

Hybrid Engined Vehicles - 3rd SIG Combustion Meeting

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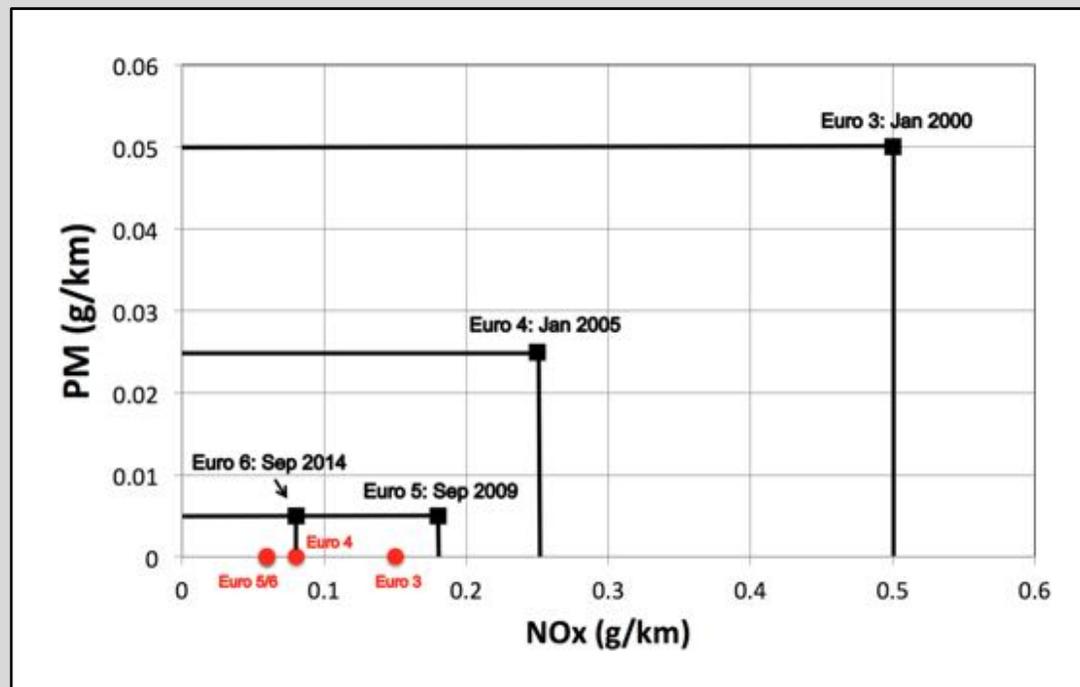
University of Cambridge
5th November 2018



Perception and reality

Euro 1 (1992)
Public perception of
the diesel engine ?

Historical Development of European Regulations



- Black – CI
- Red – SI

A climate of change

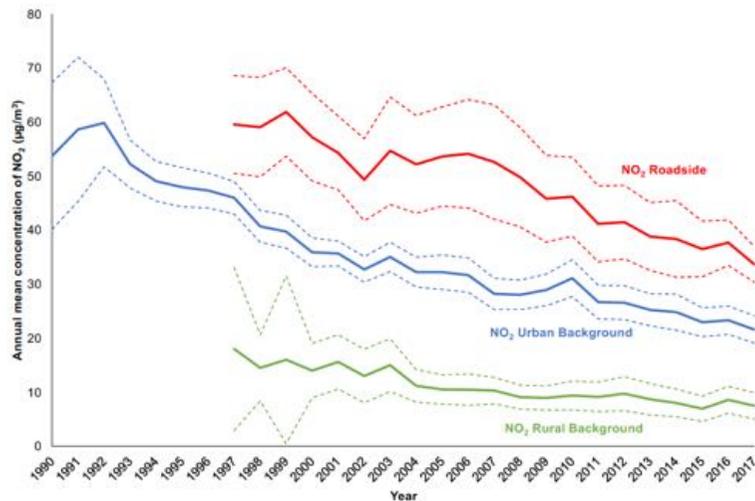


- VW 'dieselgate' scandal
- Urban NO₂ levels of particular concern
- 40,000 deaths a year – [really?](https://wintoncentre.maths.cam.ac.uk/news/does-air-pollution-kill-40000-people-each-year-uk)
- <https://wintoncentre.maths.cam.ac.uk/news/does-air-pollution-kill-40000-people-each-year-uk>
- Global climate concerns or local air quality – can we have both?
- Significant push towards electrification

Do IC engines have a place in the future transport fleet?

Emissions in the UK have fallen

Figure 9: Annual mean concentrations of NO₂ in the UK, 1990 to 2017



Natural Gas used in heating is ~16% of NO_x emissions

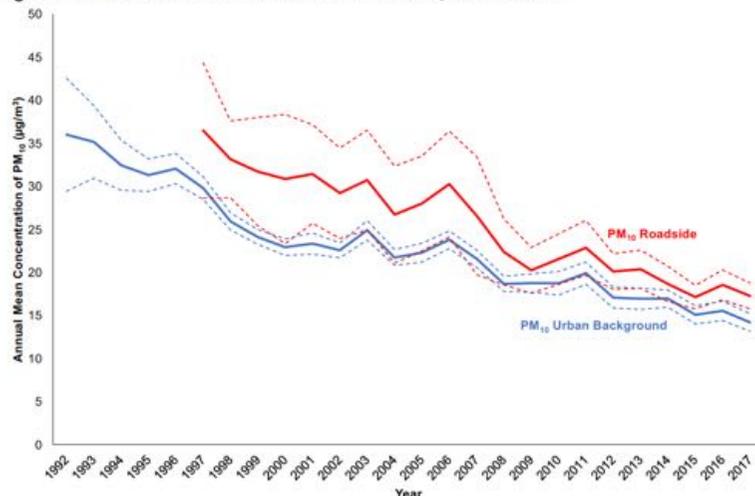
NO_x Emissions from Domestic Boilers in London

Katie King

TFEIP Workshop, 12th May 2014

Study suggests domestic boiler contribution may be gross (100%) underprediction

Figure 1: Annual concentrations of PM₁₀ in the UK, 1992 to 2017



https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/702712/Air_Quality_National_Statistic_FINALv3.pdf

Fireworks

Concerns over particulate matter from metal oxides?



