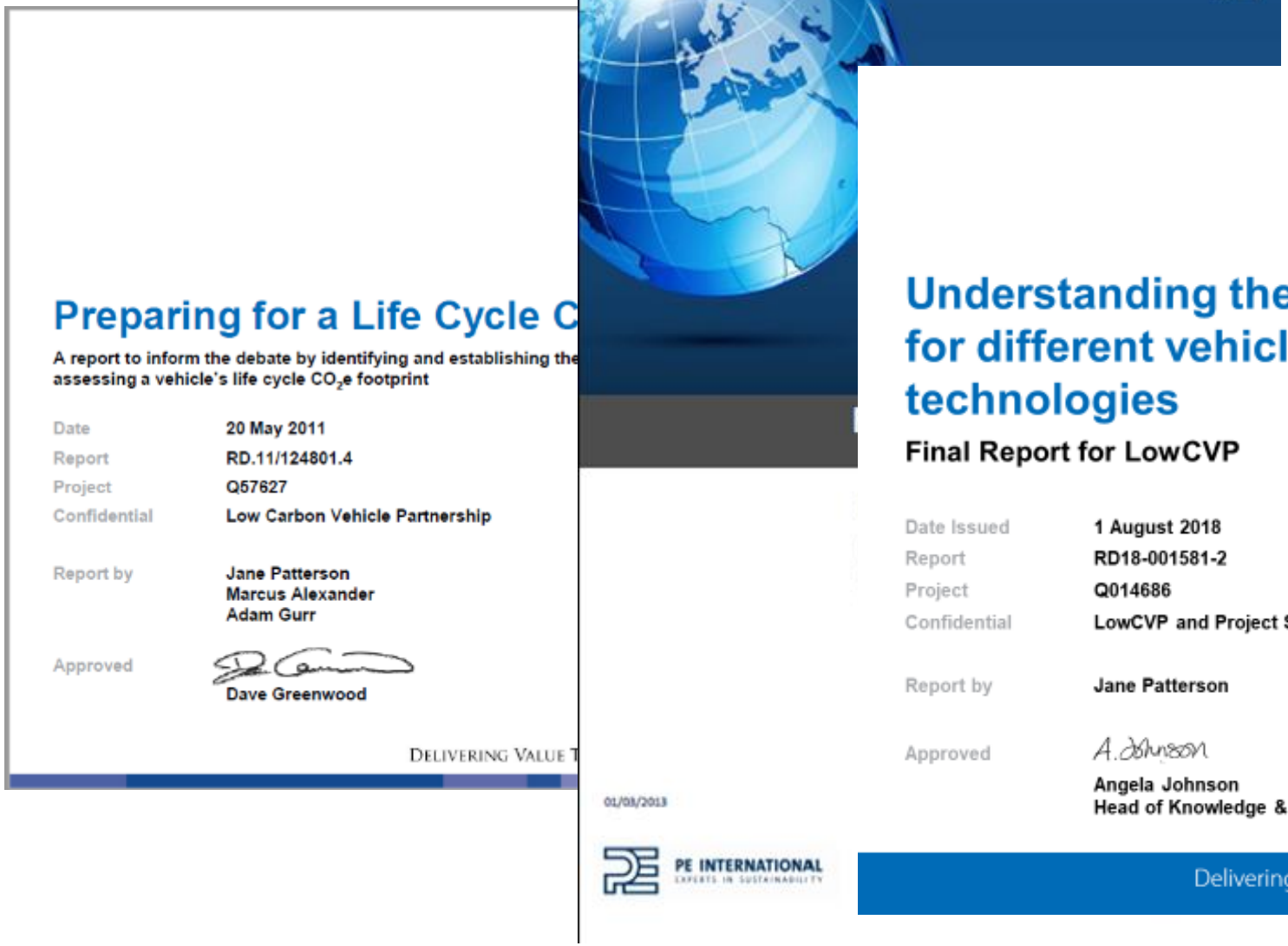

Preparing for a Life Cycle C

A report to inform the debate by identifying and establishing the
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

DELIVERING VALUE T

RICARDO

Understanding the life cycle GHG emissions for different vehicle types and powertrain technologies

Final Report for LowCVP

Date Issued	1 August 2018
Report	RD18-001581-2
Project	Q014686
Confidential	LowCVP and Project Steering Group
Report by	Jane Patterson
Approved	Angela Johnson Head of Knowledge & Technology Strategy

