# The Socio-Economic Impact of Realising Zero Carbon Heat in the LHEES Zones of Edinburgh, Midlothian and East Lothian

## *Methodology*

The co-benefits modelling assesses wider social impacts of selected low-carbon interventions.

Similar social impact modelling has previously been developed and utilised[1] by local authorities and actors in compliance with UK Green Book methodologies. This analysis has built on previous projects developed for the CCC and in conjunction with PwC[2] to quantify impacts on health and society from net-zero interventions, specifically in relation to heat network connections to buildings in conjunction with fabric improvements.

It uses reported data at the highest available resolution (data zones or LSOAs) in the UK to aggregate populations into archetypes based on social and economic characteristics. The interventions are modelled and distributed through these archetype groupings, while accounting for local variation by geographic area (congestion bands, population density, EPC ratings, etc.).

Household data was collected through EPC certificates[3], weighted and upscaled at the datazone level. Based on data including typology, construction age, EPC band and tenure, each household was classified into pre-existing archetypes (*publication imminent*) to inform assumptions around necessary retrofit levels. The level of retrofit determined per household archetype was multiplied by the number of households in that archetype per datazone, outputting the commensurate estimate of individual buildings retrofit measures.

The households in each datazone were classified into one of 15 archetypes developed for the CCC[4] to enable modelling of social impacts while incorporating variables relevant to a just transition. Given that interventions like fabric improvement have a greater impact on low-income households, or elderly residents, a literature review was conducted to collect datazone-level reported outputs across ~20 variables for each small area across the local authorities. This unlocked the capacity to investigate distributional impacts by variable type from proposed interventions through real-world data. Random forest modelling was utilised to categorise the

---

[1] https://www.lse.ac.uk/granthaminstitute/publication/financing-uk-place-based-climate-action-from-westminster-to-cumberland/

[2] Sudmant, A., Boyle, D., Higgins-Lavery, R. *et al.* Climate policy as social policy? A comprehensive assessment of the economic impact of climate action in the UK. *J Environ Stud Sci* (2024). https://doi.org/10.1007/s13412-024-00955-9

[3] https://www.scottishepcregister.org.uk

[4] https://www.frontier-economics.com/uk/en/news-and-insights/articles/article-i9730-the-distributional-impact-of-net-zero-policies/

probability of each household belonging to a specific archetype, which was then fed through to the co-benefits modelling infrastructure.