Ba	Barium	Green
Cs	Caesium	Indigo
Cu	Copper	Blue-green
Rb	Rubidium	Violet-Red
Sb	Antimony	Glitter Effects.
Sr	Strontium	Red

<https://en.wikipedia.org/wiki/Fireworks>

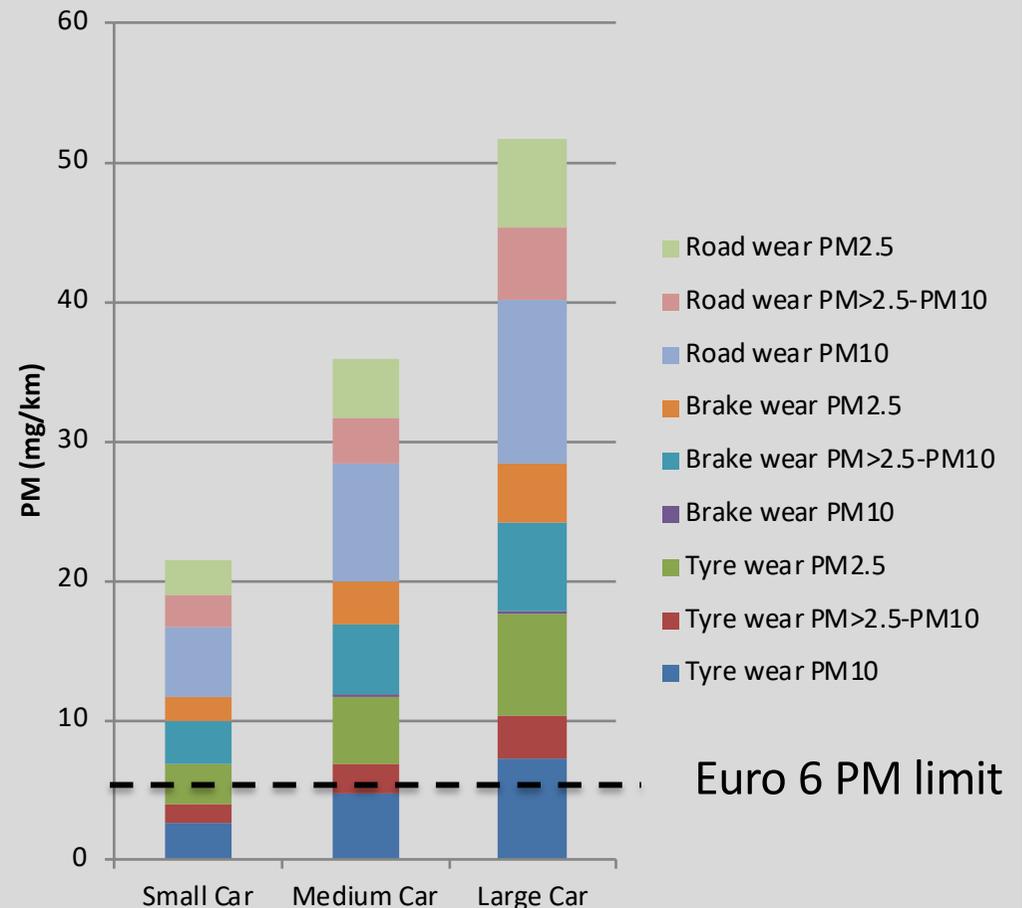
Is Delhi's Diwali firework ban an attack on Hinduism?

<https://www.bbc.co.uk/news/blogs-trending-41670543>

Where do the particles come from?

- Was it even a vehicle?
 - EVs emit PM too
- Catering
- Wood Stoves
- Ambient measurements from recent research campaigns show considerable (6-25%) contributions of wood burning to PM in urban areas during winter. The majority of the PM (>90%) is likely to be within the PM2.5 fraction.
- Much of the potential impact on air quality comes from small-scale domestic burning which is the most uncertain source sector in terms of emissions estimates.
- Wood stoves 3 g/hr; truck 0.5 g/hr, cars 0.17g/hr

https://uk-air.defra.gov.uk/assets/documents/reports/cat11/170808102_7_170807_AQEG_Biomass_report.pdf



NOx Emissions - Diesel Engined Cars can be Clean

- Mercedes-Benz models certified in accordance with Euro 6d-TEMP Norm (RDE Stage 1) – a full year before this is mandatory for all vehicles.
- TÜV Hessen tested a wagon version of the new C-Class with a new 1.6-liter four-cylinder OM 654 engine according to the currently applicable RDE regulations: NOx below 10 mg/km, including cold starts
- The current RDE limit is 168 mg/km.

