

# Air pollution modelling and its role in policy development, human health and Net Zero

## **Environmental Research Group**

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Imperial College London

# AQ co-benefits of Net Zero policy



MRC Centre for Environment & Health









Centre for Environment & Health

**NIHR** Health Protection Research Unit in Environmental Exposures and Health at Imperial College London NIHR

# Imperial College BAU, BNZP and WI pathways 2030/40/50 London

The UK has adopted legally binding targets for Net Zero (NZ) that are consistent with the Paris agreement

Independent advice on achieving NZ goals from the Climate Change Committee (CCC)

Business as usual – agreed air quality policy

From the CCC's 6<sup>th</sup> Carbon Budget we have investigated the Balanced Net Zero Pathway (BNZP), a 'middle ambition' pathway for compliance with UK Net Zero commitments by 2050, which is projected to reduce greenhouse gas emissions to 78% below 1990 levels by 2035.

Widespread Innovation (WI) pathway, which assumes greater success in reducing costs of low-carbon technologies, allowing more widespread electrification and active transport.

## **Road Transport assumptions**

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- Vehicle km
- EV proportions
- HGV options
- Non-exhaust emissions



EV LGV (%) 2019 to 2050



EV HGVr (%) 2019 to 2050





EV Bus (%) 2019 to 2050



EV HGVa (%) 2019 to 2050





- Walking is expected to grow steadily from 2019 by +5% (by 2030 BNZP), to +7.5% (by 2040 BNZP). WI and BNZP scenarios have the same level of walking.
- Cycling will see a huge rise from 2019 to 300% in 2030 (BNZP), +458% 2040 (BNZP).
- WI scenario has even higher increases +427% by 2030 and +664% by 2040. WI
   > BNZP due to e-bike uptake.

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## **Building emissions**

- Behaviour and energy efficiency
- Low carbon district heating
- Heat pumps
- New homes
- Cooking

Acronyms Bior Reduction Heat Demand RHD p Reduction in Energy Consumption REC Local authority (IA) / Owner Occupied (OO) Private Rented (PR)	nass, oil and coal sidential boiler hased out 2028 phased out 2025 2030 -	Gas residential boller phased out 2033 2040	2050
NotFuel Poor (NFP)/Fuel Poor (FP) Behavioural Change and Energy Efficiency Measures (BCEEM) Total Reduction: 12% RHD Deployment to be applied by Country/Tenure/FuelPovertySatus Using EPC dataset by LA/Tenure and Fuel Poverty status data (available for England and Wales at LA level) and Income Deprivation Domain Score data (available for Scotland and Northern Ireland at LA level)	Total         18.012m homes (64'           LA NFP         4.283m (100%)           LA FP         0.613m (100%)           OO NFP         6.109m (37%)           OO FP         1.295m (100%)           PR NFP         4.394m (100%)           England 15.625m (64%) OO NFP           Soctiand         1.3628m (64%) OO NFP           Wales         0.654m (57%) OO NFP           NI         0.365m (57%) OO NFP	<ul> <li>K)</li> <li>Total 25.144r OO NFP 13.241m England 21.667m OO NFP 11.229m Sociand 1.926m OO NFP 0.037m</li> <li>Kales 0.995m OO NFP 0.632m</li> <li>NI 0.555m OO NFP 0.6343m</li> <li>ON SFP 0.6343m</li> </ul>	Total         28.304m (100%)           (81%)         OO NFP         16.401m (100%)           (89%)         England 24.63am (100%)           (81%)         OO NFP         13.925m (100%)           (81%)         Soctiand         2.174m (100%)           (81%)         OO NFP         1.285m (100%)           (81%)         OO NFP         1.285m (100%)           (81%)         OO NFP         0.782m (100%)           (85%)         NI         0.622m (100%)           (81%)         OO NFP         0.782m (100%)           (81%)         OO NFP         0.742m (100%)           (81%)         OO NFP         0.420m (100%)
Low-Carbon District Heat Networks (LCDHN) Deployed using heating and cooling demand and supply combined with a geospatial assessment of the economic potential for district heating as an efficient heating solution. Largely electrified using industrial HP drawing on heat sources such as water and wasch heat from industry and severage treatment (CHP schemes convert to LCDHN between 2033 and 2040)	Total 1.264m (4.5% England 1.146m (4.7% Scotland 0.100m (4.6% Wales 0.012m (1%) NI 0.006m (0.9%	%)         Total         3.766m           England         3.414m (         Scottand         0.299m (           %)         Wales         0.035m (         NI         0.017m (	(13.3%)         Total         5.467m (19.3%)           14%)         England         4.957m (20.3%)           13.8%)         Scotland         0.434m (20%)           3%)         Wales         0.051m (4.4%)           NI         0.025m (4.1%)
Heat Pumps (HP), Hybrid HP (HHP) and Electric measures HP, Electric, HHP-Electric (ASHP, GSHP, ElectricResistive+Solar, ElectricStrage, Hybrid ASHP+ElectricResistive+Solar, ElectricStrage, Hybrid ASHP+ElectricResistive: 100% NOX/PM HHP+H2Boiler(+HWStorage): 64%(80%)/100% NOX/PM (H2Boiler: 100% PM reduction and 65% NOx reduction) HHP+BioBoiler(+HWStorage): 64%(80%) NOX/PM ReductionShare annual Heat demand: Boiler 20% vs HHP 80 Total HD = Space+cooking 773–380%) + Water(20%) Deployment (see &CEEM method above) to be applied by Construct/Grean fourBinardHost bits/(CAPOHE)	Total: 3.6m (12.7%) HP, Electric, HHP+E:3.033m HHP+H280iler; O.021m HHP+H280iler; O.021m HHP+BioBoiler; HWStorage: HHP+BioBoiler; O.005m On/Off Gas grid: 2.03/1.28m	0.059m 0.059m 0.481m http://tectric.http://tectric.http://tectric.http/tectric.http/tectric.http://tectric.h	2%)         Total: 22.837m (80.7%)           11.750m         HP,Electric,HHP+E: 18.064m           11.613m         HHP+H2Boiler:1.029m           5:0.764m         HHP+H2Boiler: 1.029m           9m         HP/H8i0Boiler: 0.010m           0n/0ff Gas grid: 17.85/3.11m
New homes CCC BNZP scenario assumes that a proportion (1.566m) of new homes will continue to be built (between 2018 and 2024) with gas boilers with 100% of them replaced with heat pumps 15 years later.	Total: 2.356m With gas: 1.566m (+5.53% hor England 1.313m (5.35%) / Sociand 0. With gas and HP Retrofits(HPR With HP: 2.188m With LCDHN: 0.168m	mes) 136m (6.75%) 1350 (6.75%) 10 With gas and HPR: With HP: 3.758 m With LCDHN: 0.61	Total: 7.434m • 1.566m With gas and HPR: 1.566m With HP: 4.743m With LCDHN: 1.124m
Cooking 100% replaced by electric cooking with HP/HHP/Electric/ LCDHN as retaining a gas connection after installing such measures is unlikely to be economic	HP/HHP/Electric/LCDHN : 4.864m (17.2%)	HP/HHP/Electric/LCC 18.477m (65.3%)	DHN : HP/HHP/Electric/LCDHN : 28.304m (100%)