LowCVP
Low Carbon Vehicle Partnership

01/08/2013

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Most elements are regulated already

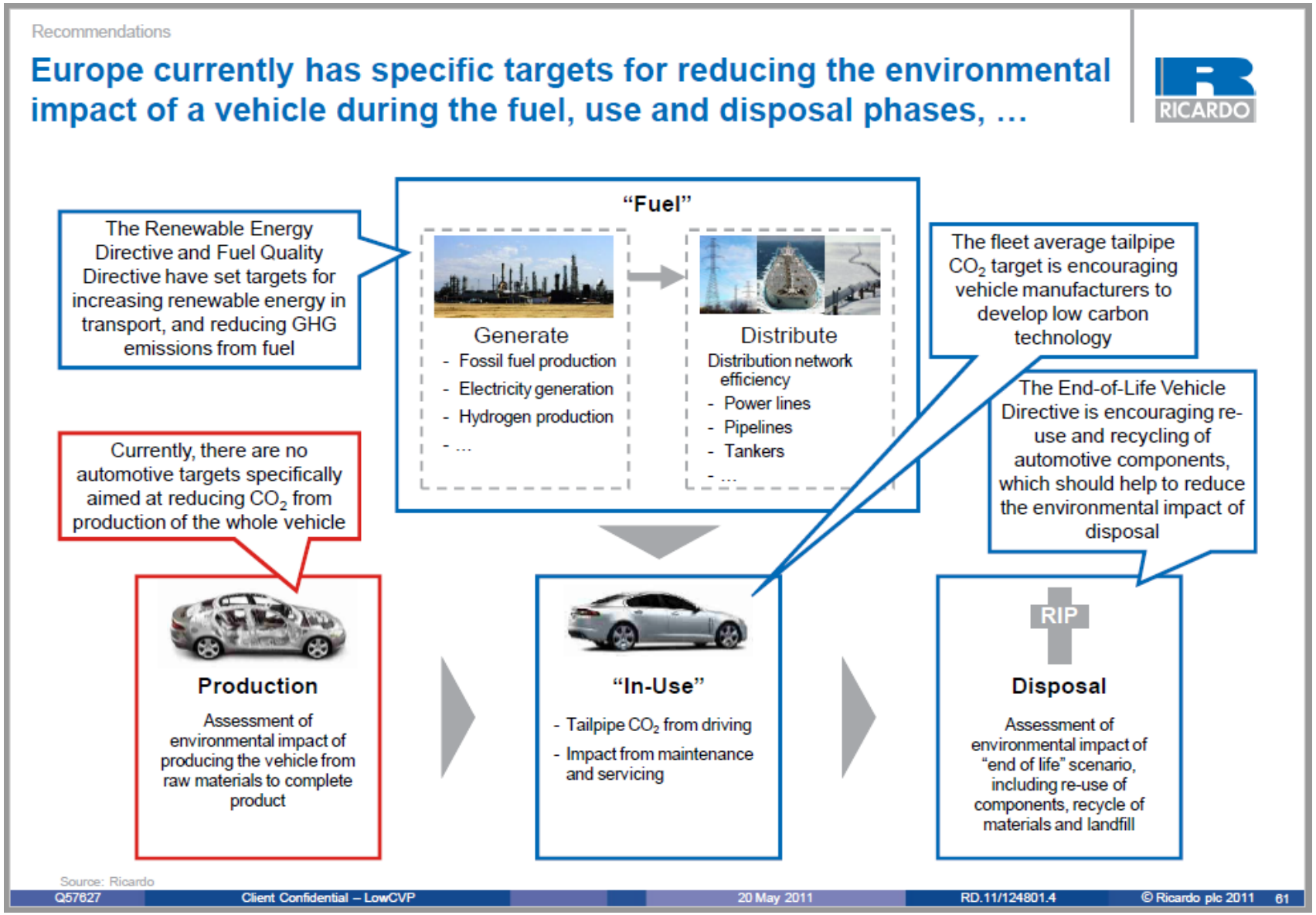
With Electric vehicles OEMs must focus on Productions and Disposal, since fuel and use phases are trending to zero.

But – no regulations exist for energy efficiency – yet

Eg Charging losses

Electricity consumption

Battery Tax?



