Imperial College London

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Electrification of Road Transport and the Impacts on Air Quality and Health in the UK

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Outline

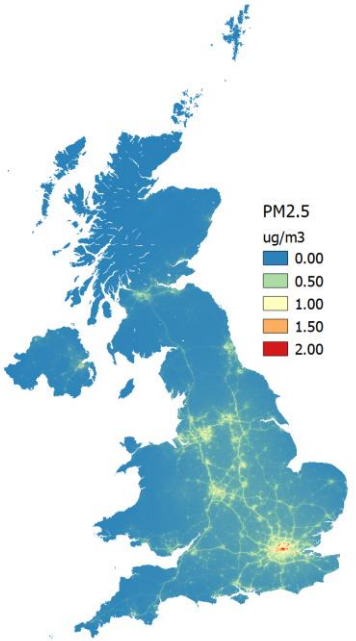
- Part 1: Electrification of Road Transport…
  - Introduction
  - Scenarios
  - Results

- Part 2: Electricity generation for EVs

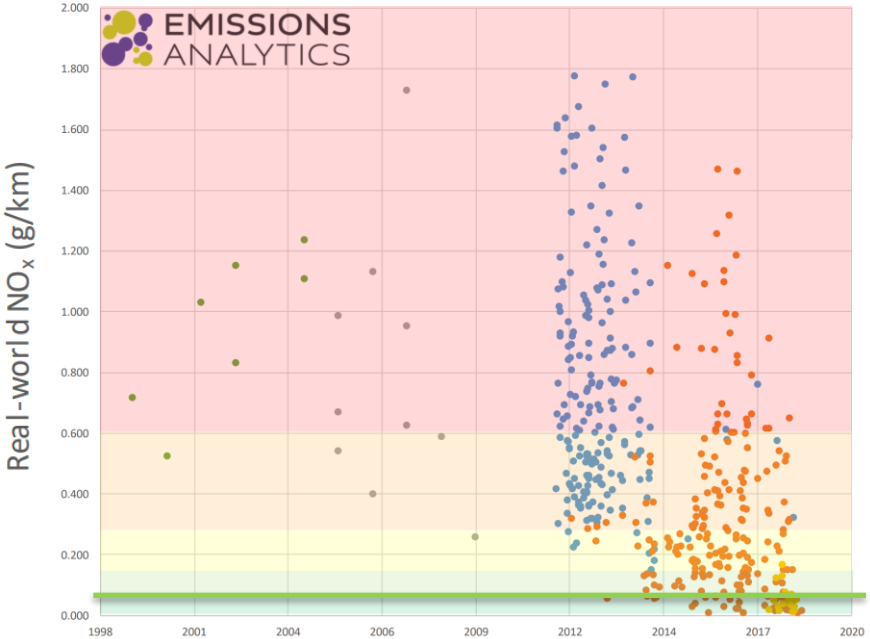
Introduction: UKIAM framework and road transport

- UKIAM:
  - Helen ApSimon - previous EPCAC meeting
  - Framework of models
  - 1 km x 1 km grid

- BRUTAL – road transport model:
  - Bottom-up model of the road network
  - COPERT based exhaust emission factors
  - EMEP/EEA Tier 2 non-exhaust emission factors



