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The Efficiency and CO₂ Emissions of Electric Vehicles

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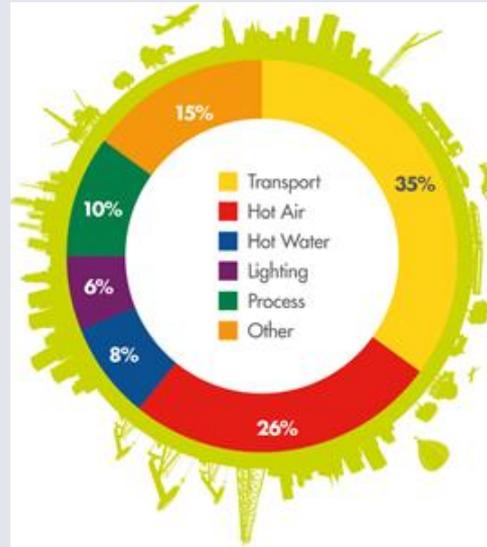
Where opportunity creates success

Overview of Presentation

- Why the focus on decarbonizing passenger cars?
- Comparison of different consumer transport options
 - Energy efficiency, CO₂ emissions, other emissions, cost etc.
- CO₂ content of electricity from different fuel types (UK Govt figures)
- Total lifecycle CO₂ emissions of EVs versus conventional vehicles
- What has happened to the UK electricity supply in the last 30 years?
- Freight fuel options for the future
- Discussion/Q&A

Why Focus on Decarbonizing Passenger Cars?

- Transport contributes 35% to worldwide CO₂ emissions(includes cars, trucks, planes, ships)
- Road transport (cars/buses) account for 45% of transport CO₂ emissions, with heavy duty trucks accounting for 29%



- “Average” energy budget per person per day (for the UK) is around 125 kWh

Comparison of different transport options

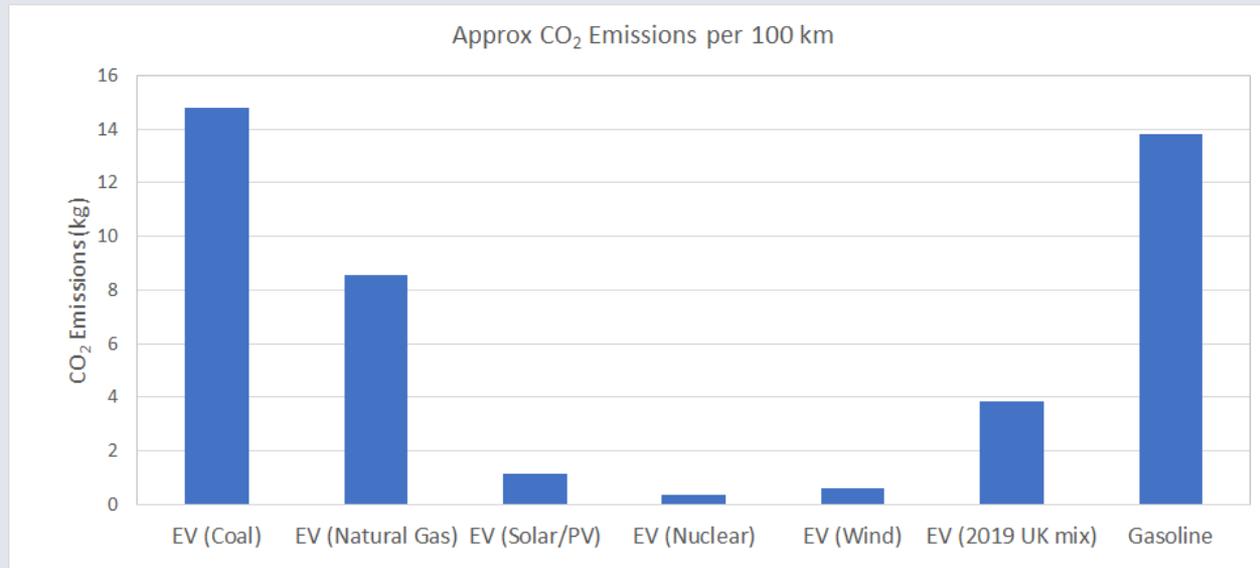
	 Electric	 Conventional	 Hydrogen	 Cycling
Energy to travel 100 km	15-25 kWh	6 litres gasoline ≈ 205 MJ ≈ 57 kWh	1 kg H ₂ (≈ 50 kWh to make 1 kg H ₂ by electrolysis)	2.2 kWh (David MacKay book)
CO ₂ Emissions	≈ 4 kg (UK electricity mix)	≈ 14 kg	≈ 9 kg**	≈ 2 kg (food production)
Approx cost*	£2.70 - £4.50	£7.80	£10 - £14	£5 (food)
Refuelling time	20 mins to few hours (depends on charger)	3-5 mins	5 mins	A few hours!
Other emissions	No tailpipe emissions	NO _x & PM (impacts local air quality)	Water	None