Common vocabulary

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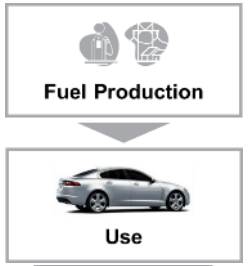
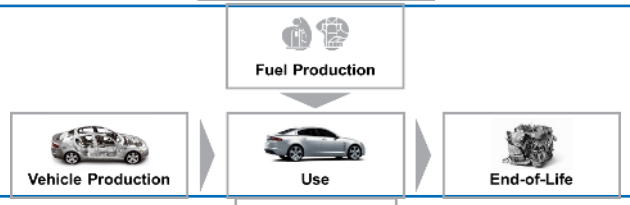
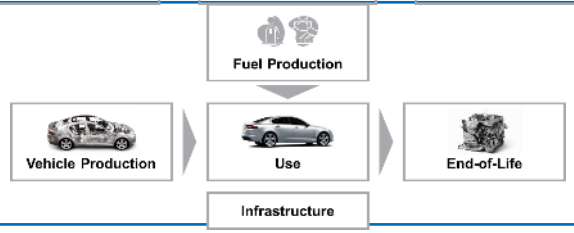
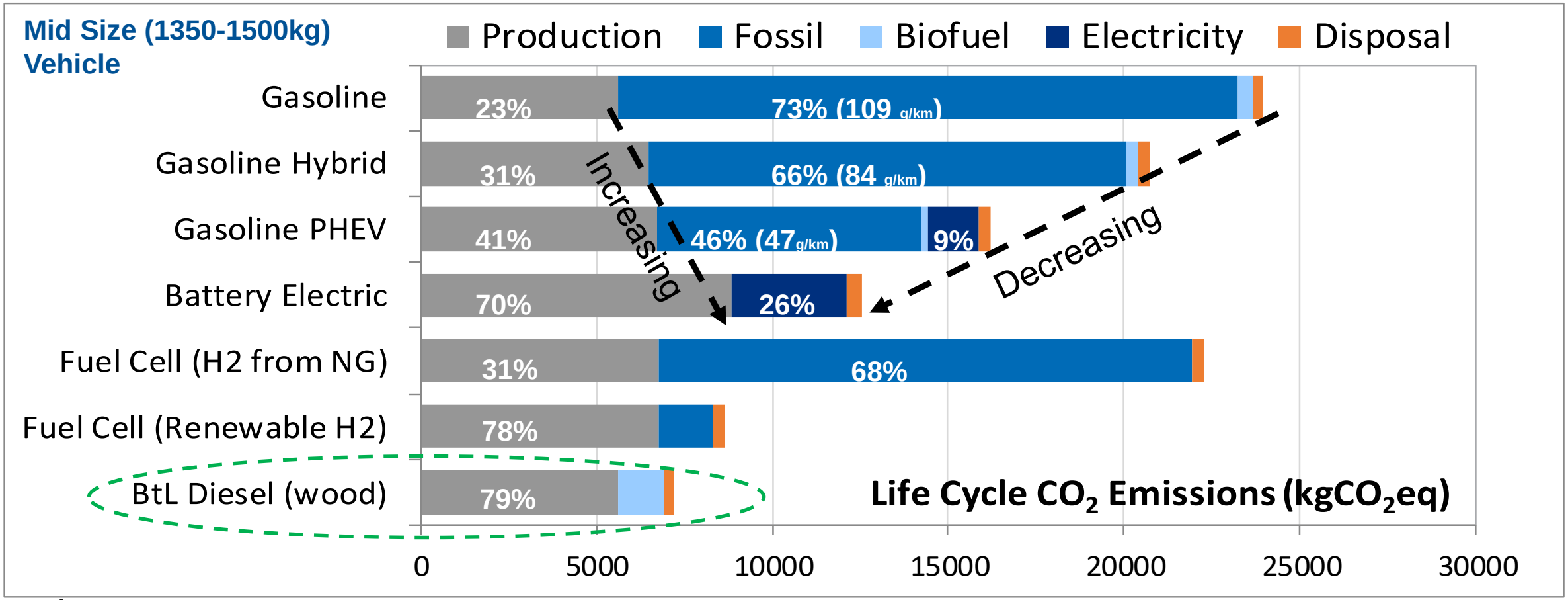
LCA Study Categorisation – Life Cycle System Boundary

