IMPERIAL

Air quality impacts of energy system decarbonisation using hydrogen

TFIAM 2026

Dr Adam Brighty

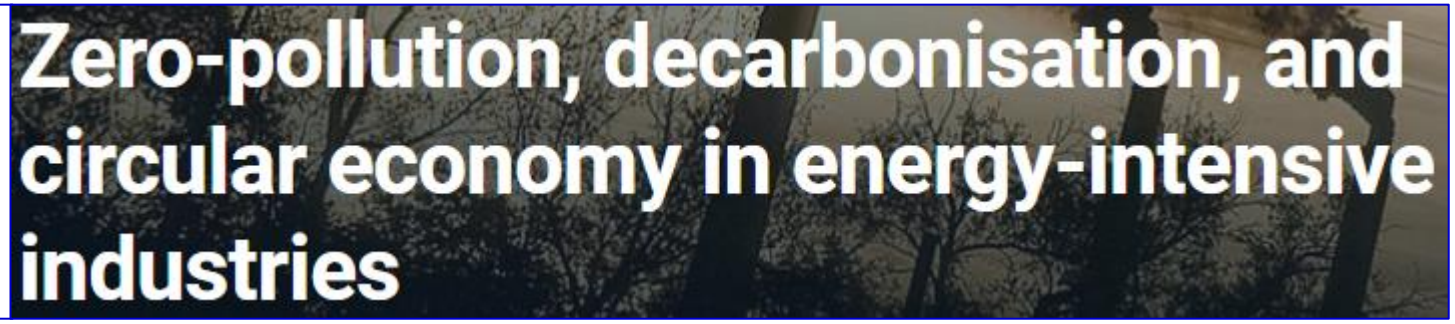
Agenda

1. Decarbonisation and EU energy system scenarios
2. Linking energy system and air pollution modelling
3. Developing emissions scenarios
4. Air pollution implications
5. Key takeaways and future work

Decarbonisation and EU energy system scenarios

The potential impact of decarbonisation on air pollution

European Environment Agency



Circularity and decarbonisation…offer significant co-benefits for pollution prevention.

A clear understanding of these co-benefits and risks should be used to guide investments and maximise environmental, health and competitiveness gains.

Decarbonisation and EU energy system scenarios

The issue of decarbonisation direction

Baseline scenarios

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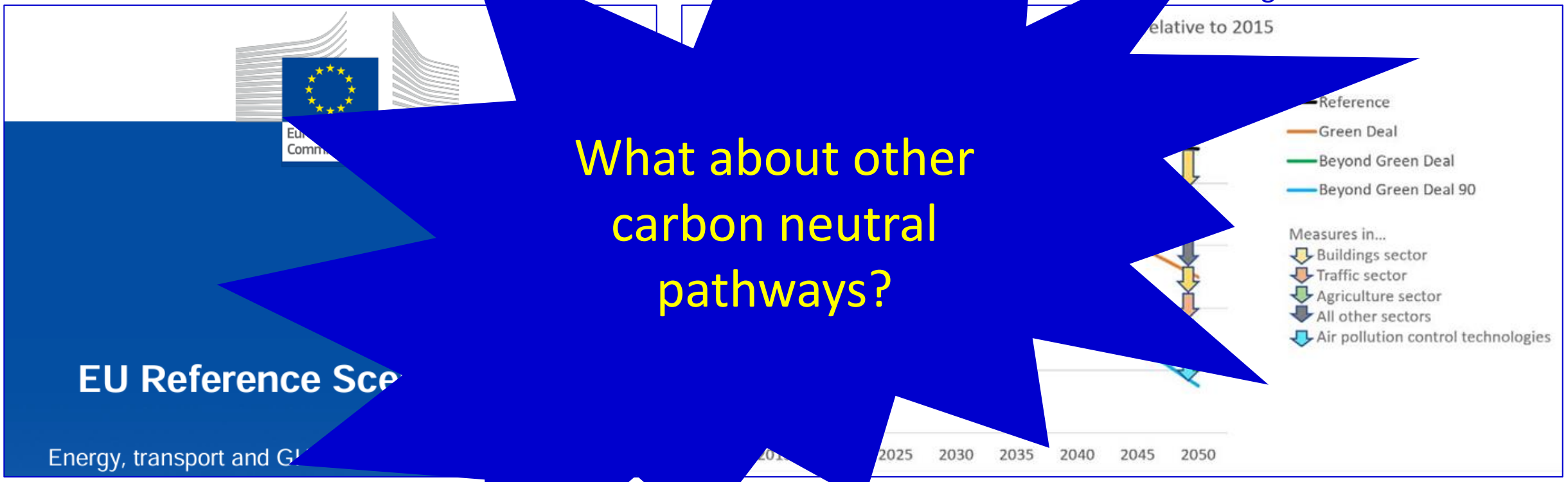
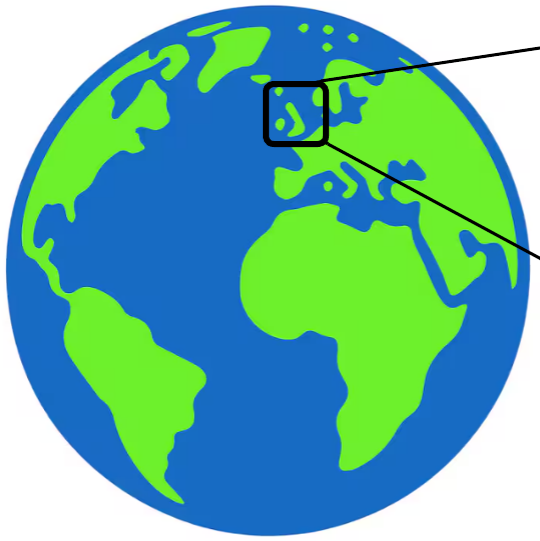


What about other carbon neutral pathways?