* Assumes UK electricity price of 18p per kWh, petrol price of £1.30 per litre & current UK H₂ costs

** <https://www.forbes.com/sites/rpapier/2020/06/06/estimating-the-carbon-footprint-of-hydrogen-production/>

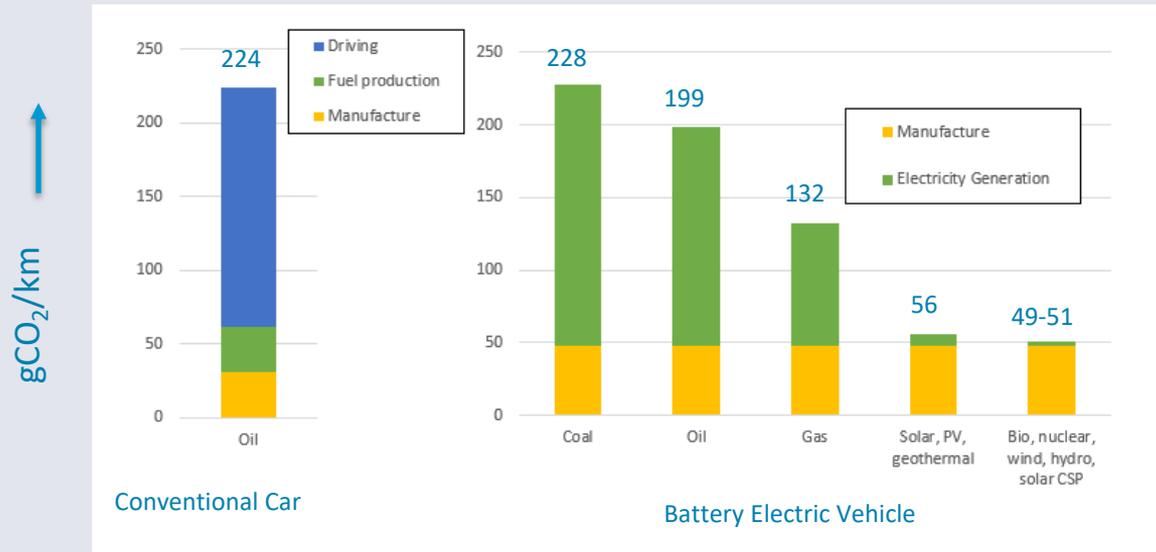
CO₂ Emissions from Electricity Fuel Type

- Comparison of Electric and Conventional Vehicles
 - Electric vehicles – no CO₂ emissions at tailpipe of vehicle, but there are CO₂ emissions at the power station – these depend on how electricity is generated
 - Data below shows approx. CO₂ emissions (kg) for 100 km (15 kWh or 6 litres of gasoline)



CO₂ Emissions – Lifecycle Analysis

- Comparison of Electric and Conventional Vehicles
 - CO₂ emissions generated during vehicle manufacture should also be included (graph below shows numbers from Holmberg & Erdemir 2019)