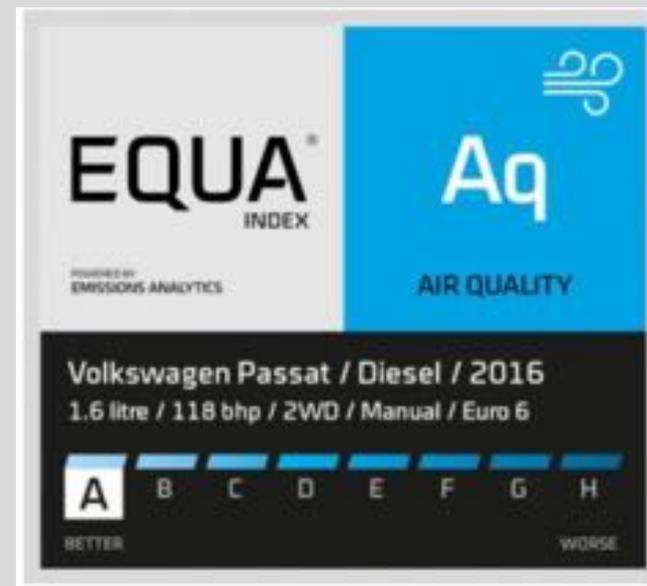
<https://media.daimler.com/marsMediaSite/en/instance/ko/State-of-the-art-diesel-technology-from-the-A--to-the-S-Class-Latest-Mercedes-Benz-diesel-technology-with-NOx-emissions-significantly-below-certification-limits.xhtml?oid=40361757>

Emissions Analytics

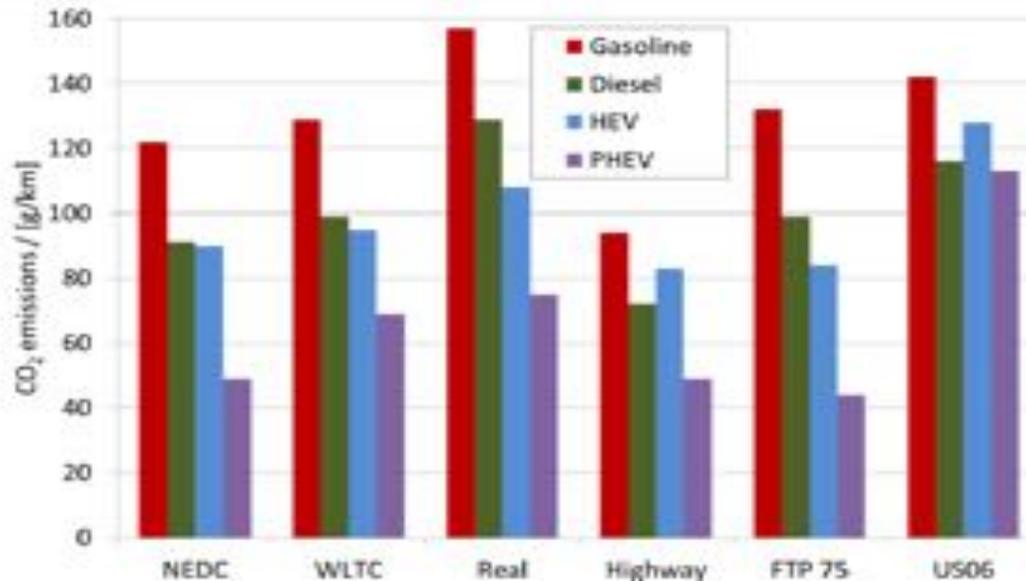
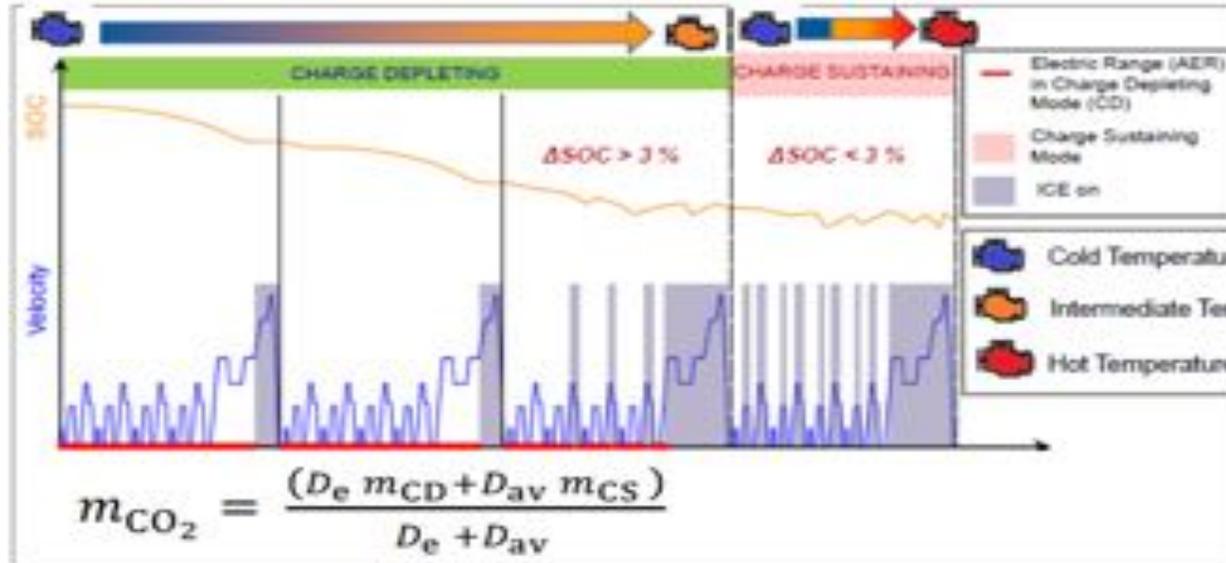
<https://www.emissionsanalytics.com/>