Level A **Tailpipe only**		• Considers vehicle point-of-use only
Level B **Well-to-Wheel (WTW)**		• Considers the fuel or energy vector life cycle, from primary energy (e.g. drilling for oil) through to use in the vehicle • Frequently split into "Well-to-Tank" (fuel production and distribution) and "Tank-to-Wheels" (vehicle consumption during use)
Level C **Vehicle Life Cycle**		• Considers the whole vehicle life cycle (cradle-to-grave) from material extraction, through production to use and end-of-life processes
Level D **Whole mobility system life cycle**		• Considers impact of subject within the wider techno-, socio- and eco-spheres, such as including changes to infrastructure or analysing externalities
Cradle-to-gate		• Considers production phase of the vehicle or component, including material extraction • Analysis stops at end of production. Use and end-of-life phases not included in analysis

Light Duty Vehicle - Ricardo analysis - hybrids & EVs have lower life cycle CO_2, higher embedded emissions – bio/e-fuels also attractive?

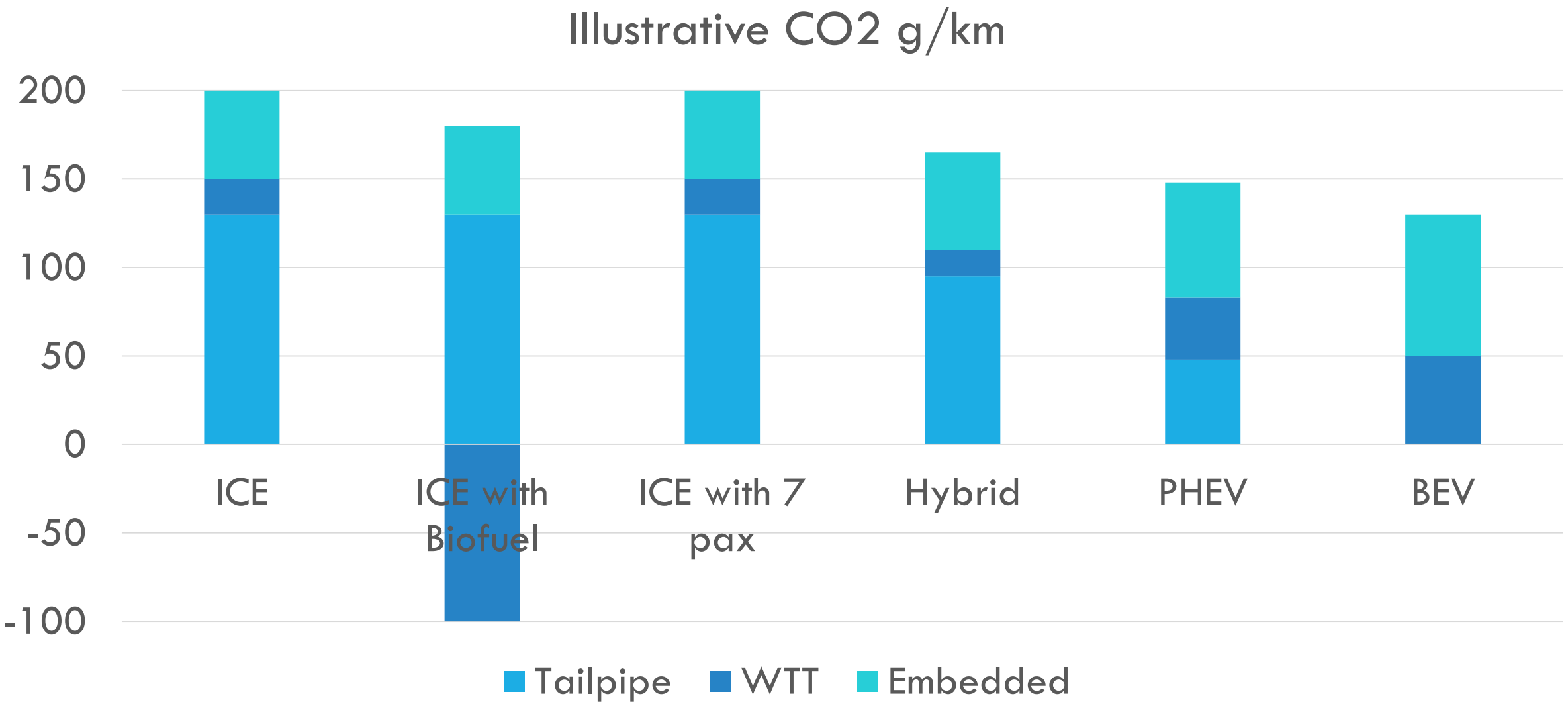


Source: Based on "Preparing for a Life Cycle CO_2 Measure", Low Carbon Vehicle Partnership