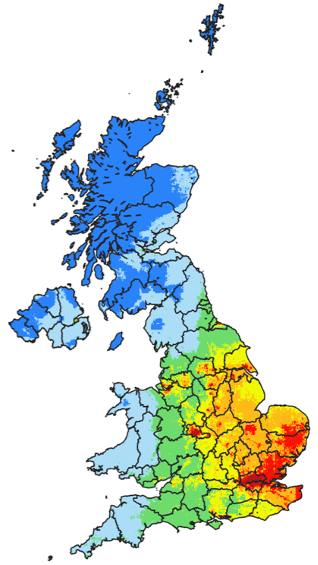
Decarbonisation and EU energy system scenarios

Investigating wider UK decarbonisation scenarios



Boundary conditions and international shipping

Energy and emissions inventory matching



TIAM-UCL
Global energy system model

UK TIMES
UK energy system model

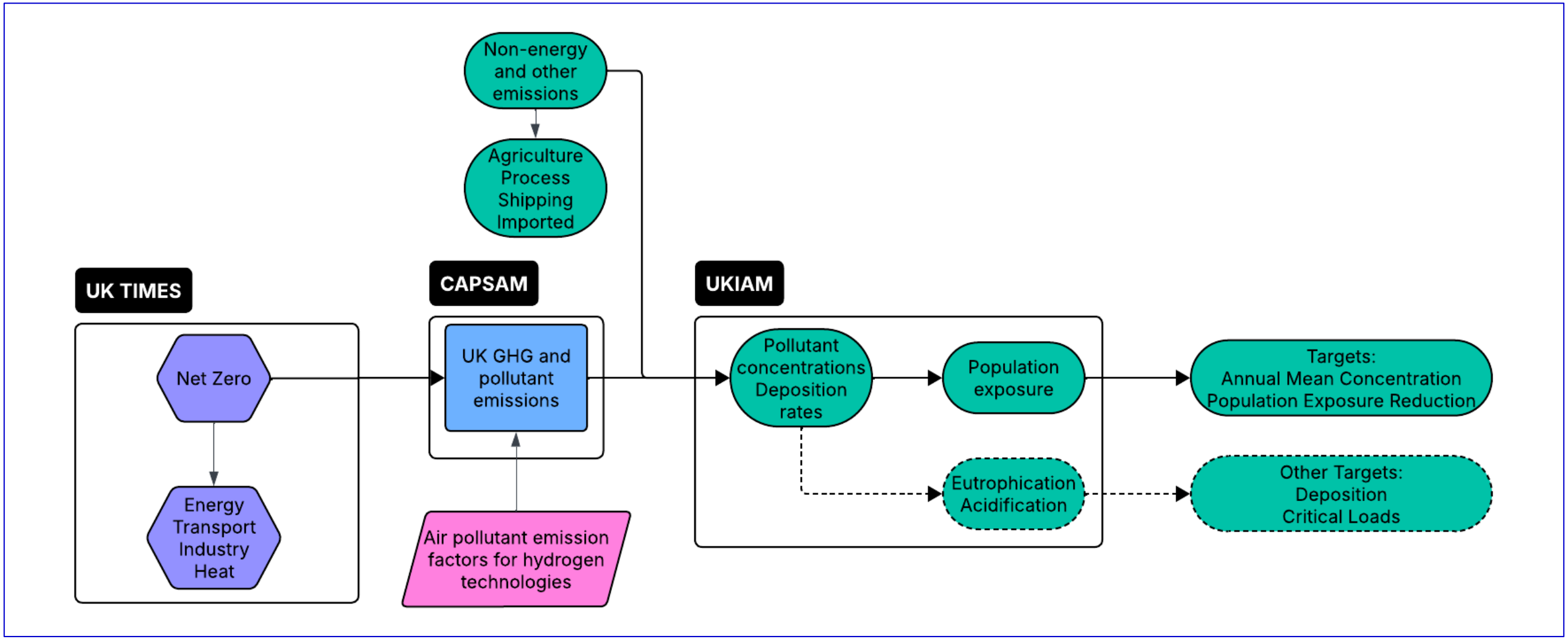
Climate Change Committee

UKIAM
UK air quality model

Department for Environment Food & Rural Affairs

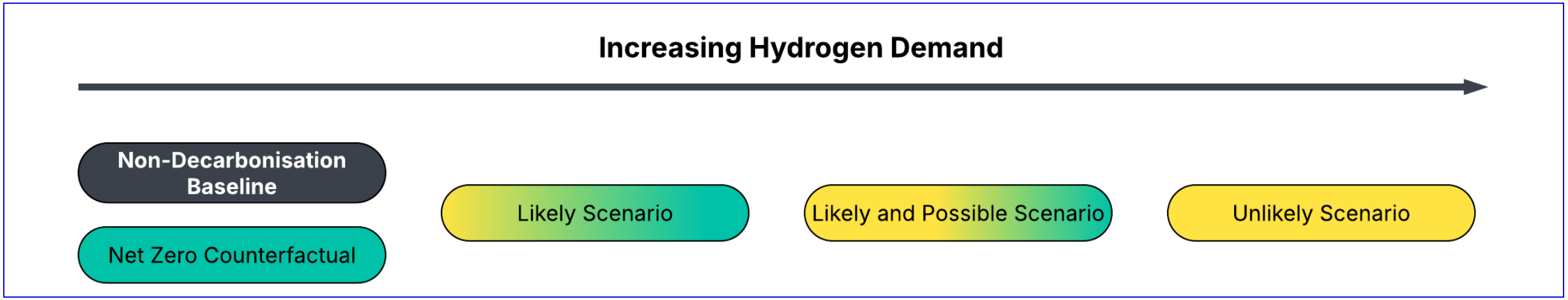
Linking energy systems to air pollution modelling