(an independent test house) have developed the EQUA Index to assess a full range of vehicles

<https://equaindex.com/equa-air-quality-index/>



Tailpipe CO₂ performance: gasoline / diesel / HEV / PHEV



m_{CD} = CO₂ emission in charge-depleting mode

m_{CS} = CO₂ emission in charge-sustaining mode

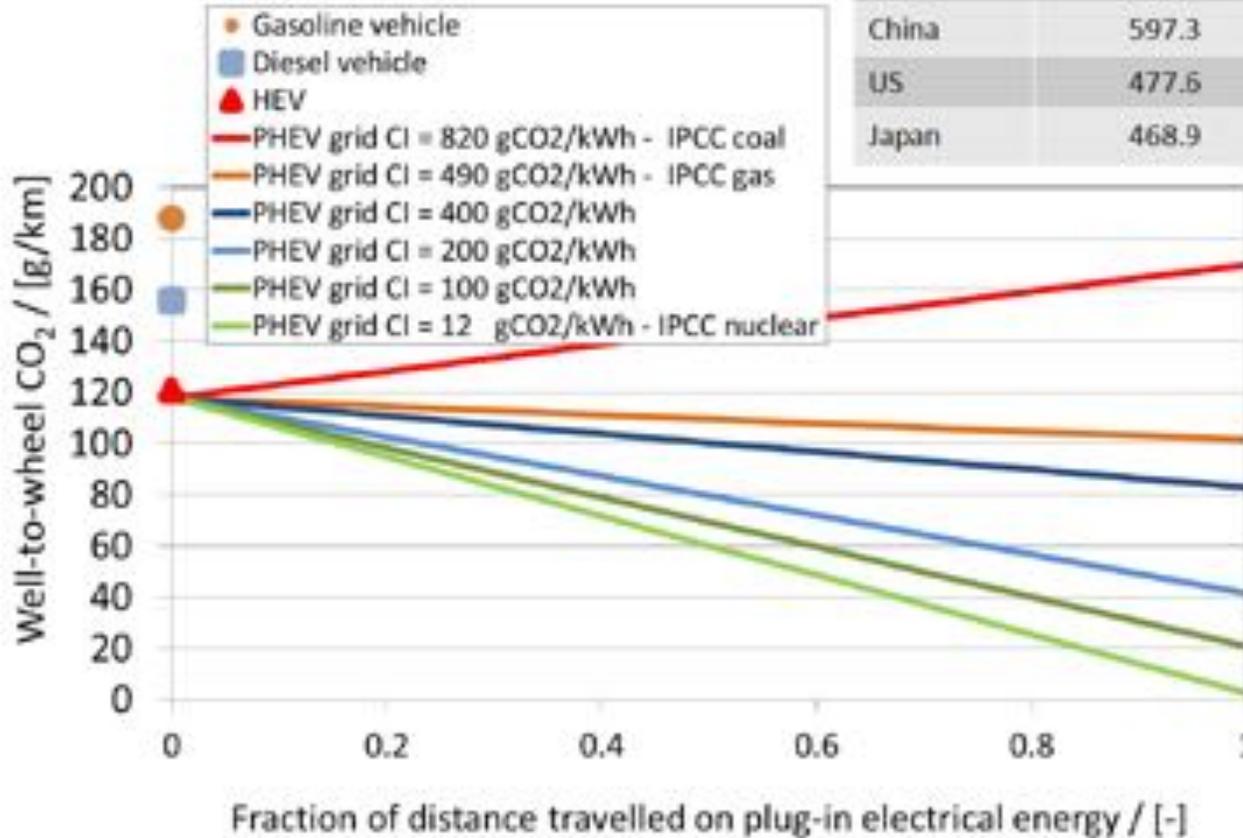
D_e = electric range in charge-depleting mode

D_{av} = 25 km

WTW CO₂ – based on real driving results

Country	gCO ₂ /kWh 2017	gCO ₂ /kWh 2040	% change
France	19.6	49.6	+153.7
UK	263.8	90.4	-65.7
Germany	440.7	177.6	-59.7
China	597.3	271.0	-54.6
US	477.6	291.4	-39.0
Japan	468.9	362.9	-22.6