Assumptions:

Vehicle specifications based on real world 2020 values
Assumed lifetime mileage 150,000 km.
Gasoline fuel E10. Diesel fuel B7
Fischer-Tropsch diesel from farmed wood (WTW = 6 gCO2eq/MJ)
Hydrogen carbon intensity 99.7 gCO_2e/MJ (NG Steam Reforming)
Electricity carbon intensity 200 gCO_2/kWh (~2025 best case)
Hybrid Battery 1.8 kW.hr NiMH, 56 kW Motor
EV Battery 32 kW.hr Li-ion ~ 150 km range
PHEV Battery 5 kW.hr ~ 20 km range
FCEV Battery 1.8 kW.hr

Current CO_2 (tax, access, policy) doesn't work for future climate policy



LowCVP "tool"

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Life Cycle CO2e Emissions Calculator

Q014686 - LowCVP - Understanding life cycle CO2e emissions for different vehicle segments, technologies and fuels

Project Variation Request 1

This spreadsheet is a calculator for estimating the life cycle GHG emissions [$kgCO_2e$] for various vehicle segments and powertrain technologies in UK context. The calculator uses a high-level top-down methodology developed by Ricardo in previous work. The calculator has been prepared in an extension to the "Understanding life cycle CO2e emissions for different vehicle segments, technologies and fuels" study (Q014686). It uses results from this study provided in LCA Literature Databse (RD18-001155), and data provided by LowCVP from their consultation with the LowCVP LCA Interest Group.

The Calculator considers these vehicle segments and powertrains:

- **L-category vehicles** :- Gasoline and Electric Vehicle (EV)
- **Medium Passenger Car** (C/D segment) :- Gasoline, Gasoline Hybrid, Gasoline Plug-in Hybrid (PHEV), and EV
- **Small Rigid Truck** :- Diesel, CNG, PHEV and EV
- **Medium Rigid Truck** :- Diesel, CNG, PHEV and EV
- **Articulated Truck** :- Diesel, CNG, and PHEV
- **Single Decker Bus** :- Diesel, CNG, diesel hybrid and EV
- **Double Decker Bus** :- Diesel, CNG, diesel hybrid and EV

The Life Cycle GHG Emission Calculator has been created for LowCVP, **for use by LowCVP staff only**. It is not suitable for publication, or distribution to LowCVP members

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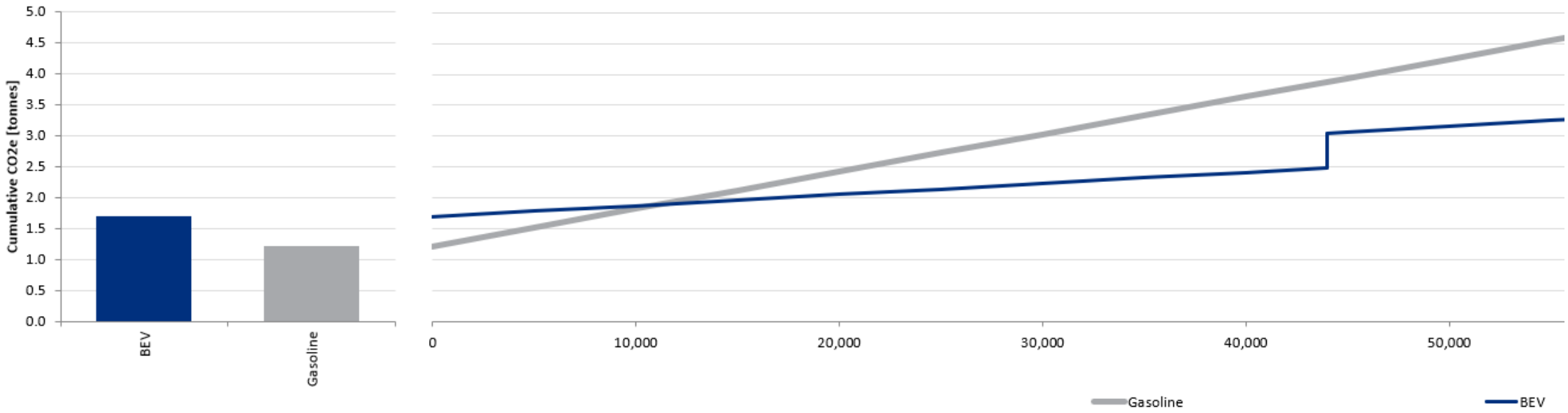
Evaluation of carbon payback period