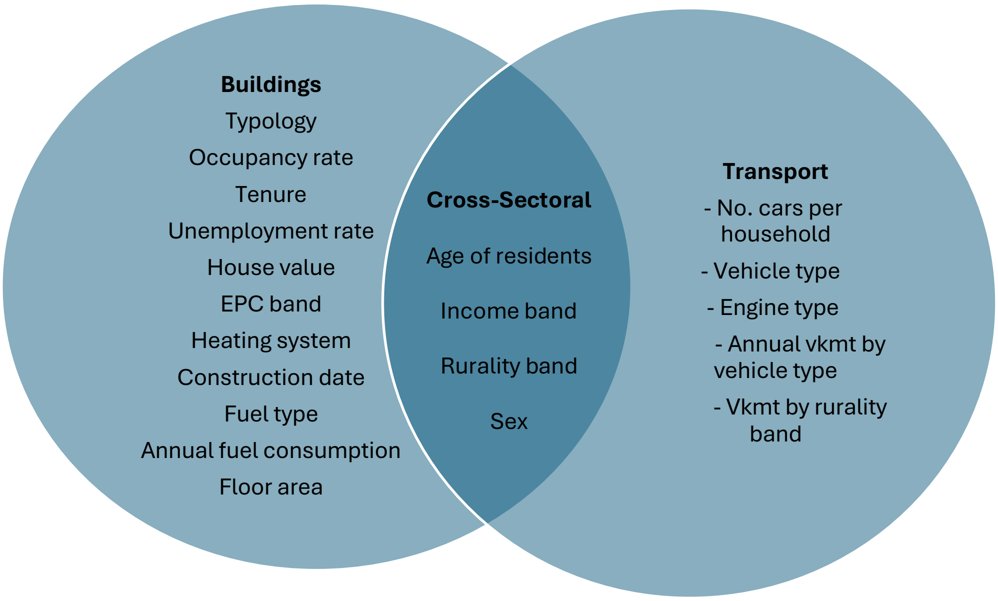

*Figure 1 - Datazone-level data for archetypal analysis*

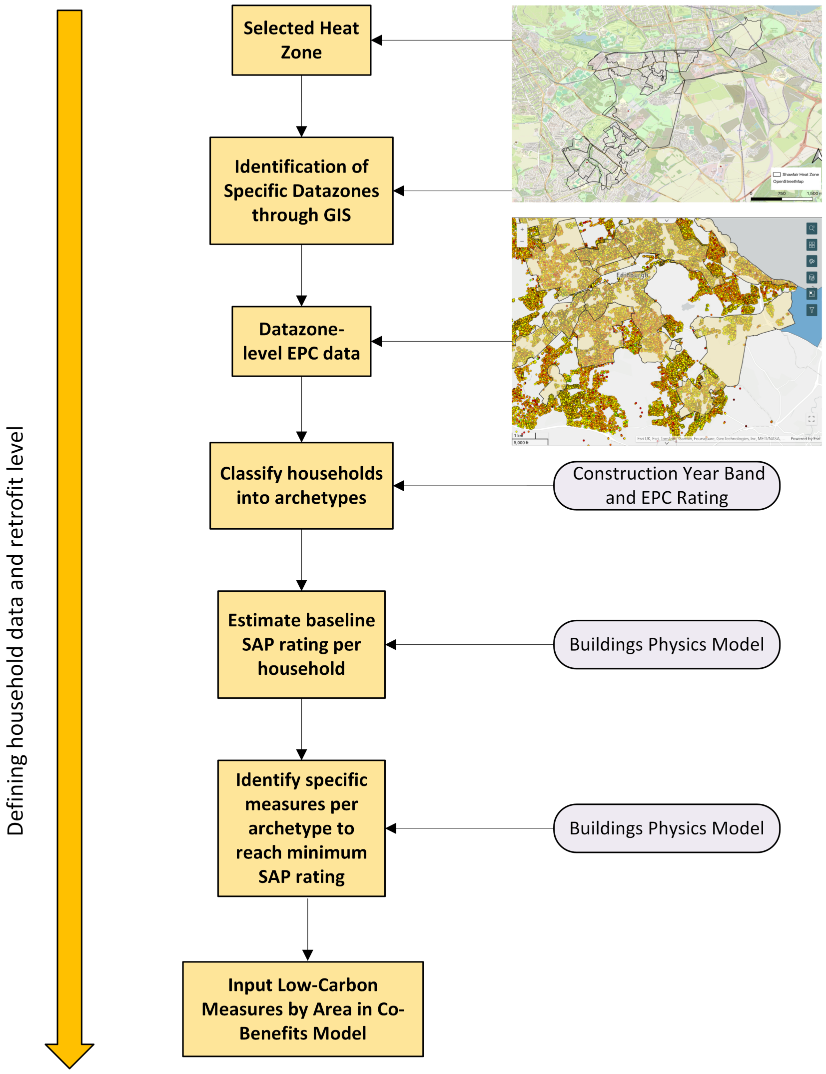

*Figure 2 - Defining retrofit level methodology flowchart*

Heat zones in shapefile format were provided by the ECCI and Net Zero Edinburgh Leadership Board[5] and overlayed by datazone boundary designations. This geospatial data was combined with EPC data, which was aggregated, refined and upscaled at the datazone level for each small area across each heat zone, providing data on housing stock for each relevant household.

This data was collated across each heat zone and utilised to assign households into archetypes based on typology, EPC band and construction date per household. A proprietary buildings physics model modelled the necessary fabric improvement interventions per household archetype to achieve a necessary SAP score (equivalent EPC band C) to enable suitable internal temperatures for heat network connection. The total number of interventions by type (including internal/external/cavity wall, roof, floor

---

[5] https://experience.arcgis.com/experience/c2714dd1647449bca511d7f445b73f29/?draft=true

insulation, draught-proofing, double/triple-glazing, etc) were collated by datazone and heatzone for use in the co-benefits analysis.