#### **Co-benefits of Net Zero policy Imperial College** air pollution London

- Under Business as Usual (BAU) reductions in NO<sub>2</sub> and PM were predicted by 2030 due to new vehicle technologies, but plateau by 2040.
- The BNZP and WI 2040 benefits were driven by accelerated electric vehicle (EV) uptake, reduced veh-km and low-carbon heating in buildings, with the building contribution to PM reduction being 2-3 times greater than road transport.
- NZ transition to EVs (cars and vans) reduces both exhaust and non-exhaust emissions.
- O<sub>3</sub> trends are complex with a small overall increase by 2030 and a decrease by 2040.
- Although uncertain, 2050 predictions of BNZP showed important additional air pollution benefits.







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- The BNZP vs. BAU resulted in 4.9 (1.0-9.0) million life-years gained (LYG) for the UK population to 2154, and 1.1 (0.7-1.6) million LYG from active travel improvements.
- Avoided case for stroke, childhood asthma and cardiovascular diseases such as acute myocardial infarction, asthma in adults and lung cancer.
- Some outcomes with weaker evidence for the health effects, were included in sensitivity analysis, e.g. dementia, diabetes and acute lower respiratory infections in children.
- Monetised morbidity benefits of £95.3b (75.0-116) exceeded the mortality benefits of £78.9b (43.5-92.0).
- Total yearly monetised benefits for BNZP vs BAU summed to 2154 for air pollution and active travel were from £198b (171-226) up to £325b (271-380), including outcomes with weaker evidence.
- There were higher physical activity benefits for WI than BNZP.



## PM<sub>2.5</sub>, 2040BNZP - 2030BAU





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#### **Co-benefits of Net Zero policy Imperial College** London Money

- Air quality ("core") health benefits for the BNZP buildings sector were £31.1 billion (24.9 to 37.4) by 2050 and £130.7 billion (104.8 to 156.6) by 2154.
- Results for transport were £10.7 billion (8.4 to 12.9) by 2050 and £43.0 billion (33.9 to 52.1) by 2154.
- NZ building sector operating costs did not achieve break-even via efficiency savings, but with GHG (lower benefits) breakeven was achieved in 2052.
- With additional air pollution health benefits the building sector ٠ time to break-even improved by between 5.4 (4.7 to 6.1) and 8.1 (6.8 to 9.1) years to between 2044 and 2047.







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## Indoor air pollution exposure



- Removing gas cooking at home, for NZ, may result in greater exposure reductions than outdoor air pollution, especially for NO<sub>2</sub>.
- Improved insulation and NZ transition provides an important opportunity to reduce the inequality gap and to benefit cold, damp and mouldy homes.

Ventilation scenarios: All closed: Cooking hoods and windows were closed; Windows closed: all windows were closed, except cooking extractor fans; Ventilation 1: Rear kitchen window was opened during cooking; Ventilation 2: Rear kitchen and front lounge windows were opened during cooking; Ventilation 3: Windows in kitchen, living, and bedroom were opened during cooking; Ventilation 4: Windows in kitchen were opened all the time while others are opened during cooking. All opened: All windows were opened all the time.

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## Geodemographic Classification for England & Wales five Imperial College distinct clusters based on 2021 UK Census variables



Nitrogen dioxide (NO<sub>2</sub>)

Urban professionals Multicultural urban living Multiethnic professionals Affluent aging rural Hard pressed

2019 exposure inequality patterns persisted into the future under all scenarios but to a lesser degree, due in part to NZ policies.



## Thank you to the air pollution modelling team David Dajnak, Gregor Stewart, Tuan Vu, Andrew Beddows, Nosha Assareh, Fei Gao and Phillip Punter

# Any Questions?

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# Imperial College Behaviour and engagement



#### https://vimeo.com/807838264

NIHR funded project – A 50-minute film on the views and opinions on air pollution and climate change of two groups of students from near Glasgow and London.

#### Imperial College Co-benefits BNZP - annual average NO<sub>2</sub> (µg m<sup>-3</sup>) London