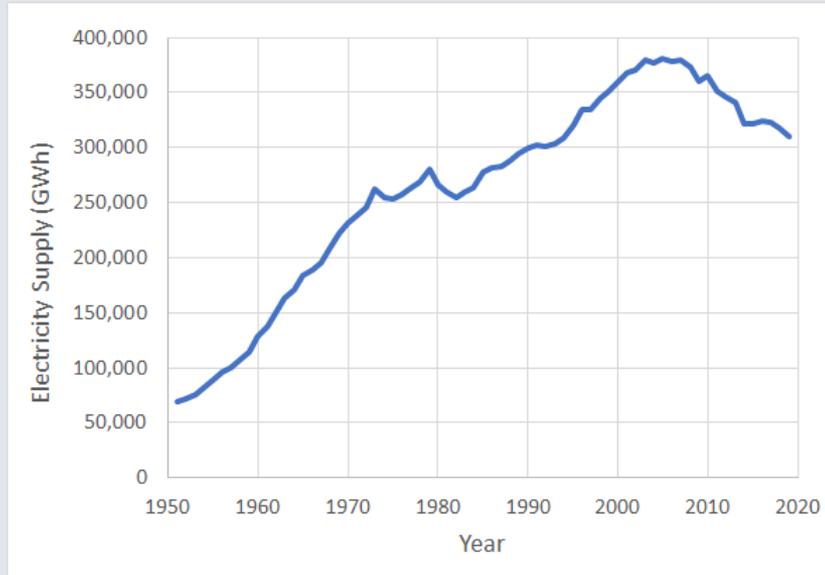


*Q. Qiao et al, “Life cycle greenhouse gas emissions of electric vehicles in China: Combining the vehicle cycle and fuel cycle”, Energy, 2019

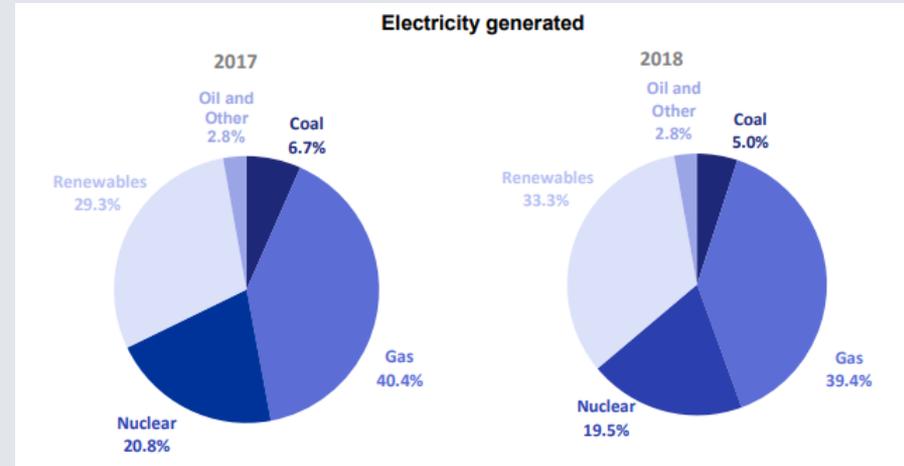
**Holmberg & Erdemir, “The impact of tribology on energy use and CO₂ emission globally and in combustion engine and electric cars”, Trib. Int. 2019