Data source: BNEF

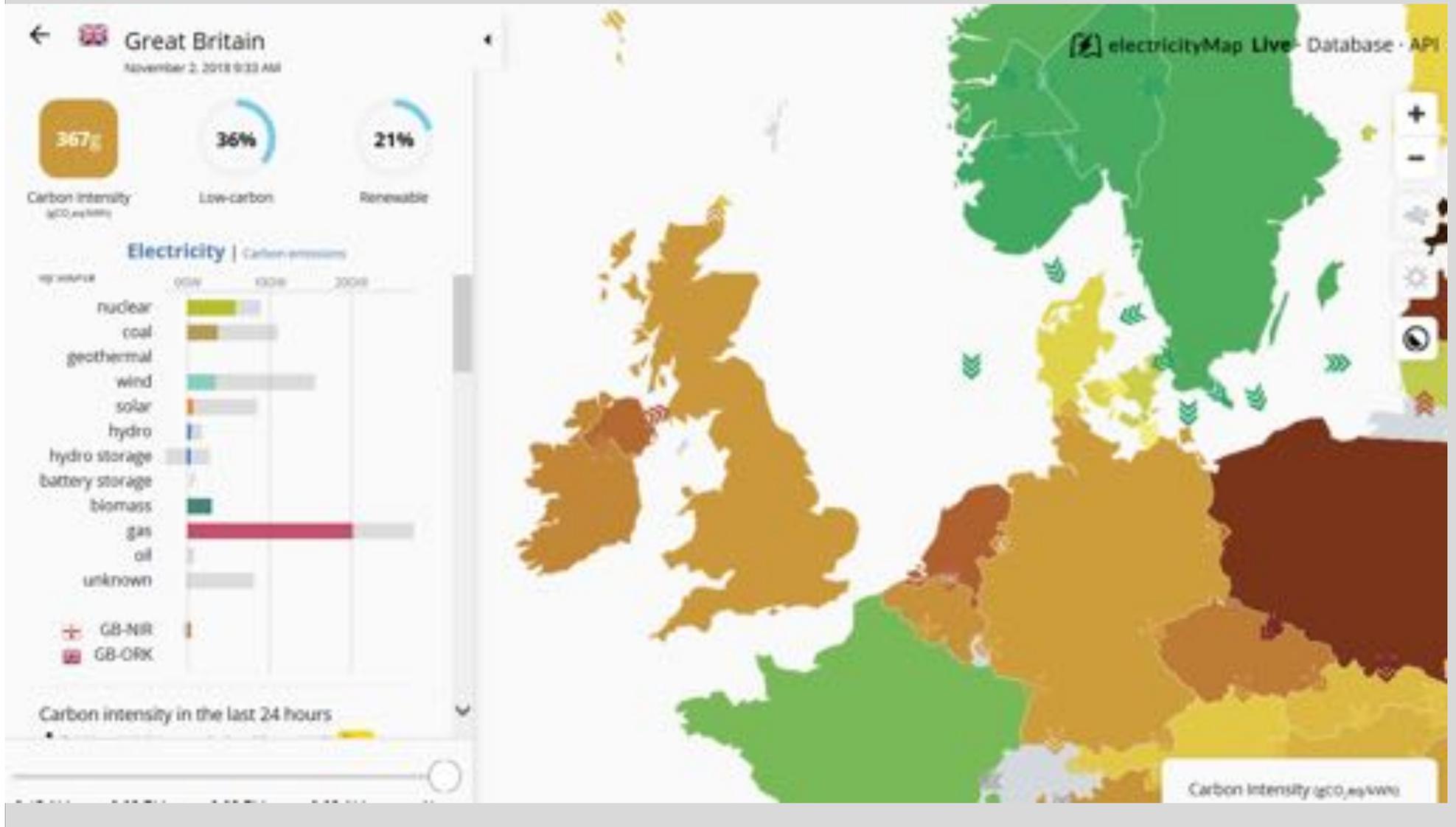


Understanding the Efficiency of Gasoline, Diesel, HEV, and PHEV Powertrains across a Range of Driving Cycles. Richard Pearson, Ben Leach, Stephen Jones & Rolf Albrecht. ICEV Conference, Japan, 2017

Note PHEV results shown in this slide are not based on the same PHEV as shown on the earlier slides.

Where Does The Electricity Come From?

<https://www.electricitymap.org/?page=country&solar=false&remote=true&wind=false&countryCode=GB>



Real World BEV Range?

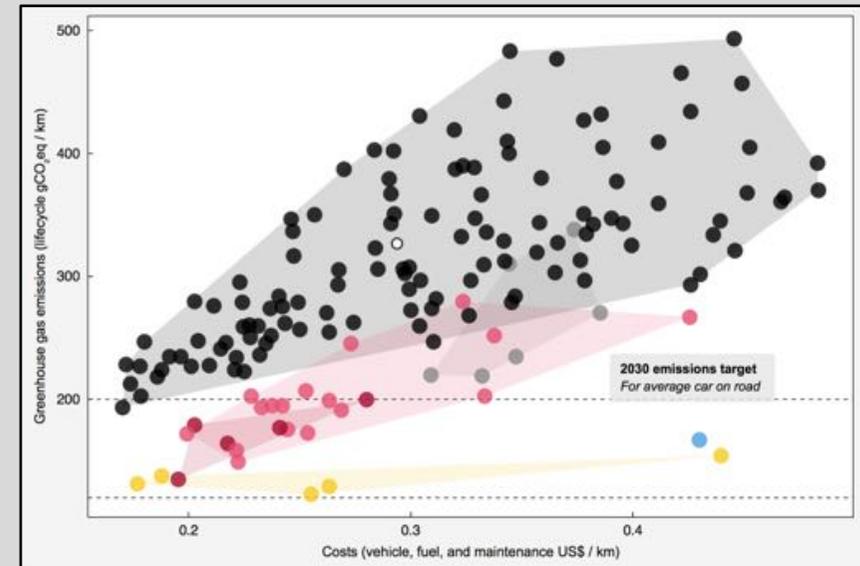
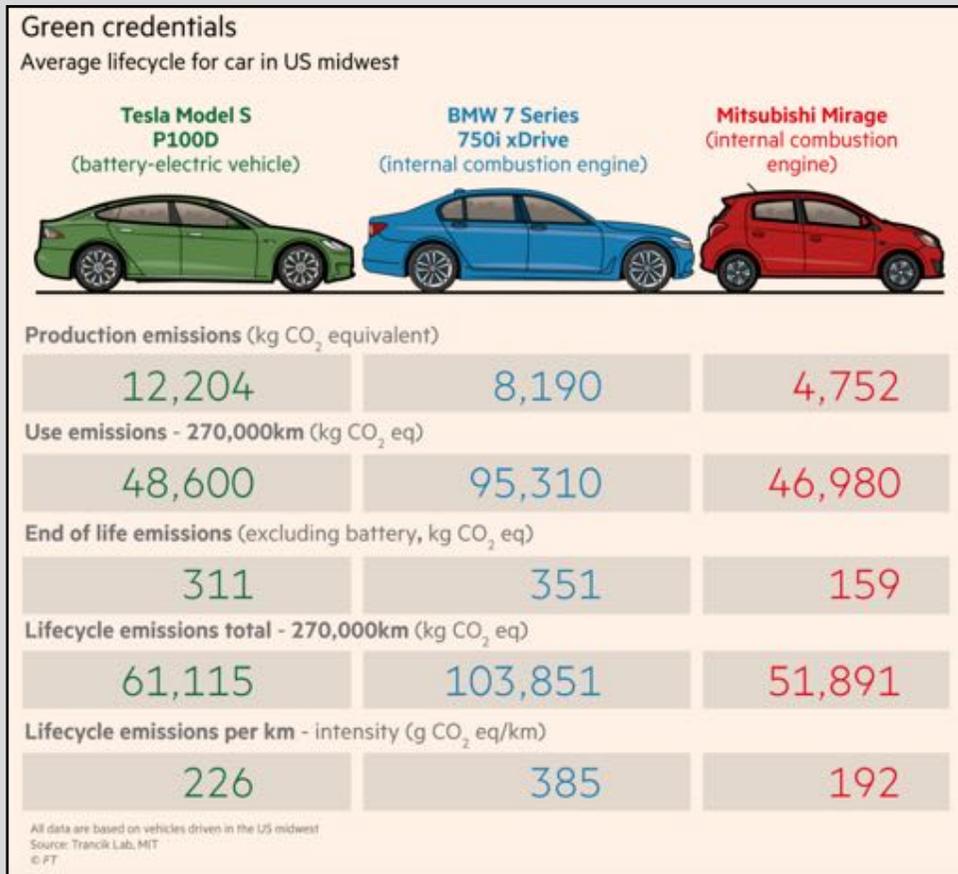
- Official Figures are for the NEDC
- What about?
 - The Real World
 - Winter
 - Battery Ageing

