Net zero measures & air pollution

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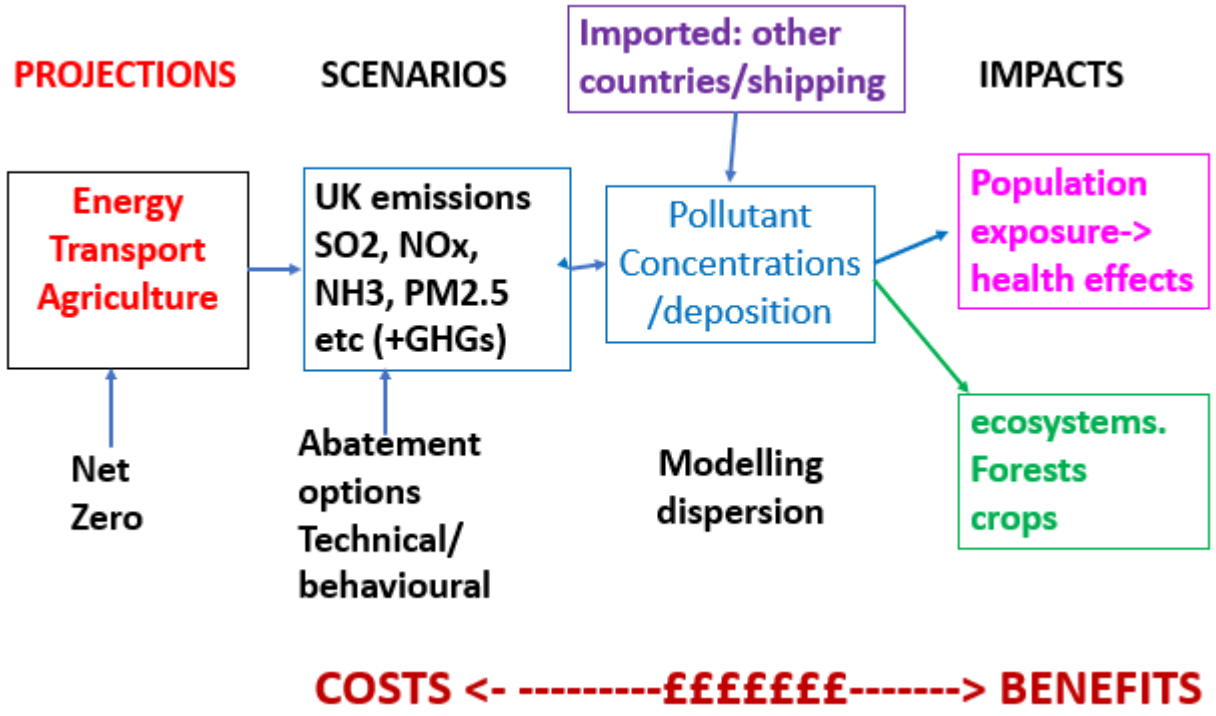
Strategies aimed at reaching net zero for greenhouse gas emissions also affect air pollutant emissions and their impacts

1. **Energy generation and use** - Helen ApSimon

2. **Land-use and agriculture –** Huw Woodward

UK Integrated Assessment Model, UKIAM

Simple model superimposing and scaling the footprints of different sources



Scenario analysis future AQ in UK to 2050

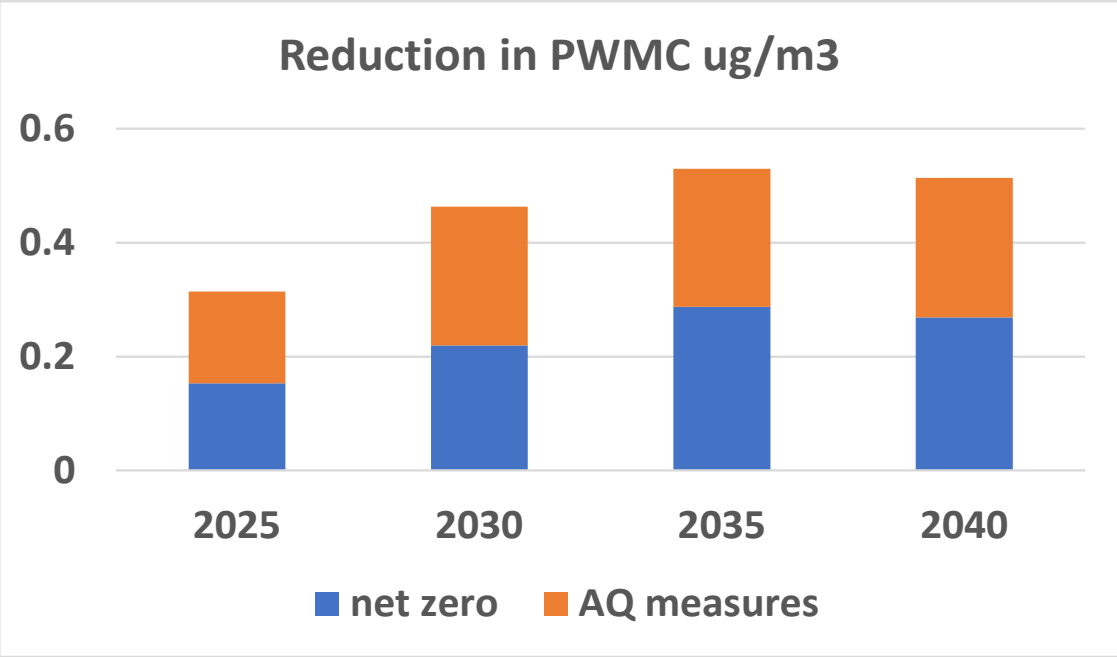
Applied to $PM_{2.5}$ in setting targets NECR and NAPCP reporting

PM2.5 and NO2 concentrations & exposure -> health impacts and CBA

Nitrogen deposition re ecosystems

Detailed source apportionment and calculates " impact factors" as effect of unit pollutant emission reductions for each source on exposure

In scenarios superimposing pollution abatement measures on net zero scenarios, the net zero measures can account for a large part of the improvement in AQ.
But this varies with the energy scenario.



Relative contributions to improvement in population exposure to PM2.5 relative to the baseline from net zero and added AQ measures for illustrative scenario.
NB EVs included in net zero

NZ measures+ demand management/efficiency

Power: solar/wind, nuclear, Gas+CCS,BECCS (Hydrogen NB Intermittency)

Domestic: efficiency/electrification, heat pumps, biofuel boiler, hydrogen (gas mixture 20%, **or as H2)**

Industry: CHP, electrification, biomass, gas+CCS, (hydrogen?)

Transport: modal change, electrification (NOx, PM), H fuel cell (NOx,PM)

Detailed sub-model for road transport, BRUTAL, across UK road network
-applied to electrification of the fleet and extend to use of hydrogen
Now being used for DfT and updated to their latest scenarios.