Some Data on the UK Electricity Grid

- Historic UK electricity consumption & current mix of electricity generated

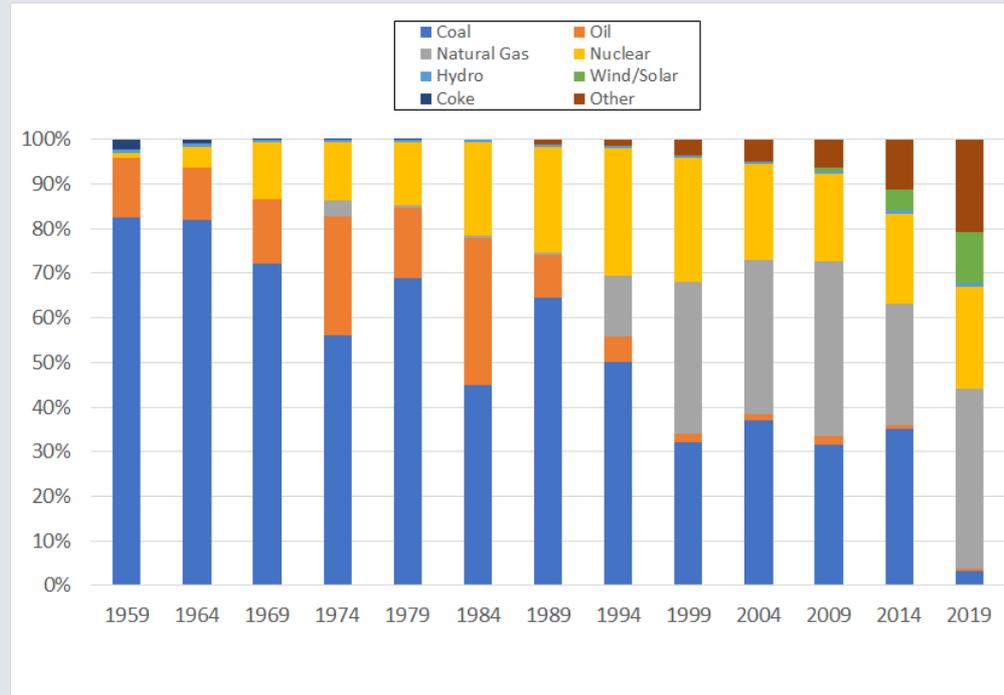


In 2018, 52.8% of UK electricity was from low carbon sources (nuclear and renewables)



Some Data on the UK Electricity Grid

- Changes in mix of UK electricity over time



Freight Options

- Table below shows CO₂ emissions for different freight options

	Train	Plane	Heavy Duty Truck	Ship
Current approx CO ₂ Emissions (grams per tonne km)	25	1200	40 (if fully loaded)	15 (average) 2-3 (bulk shipping)
Current Fuel Used	Electricity & diesel	Kerosene	Diesel/LNG/CNG	Bunker fuel/Marine gas oil/LNG
Future Fuel Options	Electric/H ₂	Bio/e-Kerosene	Electric/H ₂ /LNG/CNG/Bio	LNG/H ₂ /Electric/Bio/Methanol/Nuclear
2020 CO ₂ Emissions (%)	0.3	2.5	8	2.5

Conclusions

- Electric cars can result in lower CO₂ emissions (compared to current petrol/diesel cars) provided the electricity grid has a high proportion of low carbon electricity generation
- In the UK, over 50% of electricity is now low carbon (wind/solar/nuclear) with much of the remainder gas (which has a lower carbon content than coal or oil)
- One challenge will be to decarbonize harder transport sectors (such as heavy-duty trucks, ships, planes, where electrification will not be as straightforward)

Useful Resources & Further Reading

- **Book: “Sustainable Energy – Without the Hot Air” – David Mackay**
- King Review of Low Carbon Cars (2007):
<https://www.lowcvp.org.uk/assets/presentations/Julia%20King.pdf>
- Bloomberg electric vehicle outlook at: <https://about.bnef.com/electric-vehicle-outlook/>
- McKinsey electric vehicle forecast at: <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/electric-mobility-after-the-crisis-why-an-auto-slowdown-wont-hurt-ev-demand#>
- Shell Sky Scenario: <https://www.shell.com/energy-and-innovation/the-energy-future/scenarios/shell-scenario-sky.html>
- Recent paper of mine on vehicle electrification: <https://www.mdpi.com/2075-4442/9/7/66>

Many thanks for attending the talk

Any questions?

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