BEV Types?

- High Specification
 - Tesla Model S, Jaguar I-Pace
- Small Cars
 - Nissan Leaf, Renault Zoe

Life cycle analyses

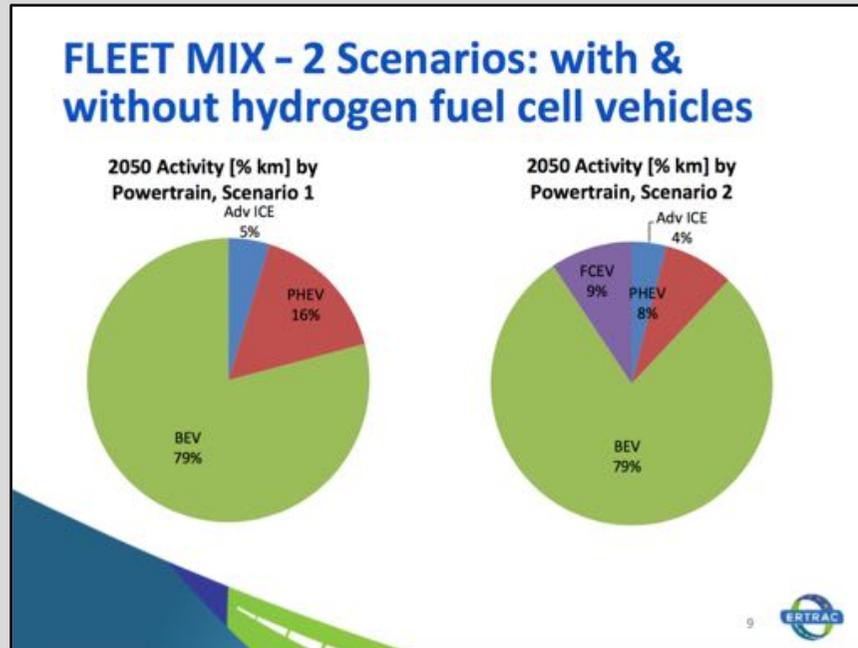
All results from MIT, Trancik Lab.
CarbonCounter.com



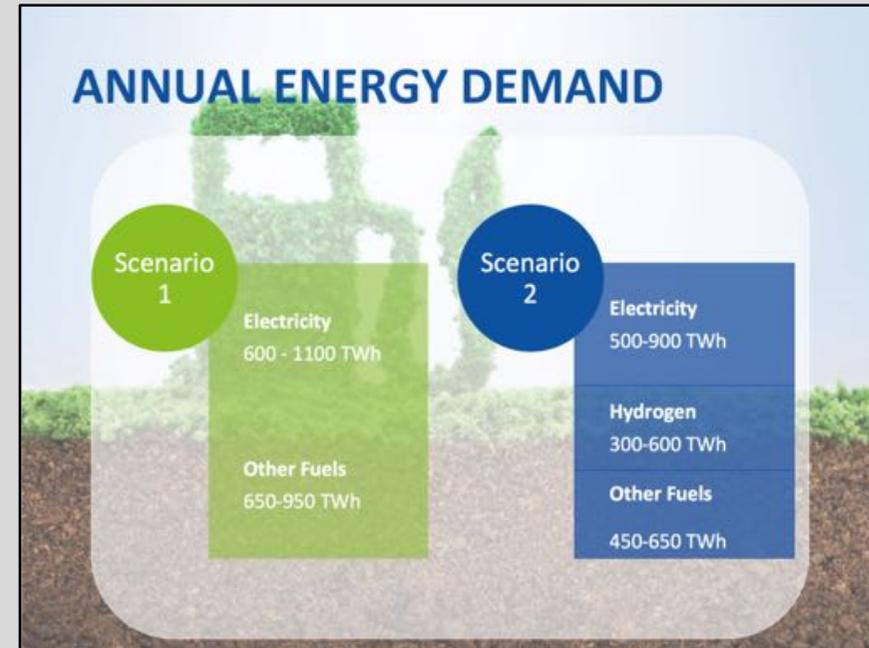
- Internal Combustion Engine (Gasoline)
- Internal Combustion Engine (Diesel)
- Hybrid
- Plug-In Hybrid
- Battery Electric Vehicle
- Fuel Cell Vehicle
- Sales-Weighted Average