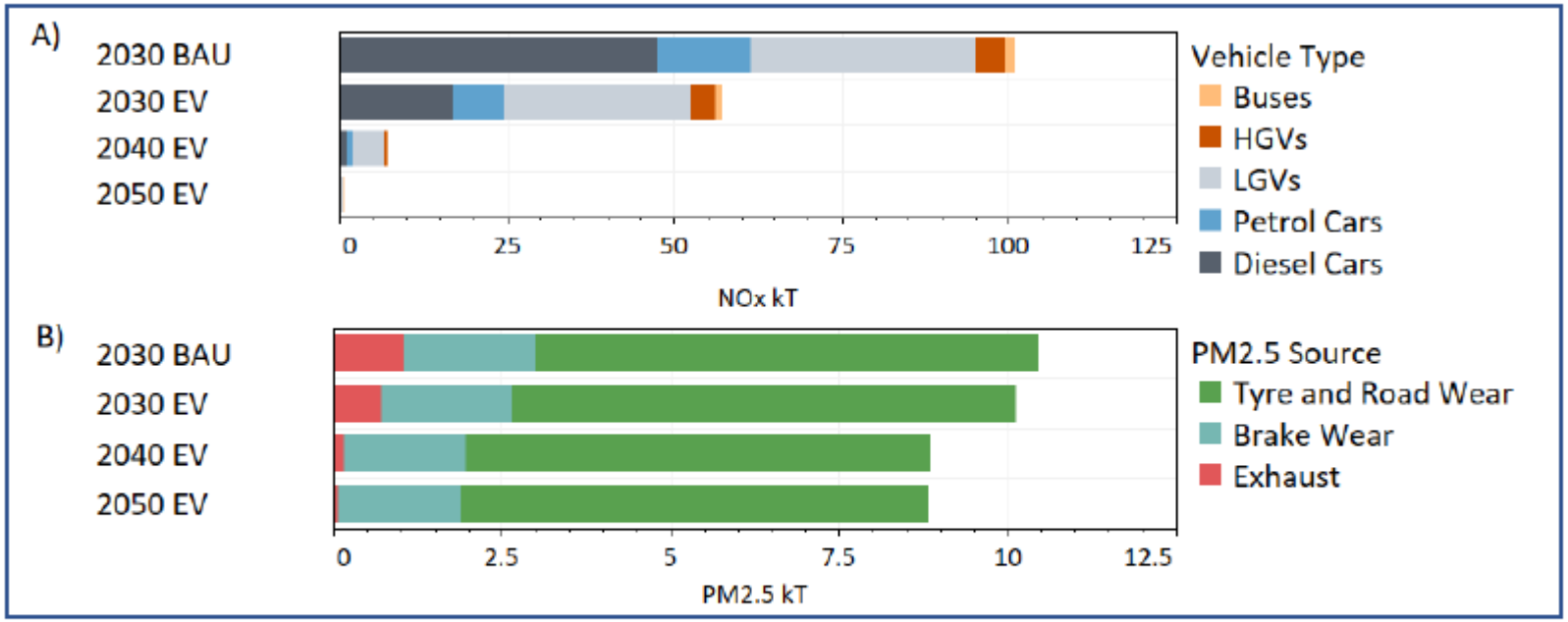


Figure 5.3. Projected emissions from road transport to 2050 for EV scenario. . A) Emissions of NOx, where colour shows the emissions from each vehicle type. B) $PM_{2.5}$ Emissions where colour shows the emission source.

Mehlig D, Woodward H, OxleyT,Holland M, ApSimon H, Electrification of road transport and the impacts on air quality. Atmosphere 2021,12, 1491. https://doi.org/10.3390?atmos12111491

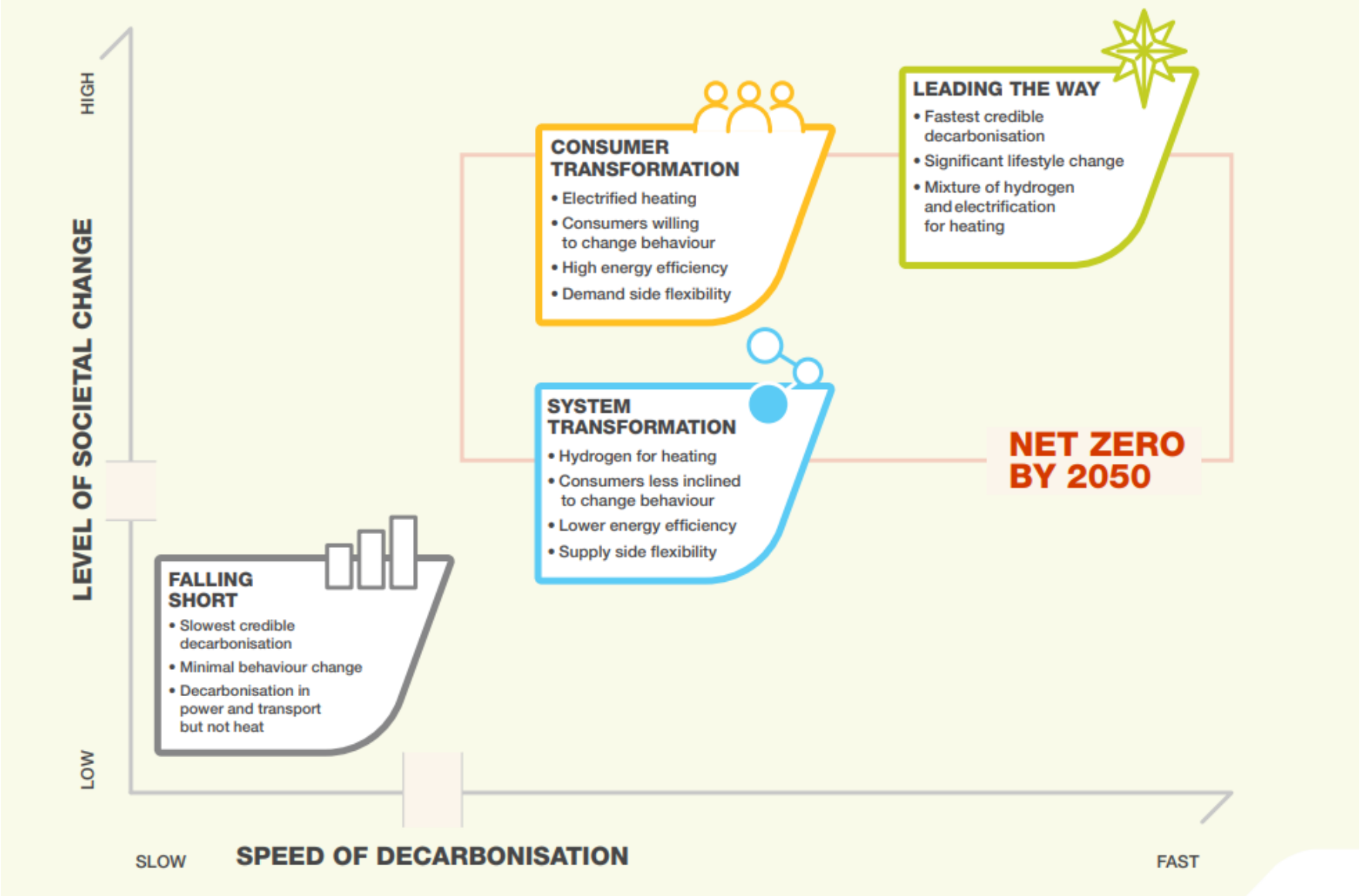
Electrification/hydrogen needs to be synchronised with energy projections .