L-Category (Motorcycle)

Assumed Lifetime Mileage [km]:	66,000
Assumed Annual Mileage [km]:	**5,500**
Assumed Lifetime [years]:	12



Assumed Lifetime Mileage	**[km]**	**66,000**	**66,000**	

The contribution of each life cycle stage is highly dependent on the vehicle type and powertrain

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Results Summary – 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: Review of published LCA literature, pro

LCA Its all about the assumptions

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Life Cycle CO_2e emissions for different powertrains in 2019

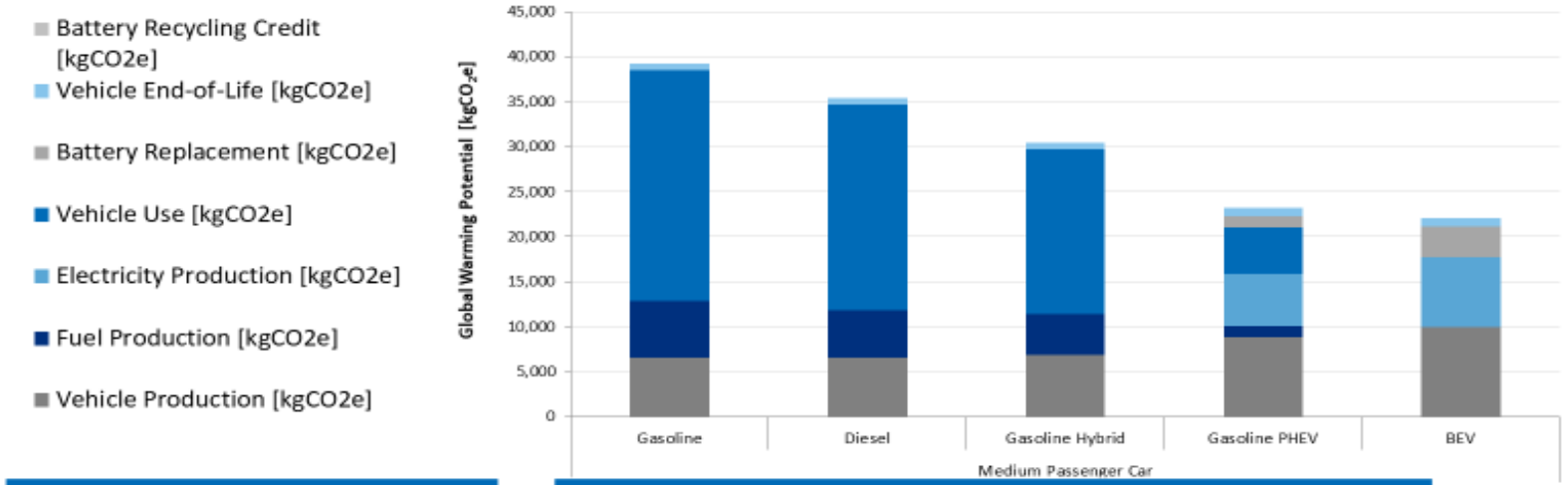
Mileage

Large Battery High Mileage

PHEV – EV utilisation factor – 0% (anecdotal evidence some are never plugged in to charge)

Battery Recycling Credit – Should second life be factored in?

UK Battery Electric Car – Produced in China



Vehicle Segment		Medium Passenger Car				
Powertrain Type		Gasoline	Diesel	Gasoline Hybrid	Gasoline PHEV	BEV
TOTAL Life Cycle CO_2e Emissions	[$kgCO_2e$]	39,173	35,367	30,436	23,194	22,090
TOTAL Life Cycle CO_2e Emissions per kilometer travelled	[gCO_2e/km]	223.8	202.1	173.9	132.5	126.2

How soon until ‘big batterygate’

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The Guardian

BA to review 'fuel tankering' after Panorama revelations

Gwyn Topham Transport correspondent 11/11/2019

GREEN POWERHOUSE

T&E blueprint for battery regulations in Europe

November 2019

Summary

Decarbonising road transport requires a shift away from petroleum-powered combustion engine vehicles towards zero emission mobility. Thanks to significant improvements in quality as well as steep cost reductions, a surge in the sales of lithium-ion battery powered electric vehicles is expected in the coming years. One million plug-in cars will need to be sold in 2020 to meet the EU's car CO2 standards, and achieving the bloc's 2030 goals would require sales of up to 40%.