Projected vehicle fleet 2050

2017 Eurtrac CO₂ Evaluation Group – CO₂ Integrated approach

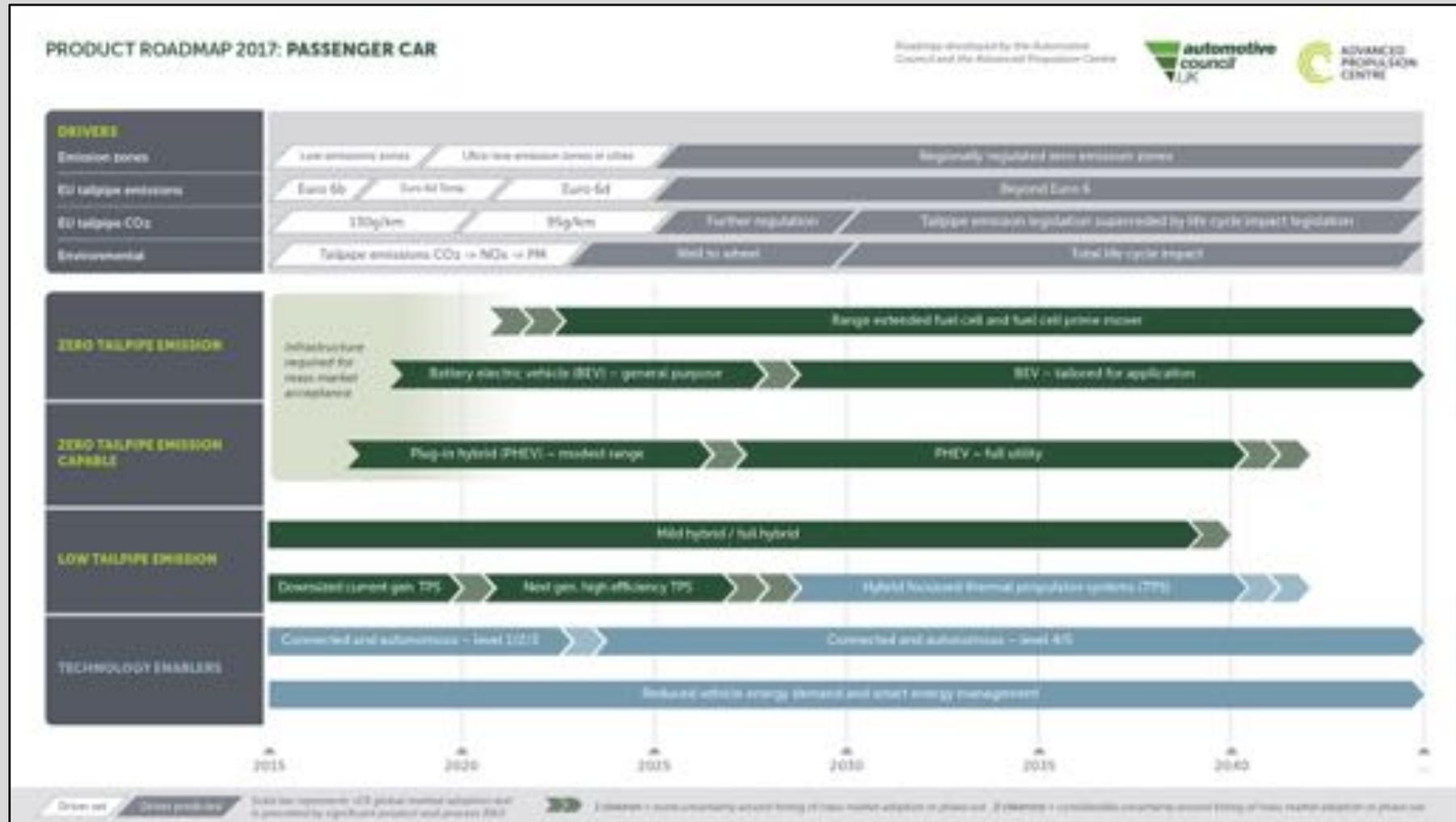


80% BEV

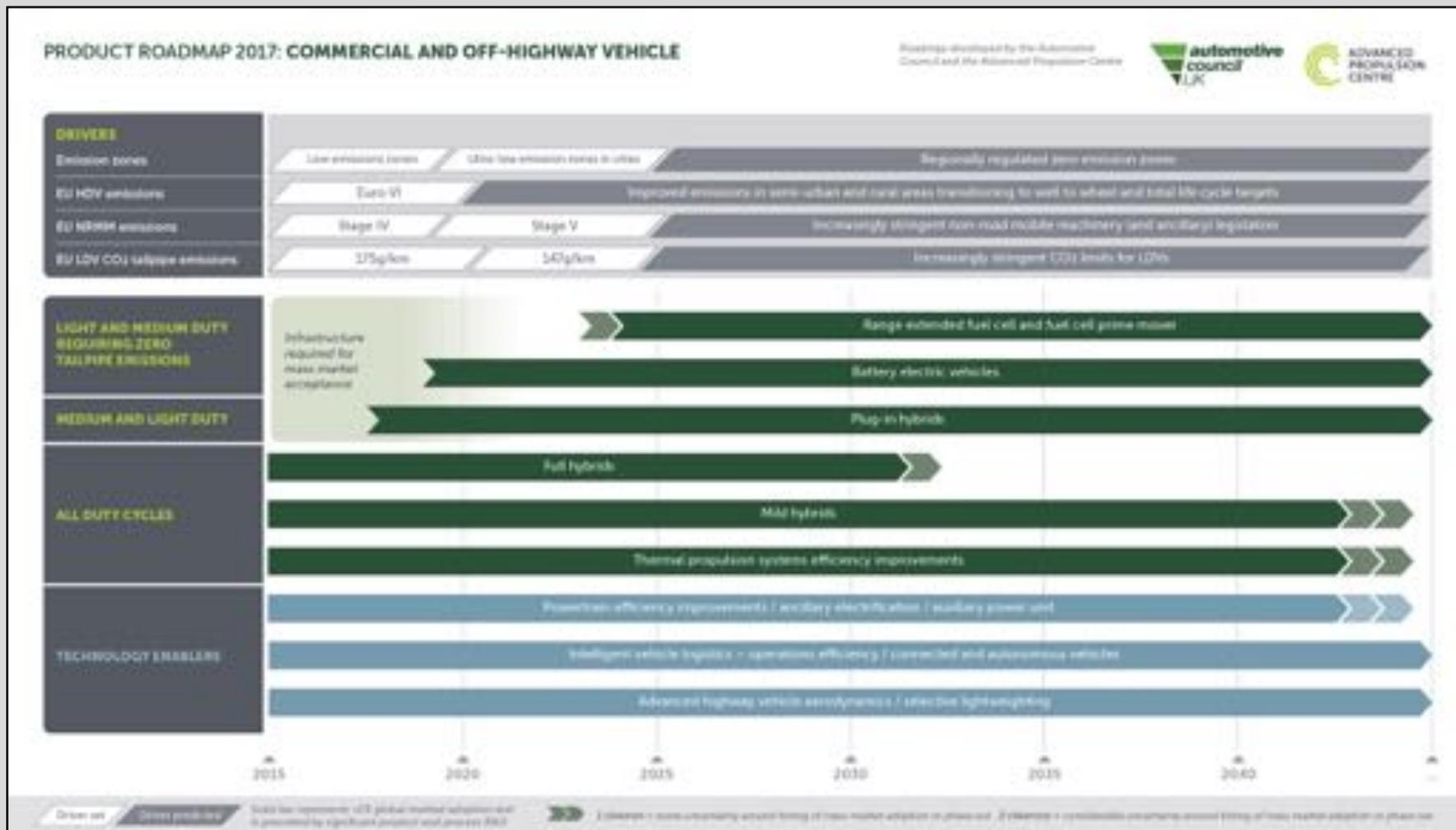


~50% energy demand from non electric fleet

Technology roadmaps 2017 - Cars



Technology roadmaps 2017 - Trucks



Rail electrification ?

28 Mar 2018 - **Rail electrification plans cancelled purely for cost reasons, says NAO**

Chris Grayling

“New bi-mode train technology offers seamless transfer from diesel power to electric that is undetectable to passengers,” Grayling said at the time. “This means that we no longer need to electrify every line to achieve the same significant improvements to journeys, and we will only electrify lines where it delivers a genuine benefit to passengers.”

Fuel Cells ?

World's first hydrogen fuel cell-powered train enters service, September 18th, 2018

“200 kW Fuel Cell
225 kW (sic) traction battery that stores surplus fuel cell energy

600 km range at speeds up to 140 km/hr”
Professional Engineering, Issue 7, 2018



<https://newatlas.com/worlds-first-hydrogen-fuel-cell-train-service/56372/>