The energy usage pre-and-post retrofit per archetype, alongside data on fuel-type and counterfactual heating systems was utilised to estimate mitigation potential for further valuation. The model was run individually at the datazone-level with the specific number of households connected to heat networks and their respective fabric improvements. The co-benefits modelling methodology is continued below for each specific and applicable social impact type.

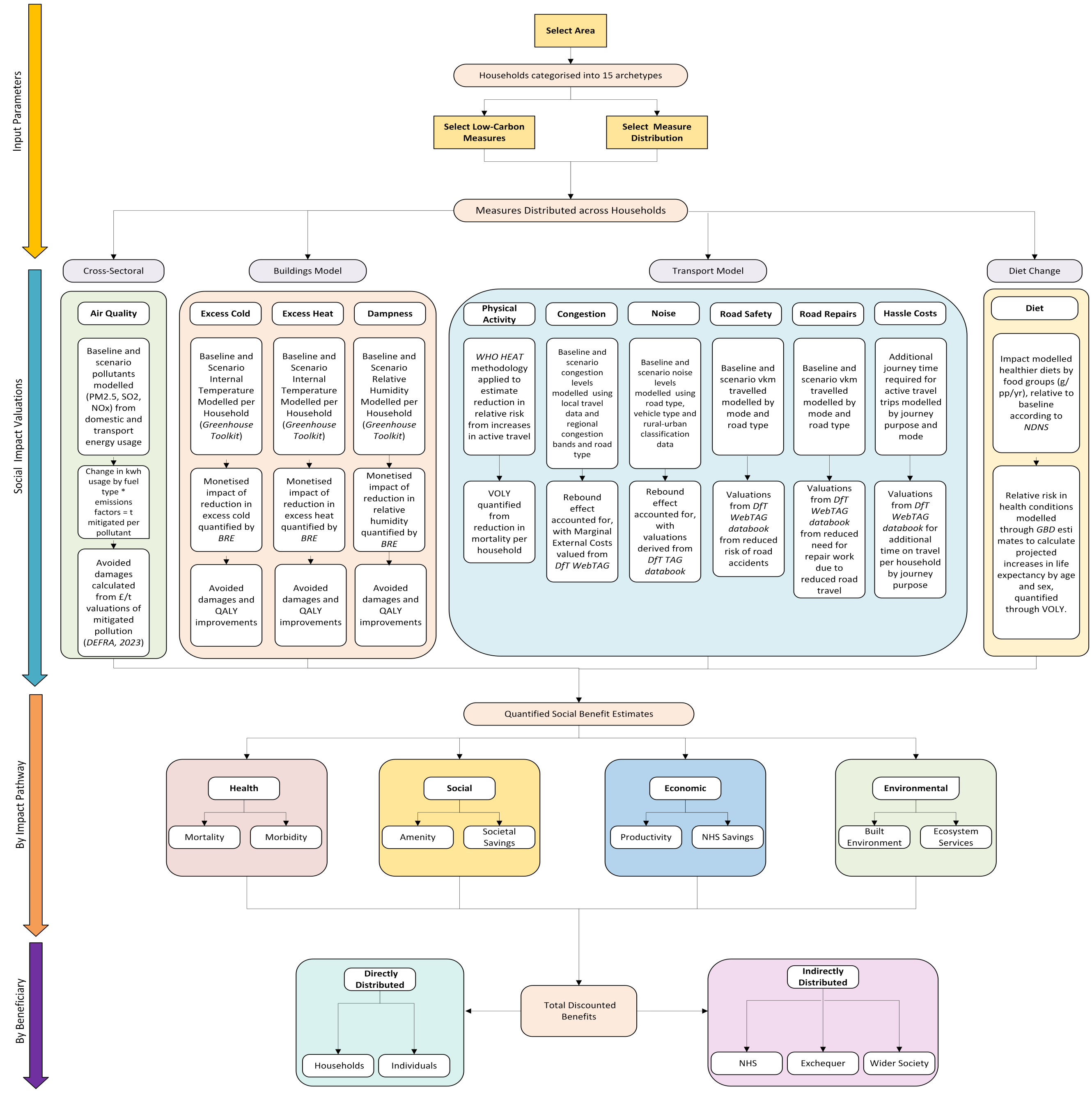

*Figure 3 - Co-benefits modelling methodology flowchart*

### i) Air Quality

The air quality co-benefit measures the reduction in air pollution, primarily as a result of decreased fossil fuel combustion, and quantifies the benefit to individuals and society.

Air quality improvements are quantified by modelling the delta of energy consumption between the low-carbon intervention (e.g. heat networks) and the counterfactual (e.g. gas boilers), before estimating the tonnes of pollutants mitigated by type. The reduction in pollutants ($PM_{2.5}$, $PM_{10}$, $SO_2$, $NO_x$) from fossil fuel combustion are valued according to UK Green Book valuations (developed by Ricardo[6]).

These avoided damages are allocated according to beneficiary type (health/non-health, productivity, etc.), and distributed to households indirectly, before being discounted according to HM Treasury's Green Book appraisal guidance for social (1.5% p.a.) and central discount rates (3.5%)[7].

We first calculate the baseline emissions of damaging pollutants by multiplying the deployment of the counterfactual by fuel type (e.g. gas boilers, combi boilers, oil boilers (according to EPC data of the local area)) by energy usage per unit. We multiply the energy usage in kwh by factors developed by Ricardo[1] according to fuel type to calculate tonnes of emitted pollutant. These estimates are multiplied by damage costs[1] to calculate the total valuation of mitigated air pollution.