The shift to electric cars offers multiple benefits including lower energy imports, reduced air and noise pollution and increased resource efficiency - unlike oil, lithium, nickel and cobalt can be recycled and do not need to be burned to power vehicles. Thanks to recent investments by CATL, Northvolt, Tesla, LG, Umicore and others the EU is now also much better placed to play a leading role in the global battery race.

The current policy framework for batteries predates the electric car revolution and is completely outdated as a result. The EU Commission's ongoing review of policy options for batteries provides a unique opportunity to introduce smart regulations underpinning the rapid development of a green, ethical and world-leading battery supply chain in Europe. The key areas to be addressed to ensure battery sustainability include the manufacturing of batteries, the sourcing of key minerals as well as the rules governing battery reuse and recycling.

Influencing LCA adoption in policy and automotive supply chains - early thinking

European Commission consideration of lifecycle metrics in new car CO_2 policy

Provide insights to influence European policy – mandatory and voluntary standards, be at the forefront

Develop automotive guidelines to compliment existing LCA methodologies

Consistency in assumptions, LCA boundaries, use of CO2e emission factors & presenting results.
Influence methodology behind future regulation (LowCVP did this for biofuels)

Review and update of existing automotive lifecycle inventories (LCI)

How representative are current LCI for different powertrain technologies and vehicle types?
Where is improved data required eg battery chemistry and manufacturing, electric motors, end of life?

UK automotive supply chain and vehicle manufacturing

Embed lifecycle thinking into UK supply chains. Develop automotive supply chain LCI and digital tools.
Voluntary standards for reducing CO_2e in vehicle manufacture, linking LCA with future fiscal incentives

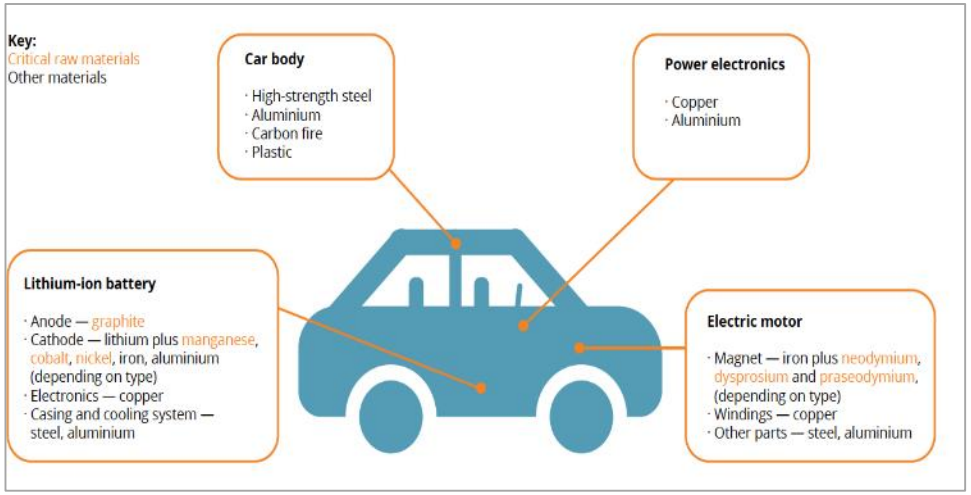
Why do we need to start looking beyond ‘carbon’ in lifecycle thinking and future policy?

- Imperative that ‘sustainability’ is considered when developing vehicle lifecycle CO_2 policy - especially for vehicle production across zero emission technologies
- Identifying and mitigating significant environmental and social risks must be addressed.
- Risks include; depletion of natural resources (minerals), land and air pollution, human rights, geopolitical conflicts, forced labour, impacts on human health, hazardous waste, deforestation

Why is this important?

- Risks automotive supply chain – raw material availability
- Security and resilience of the supply chain
- Impacts manufacturer reputation, consumers interest rising
- Growing finance/Investor community interest in ESG

Stimulate exchange of information about sustainability for current and future supply chains, set guidelines and standards.