Engine efficiency will improve by small increments 0.5%

- Improvements of 0.5% are very challenging to measure
- Emissions will continue to reduce

IC engines will have a place in the future transport fleet

“Thank you for your attention”

- 22 Current Projects £8.3m
- February 2019

Grant Ref No.	Title	Start	End	Organisation	Value
EP/R04197 0/1	A Zero-Emission Closed-loop linear-Joule CYcle (ZECCY) engine generator	01 Sep 2018	31 Aug 2021	Newcastle University	£897,057.19
EP/P03117 X/1	FACE - Novel Integrated Fuel Reformer-Aftertreatment System for Clean and Efficient Road Vehicles	01 Sep 2017	31 Aug 2020	University of Birmingham	£890,289.93
EP/P03122 6/1	FACE - Novel Integrated Fuel Reformer-Aftertreatment System for Clean and Efficient Road Vehicles	01 Sep 2017	31 Aug 2020	Brunel University London	£536,639.98
EP/P00166 1/1	In-situ Chemical Measurement and Imaging Diagnostics for Energy Process Engineering	01 Oct 2016	30 Sep 2021	University of Edinburgh	£1,023,515.74
EP/P01143 8/1	Supercritical fuel jets - resolving controversy	01 Mar 2017	28 Feb 2021	University of Edinburgh	£354,166.24