Soft-linking UK Government ‘business-critical’ models



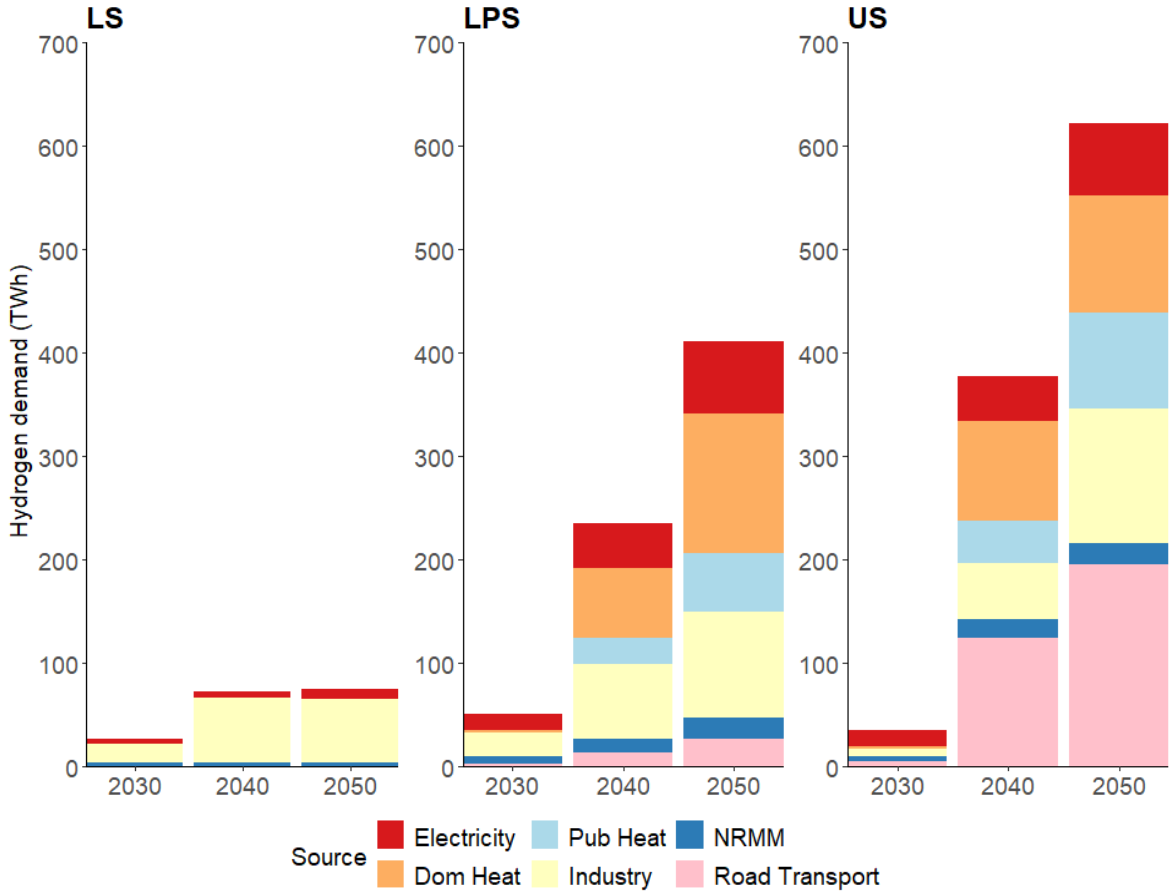
Linking energy systems to air pollution modelling

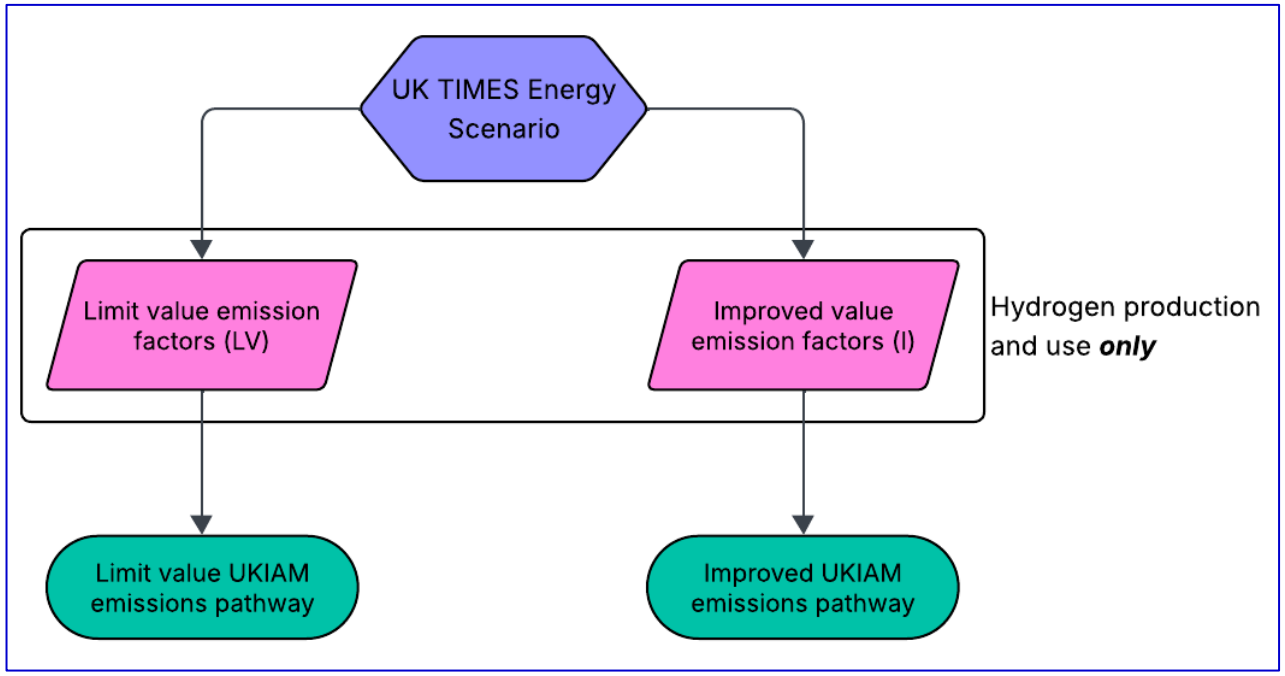
Investigating hydrogen-based decarbonisation scenarios