Electric cars and raw materials

Joined-up-thinking: 'Cradle to Grave' approach For policies as well as engineering

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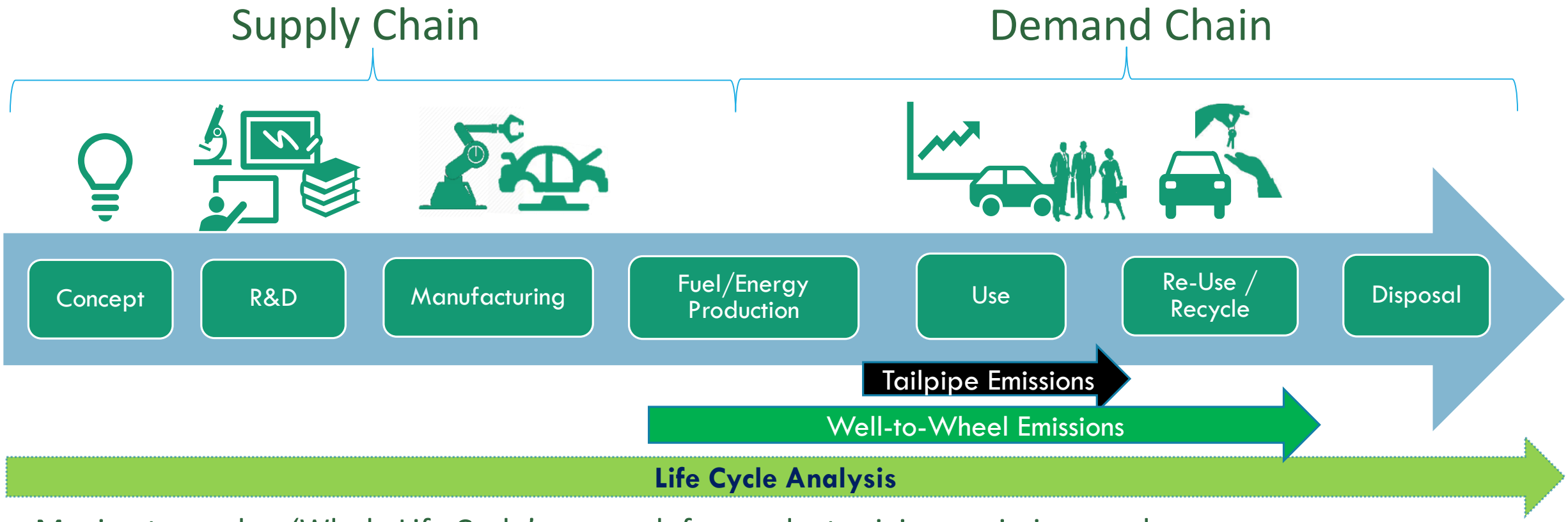

- Moving towards a 'Whole Life Cycle' approach for product origins, emissions and energy use.
- Supply chain emissions and practices can be shifted quickly, demand side can take much longer (cultural).
- *Demand chain needs innovation in policy to ensure whole life carbon reductions.*

LowCVP & APC Workshops

LCA Workshop – 28th November 2019	Sustainability Workshop – March 2020
Where are we now, how can LowCVP influence lifecycle CO_2e emission thinking?	**Looking beyond lifecycle CO_2e emissions – encouraging sustainability**
Current lifecycle thinking in the automotive sector How can a lifecycle metrics be integrated in vehicle CO_{2e} policy? Where should we prioritise? How can the UK automotive supply chain be encouraged to adopt LCA in product design and manufacture? What are the barriers and opportunities, how can these be over come? What role can LowCVP have in this agenda? Developing a framework for roadmap.	What sustainability issues do we need to consider alongside vehicles lifecycle CO_2e emissions metrics in policy and why? How should sustainability principles be taken into account alongside lifecycle CO_2 metrics in policy, and long-term transition to zero emission vehicles? How can the UK automotive supply chain be encouraged to take into account sustainability to ensure manufacturing and material innovation needs, supply chain resilience? What role should LowCVP take into ensure the sustainable transition to a zero-emission future for road transport?

The future of mobility impacts – done well

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Zero Tailpipe Emissions ≠ Zero carbon ≠ Zero energy consumption≠ Zero impact

Energy and resource efficiency measures (Life cycle MJ?)

Renewable and sustainable materials

Optimised – Operation/Vehicle/Infrastructure

Policies based on life cycle GHG gCO2e/passenger km?

Start to collaborate to provide ‘Framework of Facts’ not a “Spreadsheet of Suspicion”