If current ban on new ICE vehicles etc brought forward insufficient clean electricity production

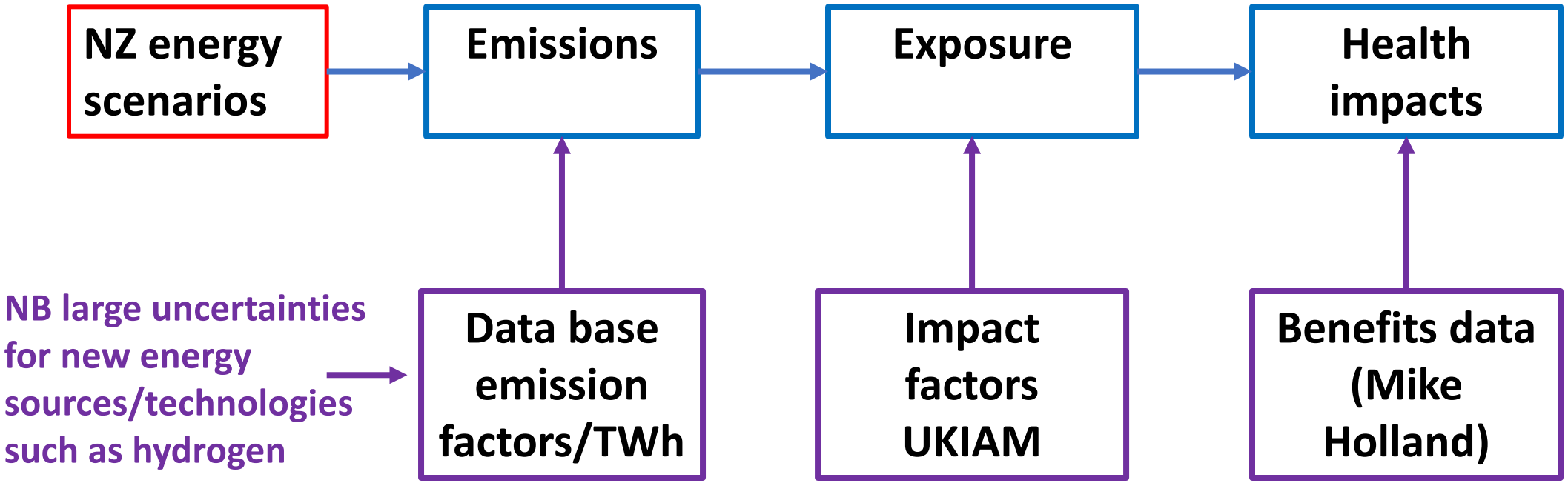
But if delayed by e,g, 5 years adds 0.5 GT to cumulative CO2 emissions by 2050

Illustration from UK National Grid scenarios

https://www.nationalgrideso.com/document/263951/download



CAPSAM model (A Brighty)
Climate & Air Pollution Synergies Assessment Model

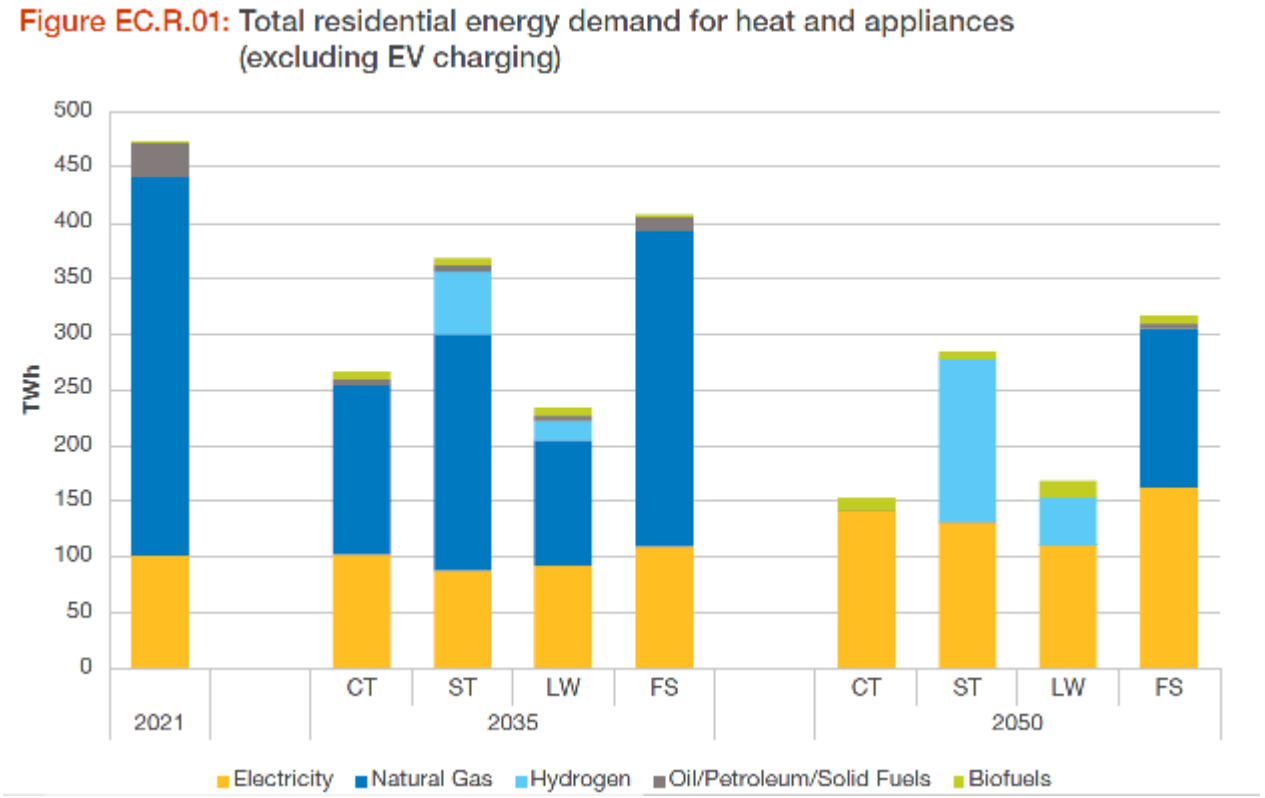


Also produces “exposure factors” = PWMCs per TWh of H production or use

Illustration of application of CAPSAM to domestic sector in National Grid scenarios (decision required on use of hydrogen in domestic sector before 2026)