These avoided damages cover economic, social and environmental degradation, and are distributed to inhabitants specific to the area in question (improvements in life expectancy, health outcomes, etc.), or nationally where appropriate (NHS savings, productivity gains, etc.). Due to constraints in the literature and negligible contributions to overall results, changes to indoor air quality were not modelled in this analysis.

The avoided damages (benefits) are measured annually, accounting for forecasted changes in population growth, fuel usages, and emissions intensities. All costs are discounted through to 2050.

$$
\begin{aligned}
\sum \mathit{Fuel\ Use}\ (\mathit{Change\ in\ Energy\ Consumption}\ (\mathit{GWh}) \times\ \mathit{Particulate\ Emissions\ Factors}) \\
\times\ \mathit{Air\ Quality\ Damage\ Cost\ by\ Pollutant\ Type} \\
\times\ \mathit{Share\ of\ Damages\ Attributable\ to\ Impact\ Pathway} \\
\times\ \mathit{Share\ of\ Impacts\ to\ Beneficiary} \\
= \mathit{Total\ Value\ of\ Avoided\ Damages}\ (£)
\end{aligned}
$$

---

[6] https://uk-air.defra.gov.uk/assets/documents/reports/cat09/2301090900_Damage_cost_update_2023_Final.pdf

[7] https://www.gov.uk/government/collections/the-green-book-and-accompanying-guidance-and-documents

## ii) Excess Cold

Excess cold co-benefit represents the avoided costs of poor health and NHS costs resulting from individuals living in homes with low internal temperatures.

A buildings physics model is used to estimate internal temperature before and after the low-carbon intervention, based on the household's physical properties and characteristics. Buildings with temperatures below the excess cold threshold (19° Celsius) are then mapped to damage costs developed by BRE[8][9] to estimate improvements in health, quality of life, and NHS savings, with seasonal variations in temperature are accounted for.

Damages are more heavily-weighted at the lower end of the temperature spectrum, using a sigmoidal function from 10° – 19° Celsius. This allows us to properly quantify the reduction in excess cold damages if a property's temperature increases from 12° - 18° Celsius; i.e. the most severe health outcomes originate from the lowest-temperature households. All households over 19° Celsius are not at risk of excess cold.