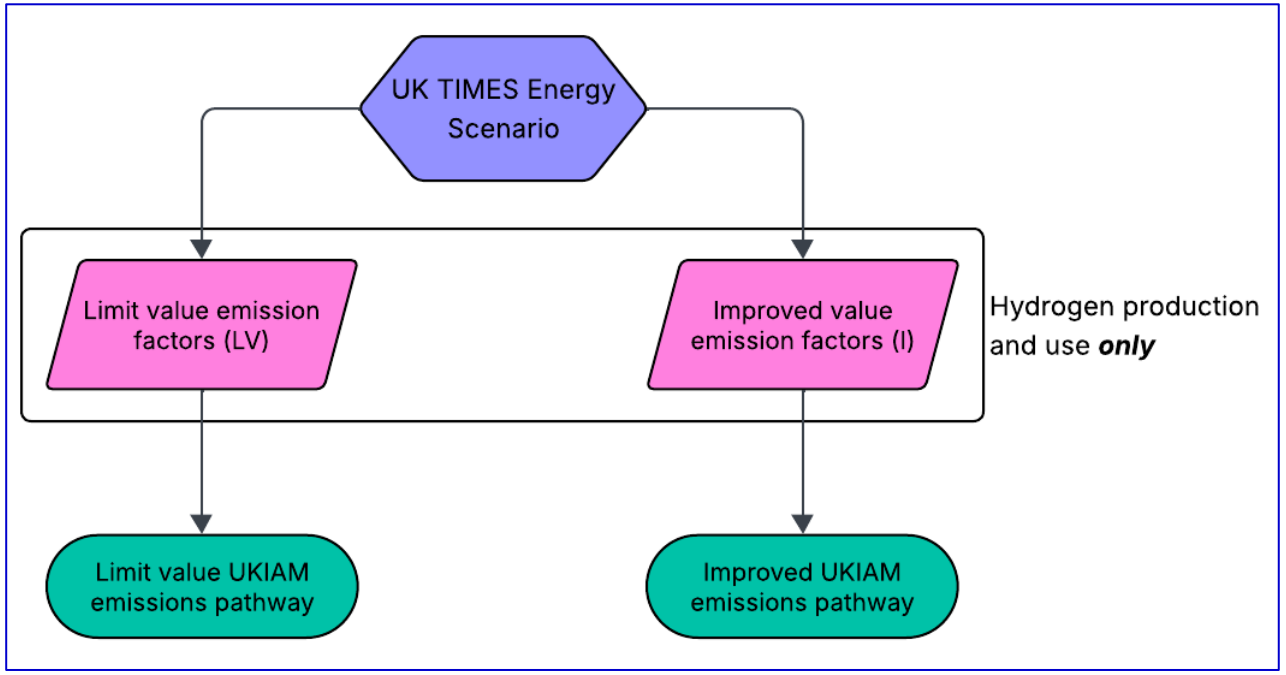
Developing emissions scenarios

Air pollution implications from the hydrogen economy





Developing emissions scenarios
Air pollution implications from the hydrogen economy