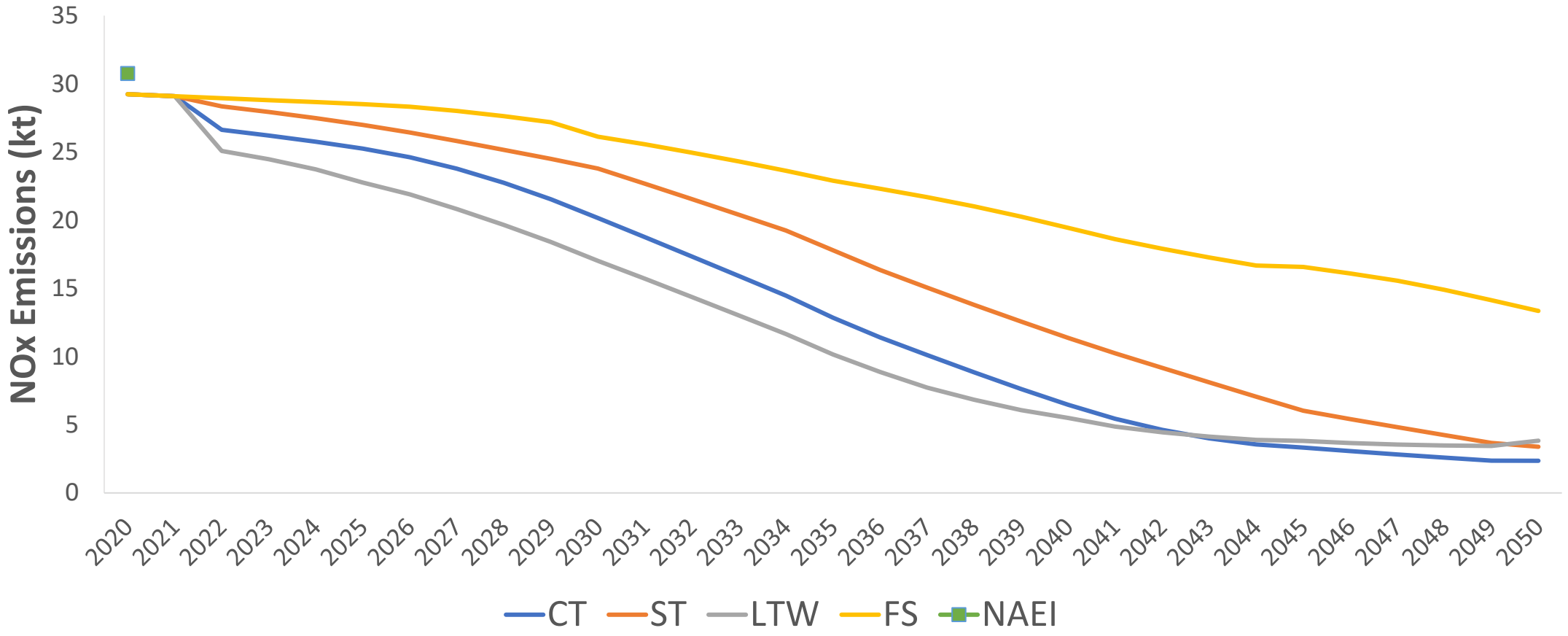
(does not include domestic wood burning)

NB preliminary and needs more work on database of emission factors

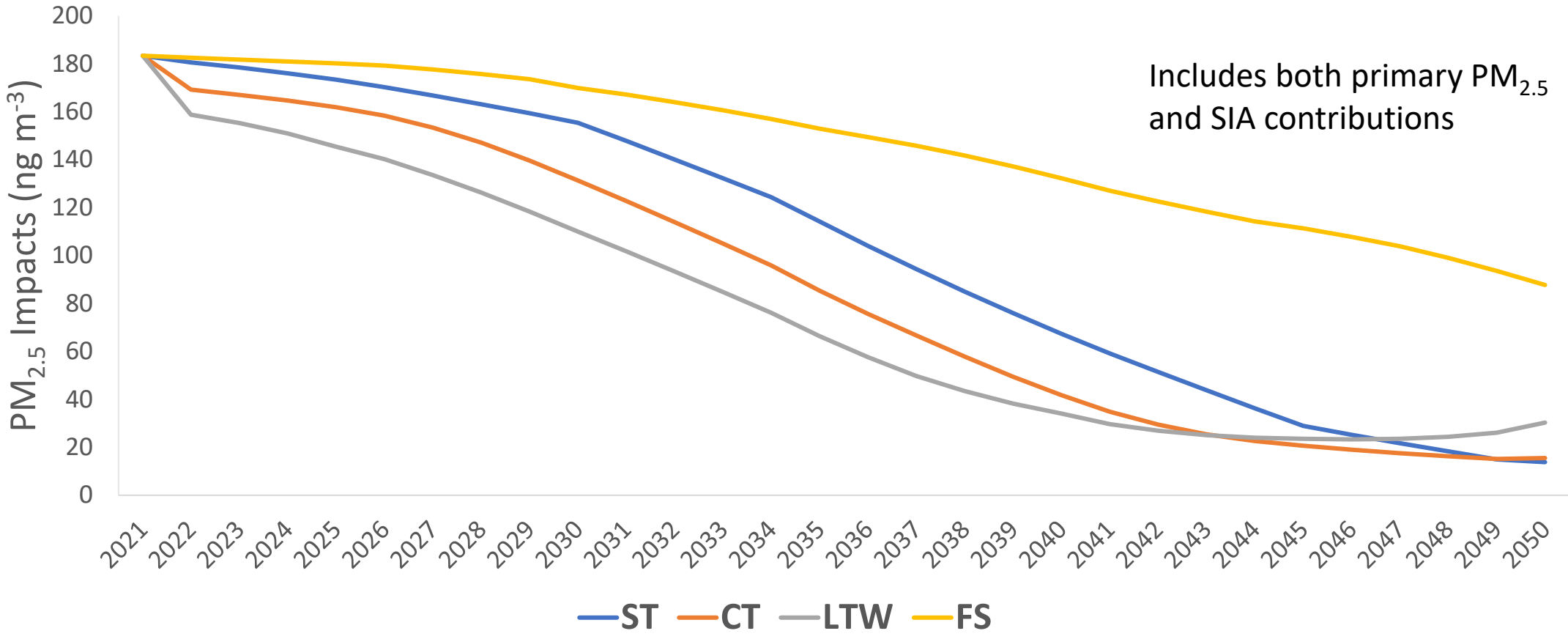


Energy demand (TWh) for domestic sector for each scenario in 2021, 2035 and 2050

Domestic Heating – NO_x Emissions



Domestic Heating – $PM_{2.5}$ impacts (as PWMC)



Future steps

Use National Grid scenarios to extend to all sectors; but plan is to link UKIAM and the TIMES model for future energy projections (COSHAIR project on hydrogen and impacts of its production and use on air quality)

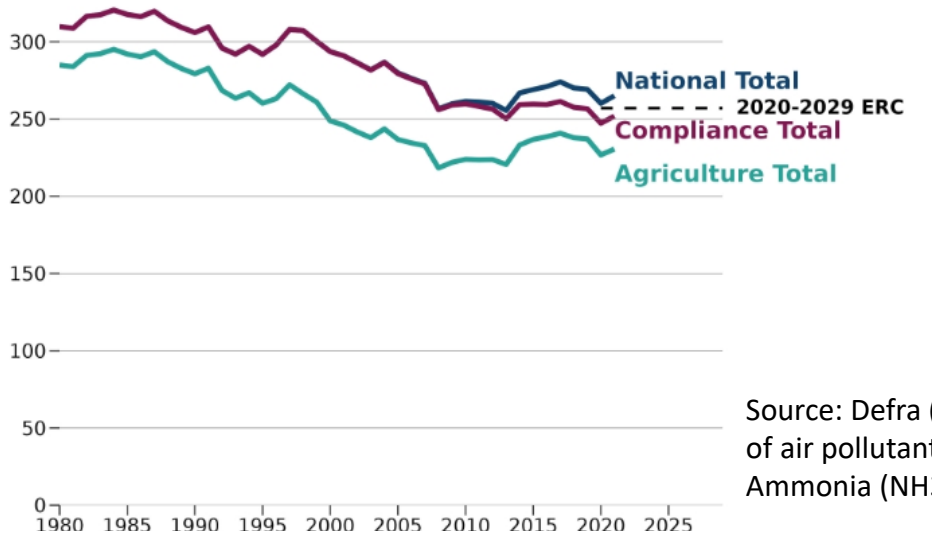
Further work on the database of EFs, and production of exposure factors

Uncertainty/Monte Carlo analysis re uncertainties in emissions and sensitivity to scenario assumptions (e.g. no of heat pumps installed) with CAPSAM

Apply UKIAM to new TIMES scenarios and attention to mapping and spatial issues

NH3 emissions in the UK and Critical Load/Level exceedances

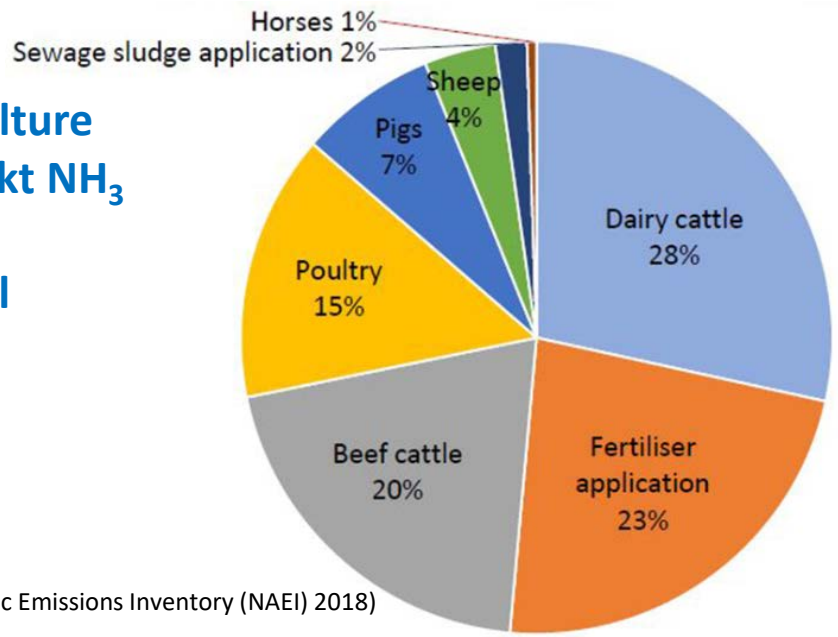
UK NH_3 emissions (kt)



Source: Defra (2023) Emissions of air pollutants in the UK – Ammonia (NH3)

Total UK agriculture emission = 226kt NH_3

87% of UK total emission



(UK National Atmospheric Emissions Inventory (NAEI) 2018)

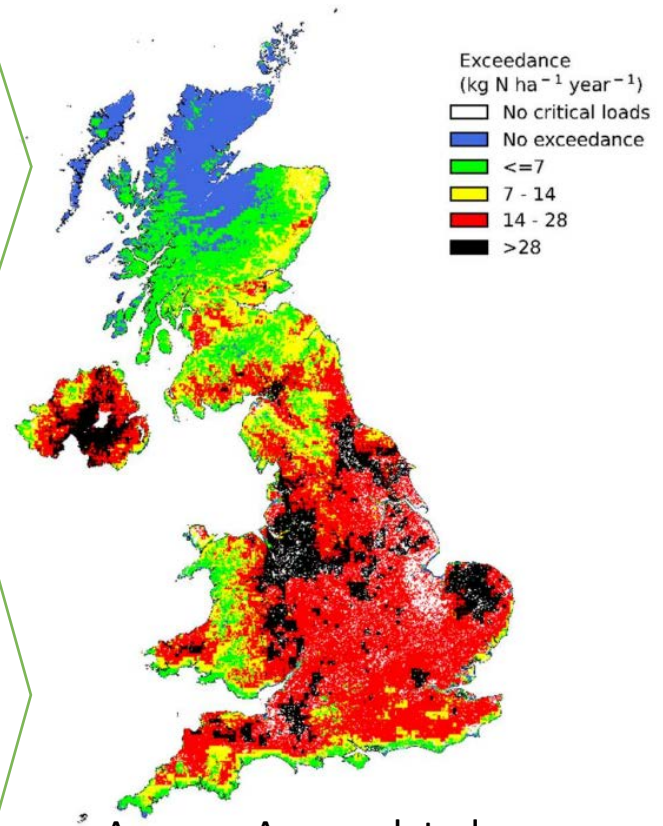
UK Critical Load/Level exceedances

67.7% of the area of N-sensitive habitats in exceedance of nutrient N critical load.

-(2022 Trends report)

6.3% of UK land area dexposed to NH_3 concentrations above the critical level for *higher plants* ($3\mu g/m^3$) and **69.2%** to concentrations above the critical level set to protect *lichens and mosses* ($1\mu g/m^3$).

-(2022 Trends report)



Average Accumulated Exceedance (AAE) in 2018-20 of critical loads for nutrient nitrogen

-(2022 Trends report)

Current policy tools

Environmental Land Management Schemes

- Replacement to CAP post-Brexit - revenue options supported by a menu of capital items
- Options are outcome focused. Key drivers include Net Zero, biodiversity and water quality
- Broadly three types of activity:
  - Widespread, non targeted sustainable farming practices
  - More spatially targeted outcome specific actions e.g. restoration or creation of priority habitats.
  - Joined up landscape scale projects

Farming Investment Fund and Farming Innovation Programme

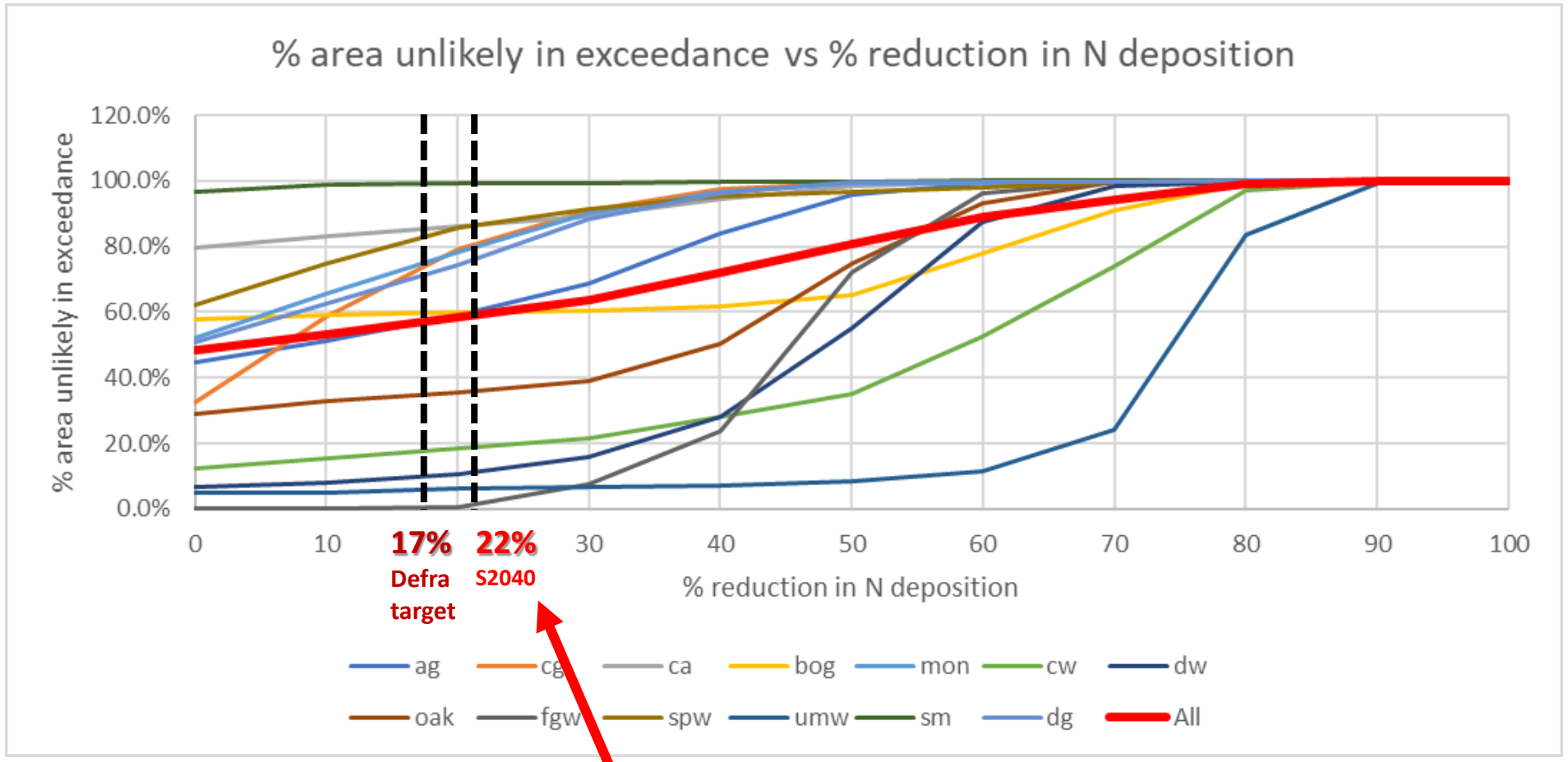
- Investment in technology, innovation and research

Nature for climate fund

- Supporting peatland restoration and woodland creation

Key role seen for private finance

The path to reducing exceedance – UKIAM modelling



Ambitious tech measures scenario

ag = Acid grassland
cg = Calcareous grassland
ca = Dwarf shrub heath
bog = Bog
mon = Montane
cw = Coniferous woodland
dw = Broadleaved woodland
fgw = Beech woodland
oak = Acidophilous oak
spw = Scots pine
umw = Mixed woodland
sm = Saltmarsh

dg = Dune grass

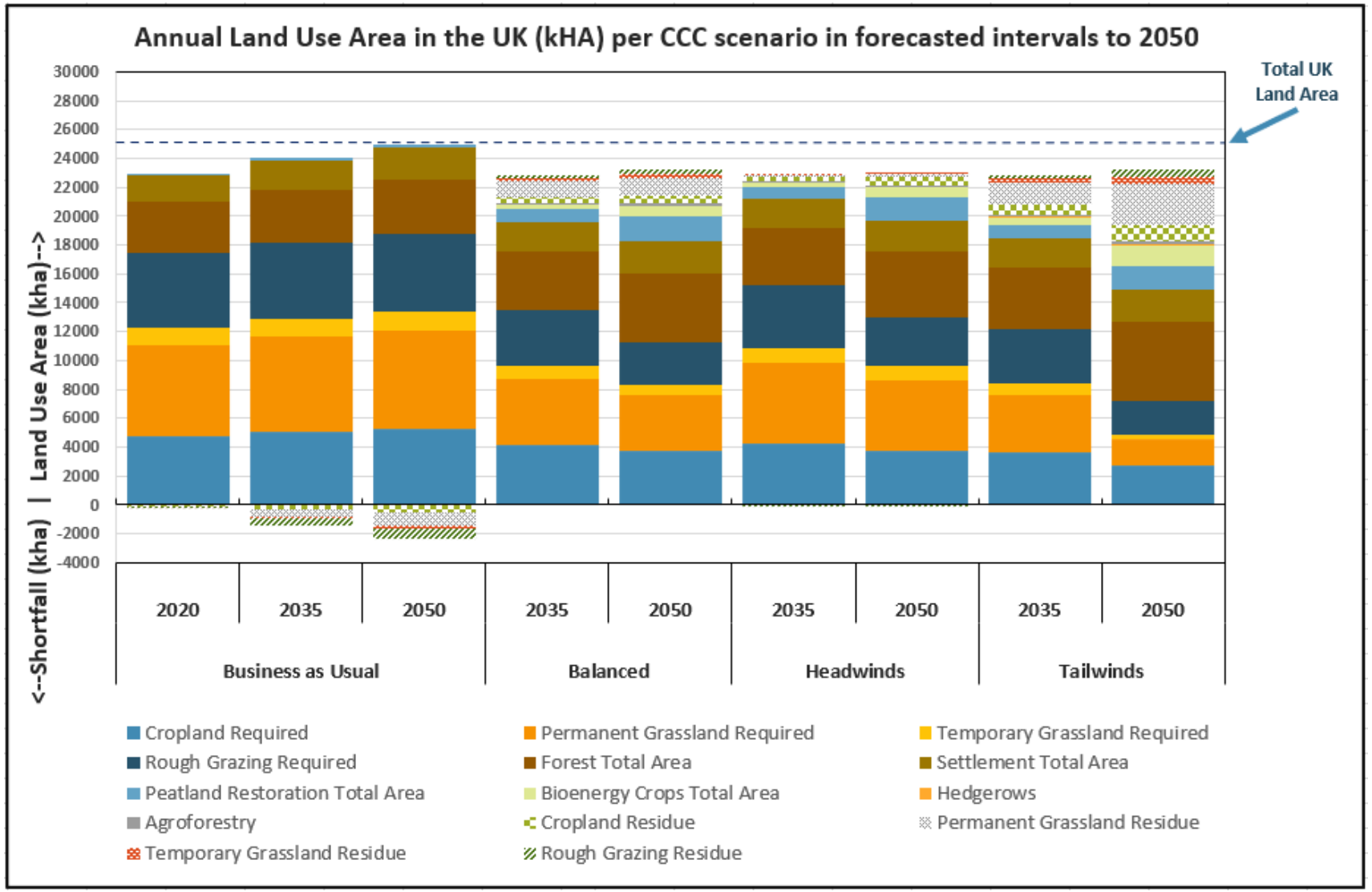
Future land use recommendations

UK Committee on Climate Change

Balanced Pathway Measures

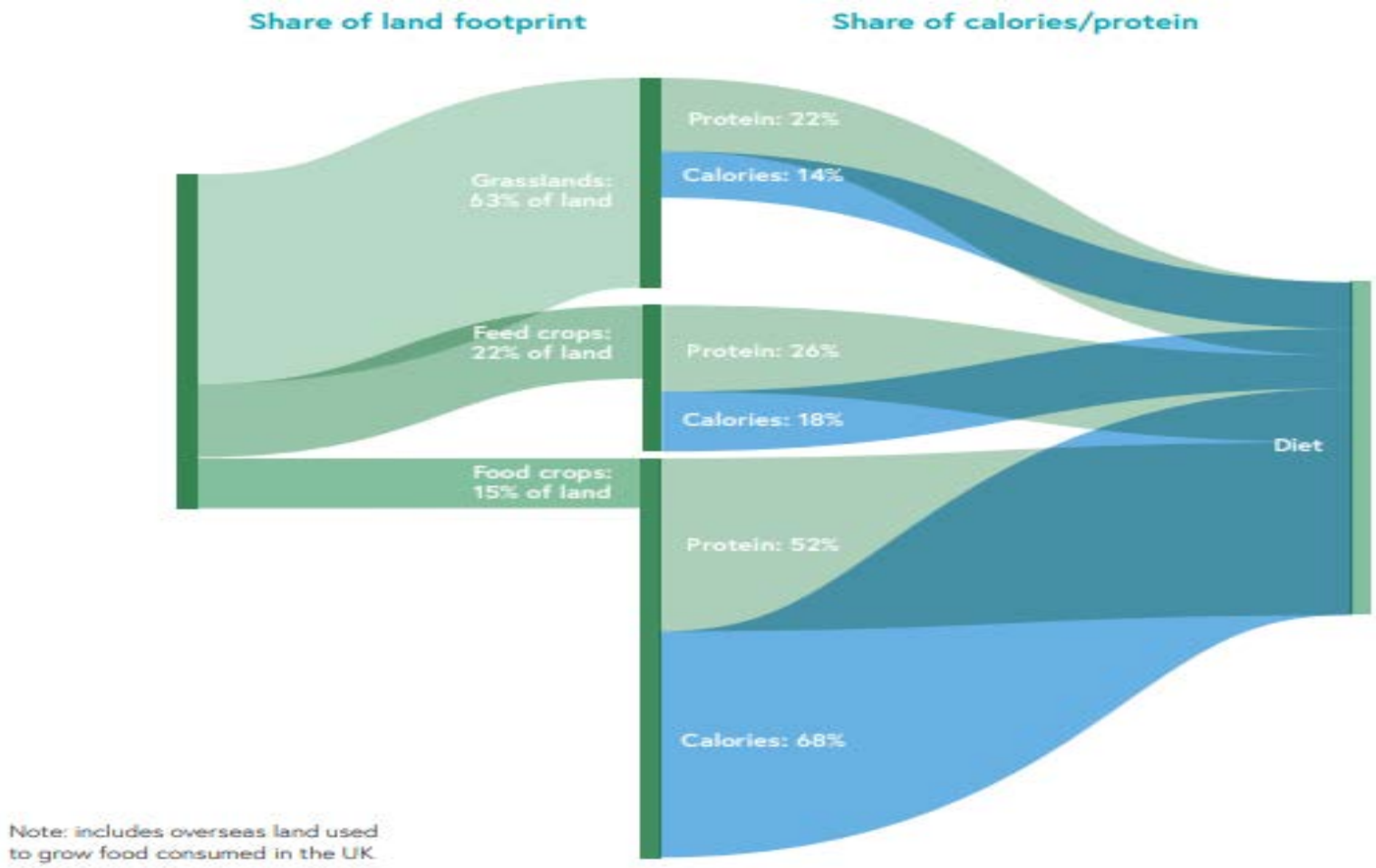
- **Low carbon farming**
  (Annual reduction of 4MtCO_{2e} by 2035)
  - Livestock measures
  - Soil measures
  - Waste & Manure management
    - Anaerobic Digestion
    - Covering slurry tanks
- **Fossil fuels in farming**
  (Annual reduction of 1MtCO_{2e} by 2035)
  - Low carbon technology
  - Biogas from AD
- **Releasing Land in farming**
  (Annual reduction of **8MtCO_{2e}** and 4.7M ha freed by 2035, **11MtCO_{2e}** and 7.5M ha by 2050)
  - Reduce food waste
  - Improve crop yields
  - Move horticulture indoors
  - Increase grazing intensity
  - Reduce livestock production
    (Annual Reduction of **7MtCO_{2e}** & 3M ha by 2035, **10MtCO_{2e}** & 4.5M ha by 2050)

Future land use recommendations



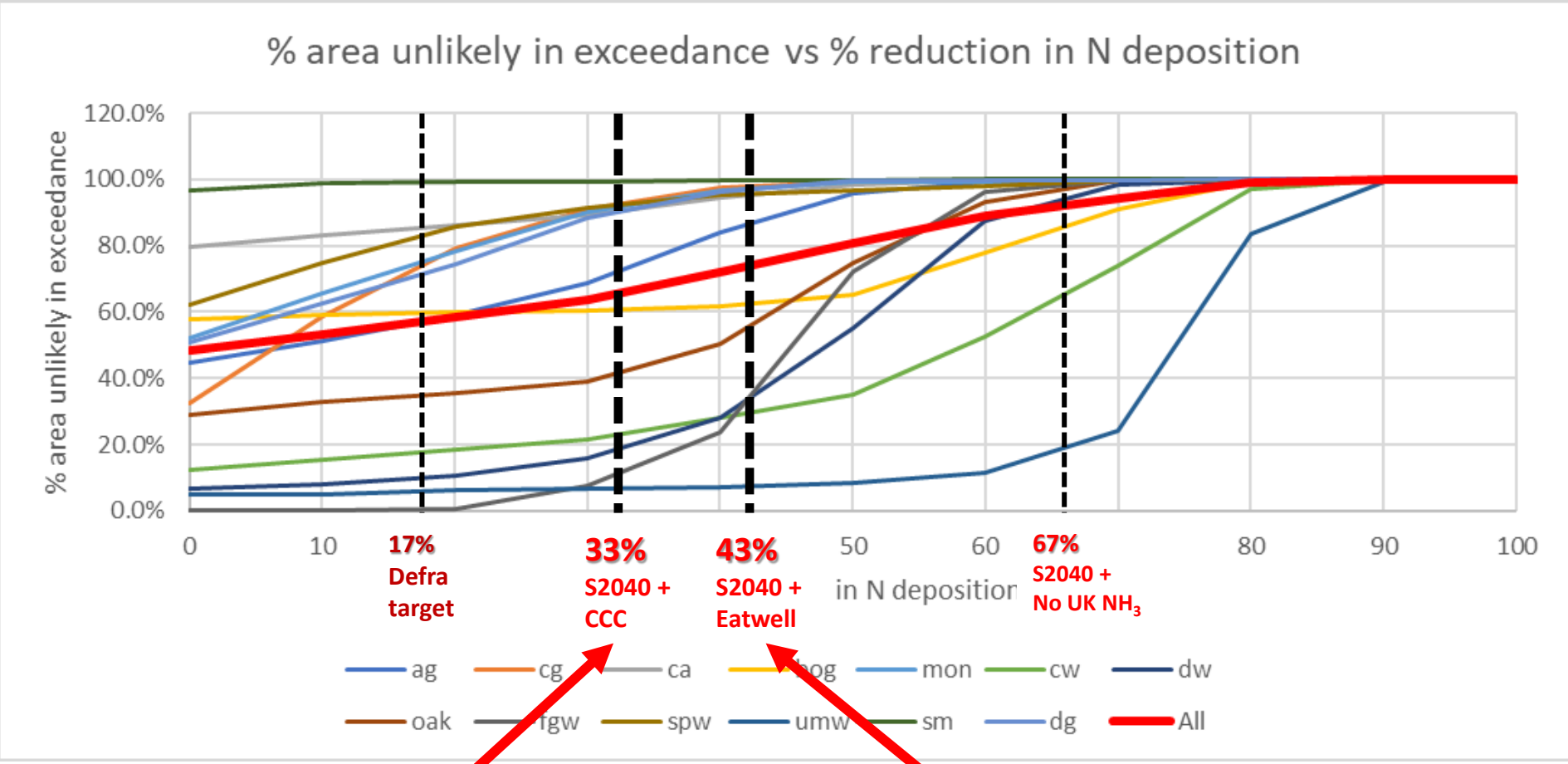
Data source: Updated quantification of the impact of future land use scenarios to 2050 and beyond, UKCEH (2020)

Diet, Land use & Nutrition – National Food Strategy



Source: National Food Strategy (2021)

The potential role of reduced livestock production



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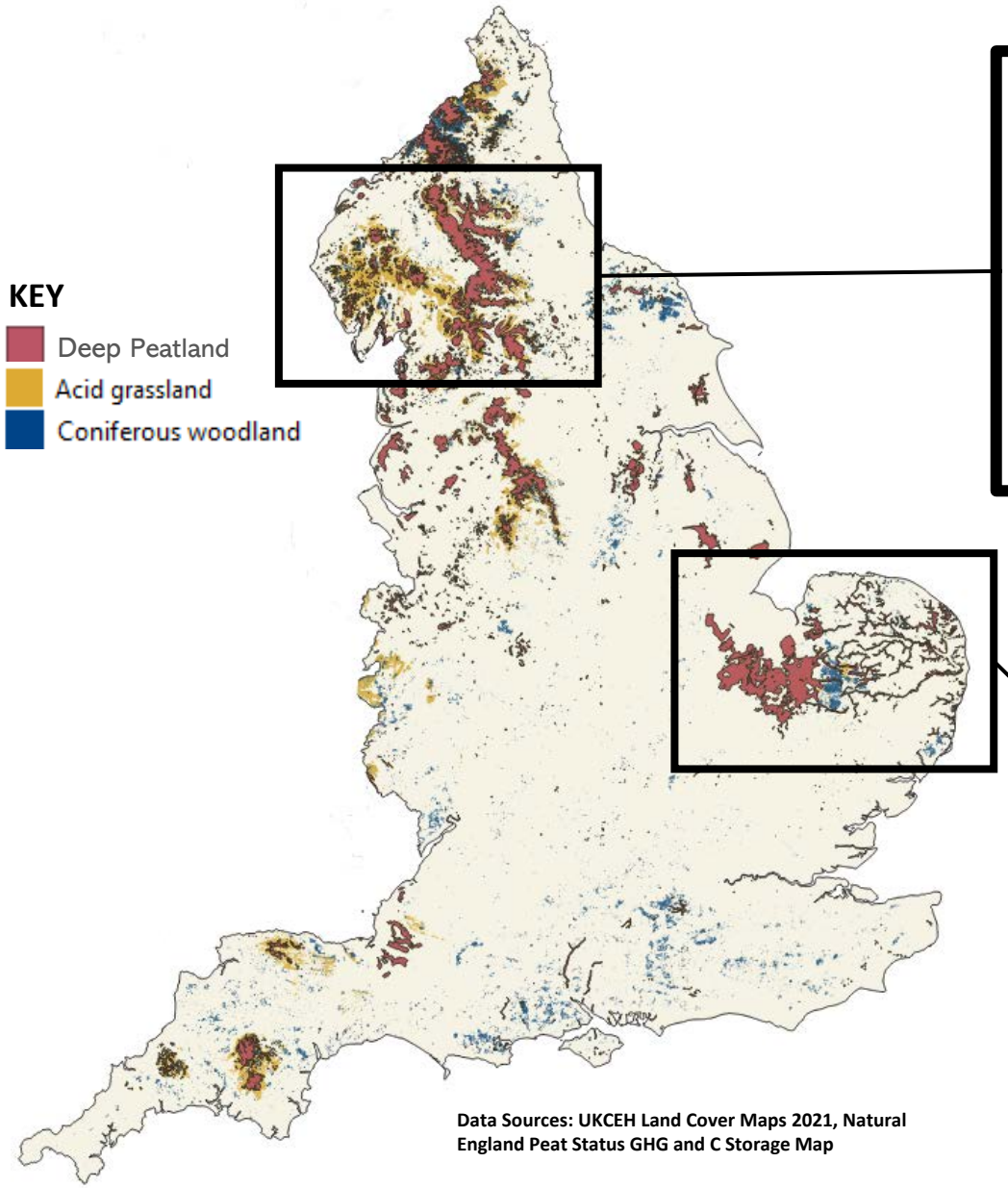
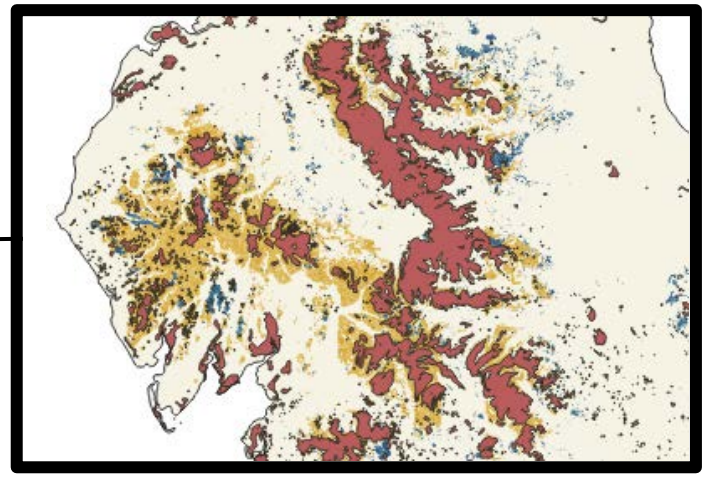
S2040+CCC
Meat production – 35% reduction
Dairy production – 20% reduction
+ Ambitious tech measures

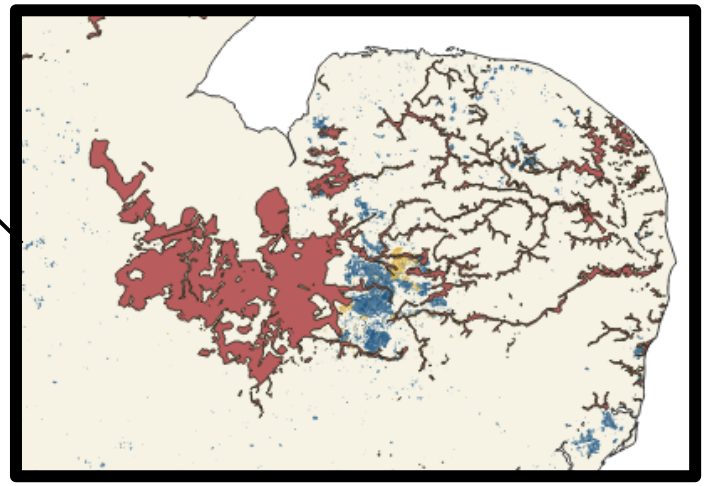
S2040+Eatwell
Meat production – 63-89% reduction
Dairy production – 22% reduction
+ Ambitious tech measures

Using spatial data to prioritise land-change policy implementation





Upland Peatland grazing areas with proximate acid grassland habitat



Lowland Peatland areas with proximate coniferous woodland habitat.

Data Sources: UKCEH Land Cover Maps 2021, Natural England Peat Status GHG and C Storage Map

Summary

- NH_3 emission reductions from technological measures are not enough to protect the majority of N-sensitive habitat areas.
- There are growing pressures on UK land use. A reduction in livestock production is required in order to both free up land for use towards other NZ goals, and to reduce the direct emission of GHGs from the sector.
- Reducing livestock production can also deliver significant reductions in NH_3 emissions and in turn significantly reduce the pressure on N-sensitive habitats.
- Current policies provide financial incentives for land use change however do not specifically target livestock production, and it is not understood to what extent these policies can deliver the land use changes needed to meet environmental targets.
- Spatially-explicit analysis is required in order to fully understand the implications of land use change targets. It is also not clear how the spatial interplay between critical load/level exceedances and future land use changes will affect the protection of N-sensitive habitats – focus of current research