

Appendix

Cooling demand modelling

We used a simple physics-based building energy model for calculating the cooling demand (and associated electricity demand) estimates in this paper. The main inputs into the model are an hourly outdoor temperature profile, an hourly solar irradiance profile (vertical and horizontal), and key building parameters such as the heat transfer coefficient, total floor area, window area, and air change rate. The outdoor temperature and solar irradiance data was downloaded from JRC Photovoltaic Geographical Information System (PVGIS), developed by the European Commission¹. Occupant behaviour and preferences are captured in the model with these parameters: cooling zone floor area (i.e., how many rooms the occupant decides they want to cool) and target indoor temperature for the daytime and overnight.

At an hourly timestep, the model calculates the following:

- conduction gains and losses through the building fabric (this includes gains from solar irradiance on the building exterior),
- solar gains through the window,
- air infiltration gains and losses,
- and the cooling demand, which is the sum of the above (if greater than zero) or zero.

It is assumed that the indoor temperature is always at either the daytime or overnight target indoor temperature (depending on the time of day), which ignores the time delay involved with a cooling system. The model also ignores the effects of the thermal mass of the building, which can cause a lag between outdoor conditions and cooling demand.

Parameter values and assumptions

Here are the specific parameter values and assumptions we used in the cooling demand modelling that produced the estimates given in this paper:

- Cooling system COP = 3.5 (3.5 units of cooling kWh per 1 unit of electricity kWh)
- Electricity demand (associated with cooling) = cooling demand / cooling system COP
- Cooling system only operates between April and September (inclusive)
- Daytime is defined as 9am–9pm and overnight as 9pm–9am
- Building archetype
 - Total floor area = 90 m²
 - HTC = 225 W/K (2.5 W/m².K — which is fairly average)
 - Air change rate (ACH) = 0.4 /h

¹ https://re.jrc.ec.europa.eu/pvg_tools/en/

- Living room floor area = 25 m²; master bedroom floor area = 20 m²; other bedrooms floor area = 30 m²
- 2026 cooling scenario:
 - Temperature profile is from a typical meteorological year (TMY) for a location in West Yorkshire². However, we scaled the TMY profile so that the monthly averages equal 2026 monthly averages so far (Jan-Jul) for the hottest GB region (East Anglia), and for the remaining months (Aug-Dec) monthly averages equal the respective highest monthly average over the last 5 years (also East Anglia).
 - Solar irradiance is from 2018 (a particularly sunny year) at London Heathrow Airport: GHI = 1151 kWh/m²
- Extreme summer cooling scenario:
 - Same temperature as above but a **universal increase by + 2°C**
 - Same solar irradiance as above but a **universal increase by 20%**: GHI = 1382 kWh/m²
- For each scenario, the ranges in the figures are due to considering two building aspects: North- and South-facing. A different vertical solar irradiance profile is used in each case, and the one used for South-facing has an annual kWh/m² three times higher than the one used for North-facing.

Fuel poverty modelling

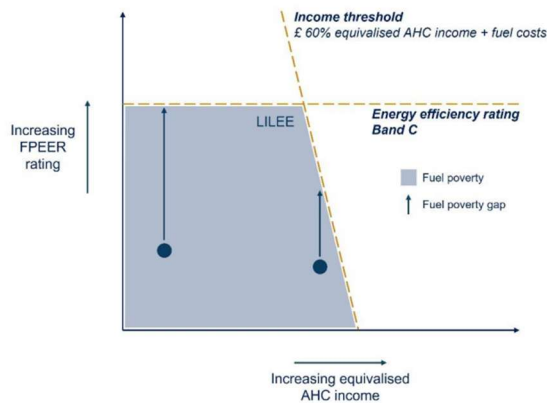
Estimating the “negative fuel poverty gap”

Official fuel poverty statistics [\[link\]](#) report the number of fuel-poor households and the distribution of the *fuel poverty gap* — the bill reduction needed to lift a household out of fuel poverty. They do not, however, publish the *negative fuel poverty gap*: the bill *increase* that would push a household *into* fuel poverty. CSE has therefore calculated this for each English Housing Survey (EHS) household by reversing the standard method, under both the LILEE and 10% definitions. 2023 English Housing Survey data and fuel costs are used, as this is the most recent iteration publicly available.

LILEE definition

Each household has an *income gap* (equivalised income plus energy costs, relative to 60% of weighted median after-housing-cost income) and an *energy efficiency gap* (current estimated energy costs versus costs at SAP 69, the EPC C lower bound). Households are in fuel poverty if they appear in the bottom left quadrant in the figure below i.e. both low income and low efficiency. There are two potential fuel poverty gaps for any household, the gap in their income and the gap due to the low efficiency of their home. The gap used in the official statistics is the smaller of these values.

² 53°38'06.0"N 1°22'58.8"W

Figure 1: Fuel poverty under the Low Income Low Energy Efficiency indicator³

To identify the change in fuel poverty due to the LILEE definition we therefore:

- Adjusted the income gap for those households where DESNZ had published the gap using their published method.
- Estimate the increase in bills that would be equivalent to reducing their SAP rating downwards to a lower energy efficiency threshold.

We then compare this to the change in bills associated with different cooling regimes.

We do not adjust the SAP rating directly, but we assume that the SAP rating is lowered by an amount such that bills would increase by the same amount as the cooling costs we are estimating (imagine that energy costs in a SAP 69 property are £100 more than a property at SAP 71 due to lower efficiency – therefore, an increase in energy costs of £100 due to cooling need is *equivalent* to a reduction in SAP of 2 points). Additionally, DESNZ only publish data on the gap in fuel costs for those households in fuel poverty. Our estimates therefore include households that started with a negative fuel poverty gap (i.e. had fuel costs above the horizontal line in the figure above). To estimate changes in the fuel poverty gap we therefore used linear regression analysis i.e. ~£47 per SAP point below 69 in the 2023 data. We assume this linear relationship holds above SAP 69, applying the same gradient to estimate negative efficiency gaps for those households.

Combining both, we estimate an overall negative gap for all non-fuel-poor households, then use EHS weightings to extrapolate to the English population. This gives the number and proportion of households that a £X bill increase would bring into fuel poverty.

10% definition

A household is fuel poor here if maintaining a decent temperature standard costs more than 10% of after-housing-cost income. The EHS provides both variables directly, so the negative gap is simply the increase in fuel costs needed to reach 10% of income. As above, its distribution yields the number and proportion of households a £X increase would push into fuel poverty.

³ DESNZ 2026, Fuel Poverty Methodology Handbook (Low Income Low Energy Efficiency)