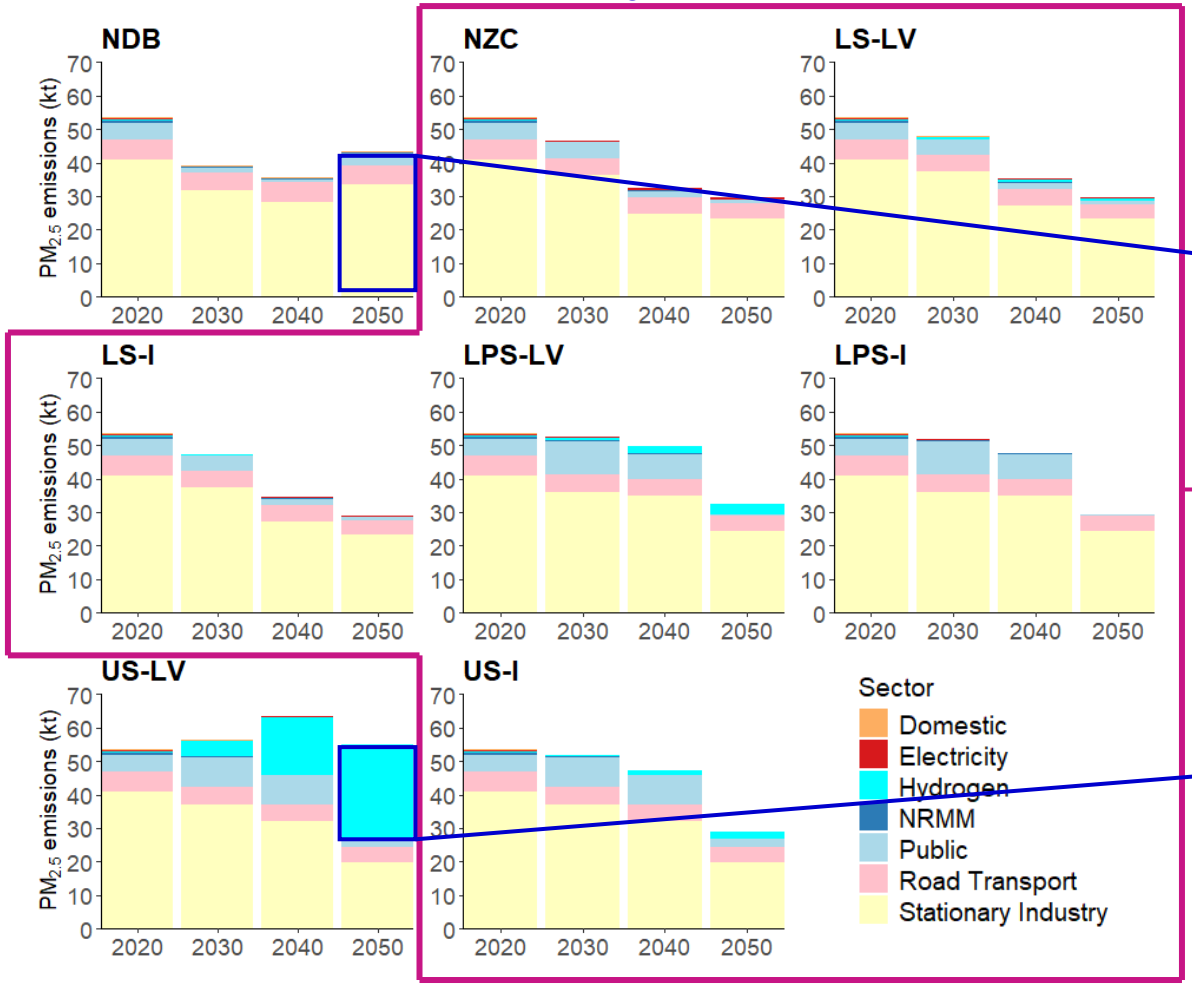


UKTM Energy Scenario	Hydrogen Emission Factors	UKIAM Emissions Pathway
Non-decarbonisation baseline **(NDB)**	N/A	Non-decarbonisation Baseline **(NDB)**
Net Zero Counterfactual **(NZC)**	N/A	Net Zero Counterfactual **(NZC)**
Likely Scenario **(LS)**	Limit values	Likely – Limit Values **(LS-LV)**
	Improved values	Likely – Improved Values **(LS-I)**
Likely and Possible Scenario **(LPS)**	Limit values	Likely and Possible – Limit Values **(LPS-LV)**
	Improved values	Likely and Possible – Improved Values **(LPS-I)**
Unlikely Scenario **(US)**	Limit values	Unlikely – Limit Values **(US-LV)**
	Improved values	Unlikely – Improved Values **(US-I)**

Air pollution implications

Energy system $PM_{2.5}$ and NO_x emissions

$PM_{2.5}$



43kt for NDB
Less efficiency and electrification

Most NZ scenarios between 29-32 kt in 2050
Biomass differences in interim years

55kt for US-LV
Biomass gasification with worst case emission factors

Air pollution implications

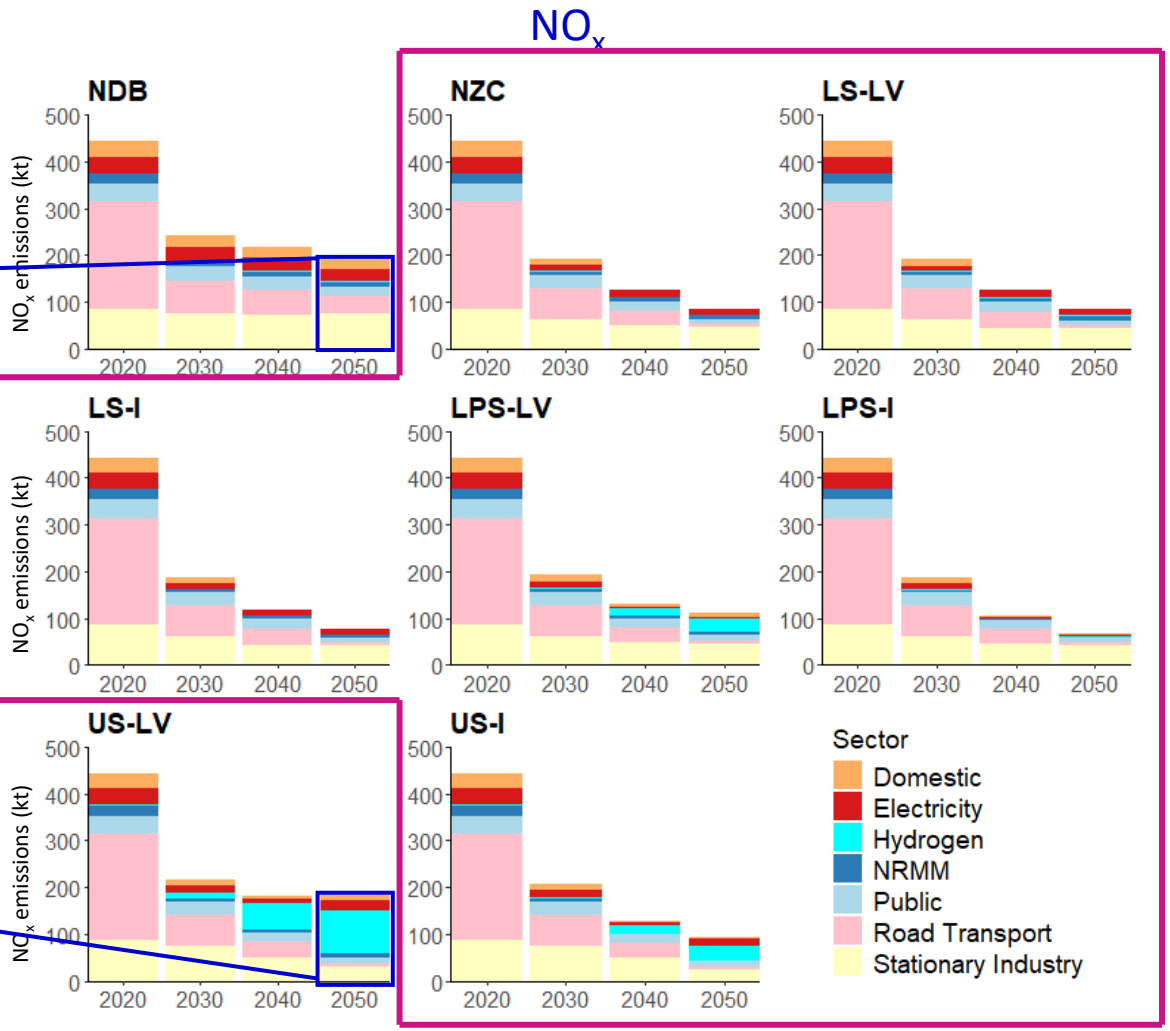
Energy system $PM_{2.5}$ and NO_x emissions

Road transport decarbonisation dominates NO_x reductions (~190kt)

192kt for NDB
Sustained natural gas usage
Less efficiency and electrification

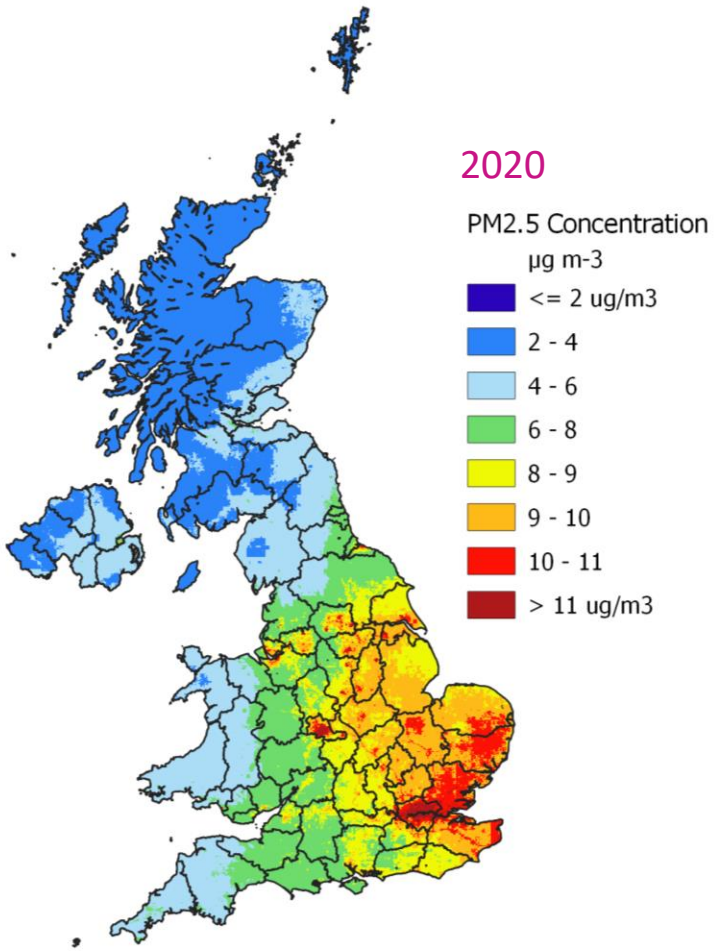
Most NZ scenarios between 66-112 kt
LS-I and LPS-I lower than NZC

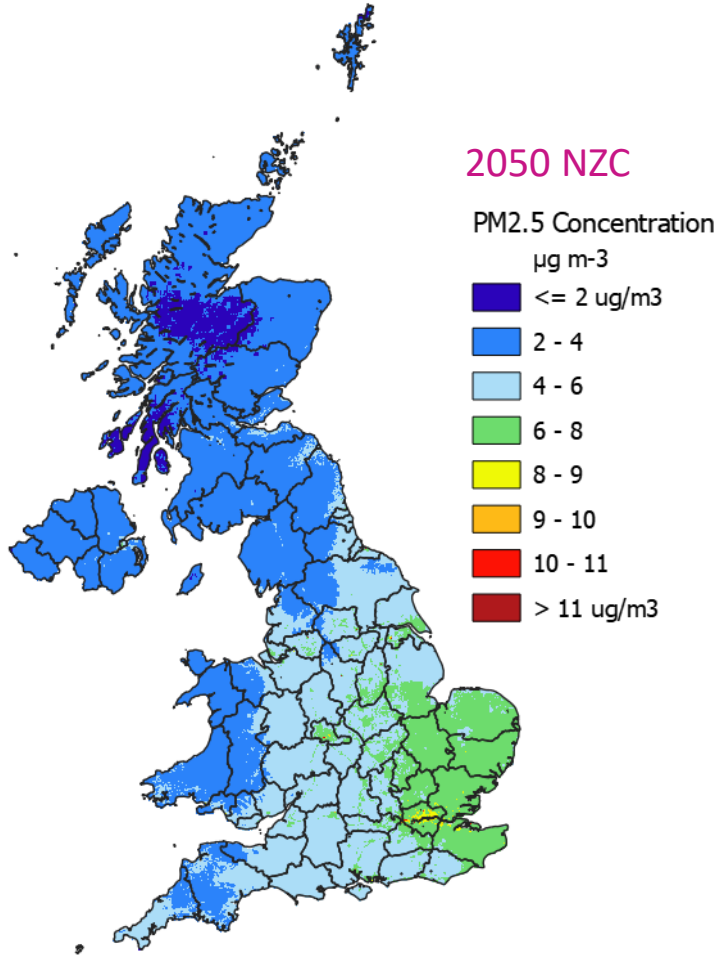
183 kt for US-LV
Biomass gasification with worst case emission factors

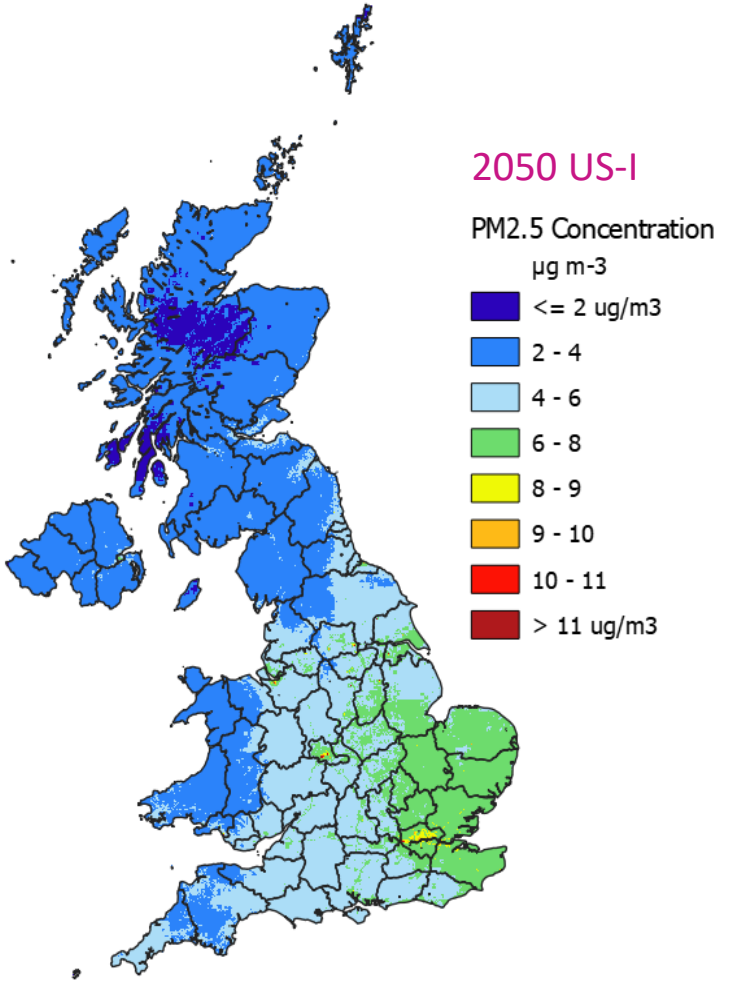


Air pollution implications

$PM_{2.5}$ annual average concentration maps

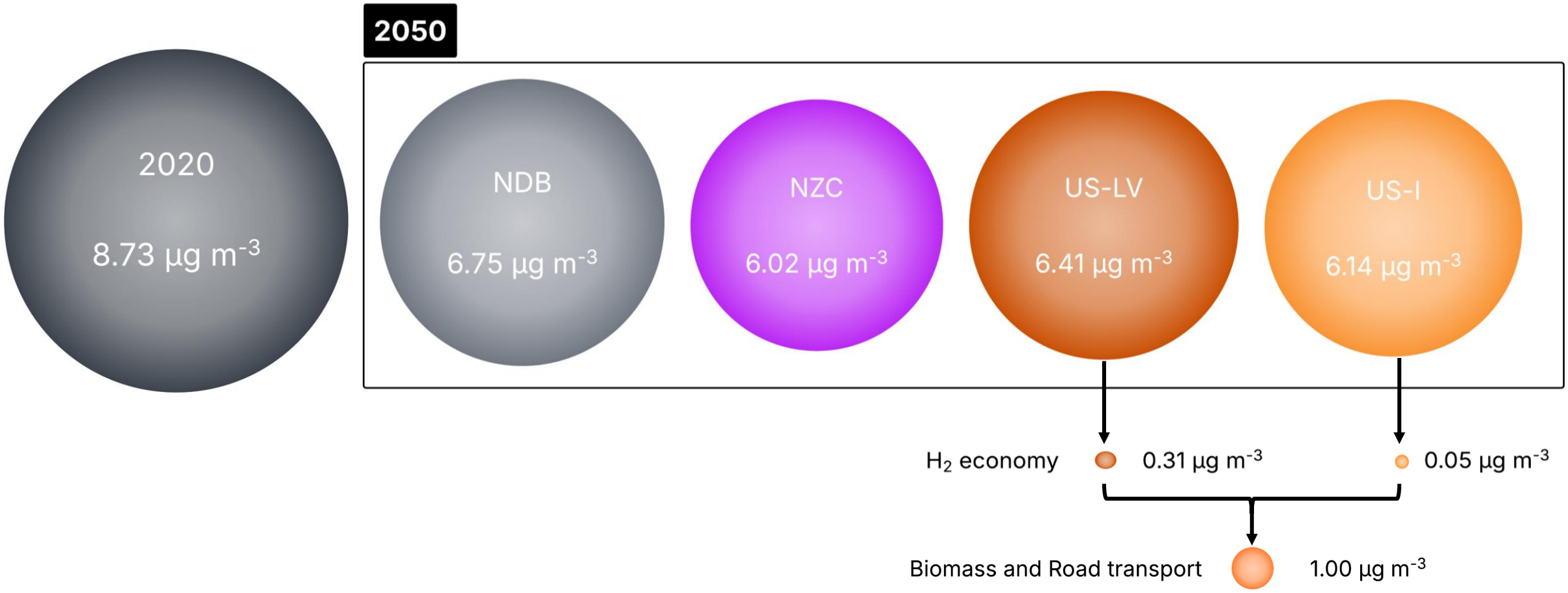






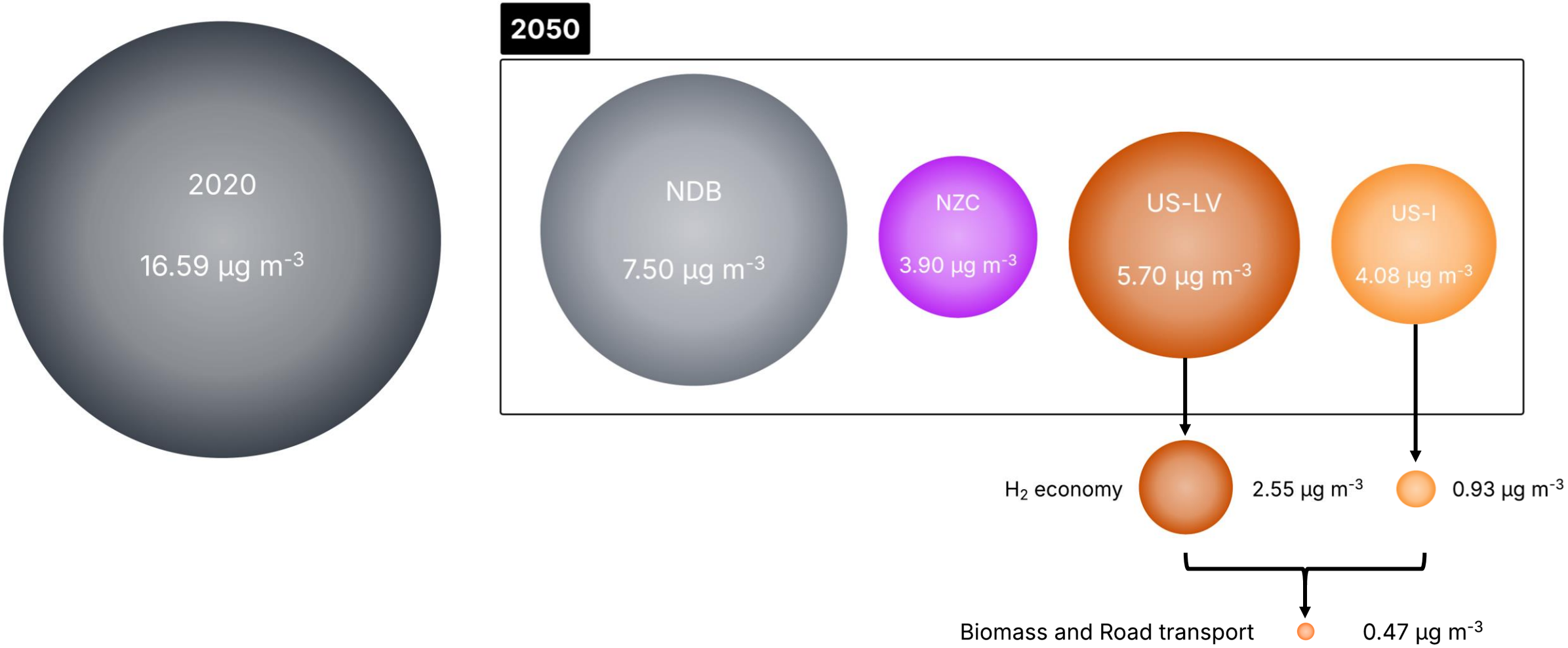
Air pollution implications

The impact of a ‘hydrogen economy’ – $PM_{2.5}$ PWMC



Air pollution implications

The impact of a ‘hydrogen economy’ – NO_x PWMC



Recommendations and future work

Recommendations

Hydrogen deployment

- May not hinder attempts to meet $PM_{2.5}$ targets, with caveats around US-LV
- Must introduce hydrogen NO_x emission limits and regulation

Framing

- Focus on biomass usage and road transport non-exhaust emissions
- Consider what sources are being replaced by hydrogen

Future Work

Alternative tech

- Alternative fuels to hydrogen (e.g., ammonia)
- Further work on carbon capture and storage
  - Updated air pollutant co-capture effects from CCS

Modelling

- Wider decarbonisation scenarios
- Further links to UK Government energy system modelling
  - Seventh Carbon Budget scenarios

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Dr Adam Brighty, Prof Helen ApSimon, Dr Tim Oxley, Dr Nicolás Ripoll, Dr Daniel Mehlig, and Dr Mike Holland

Modelling UK air quality implications of decarbonisation using hydrogen