Introduction: Diesel Euro 6 RDE Cars



- PEMS data
- RDE vehicles are compliant
- COPERT 5.4 update

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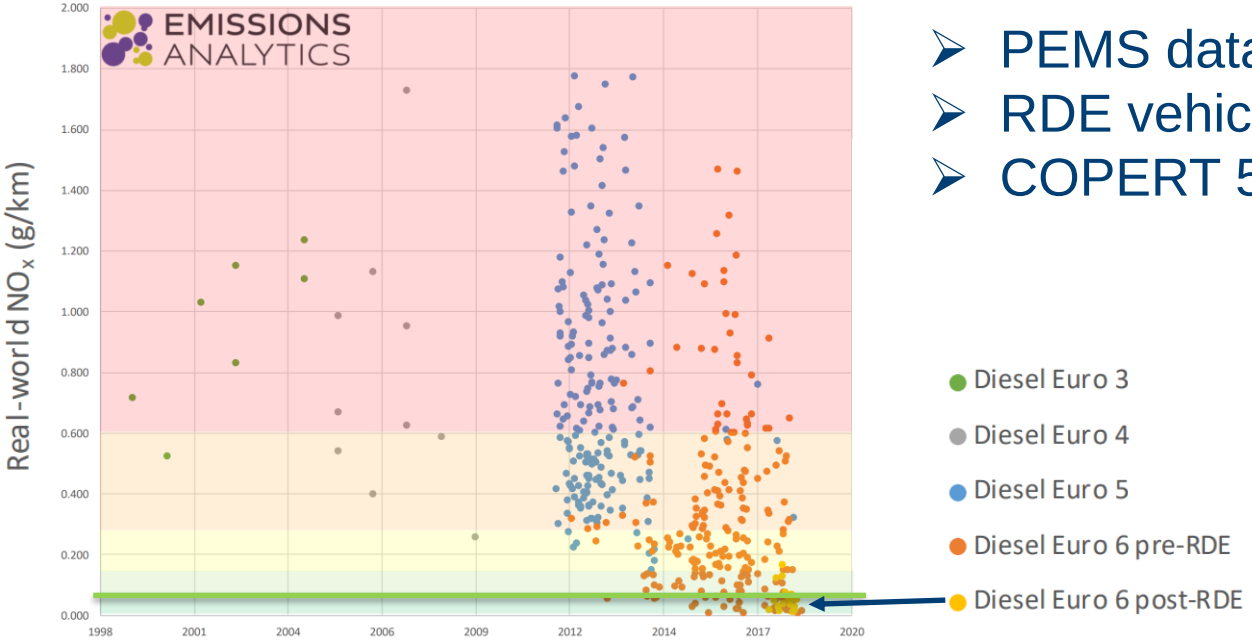


- PEMS data
- RDE vehicles are compliant
- COPERT 5.4 update

Introduction: EVs in the UK

- 2017: Cars and LGVs ICE ban in 2040
- 2021: *'Transportation Decarbonisation Plan':*

Policy		Ambition
ICE Cars & LGVs	2030	Buses
PHEV Cars & LGVs	2035	Small HGVs
	2040	Large HGVs

- What is the impact on air quality?

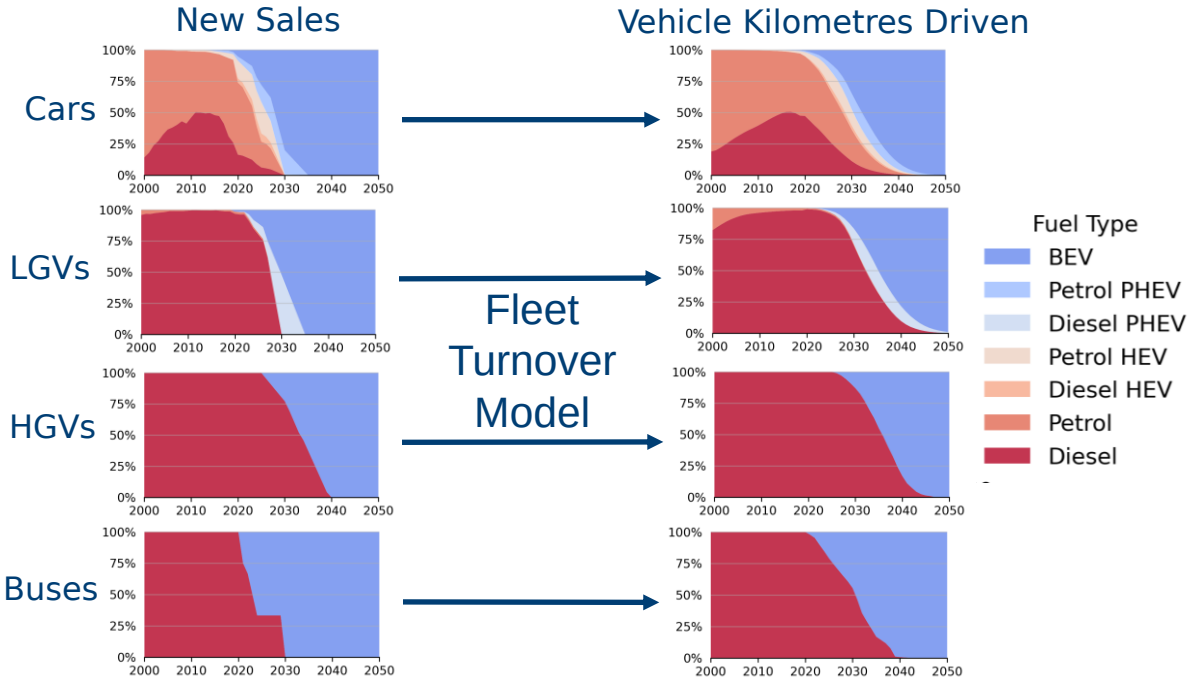
Scenarios

- BAU:
  - Petrol and diesel vehicles with no EVs
  - Fleet projections – UK's National Atmospheric Emissions Inventory

- *Euro 6 RDE:*
  - Same as BAU fleet
  - Diesel car Euro 6 RDE are compliant (COPERT 5.4)

- *EV:*
  - Transportation Decarbonisation Plan EV Uptake/Sales
  - Fleet projections from fleet turnover model

Scenarios: Fleet turnover - EV scenario



Scenarios: Fleet mix - EV scenario

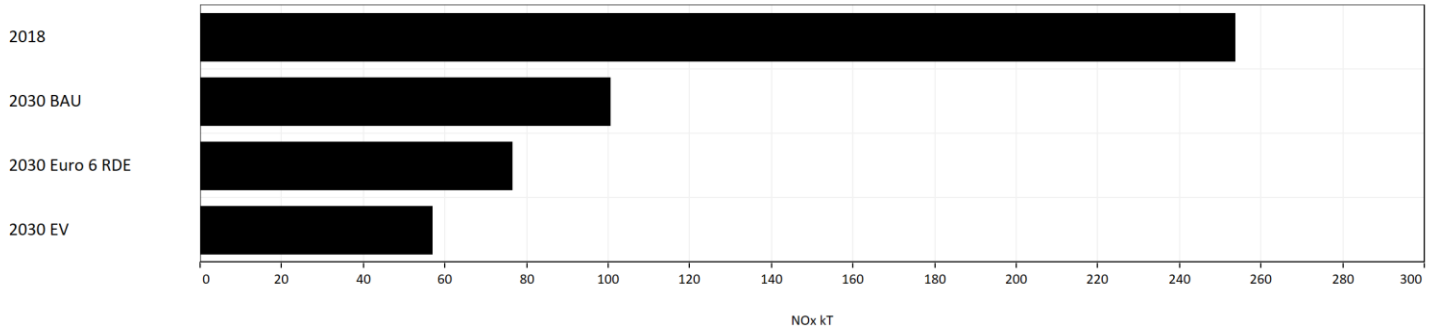
Share of vehicle kilometers driven in 2030:

- Cars
  - PHEV 13%
  - BEV 34%
- HGVs
  - BEV 16%
- LGVs
  - PHEV 13%
  - BEV 16%
- Buses
  - BEV 40%

Scenarios: Emissions from other sectors

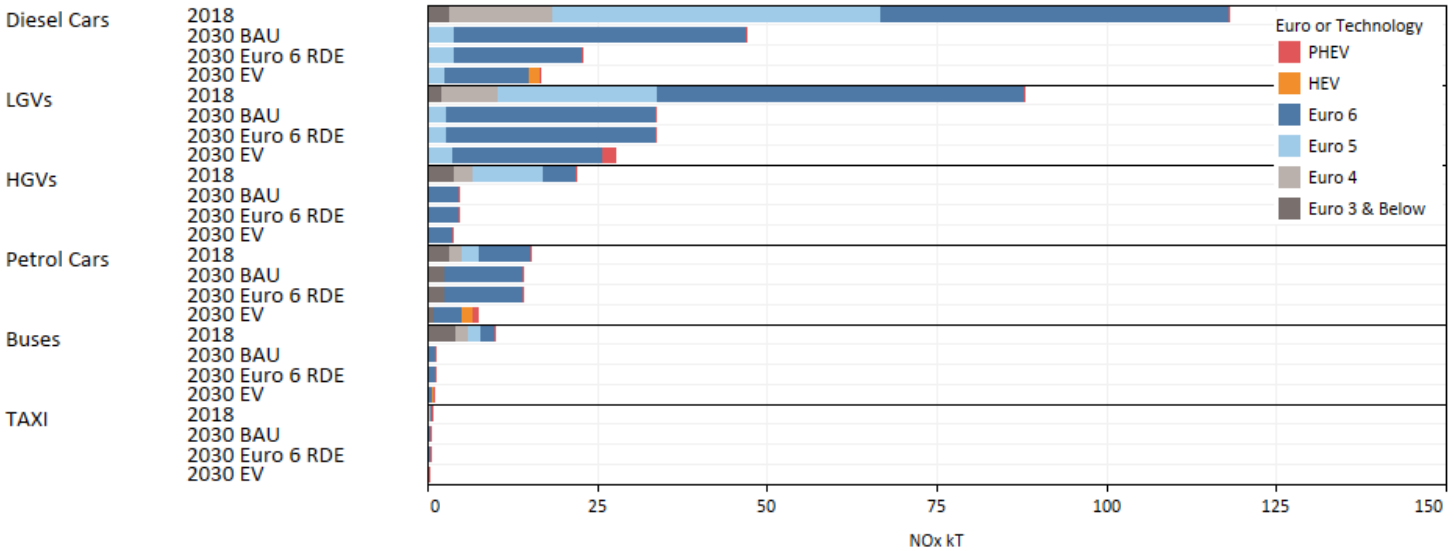
- Scenarios use the same emissions for other sectors
- Emissions projections from 2018 to 2030 from the UK's National Atmospheric Emission Inventory
- *Includes electricity generation emissions (more on this later)*
- *Isolates change in exhaust and non-exhaust emissions*

Results: NO_x emissions

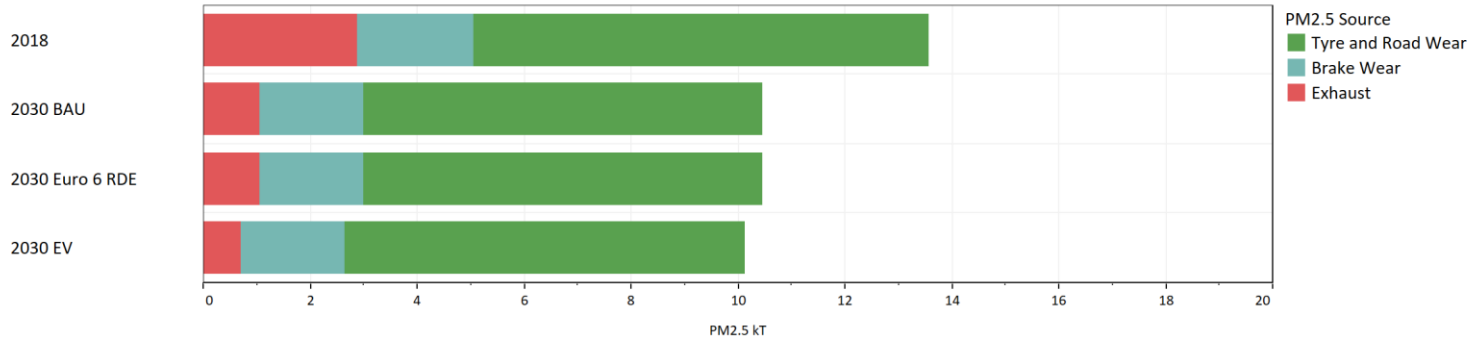


- Vehicle turnover removes highest emitting NOx vehicles (Euro 5 & below)
- Euro 6 RDE leaves little further improvement for EVs in 2030

Results: NO_x emissions



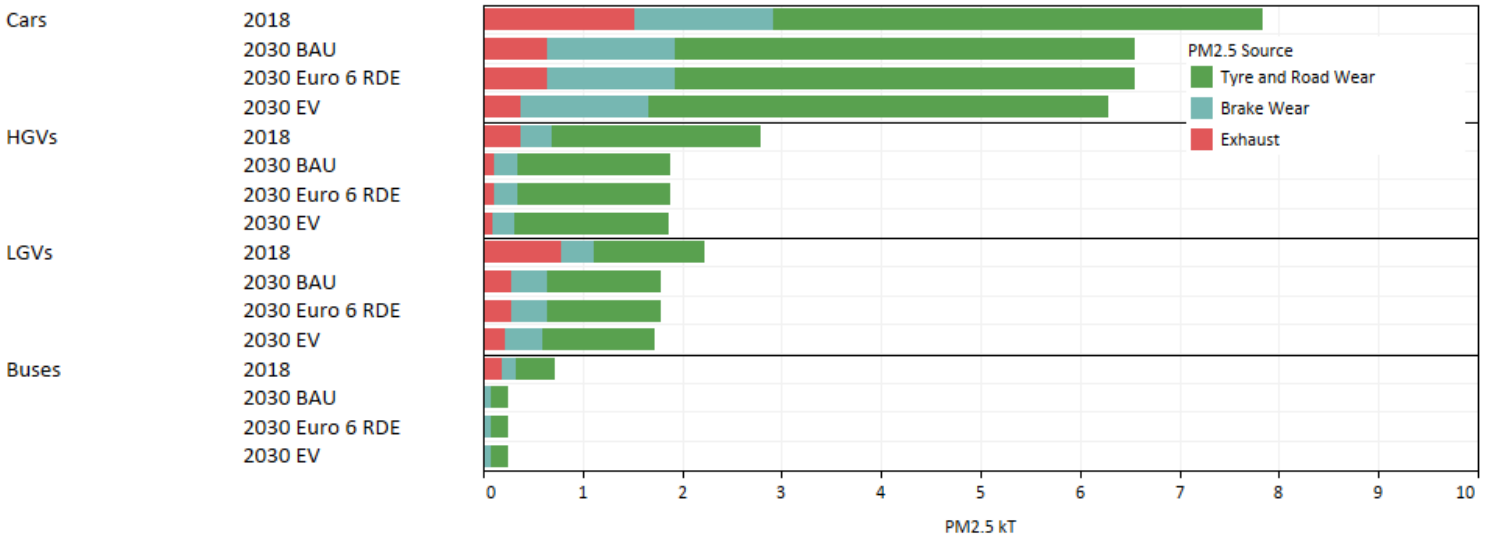
Results: $PM_{2.5}$ emissions



- Vehicle turnover removes highest emitting vehicles
- Non-exhaust emissions largest source

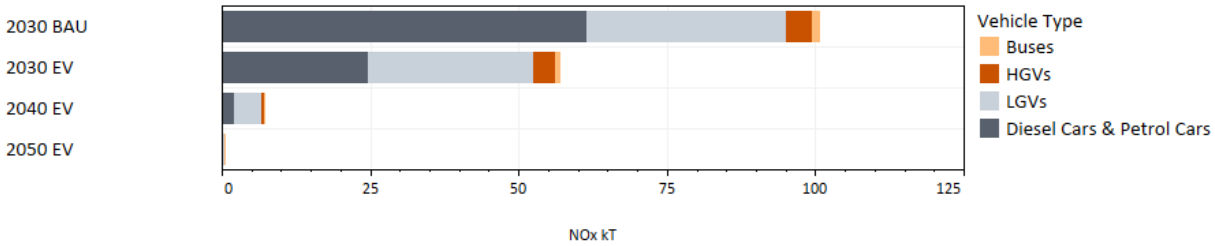
- EV = ICE non-exhaust emission factors

Results: $PM_{2.5}$ emissions

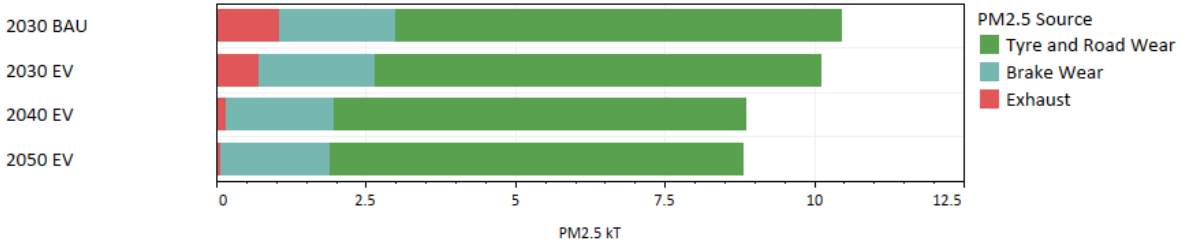


Results: EV scenario emissions up to 2050

NO_x



$PM_{2.5}$

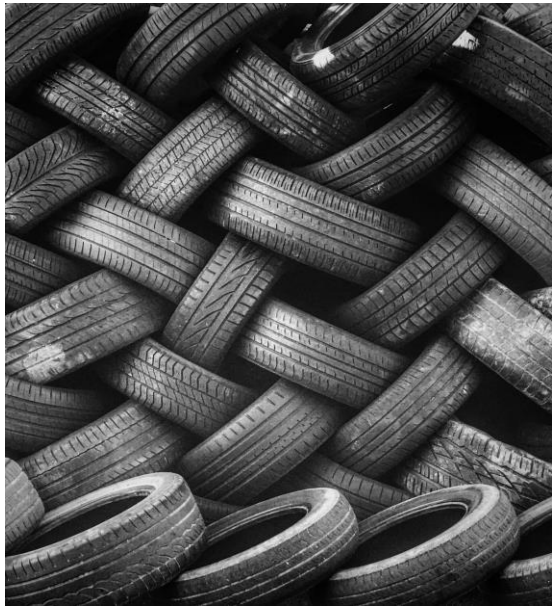


Results: EV non-exhaust emissions sensitivity study

For the EV scenario in 2030, for cars & LGVs:

1. EV mass:
    - 25% increase for all non-exhaust
    - *9% increase in total $PM_{2.5}$ emissions*
2. Regenerative braking:
    - 75% reduction in brake wear
    - *7% reduction in total $PM_{2.5}$ emissions*

- *Combined ~ 2% increase in $PM_{2.5}$*
- *Emission factor uncertainty ~ ±50%*
- *Limitations for hot spots - regen braking*

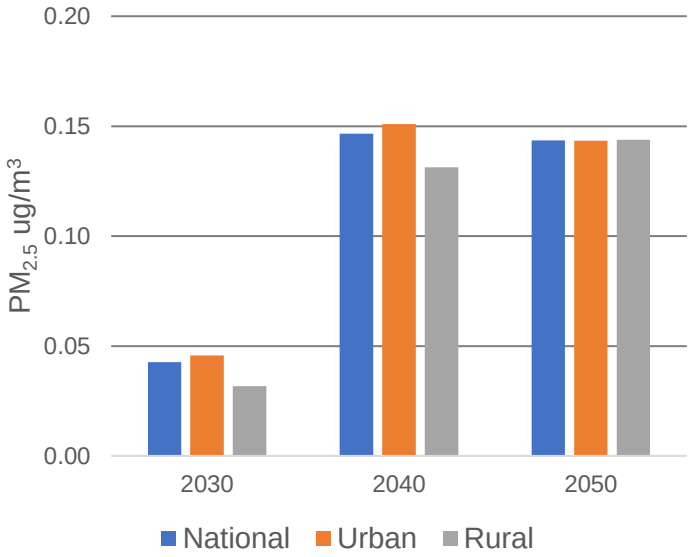


Results: Concentrations

- Population Weighted Mean Concentrations (PWMC's)
  - $\mu g/m^3$
- Change in PWMC's from 2018

Results: Euro 6 RDE scenario vs EV scenario

Change in $PM_{2.5}$ PWMC	
Euro 6 RDE	1.95 µg/m^3
EV	1.99 µg/m^3
Improvement	0.04 µg/m^3



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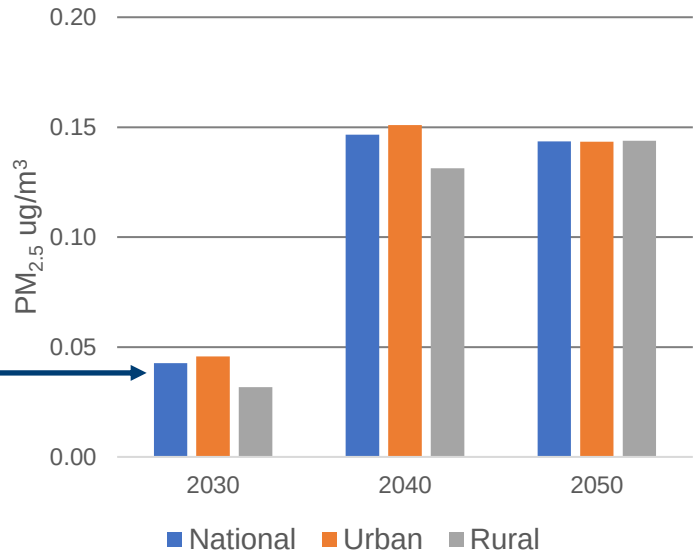
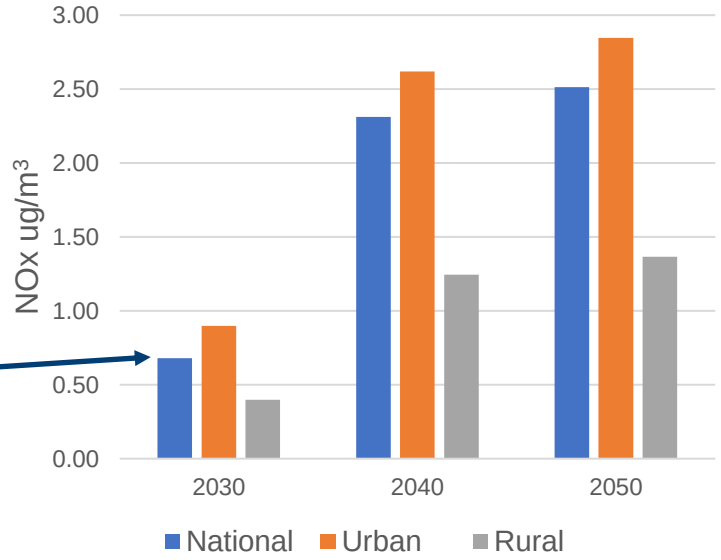


Results: Euro 6 RDE scenario vs EV scenario

Change in NO_x PWMC

Euro 6 RDE	7.17 µg/m^3
EV	7.85 µg/m^3
Improvement	0.68 µg/m^3



Results: EV Scenario health impacts

- Monetized health benefits:
  - NO_2 - £7.0 per person per μg/m^3 (£0.5 to £27.6)
  - $PM_{2.5}$ - £62.8 per person per μg/m^3 (£16.9 to £178)

- £400 million overall annualised benefits in 2030 for the EV scenario over the Euro 6 RDE scenario.

Part 2: Electricity Generation for EVs

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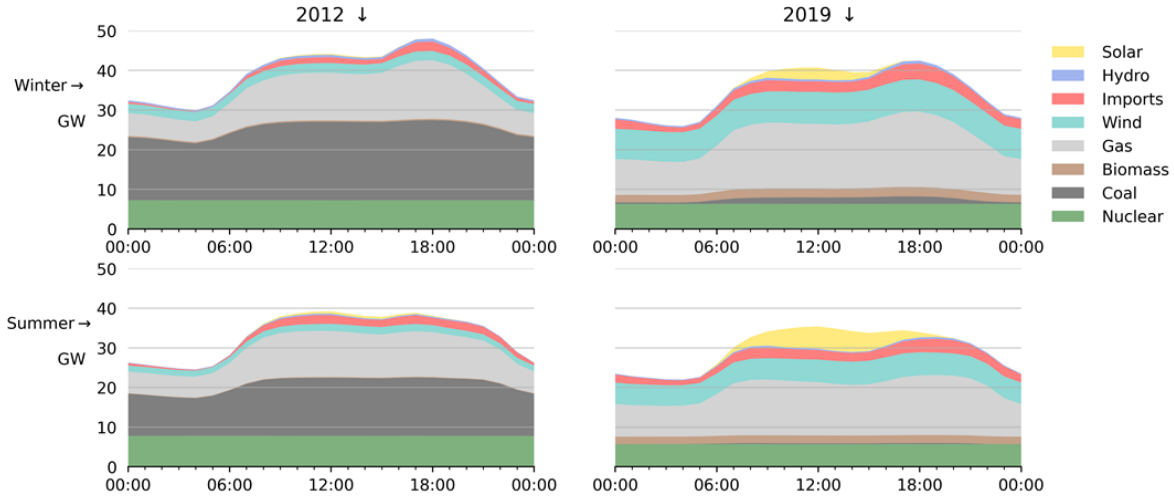
- What are the air pollutant emissions today and in 2030?



Part 2: Electricity Generation for EVs

- Net zero electricity by 2035 in the UK
- Uncertain areas for the system:
  - Carbon Capture and Storage
  - Biomass
  - Waste (landfill gas, sewage gas, MSW)
  - Geographical location of new/retrofit CCS power plants

Drax power station (Wikipedia, Paul Glazzard)

Part 2: Electricity Generation for EVs

- Road transport electricity demand in 2030 - 47 TWh (CCC Net Zero Scenario)
- Unbated natural gas CCGT ~ 10kT additional NO_x
- Increase of +18% over EV scenario road transport NO_x emissions
- Emission sources far from populated areas

Conclusions

- EVs will improve air quality over 2018 fleet, with greater improvements for NO_x than $PM_{2.5,}$ where most benefits occur before 2040
- Smaller benefits when compared to the Euro 6 RDE fleet in 2030
- Non-exhaust emissions may increase, but large uncertainties
- Net zero electricity generation is uncertain

Thank you

Department for Transport

UKRI Natural Environment Research Council

Department for Environment Food & Rural Affairs