Quality of life and health improvements are distributed directly to the household implementing the low-carbon measure, with economy and NHS savings attributed indirectly to society.

$$
\begin{aligned}
&\mathit{Change\ in\ minimum\ winter\ temperature\ by\ archetype\ and\ EPC\ band}\ (\Delta{}^\circ\mathrm{C}) \\
&\qquad \times \Big( (\mathit{Change\ in\ QALYs\ per\ person\ per\ increase\ in\ temperature} \\
&\qquad\qquad\qquad \times\ \mathit{Population\ forecast\ by\ archetype}\ \times\ \mathit{Value\ of\ Life\ Year}) \\
&\qquad\qquad\qquad +\ \mathit{NHS\ and\ societal\ savings\ per\ change\ in\ property\ temperature} \Big) \\
&\qquad \times\ \mathit{Number\ of\ households\ per\ archetype\ by\ EPC\ band} \\
&\qquad \times \mathit{Share\ of\ households\ with\ Category}\ 1\ \mathit{excess\ cold\ health\ hazards} \\
&\qquad \times \mathit{Share\ of\ vulnerable\ populations\ per\ archetype} \\
&\qquad = \mathit{Total\ value\ of\ excess\ cold\ reduction\ to\ individuals\ and\ society}\ (\pounds)
\end{aligned}
$$

## iii) Dampness

The reduction in dampness is a co-benefit resulting from decreased excess humidity in buildings, which leads to lower incidence of mould, building damage, and microbial growth; all of which can result in health deficiencies.

The co-benefit is quantified in a similar manner to excess cold, using the buildings physics model to map relative humidity to internal temperature[10], comparing the baseline humidity to the humidity levels after the intervention, and measuring the corresponding reduction on health risk[11].

---

[8] https://www.brebookshop.com/details.jsp?id=327671
[9] https://files.bregroup.com/research/BRE_Report_the_cost_of_poor_housing_2021.pdf
[10] https://www.sciencedirect.com/science/article/pii/S0360132321009756
[11] https://files.bregroup.com/research/BRE_Report_the_cost_of_poor_housing_2021.pdf

The co-benefits are distributed directly to the proponent of the low-carbon action as health benefits, with indirect impacts appropriated across relevant households and to the NHS.

$$\begin{aligned}
&\mathit{Change\ in\ minimum\ winter\ temperature\ by\ archetype\ and\ EPC\ band}\ (\Delta{}^{\circ}\mathrm{C}) \\
&\qquad \times\ \mathit{Unit\ Conversion}\ (\Delta RH/\Delta{}^{\circ}\mathrm{C}) \\
&\qquad\quad \times\ \big((\mathit{Change\ in\ QALYs\ per\ person\ per\ increase\ in\ temperature} \\
&\qquad\qquad\qquad\qquad \times\ \mathit{Population\ forecast\ by\ archetype}\ \times\ \mathit{Value\ of\ Life\ Year}) \\
&\qquad\qquad\qquad\qquad +\ \mathit{NHS\ and\ societal\ savings\ per\ change\ in\ property\ relative\ humidity}\big) \\
&\qquad \times\ \mathit{Number\ of\ households\ per\ archetype\ by\ EPC\ band} \\
&\qquad \times \mathit{Share\ of\ households\ with\ Category}\ 1\ \mathit{dampness\ hazards} \\
&\qquad \times \mathit{Share\ of\ vulnerable\ populations\ per\ archetype} \\
&\qquad = \mathit{Total\ value\ of\ dampness\ reduction\ to\ individuals\ and\ society}\ (\pounds)
\end{aligned}$$

## iv) CO2e MAC

For assessing the carbon case for action, we used the UK Government's Greenhouse Gas Emissions Value[12] to quantify the impact of the mitigated CO2e. Following the buildings archetype modelling, we model the energy usage delta pre-and-post retrofit by fuel type per archetype. Matching this annual change in kwh per household archetype with emissions intensities for each fuel type projected through to 2050 gives abatement potential across household archetypes per datazone. This modelled annual mitigation is multiplied by the equivalent annual value assigned to per tonne abatement values developed by the UK government before discounting.

---

[12] https://www.gov.uk/government/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation