

CLEAR FUTURES

Tackling Fuel Poverty and Net Zero With Electrification & Limited Resources

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Executive Summary

A key national policy to prevent fuel poverty is to raise all homes to EPC C. However, the cost to retrofit to this threshold across the UK will run into billions when there is limited disposable household income, there is limited public funding and there are competing pressures on other national infrastructure needs. The evidence also shows that, despite significant improvements in energy efficiency over the last 30 years, fuel poverty remains high, driven primarily by the increase in energy prices, not the condition of housing.

A key national policy to decarbonise our domestic buildings is to switch to the electrification of heat, with the primary solution being heat pumps. However, the evidence shows that without some fabric improvements or a reduction in energy prices, these heating solutions will make fuel poverty worse.

This paper introduces new concepts CMAX and EMAX that together demonstrate that affordable warmth and zero carbon heating is achievable, but only if policy shifts toward cheaper energy, smarter tariffs, a significantly reduced retrofit programme, and the EPC C target is dropped.

If there had to be a target it would be lifting properties that are EPC E to G to EPC D, or as near as possible. This is likely to be a short-term target depending on how the new Home Energy Model is delivered¹, but CMAX and EMAX offer a better approach to ensure that consumers, depending on both their home and circumstances, can afford energy.

The key insights of this paper are:

1. CMAX: A new method for assessing retrofit affordability

- Households in income deciles groups 1–3 cannot afford any retrofit without grants, and deciles 4–5 can afford very limited retrofit, typically up to £9,000.
- Grant funding reaches only a tiny proportion of need meaning current grant-led approaches cannot solve the issues, something else needs to change even with the Government's new Warm Homes Plan.
- Only deciles 8–10 can afford deep retrofit such as heat pumps or solid wall insulation.
- The most cost-effective measures are Group 1 & 2 fabric improvements (loft, cavity, draught-proofing, glazing, flat roof insulation) which offer meaningful demand reduction at relatively low cost
- Minimum retrofit (doors, windows and draughtproofing) with a gas boiler reliably removes people from fuel poverty
- Heat batteries offer stable form of heat, can help modulate the grid, are cheaper to install, have a long shelf life, minimum maintenance, and work well with smaller

¹ <https://www.gov.uk/government/consultations/home-energy-model-energy-performance-certificates>

homes. If electricity prices are reduced, they can be a key solution for a significant portion of housing stock.

3. EMAX: A New Method for Setting Fair Energy Tariffs

- EMAX methodology allows a dynamic electricity price (p/kWh) to be tailored for each consumer archetype, so no household exceeds a defined fuel poverty threshold
- Modelling shows that with current standing charges, fuel poverty is eliminated when electricity is priced at around 15.0p/kWh and gas at 4.1p/kWh. At the time of writing standard tariff prices up to June 2026 are set to be 24.67 p/kWh and 5.74 p/kWh respectively²
- Taking a top-down view of national energy bills and consumer archetypes, full electrification using heat pumps, fuel poverty could be eliminated if a heating tariff was created at 15p/kWh and other electricity use was charged at 20p/kWh
- Taking a bottom-up view, EPC D homes can take a heat pump and not be in fuel poverty if the electricity price is 18p/kWh
- EMAX enables social tariffs to help those most in need, dual rates (separate heating vs. standard electricity prices), and dynamic tariffs aligned with renewable generation
- Provides a fairer, more responsive method than the existing fuel poverty definition, and can accelerate take up of low carbon heating
- Heat pumps without tariff reform increase the risk of fuel poverty
- If income decile group 3 households use 25% of the energy generated by solar PV on their homes, they could be lifted out of fuel poverty even at current electricity prices

² <https://www.ofgem.gov.uk/information-consumers/energy-advice-households/energy-price-cap-explained>

Introduction

This paper aims to provide a pragmatic approach to tackle fuel poverty and net zero, which have been the primary drivers for retrofit initiatives up till now. This paper takes the position that there are not unlimited funds so policy goals cannot come at any cost to individuals or the taxpayer.

The report is structured around two analytical frameworks:

Part 1 CMAX – examining what retrofit households can realistically afford, across the range of income decile groups. Within this it goes through the methodology, assumptions and calculations on how it is derived.

Part 2 EMAX – identifying the electricity and heating tariffs required to eliminate fuel poverty across different income groups and property types, especially if CMAX demonstrates that only small amounts of retrofit can be undertaken. Again, it goes through the methodology, assumptions and calculations on how it is derived but it looks at the problem at a national level (top-down approach) and an individual home (bottom-up approach).

By combining these analytical frameworks with case-study evidence, the paper provides a scalable, cost-effective pathway to end fuel poverty and support the transition to low-carbon heat—without relying on unrealistic levels of household investment or public subsidy. CMAX and EMAX would be easy to replicate by Ofgem and DESNZ and would enable fuel poverty to be eradicated and accelerate the net zero agenda.

The challenge is making the electricity network and structure work better to drive down energy prices – something both Government and Industry will need to collaborate on and deliver³. The Government is already engaged in this with the recent announcement to reduce the impact of gas on electricity prices.⁴ This paper sets out a target price Government and industry can aim for and a methodology that will allow it to adapt over time.

Where possible, the paper only uses Government or academic based research or statistics as these will have a degree of robustness and public scrutiny that may be missing from other sources. Tables and spreadsheets created for this report can be provided on request at no cost.

³ Predicted energy prices suggest this could happen, but the downward movement is behind published tables and not helped with the recent Iran conflict. Annex M, DESNZ Energy & Emissions Projections 2021 to 2040: <https://www.gov.uk/government/publications/energy-and-emissions-projections-2021-to-2040#full-publication-update-history>

⁴ <https://www.gov.uk/government/news/decisive-action-to-break-influence-of-gas-on-electricity-prices>

PART 1 – CMAX

1. Approach

The approach that has been taken can be explained in the flow diagram in Annex 1 but in summary it is using national datasets to ascertain what income a household has available to spend on retrofit and from this what are the optimum retrofit measures that can be fitted within the household budget. This is called CMAX.

CMAX can be looked at a national level or regional if data is available.

The CMAX calculation is based on a moment in time so it does not need to take into account inflation; the calculation can be updated as and when national datasets are updates e.g. household expenditure surveys. Over time, CMAX can be plotted to see how inflation and the cost of living ultimately affects what people can spend on energy and the energy efficiency of their home.

2. Calculations

CMAX (ID# O-1)

The equation to determine the maximum amount of capital that could be available for retrofit works (C_{max}) is given below:

$$C_{max} = G + S + L_{max}$$

G is any grant that is available. Grants are unlikely to be available if S or L_{max} is high.

S is any savings that might be available.

L_{max} = Is the maximum loan that could be obtained based on the following equation:

$$L_{max} = (MP_{max} * (1 - (1+R)^{-n})) / R$$

MP_{max} is the most someone will want to pay every month after all other housing and living costs have been deducted.

R is the interest rate available from lenders

n is the total number of years or months someone wants to pay back a loan.

Figure 1 below is a summary of a worked example of CMAX using UK household income and financial data, split by national average and income decile group. Annex 2 shows the full table, source references, and how the calculations were made.

	Median	1	2	3	4	5	6	7	8	9	10
Loan											
Loan capital available	16,289	0	0	0	8,144	8,144	19,004	21,719	38,009	43,438	35,294
Savings											
Amount of savings to be used	3,427	0	92	109	293	635	1,346	2,433	3,929	7,173	18,258
Total											
	19,716	0	92	109	8,437	8,779	20,350	24,152	41,938	50,611	53,552

FIGURE 1 – WORKED OUTPUTS OF CMAX MODEL

Figure 1 shows that for income decile groups 1 to 5 i.e. the least 50th wealthiest section of the UK could only afford up to £9k or retrofit works, and the bottom 30% would not

be able to afford anything; in summary, meaningful retrofit – using current solutions – is only affordable for the wealthiest part of society.

The assumptions used in CMAX could change but this will go against the prudence of the householder in guarding against exceptional events and future needs.

Figure 2 below compares the CMAX profile with housing data in East Sussex. The housing stock in East Sussex follows the national trend in that over time it has shifted to become EPC D+ dominated . If in East Sussex we only intervened in EPC E to G, and income decile groups 1-3⁵, this would be 9,814 homes.

Decile	1	2	3	4	5	6	7	8	9	10		
EPC	A	2	1	0	2	4	2	0	3	1	1	16
	B	204	365	461	607	482	803	501	521	331	151	4,426
	C	3,860	6,029	7,518	7,520	8,018	8,596	9,698	6,867	3,978	2,852	64,936
	D	6,241	9,372	11,957	14,020	13,979	14,538	17,049	13,029	9,436	6,134	115,755
	E	1,477	2,901	3,590	3,832	4,616	4,954	5,214	4,624	5,941	2,454	39,603
	F	322	522	689	575	857	1,139	1,089	1,181	2,150	714	9,238
	G	58	123	132	145	191	256	198	219	462	161	1,945
Total	12,164	19,313	24,347	26,701	28,147	30,288	33,749	26,444	22,299	12,467	235,919	
Availle budget per household	0	92	109	8,437	8,779	20,350	24,152	41,938	50,611	53,552		
E to G	1,857	3,546	4,411	4,552	5,664	6,349	6,501	6,024	8,553	3,329	50,786	
% of decile	15%	18%	18%	17%	20%	21%	19%	23%	38%	27%		
% of stock	0.8%	1.5%	1.9%	1.9%	2.4%	2.7%	2.8%	2.6%	3.6%	1.4%	21.5%	
Monthly fuel poverty threshold	133	141	186	228	266	306	350	403	470	592		
Total available retrofit budget for E to G	0.0	0.3	0.5	38.4	49.7	129.2	157.0	252.6	432.9	178.3		

FIGURE 2 – SPREAD OF PROPERTIES IN EAST SUSSEX BY EPC BAND AND INCOME DECILE GROUP, PROVIDED BY COTALITY PATHWAYS (FORMERLY PARITY). HOMES WITHOUT LODGED EPCS HAVE BEEN CLONED.

Grants at best have been able to help approximately 100 homes a year in East Sussex⁶ so it can be assumed that to tackle nearly 10,000 homes just using previous levels of grant would take 100 years to resolve. The proposed Warm Homes Plan⁷ will provide higher amounts of funding but it will be spread over approximately 20% of **all** homes in East Sussex not just the relatively small number of homes identified above (i.e. 9,814) which account for 4.2% of local stock. – something else needs to happen for just these 9,814 homes to have affordable heat.

⁵ Income decile groups 1-3 are recognised as being the most vulnerable to fuel poverty given the level of below average incomes. DESNZ Warm Homes: Local Grant Policy Guidance for Local Authorities Updated 16th June 2025, P20-21

⁶ Current target delivery for WHLG programme in East Sussex is 111 homes, similar levels to previous years.

⁷ <https://www.gov.uk/government/publications/warm-homes-plan>

The national picture is similar. Figure 3 below shows the number of homes that received a grant for substantial retrofit measures – approximately 80,000 homes across dwelling stock of approximately 20m is small fraction.

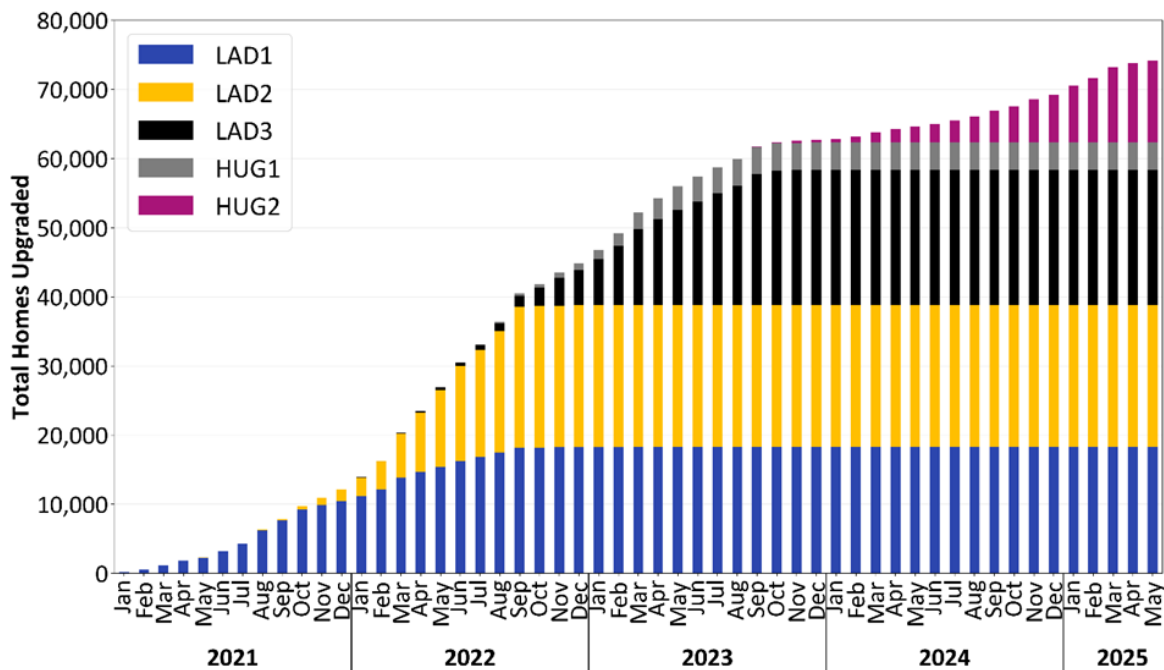


FIGURE 3 – CUMULATIVE NUMBER OF PRIVATE HOMES THAT HAVE RECEIVED GOVERNMENT GRANTS⁸¹

People on low incomes are also unlikely to be able to afford pre-works surveys (e.g. PAS), which could increase the likelihood of the correct measures not being installed and not to a high standard. A poor retrofit will be counter-productive to low-income homes, which has been highlighted with the recent National Audit Office investigation into ECO retrofit.⁸

Upgrading homes for people in income decile groups 6 to 10 is less of an issue. The decisions they are likely to take is “is any investment worth it” given that they are likely to be able to afford higher energy bills – they may want to spend their disposable income on other life priorities. If income deciles 6 to 10 do decide to upgrade their homes, they should be able to afford more sustainable materials which have a lower environmental impact and can support the circular economy i.e. sheep’s wool for loft insulation.

3. Retrofit Construction Costs

ID#F

Table 1 below is an average set of costs for the most common retrofit measures. The data comes from multiple sources and is averaged over different tenures and property

⁸ <https://www.nao.org.uk/reports/energy-efficiency-installations-under-the-energy-company-obligation/>

sizes , so costs have been smoothed out as best as possible. Figure 4 expands this table by measures and the data source.

Measure	Average (£)
EWI	16,417
IWI	11,478
Flat roof	8,940
Glazing	8,236
Floor	4,689
Doors	3,273
CWI	2,539
LI	1,857
Draughtproofing	934
ASHP	15,032
Heat Battery	6,329
Solar PV	7,011

TABLE 1 - AVERAGE COST OF RETROFIT MEASURES

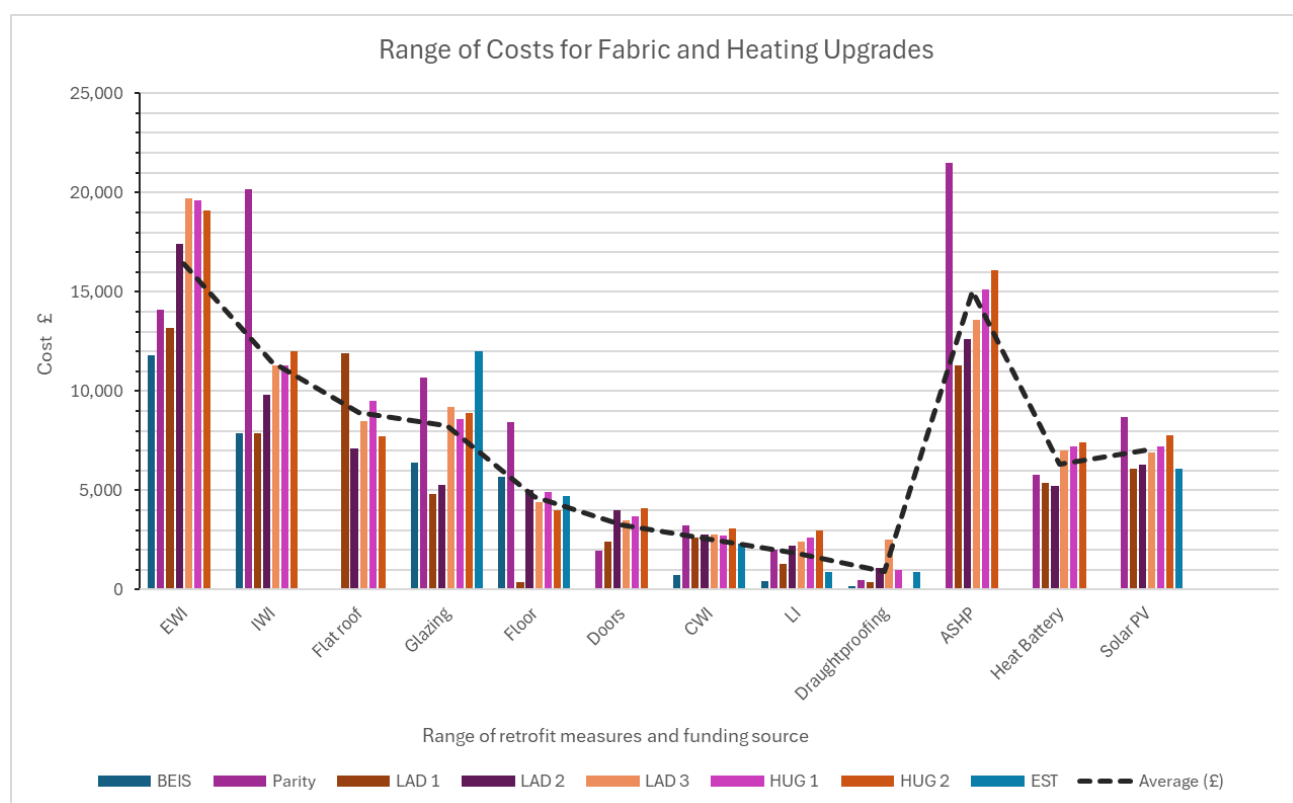


FIGURE 4 – RANGE OF COSTS FOR FABRIC AND HEATING UPGRADES. THE FOUR MAIN DATA SOURCES ARE (I) BEIS REPORT (II) COTALITY (FORMERLY PARITY) (III) ENERGY SAVING TRUST (EST) (IV) GOVERNMENT GRANT PROGRAMMES LAD & HUG

Costs for any measure will of course vary by property type, age and specification and these issues were neatly summarised in the report commissioned by the then BEIS⁹ and

⁹ BEIS, What Does It Cost To Retrofit Homes, April 2017, Jason Palmer, Mary Livingstone, Angela Adams https://assets.publishing.service.gov.uk/media/5a82338f40f0b62305b93052/BEIS_Update_of_Domestic_Cost_Assumptions_031017.pdf

published by the Cambridge Architecture Research (and one of the data sources for Figure 5). This is understood to be the last known nationally commissioned research for costs and since then we have had Covid, the Ukraine war and the inflation crisis.

Cotality data (formerly Parity) is based on taking East Sussex stock to an average EPC C – this involves upgrades to just under 168k homes, and just over 508k measures so it is a good spread of costs. The total investment needed to get properties in East Sussex to an average of EPC C would be £2.1bn. A breakdown of the measures is in the following Table 2.

Measure	Nr Installed
Doors	9,298
Draughts	72,449
Floors	13,744
Glazing	5,813
Heating - ASHP	8,582
Heating - Gas	20,573
Heating - HHSRH	13,667
Lighting	120,899
Roof	79,310
RoomInRoof	662
Solar PV	78,884
Wall - CWI	61,771
Walls - IWI	21,098
Walls- EWI	1,447

TABLE 2 - NUMBER OF MEASURES FOR EAST SUSSEX HOMES TO REACH EPC C

EST data is taken from their website, and Government grant scheme data is taken from published data¹⁰ based on approximately 80,000 homes. Government scheme costs also include costs to administer the PAS¹¹ retrofit process.

ECO¹² funded measures, which are delivered through energy companies, assisted a much larger section of homes and focussed mainly on loft insulation, cavity wall insulation, heating controls, and new gas boilers. Solid wall insulation played a role, but the majority of these measures were for IWI. – Figure 5 below gives a split by measure type. Overall, there were 4,385,170 measures helping 2,579,164 homes over a period of 12 years 9 months. Approx 200k homes a year on average¹³. Data for measures' costs have not been published by energy companies however it is known that ECO up to the end of 2024 cost energy companies £9.86 bn, which on average is £2,375 per measure or £3,900 per home.

¹⁰ [Green Homes Grant Local Authority Delivery \(LAD\) and Home Upgrade Grant \(HUG\) release, November 2025 - GOV.UK](#)

¹¹ <https://www.trustmark.org.uk/business/information-guidance/pas-20352019-pas-20352023>

¹² [ECO4 Delivery Guidance | Ofgem](#)

¹³ Table T1.1, UK Government Household Energy Statistics, 18 December 2025.

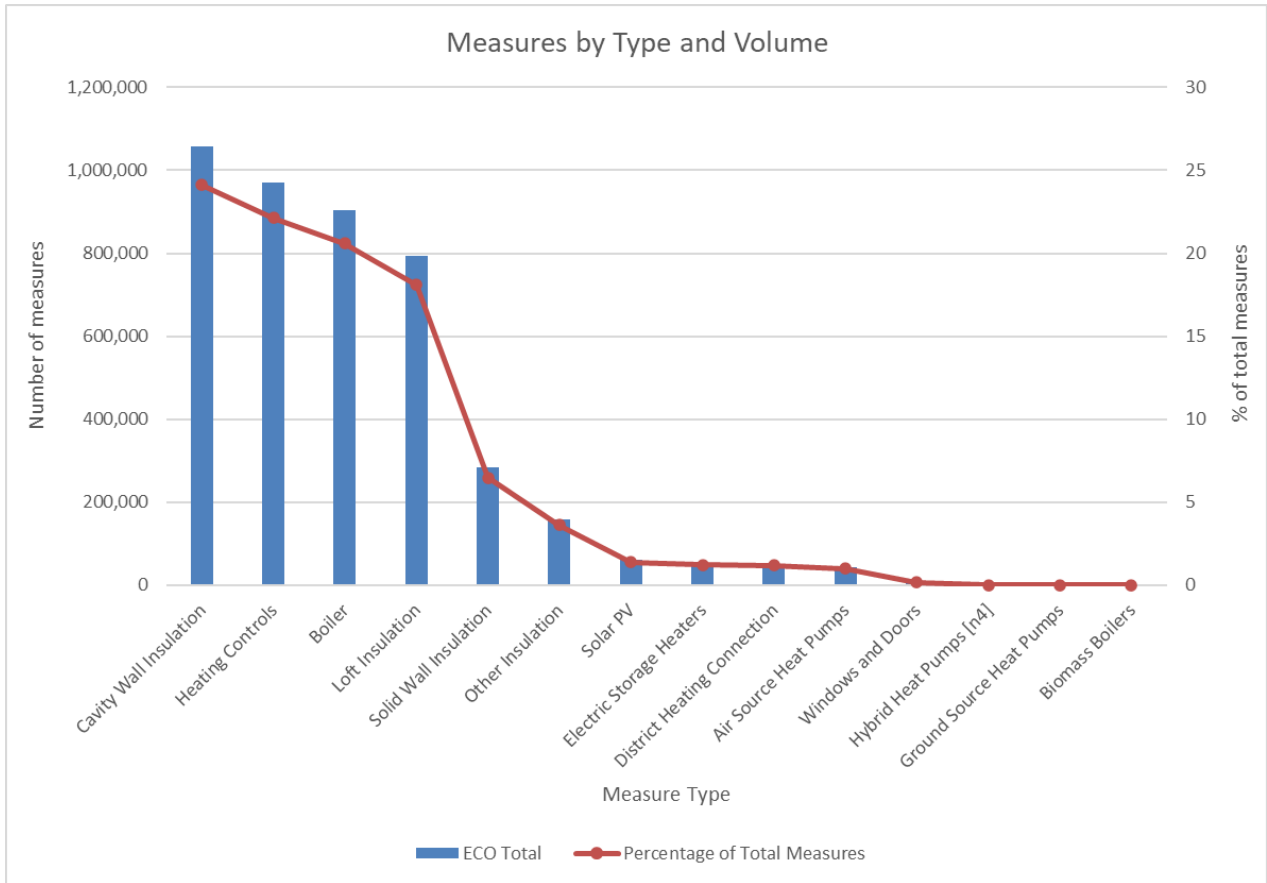


FIGURE 5 SPREAD OF ECO FUNDED MEASURES. DATA TAKEN FROM TABLE T1.7, HOUSEHOLD ENERGY EFFICIENCY STATISTICS

As costs will vary it is better look at the relative costs to each other and to understand the scale of affordability taking into account CMAX. With this in mind the following Table 3 can be created.

Group 1 – Lowest cost (< £5k)	Group 2 – Mid cost	Group 3 – High cost (> £10k)
1. Draughtproofing 2. Loft Insulation 3. Cavity Wall Insulation 4. Doors 5. Floor Insulation	6. Glazing 7. Flat Roof Insulation 8. Storage Heater 9. Solar pV	10. Internal Wall Insulation 11. External Wall Insulation 12. ASHP

TABLE 3 BANDING OF RETROFIT MEASURES

The majority of measures are fabric related and so will reduce demand, but the table includes solar PV (as this will also reduce energy demand), and two of the leading low carbon heating solutions; storage heaters are named as such in published statistics but are now coming under the heat battery classification.

4. Impact of Measures

The Building Research Establishment (BRE), who created SAP, have carried out extensive research into the effectiveness of the different retrofit measures and two useful publications are those that support the Government’s ECO grant programme, “ECO 3 & ECO4 Deemed Scores Methodology”¹⁴. These documents set out the relative costs and benefits of the different retrofit measures and for key measures are summarised in Table 4 below. The actual demand reduction is much more complicated than the simple table below (and is the basis for SAP) but what this table demonstrates is the relative effectiveness of each measure. Taking glazing, as an example, it is one of the most energy efficient components but as it only covers a small percentage of the building’s external envelope it won’t reduce energy demand as much as EWI or IWI as these have a much larger surface area.

	Best	Least	Range
EWI / IWI	1.8	0.3	1.5
CWI	1.0	0.4	0.6
LI	0.5	0.1	0.4
Flat roof insulation	2.1		2.1
Floor insulation	0.5	0.2	0.3
Glazing	3.2	0.6	2.6
Doors	1.2		1.2

TABLE 4 RANGE OF U VALUE CHANGES (W/M²K) FOR DIFFERENCE MEASURES; BRE ECO3 DEEMED SCORES METHODOLOGY

The research paper led by University of Brighton for Lewes District Council explored the cost-effective approach¹⁵ in more detail. It concluded that whilst measures like EWI are good at reducing energy demand, the cost makes it unsuitable as an option for retrofit.

Improving low-rated homes (F and G) yields the greatest SAP rating increases and potential energy cost savings, often through a combination of insulation and heating system upgrades. Conversely, low-cost measures like draught-proofing or improving lighting are generally more cost-effective upfront and can significantly improve the rating

¹⁴ BRE Client Report , ECO 3 Deemed Scores Methodology, July 2018, Report Number HPR086-1004 (version 2), [Methodologyhttps://www.ofgem.gov.uk/sites/default/files/docs/2018/07/eco3_deemed_scores_methodology_document_200718.pdf](https://www.ofgem.gov.uk/sites/default/files/docs/2018/07/eco3_deemed_scores_methodology_document_200718.pdf)

¹⁵ [The role of Building Performance Simulation in developing an evidence based retrofit strategy for Net Zero social Housing](#), 2023, Marco Picco, Duncan Baker Brown, Nick Adlam

of F and G homes without requiring major investment. This pragmatic approach was one of a key set of conclusions published by Lewes District Council¹⁶

5. Additional Uptake Factors

In addition to cost and impact of measures three other important factors will affect the uptake of works namely (i) Complexity and risk (ii) Disruption (iii) Desirability (iv) Accessibility

- Complexity and risk – major interference with external fabric. If it has complexity, it will require detailed design and ongoing inspections during the works to ensure that the envelope of the building is not compromised, and problems will not occur during the next 20+ years. The PAS process or a building professional would be needed to support this which will increase cost
- Disruption – How much disruption will it have on residents. Factors include number of a workforce is on site, loss of internal and external space, loss of movement circulation, mess created, and exposure to elements.
-
- Desirability – Some measures might not reduce demand by a significant amount, but residents might just want to have particular measures because they are good to look at or make the home feel cosier or nicer i.e. door and windows.
- Accessibility – Government may change regulations to make access to measures easier such as permitting 800Wp of plug-in solar PV.

6. Measures Hierarchy

(ID# O-2)

Overall, a definitive, one-size-fits-all cost-effectiveness table for energy efficiency improvements doesn't exist, as costs vary widely by property, region, and how the property is used. Using the above outputs a summary hierarchy table can be created (Table 5 below) that acts as a guide in determining which order to follow for fabric measures to reduce energy demand, if finance is restricted, as has been shown in the Cmax calculations.

	Range of effectiveness	Complexity	Disruption	Desirability	Cost	
Draughtproofing	4	5	5	5	5	24
Doors	3	5	5	5	3	21
Glazing	5	3	4	5	2	19
LI	1	4	5	5	4	19
CWI	2	2	4	3	4	15
Flat roof insulation	5	2	2	3	2	14
Floor insulation	1	2	2	3	3	11
EWI / IWI	4	1	1	3	1	10

¹⁶ Decarbonising our Housing Stock, Roadmap for 2030, Summary Report, Lewes District Council and Eastbourne Borough Council, February 2023, Ian Fitzpatrick, Nick Adlam, Lewes District Council, Duncan Baker Brown, Marco Picco University of Brighton, Professor John Counsell. [Decarbonising Our Housing Stock Roadmap revised Oct 23.pdf](#),

TABLE 5 MEASURES HIERARCHY FOR RETROFIT

The criteria for the scoring is given in Annex 3 and can be changed but the outcome is similar to the University of Brighton study that looked at cost benefit of measures. A score of five is the best a particular criterion whilst one is the worst.

Solar PV is unique in that it can reduce energy demand even though is not a building fabric component, and as such can significantly reduce energy bills, with good payback periods. It is also a common technology and should be a high priority if it can be afforded.

If homes need to replace boilers (the dominant source of heating in the UK), the two leading electrical led solutions are (i) heat pumps (ii) heat batteries (including storage heaters). Low temperature heat pumps are preferred over high temperature heat pumps as the capital cost is less and heat batteries are all forms of equipment that store heat to be used for later use and include storage heaters.

Government policy is for grid electricity to be zero carbon by 2035 so if electrification of heat is going to be the solution for zero carbon heat, then the decision is which heating appliance is the most cost effective for the resident – taking into account capital cost and running costs. Whatever technology is chosen it is important that electricity prices are competitive so as to not push a resident into fuel poverty – this is discussed in Part 2.

7. Optimum Retrofit

Using the conclusions from CMAX and Measure Hierarchy you can create a summary of the optimum retrofit options just based on capital costs and funds, shown in Figure 6 below.

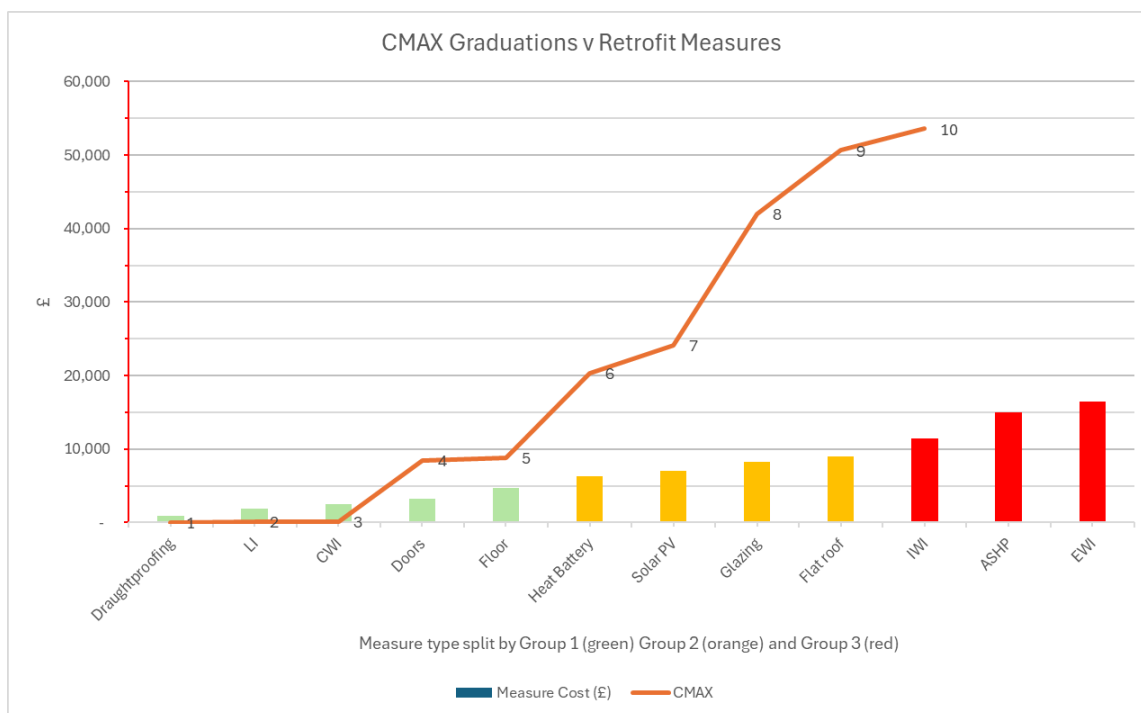


FIGURE 6 – OPTIMUM RETROFIT OPTIONS

From this summary you can also see if a particular income decile group can afford multiple measures i.e. if they are stacked up, do they still fall below the CMAX curve for a particular decile group.

Income decile groups 1 to 5 will be restricted to Group 1 measures (green), or a single Group 2 measure (orange). Income decile group 6 and above will be able to afford more than one item from Group 2, and income decile groups 8, 9 and 10 could afford deep retrofit including Group 3 measures (red).

Income decile groups 1-3 will be reliant on grants but there is unlikely to be sufficient funds to help all homes, so if these homes could be subject to fuel poverty, then an intervention other than retrofit needs to be introduced¹⁷. Also, if grant money is limited then there may need to be a process that identifies the most in need and this could be those that are most likely to suffer serious health issues, possibly even a fatality. Organisations like Public Health will be best placed to advise on how to prioritise funding to offset the most serious health issues.

Within Figure 6, there will be some archetype sensitivity. The groupings will generally stay the same, but variation ranges would be expected on the costs, meaning that in some cases income decile groups 1-5 might be able to afford things – where they are in small terraces for example. Similarly, income decile groups 6 and above may not be able to afford EWI for large, detached properties.

¹⁷ Data from Cotality (formerly Parity) suggest the costs to upgrade East Sussex homes that are just in Deciles 1-3 and are EPC G to E, to EPC D, would be in excess of £50m. For the latest round of WHLG grants (2025-2028), a budget of £4.7m has been allocated for private homes. The Warm Homes Plan should increase the funding, but it is likely to fall short of the £50m required.

PART 2 – EMAX

1. Fuel Poverty & Energy Prices Background

In 2000, the Warm Homes and Energy Conservation Act created duties for Government to tackle fuel poverty which, in its amended form, remains in force today. The Act characterises fuel poverty as the problem of someone on a “lower income [living] in a home which cannot be kept warm at reasonable cost.” The first UK fuel poverty strategy, published in 2001, set out the way fuel poverty would be measured in practice – a household would be considered “fuel poor” if it needed to spend more than 10% of its income on energy in the home. The 10% indicator allowed fuel poverty to be measured at a national level but was sensitive to energy prices.

The range of issues surrounding fuel poverty and how it can be tackled were fully explored in the 2012 report authored by John Hills and titled “Getting the Measure of Fuel Poverty”¹⁸. This should be a key reference document when discussing fuel poverty and was used by the Government to create the Low-Income Low Energy Efficiency (LILEE) indicator which replaced the 10% rule.

Other useful reference documents are the 2025 House of Commons research report on Fuel Poverty which gives a good assessment of the UK’s progress¹⁹, the 2024 English Housing Condition Survey, Chapter 2 Energy Efficiency²⁰ again highlighting progress, and the 2025 House of Commons research briefing on Domestic Energy Prices²¹.

From these documents there are some clear statements that can be made

- Energy efficiency of homes has improved significantly over the last 30 years, so much so that the average SAP rating has shifted from 45 in 1996 to 67 in 2023
- The social sector is outperforming the private sector on energy efficiency improvements
- Properties are now predominately EPC D or above
- Properties in EPC C can still be vulnerable to fuel poverty with high energy prices
- Despite the significant energy efficiency improvements fuel poverty is still an issue – there were 2.35 million fuel poor homes in 2013²² and 2.73 million households in 2024 using the same LILEE definition. The % of stock is improving but fuel poor homes is not shifting

¹⁸ Hills, J. (2012). *Getting the measure of fuel poverty*. Hills Fuel Poverty Review . London: Centre for Analysis of Social Exclusion. Retrieved from <https://sticerd.lse.ac.uk/dps/case/cr/casereport72.pdf>

¹⁹ House of Commons Library, Fuel Poverty, Paul Bolton & Suzanna Hinson, April 2025 [CBP-8730.pdf](#)

²⁰ MHCLG Chapter 2:Energy Efficiency, January 20205 [Chapter 2: Energy efficiency - GOV.UK](#)

²¹ House of Commons Library, Domestic Energy Prices, Paul Bolton, Iona Stewart, June 2025 [Domestic energy prices - House of Commons Library](#)

²² House of Commons Library, Fuel Poverty, paper SN05115, Cassie Barton, David Hough, February 2016 <https://researchbriefings.files.parliament.uk/documents/SN05115/SN05115.pdf> (page 3)

- Residents are 'under consuming' due to higher energy costs so are not heating their homes properly. This can have adverse impacts on the health of residents and the buildings, creating an additional economic burden

These statements are verified with the figures 8, 9 & 10 below.

- Figure 7 show the steady improvements to the average SAP score with social housing a step above private housing
- Figure 8 shows EPC E to G are now a small proportion of the overall stock
- Figure 9 shows that 15.2% of homes are EPC C or better but they are below the income threshold that would normally trigger fuel poverty (quadrant LIHEE).

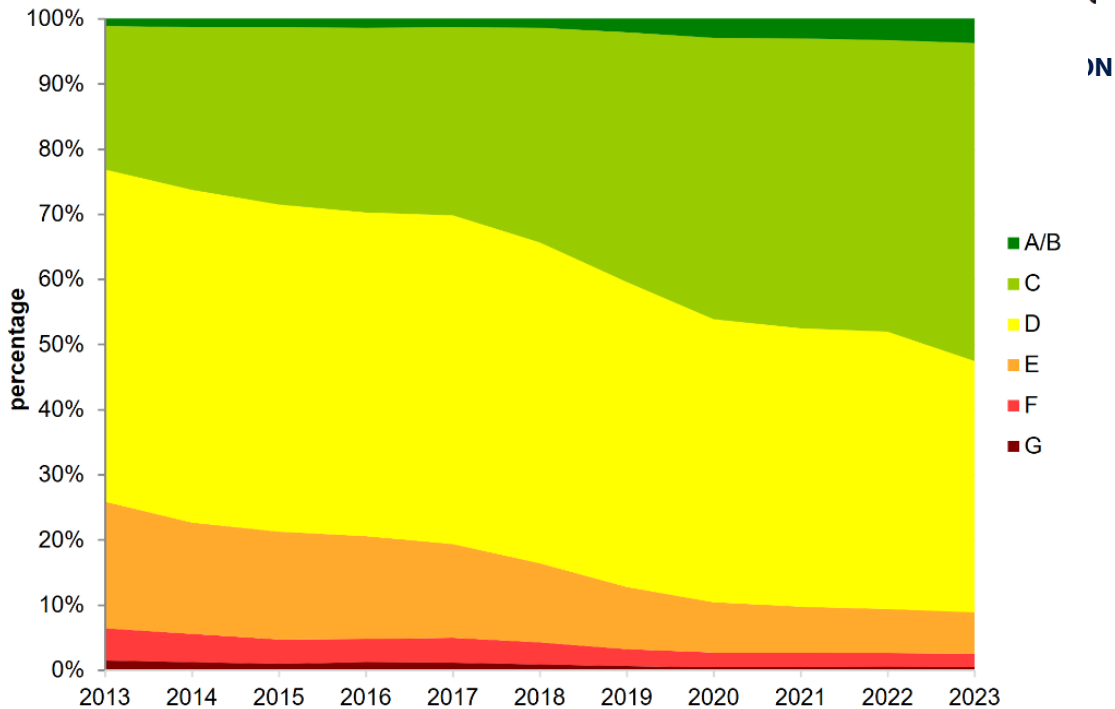
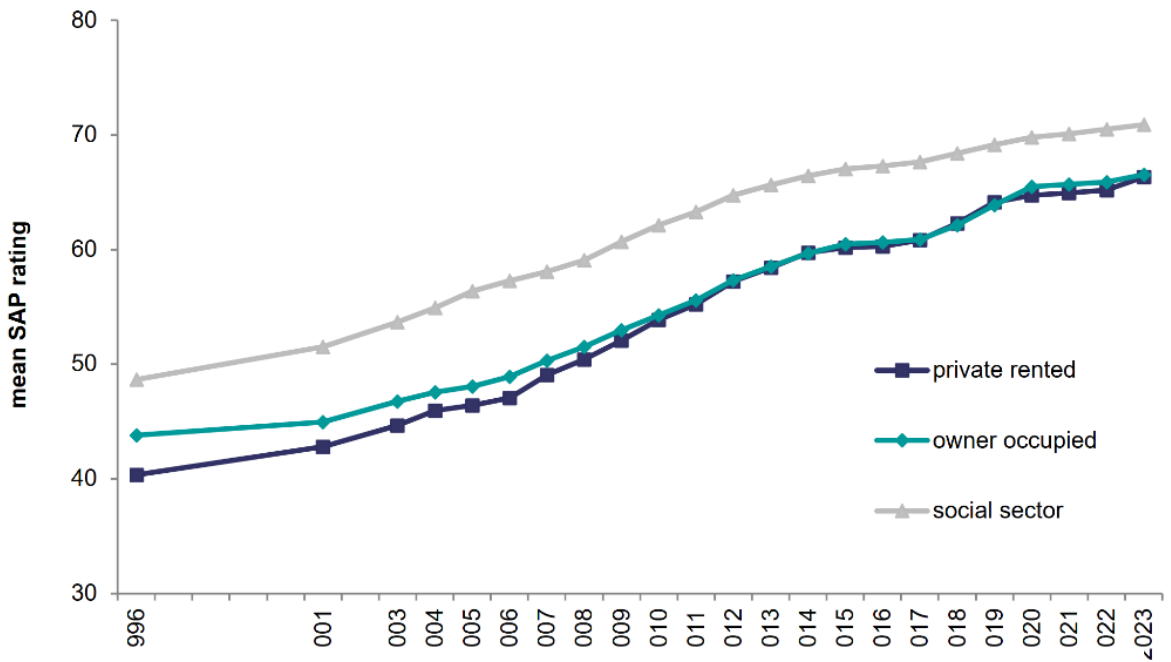


FIGURE 8 ENERGY EFFICIENCY BANDS 2013 TO 2023, FIGURE 2.2, CHAPTER 2 ENERGY EFFICIENCY MHCLG ENGLISH HOUSE CONDITION SURVEY

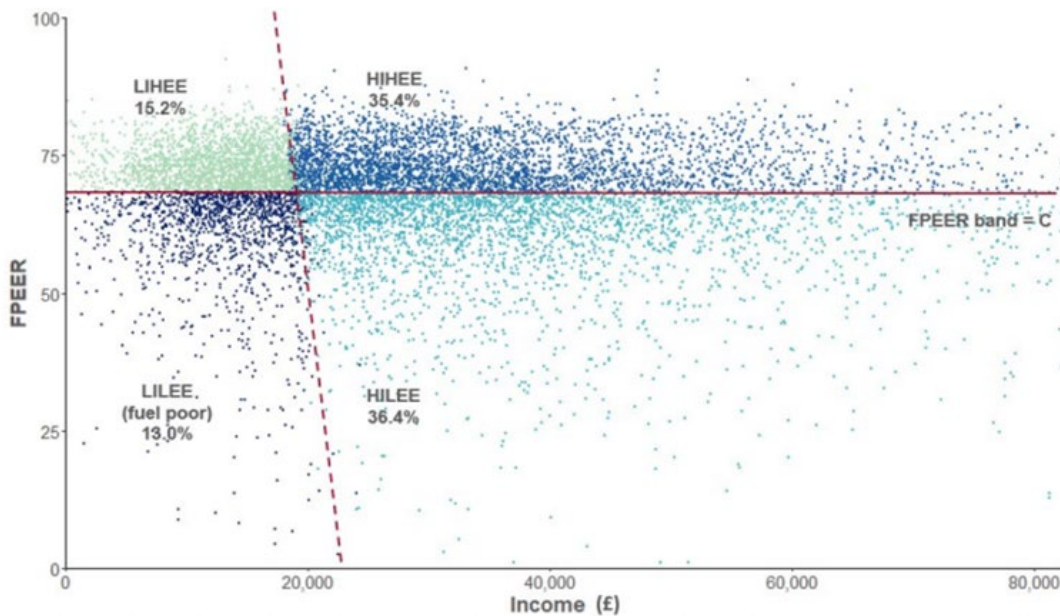


FIGURE 9 – BREAKDOWN OF HOUSEHOLDS INTO LILEE QUADRANTS (ANNUAL FUEL POVERTY STATISTICS, DESNZ, FIGURE 2.2; FPEER = FUEL POVERTY ENERGY EFFICIENCY RATING)

In 2024, 3.1 million households in England were in the lowest two income decile groups (10% groups), but were not deemed to be in fuel poverty because their property had a rating of C or better²³

FIGURE 1 BREAKDOWN OF HOUSEHOLDS INTO LIEEE QUADRANTS. FIGURE 2.2, 2024 ANNUAL FUEL POVERTY STATISTICS, DESNZ. FPEER STANDS FOR FUEL POVERTY ENERGY EFFICIENCY RATING

²³ House of Commons Library, Fuel poverty in the UK, Suzanna Hinson, Paul Bolton, Steven Kennedy, April 2025.

Figure 10 shows that from 2021 that energy prices have been a significant issue for households.

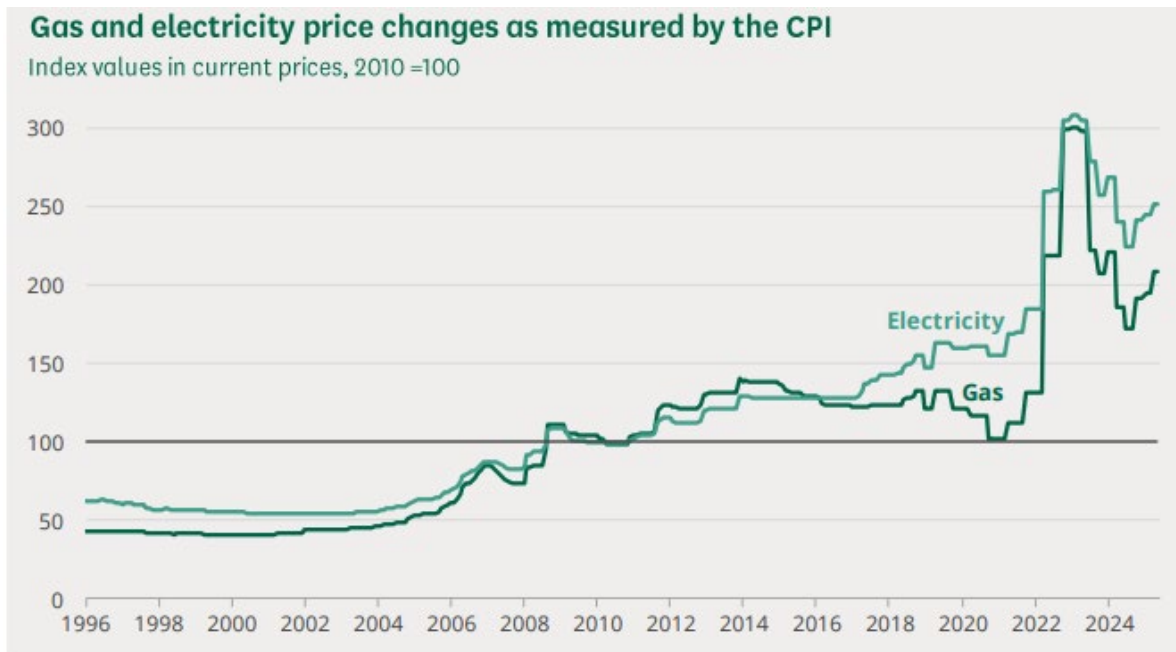


FIGURE 10 – HOUSE OF COMMONS ENERGY PRICE REPORT, PAGE 5^[25]

It should also be noted that RdSap uses a standard electricity tariff of 13.19p/kWh²⁴, and from Figure 11 below the tariffs since 1920 show that something between 10p and 15p fits a historical trend. Renewable energy should in theory provide cheaper energy as no ongoing raw material is required to produce energy however for whatever reason the energy system is not providing cheaper energy. Work is underway to address this the Government's review of electricity market arrangements (REMA)²⁵ and there has been some reduction but more needs to be done.

²⁴ <https://bregroup.com/documents/d/bre-group/rdsap-10-specification-10-06-2025>, Table 32, page 95

²⁵ <https://www.gov.uk/government/publications/review-of-electricity-market-arrangements-rem-a-summer-update-2025/review-of-electricity-market-arrangements-rem-a-summer-update-2025-accessible-webpage>

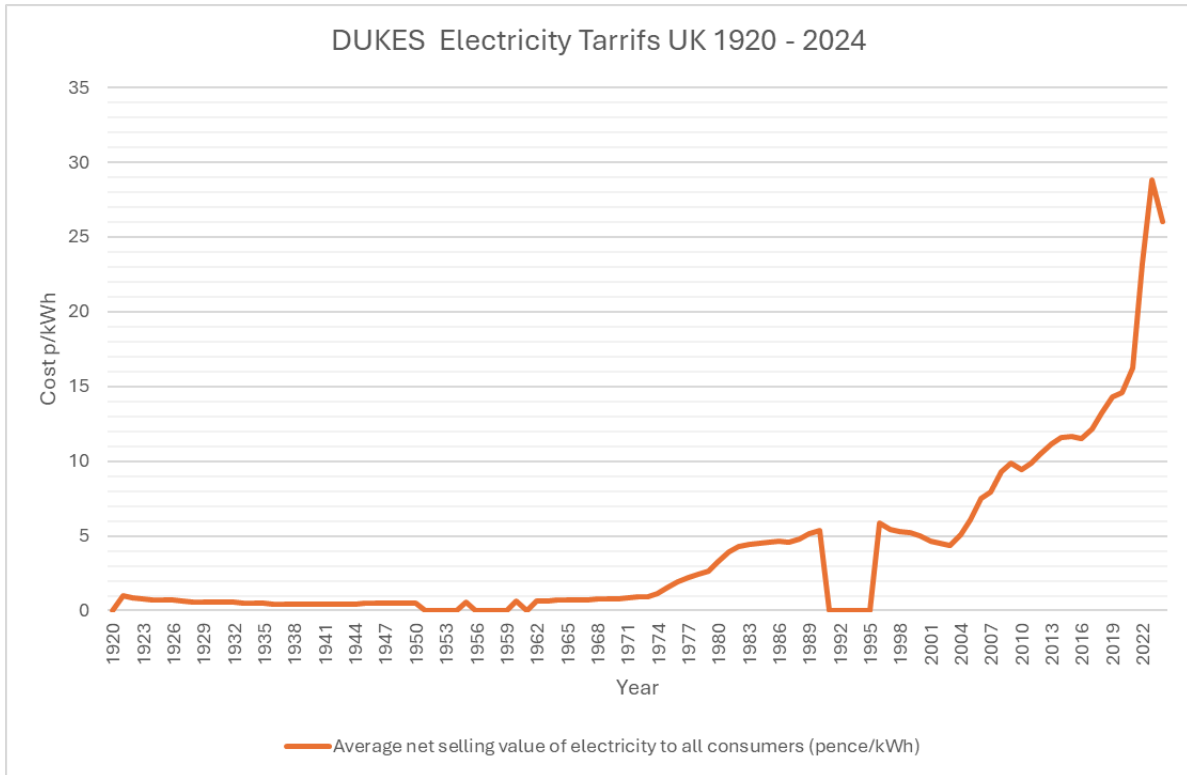


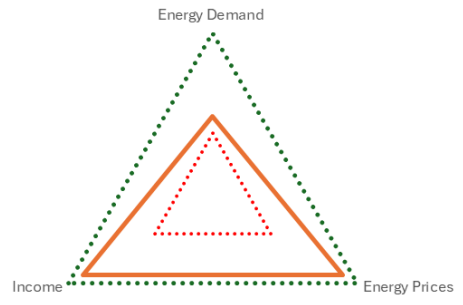
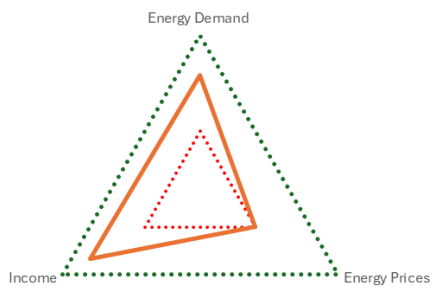
FIGURE 11 – DUKES HISTORICAL ENERGY PRICES^[28]

Higher incomes have helped to offset energy increases, but this is reducing households' ability to use their disposable income on other things which will have impact on their quality of life and the wider economy.

Due to the impressive gains that have been made with our housing stock, and that energy prices are now the leading cause of fuel poverty in the UK, there should be a shift in emphasis in from large scale retrofit to large scale introduction of cheap energy. This is the objective of GB Energy and by switching resources from retrofit to clean energy, it should save the taxpayer money and provide a more stable long future for householders and businesses.

The exception to this should be vulnerable households that are fuel poor where grants should be increased to ensure these households don't suffer physical or mental health harm.

Conceptually, the diagram below summaries what our future approach should be i.e. we have made good progress on energy demand so now need to focus on electricity prices. The target energy price can be set by adopting the EMAX proposal below.



2. EMAX Proposal Top Down

EMAX is proposing we drop the broad approach to measuring fuel poverty, including the SAP based benchmark, and instead adopt a more dynamic and representative methodology.

In general terms EMAX is the price point of an energy tariff (p/kWh) where fuel poverty is eliminated for everyone or a group of users. The definition of fuel poverty is currently accepted to be 10% of income but this might change for the 16 different Ofgem consumer archetypes²⁶ – for example it might need to be as low as 5% for those on very low incomes as small amount of budget can make a large difference to the workings of a household.

Emax can be defined as

$$FP_{ug} \leq ((E_{max} \times ED_{ug}) + E_{sc}) / I_{ug}$$

Where

FP_{gr} is the fuel poverty ratio for a particular Ofgem archetype

ED_{ug} is the energy demand for a particular Ofgem archetype

I_{ug} is the income level for a particular Ofgem archetype

E_{sc} is the standing charge for a particular Ofgem archetype

This can be further explained with the tables below.

Table 6 below shows a worked example of EMAX using March 2025 annual review of energy data²⁷. The vertical axis graduates the energy demand according to the 16 Ofgem customer archetypes that use both gas and electricity (84% of homes), with additional energy demand graduations (i) between 5,000 and 10,000 kwh to reflect what people might consume in the future with more efficient housing and (ii) the UK average energy consumption which is 14,600 kwh (gas and standard electricity) and 16,000 kwh (gas and economy 7 electricity). The horizontal axis is the household income data broken down by decile and has full household income data and income after housing costs. The income data is the same as that used in CMAX. For each vertical and horizontal data couplet [cell] we can work out the expected energy bill and in turn assess if that archetype is in fuel poverty. The inputs used for Table 6 are given in Table 7.

The kWh column in Table 6 is energy demand for a consumer archetype and the actual energy used will a proportion of this depending on what the heating COP is in Table 7.

²⁶ The Centre for Sustainable Energy (CSE) created a set of archetypes for Ofgem to help them assess the impact of energy pricing on the range of households. This work utilised the CSE's Distributional Impacts Model for Policy Scenario Analysis. 24 were originally created but 16 were used in the most recent publications.

²⁷ [Review of the Average Annual Domestic Gas and Electricity Consumption Levels: methodology note0](#)

			1	2	3	4	5	6	7	8	9	10
			15,948	16,874	22,366	27,380	31,868	36,663	42,040	48,358	56,456	71,077
User Type	Homes (m)	kWh	13,237	14,005	18,564	22,725	26,450	30,430	34,893	40,137	46,858	58,994
LU1	N/A	5,000	7%	7%	5%	4%	4%	3%	3%	2%	2%	2%
LU2	N/A	6,000	7%	8%	6%	5%	4%	3%	3%	3%	2%	2%
LU3	N/A	7,000	8%	8%	6%	5%	4%	4%	3%	3%	2%	2%
LU4	N/A	8,000	9%	9%	7%	6%	5%	4%	4%	3%	3%	2%
LU5	N/A	9,000	10%	10%	7%	6%	5%	5%	4%	3%	3%	2%
LU6	N/A	10,000	11%	11%	8%	7%	6%	5%	4%	4%	3%	3%
D11	1.20	11,264	12%	12%	9%	7%	6%	5%	5%	4%	3%	3%
A2	0.87	12,313	13%	12%	9%	8%	7%	6%	5%	4%	4%	3%
B6	0.92	13,553	14%	13%	10%	8%	7%	6%	5%	5%	4%	3%
A1	0.58	13,675	14%	14%	10%	8%	7%	6%	5%	5%	4%	3%
A3	0.88	14,141	15%	14%	10%	9%	7%	6%	6%	5%	4%	3%
DZ1	N/A	14,600	15%	14%	11%	9%	8%	7%	6%	5%	4%	3%
H20	3.54	14,820	15%	14%	11%	9%	8%	7%	6%	5%	4%	3%
DZ2	N/A	16,000	16%	15%	12%	9%	8%	7%	6%	5%	5%	4%
C7	0.66	16,768	17%	16%	12%	10%	8%	7%	6%	6%	5%	4%
C9	3.41	17,022	17%	16%	12%	10%	9%	7%	6%	6%	5%	4%
D10	1.16	17,862	18%	17%	13%	10%	9%	8%	7%	6%	5%	4%
E14	1.18	18,676	18%	17%	13%	11%	9%	8%	7%	6%	5%	4%
I21	2.21	19,531	19%	18%	14%	11%	10%	8%	7%	6%	5%	4%
D12	1.46	20,017	20%	19%	14%	11%	10%	9%	7%	6%	6%	4%
J23	1.96	20,862	20%	19%	14%	12%	10%	9%	8%	7%	6%	5%
E13	0.69	21,797	21%	20%	15%	12%	11%	9%	8%	7%	6%	5%
I22	1.79	23,214	22%	21%	16%	13%	11%	10%	8%	7%	6%	5%

TABLE 6 EMAX FUEL POVERTY STATUS FOR CURRENT ENERGY PRICES

Duel fuel	Y
Electricity Standing charge (p)	53.68
Gas Standing charge (p)	34.03
Non-heating tariff (p/Wh)	26.35
Heating tariff (p/kWh)	6.29
Heating & HW %	81%
Non-heating energy	19%
Heating COP	0.85
Housing costs	17%

TABLE 7 – EMAX BASELINE DATA FOR MARCH 2025 ENERGY DATA

The cells in Table 6 that have a red edge are the income levels for a particular Ofgem archetype group. Other cells that do not have a red edge are hypothetical results that can be used as a comparison. In each cell the level of fuel poverty has been calculated (FP_{ug}). In this example, the FP_{ug} has been set to 10% for all users so where the fuel poverty exceeds 10% for a particular cell, it is highlighted grey.

It can be seen from Table 6 that five of the Ofgem archetypes are currently in fuel poverty (namely A2, A1, A3, C7, and E13) and this affects 3.68 million homes. Four of these five are in Income Decile Groups 1-3 (namely A2, A1, A3, and C7) and affects 2.99 million homes.

Green cells are the national average.

The values in Table 7 can be changed to determine what the tariffs need to be for no-one to be in fuel poverty i.e EMAX. Tables 8 and 9 show what the EMAX tariffs could be if that standing charge remained the same – these tariffs could increase if standing

charges reduced or were dropped. For no fuel poverty (i.e., red cells are 10% or less), then electricity would be 15p/kWh and gas would be 4.1 p/kWh.

			Income Deciles Before and After Housing Costs									
			1	2	3	4	5	6	7	8	9	10
			15,948	16,874	22,366	27,380	31,868	36,663	42,040	48,358	56,456	71,077
User Type	Homes (m)	kWh	13,237	14,005	18,564	22,725	26,450	30,430	34,893	40,137	46,858	58,994
LU1	N/A	5,000	5%	5%	4%	3%	3%	2%	2%	2%	2%	1%
LU2	N/A	6,000	5%	6%	4%	4%	3%	3%	2%	2%	2%	1%
LU3	N/A	7,000	6%	6%	5%	4%	3%	3%	2%	2%	2%	1%
LU4	N/A	8,000	7%	7%	5%	4%	4%	3%	3%	2%	2%	2%
LU5	N/A	9,000	7%	7%	5%	4%	4%	3%	3%	2%	2%	2%
LU6	N/A	10,000	8%	8%	6%	5%	4%	4%	3%	3%	2%	2%
D11	1.20	11,264	9%	8%	6%	5%	4%	4%	3%	3%	2%	2%
A2	0.87	12,313	9%	9%	7%	5%	4%	4%	4%	3%	3%	2%
B6	0.92	13,553	10%	9%	7%	6%	5%	4%	4%	3%	3%	2%
A1	0.58	13,675	10%	9%	7%	6%	5%	4%	4%	3%	3%	2%
A3	0.88	14,141	10%	10%	7%	6%	5%	4%	4%	3%	3%	2%
DZ1	N/A	14,600	10%	10%	7%	6%	5%	5%	4%	3%	3%	2%
H20	3.54	14,820	11%	10%	8%	6%	5%	5%	4%	3%	3%	2%
DZ2	N/A	16,000	11%	11%	8%	6%	6%	5%	4%	4%	3%	2%
C7	0.66	16,768	12%	11%	8%	7%	6%	5%	4%	4%	3%	3%
C9	3.41	17,022	12%	11%	8%	7%	6%	5%	4%	4%	3%	3%
D10	1.16	17,862	12%	11%	9%	7%	6%	5%	5%	4%	3%	3%
E14	1.18	18,676	12%	12%	9%	7%	6%	5%	5%	4%	4%	3%
I21	2.21	19,531	13%	12%	9%	8%	6%	5%	5%	4%	4%	3%
D12	1.46	20,017	13%	12%	9%	8%	7%	6%	5%	4%	4%	3%
J23	1.96	20,862	14%	13%	10%	8%	7%	6%	5%	4%	4%	3%
E13	0.69	21,797	14%	13%	10%	8%	7%	6%	5%	5%	4%	3%
I22	1.79	23,214	15%	14%	11%	9%	7%	6%	6%	5%	4%	3%

TABLE 8 EMAX TABLE WITH NO FUEL POVERTY

Duel fuel	Y
Electricity Standing charge (p)	53.68
Gas Standing charge (p)	34.03
Non-heating tariff (p/Wh)	15
Heating tariff (p/kWh)	4.1
Heating & HW %	81%
Non-heating energy	19%
Heating COP	0.85
Housing costs	17%

TABLE 9 INPUTS FOR TABLE 8

This methodology would allow social tariffs to be created i.e. lower tariffs if you are in decile 1-3, and as mentioned above you could create a lower fuel poverty threshold of 5% to help the most in need. You can also create split tariffs for electricity – one rate for normal use and one rate for heating.

An example of how this could work for ASHPs is given in tables 10 and 11 below, again using a 10% fuel poverty rating for all Ofgem consumer archetypes. In this example consumers would pay 15p/kWh for electricity used for heat, and 20p/kWh for any other use of electricity.

				Income Deciles Before and After Housing Costs									
				1	2	3	4	5	6	7	8	9	10
				15,948	16,874	22,366	27,380	31,868	36,663	42,040	48,358	56,456	71,077
User Type	Homes (m)	kWh		13,237	14,005	18,564	22,725	26,450	30,430	34,893	40,137	46,858	58,994
LU1	N/A	5,000		5%	4%	3%	3%	2%	2%	2%	2%	1%	1%
LU2	N/A	6,000		5%	5%	4%	3%	3%	2%	2%	2%	2%	1%
LU3	N/A	7,000		6%	6%	4%	3%	3%	3%	2%	2%	2%	1%
LU4	N/A	8,000		7%	6%	5%	4%	3%	3%	3%	2%	2%	1%
LU5	N/A	9,000		7%	7%	5%	4%	4%	3%	3%	2%	2%	2%
LU6	N/A	10,000		8%	7%	6%	5%	4%	3%	3%	3%	2%	2%
D11	1.20	11,264		9%	8%	6%	5%	4%	4%	3%	3%	2%	2%
A2	0.87	12,313		9%	9%	7%	5%	5%	4%	4%	3%	3%	2%
B6	0.92	13,553		10%	10%	7%	6%	5%	4%	4%	3%	3%	2%
A1	0.58	13,675		10%	10%	7%	6%	5%	4%	4%	3%	3%	2%
A3	0.88	14,141		11%	10%	8%	6%	5%	5%	4%	3%	3%	2%
DZ1	N/A	14,600		11%	10%	8%	6%	5%	5%	4%	4%	3%	2%
H20	3.54	14,820		11%	10%	8%	6%	5%	5%	4%	4%	3%	2%
DZ2	N/A	16,000		12%	11%	8%	7%	6%	5%	4%	4%	3%	3%
C7	0.66	16,768		12%	12%	9%	7%	6%	5%	5%	4%	3%	3%
C9	3.41	17,022		12%	12%	9%	7%	6%	5%	5%	4%	3%	3%
D10	1.16	17,862		13%	12%	9%	8%	6%	6%	5%	4%	4%	3%
E14	1.18	18,676		13%	13%	10%	8%	7%	6%	5%	4%	4%	3%
I21	2.21	19,531		14%	13%	10%	8%	7%	6%	5%	5%	4%	3%
D12	1.46	20,017		14%	14%	10%	8%	7%	6%	5%	5%	4%	3%
J23	1.96	20,862		15%	14%	11%	9%	7%	6%	6%	5%	4%	3%
E13	0.69	21,797		15%	15%	11%	9%	8%	7%	6%	5%	4%	3%
I22	1.79	23,214		16%	15%	12%	10%	8%	7%	6%	5%	5%	4%

TABLE 10 EMAX FOR ASHP USING SPLIT TARIFFS, NO FUEL POVERTY

Duel fuel	N
Electricity Standing charge (p)	53.68
Gas Standing charge (p)	0
Non-heating tariff (p/Wh)	20
Heating tariff (p/kWh)	15
Heating & HW %	81%
Non-heating energy	19%
Heating COP	2.6
Housing costs	17%

TABLE 11 INPUTS USED FOR TABLE 10

In the ASHP scenarios presented (Table 10), the underlying space heating demand associated with each Ofgem archetype is assumed to remain unchanged relative to the baseline case. The introduction of the heat pump therefore affects final energy consumption through the application of the assumed Seasonal Coefficient of Performance (SCOP), rather than through any change in the thermal demand of the dwelling. In practice, this represents a simplifying assumption. It is recognised that ASHP systems are typically operated more continuously than conventional gas boilers, which may lead to variations in delivered heat and, in some cases, slightly higher overall heating

demand. However, this operational mode is also associated with improved system efficiency, and therefore higher SCOP values than those assumed here.

A SCOP of 2.6 has been adopted as a conservative and representative value for existing UK housing stock and typical installation conditions, particularly in the context of large-scale deployment. Higher SCOP values (e.g. 3.0–3.5) are achievable in well-designed systems with good installation practices and in buildings with improved thermal performance. An increase in SCOP would directly reduce electricity consumption for heating, thereby lowering running costs and progressively reducing the risk of fuel poverty across all income decile groups. As such, the results presented can be considered conservative with respect to the potential performance of heat pumps.

This relationship can be further illustrated by considering the cost parity condition between gas boilers and ASHP systems, which can be approximated as (not accounting for standing tariffs):

Under current price assumptions, this yields a SCOP of approximately 3.5–3.6, which is achievable under favourable conditions but not yet representative of typical installations at scale. It should also be noted that achieving cost parity on running costs alone does not account for the higher capital costs and system complexities associated with heat pump installations, which remain a key barrier to uptake, particularly for “able-to-pay” households.

These tables exclude the archetypes that do not use gas for heating (16% of homes). Many of these homes are heated by oil, or LPG so a separate analysis will be required for these homes, and for homes that are currently heated by electric they may have a different heat and hot water ratio. These results align with the bottom-up approach to electricity prices in the following section 3. There is a slight variance depending on consumer type and property type but electricity prices for heating should be within 14 and 20 p/kWh if using heat pumps, and at least well below current electricity prices.

The data sources used are national Government-based data sets so can be replicated for any given year - the full list of data sources is given in Annex 4.

Using this methodology, scenario testing of the main inputs (e.g. table 11) has been carried out for (i) the current heating stock i.e. gas boilers (ii) ASHP replacing all gas boilers and (iii) heat batteries for properties with a demand of less than 12,000 kWh as heat pumps are unlikely to be suitable for smaller properties. The full results of this are given in Annex 5.

The conclusions from this scenario testing are that:

- The average price of electricity for heating should be 13.4 p/kWh
- The average price for electricity for non-heating should be 17.0 p/kWh
- Heat pumps with a higher COP could reduce fuel poverty at 18p/kWh
- Heat batteries for heating would need to use electricity that is to 10p/kwh, but these technologies will be more suited to smaller homes (compared to ASHP) are the best at taking off peak energy, and are the best at working with intermittent grid supplies (i.e. wind)

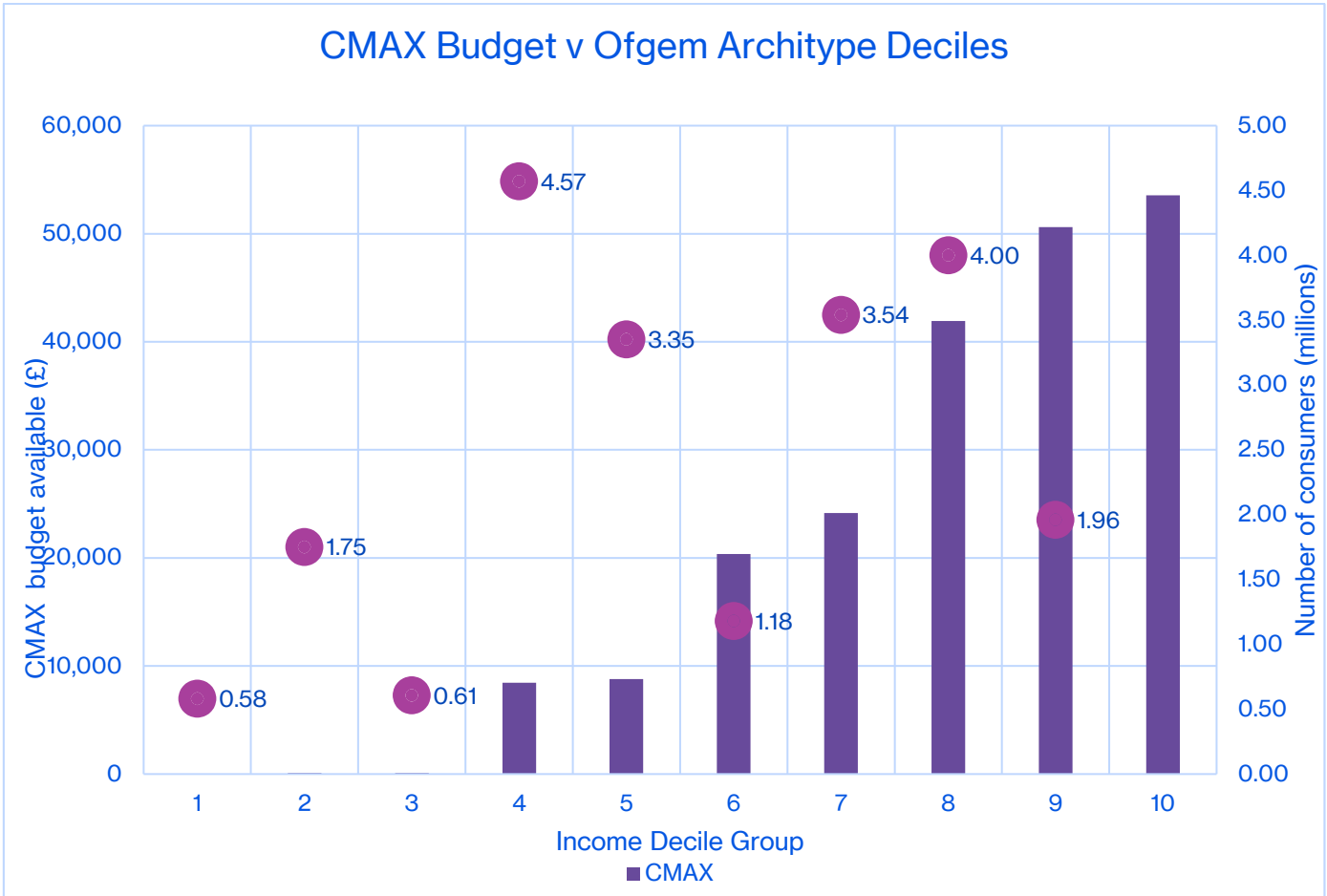
It should be noted that both heat pumps and heat batteries can provide heating and hot water with advancements made by heat battery manufacturers. There are merits and disadvantages for both technologies, and this paper is aiming to highlight where each technology could be best placed and what the energy price needs to be to facilitate their roll out.

With the use of smart meters, smart heating controls, smart billing software (e.g. Octopus's Kraken) and collation of Government data (as demonstrated in the original CSE methodology) it would be possible to replicate EMAX for all consumers.

The proposed EMAX model gives us the opportunity to eradicate fuel poverty (which the current LILEE model cannot) as we bring electricity prices low enough to a point where energy bills are affordable to those that need it, and the variability and sensitivity of energy demand becomes less relevant. That is not to say more should not be done to reduce energy demand, and this will continue to be the case, but given that we have made significant energy efficiency investments over the last 20 years and fuel poverty is still a major issue the problem needs to be redefined and as renewables have the opportunity to provide cheaper energy this should be achievable. A long-term energy plan will allow stable cheaper energy to be delivered.

Figure 12 below plots the total number of homes of the Ofgem archetypes in each decile against the CMax available for each decile. This underlines the points made in Part 1 but graphically shows that deciles 1-5 represent half of the homes (10.86 million) but have very limited capital to invest in retrofit so reduced energy bills are of primary importance.²⁸

²⁸ Ofgem archetypes did not have an income base that matched decile 10. It might be that as the Ofgem archetypes excluded off-gas properties, decile 10 could form a large number of these off-gas properties.



The challenge for Government and the electricity industry is can it deliver cheap energy

FIGURE 22 - QUANTITY OF HOMES BY DECILE AND CMAX AFFORDABILITY

to consumers – what needs to change to enable this to happen? Do we also need to encourage more mass transit systems and active travel to reduce car journeys, as if all cars switched to EVs this could push up overall electricity demand and put the grid energy demand well beyond current capabilities. The energy price reduction would need to include a reduction to standing charges which have also significantly increase over the last four years (figure 13 below).

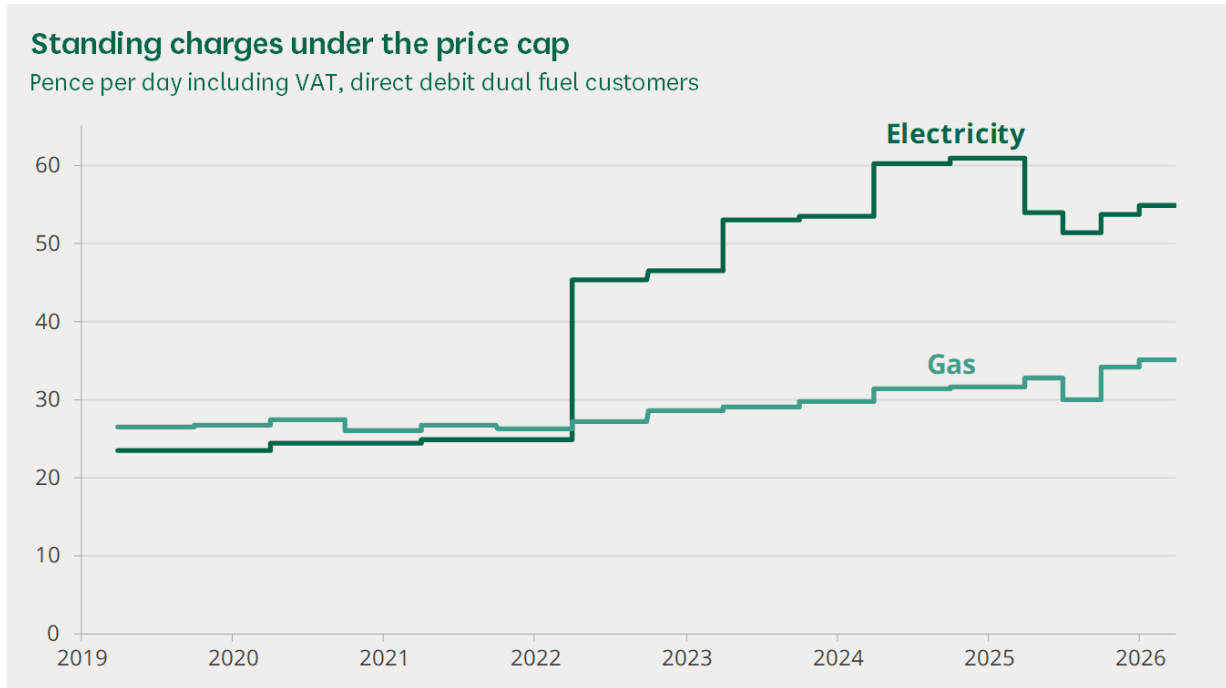


FIGURE 13 – STANDING CHARGE PRICES, HOUSE OF COMMONS ENERGY STANDING CHARGES 24 NOV 2025, SOURCE: OFGEM, ENERGY PRICE CAP (DEFAULT TARIFF): 1 JANUARY TO 31 MARCH 2026 (FINAL LEVELIZED CAP RATES MODEL (ANNEX 9)), 21 NOVEMBER 2025^[32]

Importantly, EMAX is a dynamic tool and so can react to changes circumstances. If for example homeowners do invest heavily in retrofit, then demand should fall and so there is less need to reduce energy prices. Equally if overall income improves, people will have more disposal income so again energy prices don't have to be reduced by so much, although cheap energy prices will help the UK economy be more competitive.

Adopting this approach will encourage the market to incentivise energy efficiency as without it prices will have to reduce, and it encourages wealth creation which will help UK households out of general poverty²⁹.

It also incentivises the energy system to make best use of renewable and surplus energy. For example, small generators are paid approximately 4p/kWh for spare solar energy, yet this same energy is being resold to domestic consumers for 24.67p/kWh – a significant mark up by the energy supply chain who have not had to do anything to generate the energy but make some lucrative incomes. On a larger scale, forward prices for electricity in 2025³⁰ were 8p/kWh with costs for renewables falling significantly over the last ten years.

²⁹

<https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/averageweeklyearningsingreatbritain/august2025> Figure 2, current wages are similar to 2005 levels

³⁰ <https://www.ofgem.gov.uk/news-and-insight/data/data-portal/wholesale-market-indicators#:~:text=These%20charts%20represent%20the%20wholesale,Security%20of%20supply>

To ensure homes are not wasteful with energy, each type of home could also have a nominal energy use rating based on an archetype; the Department for Work and Pensions (DWP) had already carried out preliminary work at the time of the John Hills report³¹. If a home exceeds this amount, then a higher tariff will be applied. Also, with homes of the most vulnerable and poorest, a subsidised tariff can be adopted and can replace the winter fuel payment.

Key data was obtained and used by the CSE study and could be repeated and improved by Ofgem. Building, income and energy data are readily available to Government departments so it would be relatively simple to set this up and automate it with DESNZ and Ofgem who already carry out regular energy reviews. Key data sets would be (i) VOA³² for building type and data (ii) Council Tax for demographics (iii) MHCLG House Condition Surveys (iv) DWP data for benefits, health issues and income (v) HMRC for household income (vi) billing data from energy companies and coordinated by Ofgem (vii) met office weather data to make any geographical adjustments.

On the whole, homes with greatest energy demand have higher incomes. If these homes had higher energy bills, they could have the choice of either paying the higher bills or introduce measures to reduce demand. An unintended consequence might be to increase demand for smaller homes, but this would positively influence the national housebuilding programme as more dwellings could be supplied with the limited land available.

Heat batteries will play a key role in providing heat for smaller homes and will also be a key grid modulator as they can absorb energy in any 24-hour period. Heat is also a higher societal priority than electric vehicles as lack of affordable heat will cause a danger to life so any energy that is available at cheaper rates would be given to heat batteries first. The role of heat batteries is underlined by the DESNZ consultation³³ that recognises if electrification of heat is the chosen route for decarbonisation, then heat pumps will not be suitable for all homes so support is needed for emerging alternatives.

³¹ Getting The Measure of Fuel Poverty, John Hills, March 2012, Table 2.1, page 52,

³² The Valuation Office Agency provides valuations and property advice to support taxation and benefits to the government and local authorities in England and Wales
<https://www.gov.uk/government/organisations/valuation-office-agency/about>

³³ <https://www.gov.uk/government/consultations/exploring-the-role-of-alternative-clean-heating-solutions>

3. EMAX Proposal Bottom-Up approach Through Case Study

This section aims to demonstrate the proposed approach to tackle fuel poverty through a bottom-up approach; building from a previous study developed in collaboration by Lewes and Eastbourne councils and the University of Brighton. The study aimed at defining a social housing retrofit strategy toward Net-Zero.

One of the case studies, identified as “Command Road” is taken as reference here, the building is a 1930’s two-storey semi-detached dwelling with poor energy performance, typical of much of the UK housing stock, with minimal fabric insulation and a poorly performing traditional gas boiler. Table 12 shows the summary of results obtained by the previous study. In it, EB identifies the Baseline (existing building) representing current conditions with minimal insulation and a conventional gas boiler. Three different levels of retrofit depth were identified:

- **A - MINIMUM RETROFIT (MR): DEFINED AS THE LIGHTEST OF THE RETROFIT OPTIONS, AIMED AT IMPROVING AIRTIGHTNESS OF THE BUILDING AND IMPROVING THE EFFICIENCY OF THE HVAC SYSTEM WITHOUT INTRUSIVE WORKS;**
- **B - BEST PRACTICE (BP): INTENSIVE RETROFIT ACTIVITIES AIMED AT ACHIEVING THE TARGETS SET BY LETI FOR THE LETI BEST PRACTICE STANDARD OF ENERGY USE INTENSITY OF 50 kWh/(m2 YEAR);**
- **C - EXEMPLAR PRACTICE (EP): INTENSIVE RETROFIT ACTIVITIES AIMED AT ACHIEVING THE TARGETS SET BY LETI FOR THE LETI EXEMPLAR PRACTICE STANDARD OF ENERGY USE INTENSITY OF 40 kWh/(m2 YEAR).**

Each retrofit scenario was then paired with either: (1) a high efficiency condensing gas boiler (Gas), or (2) a newly installed Air Source Heat pump (ASHP) with average COP. Only the deepest retrofit example was also paired with Direct electric heating options (HPDHW (4), where an ad-hoc heat pump is installed to provide domestic hot water, and DE (5), where all heating needs are covered by direct electric solutions). All combinations assessed in the previous study are maintained and analysed for the purpose of the present work. Energy costs per Unit used for the calculations in Table 12 were derived from real energy costs known from the case study and assumed at 0.08£/kWh for Gas and 0.32£/kWh for electricity.

TABLE 12: ENERGY DEMAND AND CONSUMPTION FOR THE SELECTED CASE STUDY

	EB	EB ASHP	A1: Min Gas	A2: Min ASHP	B1: Med Gas	B2: Med ASHP	C1: Deep Gas	C2: Deep ASHP	C4: Deep HPDHW	C5: Deep DE
Space heating demand (kWh/m2/yr)	114.20	114.20	95.96	95.96	20.68	20.68	14.49	14.49	14.49	14.49
DHW heating demand (kWh/m2/yr)	76.13	76.13	76.13	76.13	76.13	76.13	76.13	76.13	76.13	76.13
Electricity consumption (kWh/m2/yr)	40.94	124.02	29.01	104.14	29.01	78.71	29.01	76.49	74.01	112.09

Gas consumption (kWh/m ² /yr)	224.44	0.00	185.39	0.00	101.91	0.00	95.40	0.00	0.00	0.00
Running cost (£/yr)	2547	3254	1977	2732	1430	2066	1387	2007	1942	2941

It is important to note how the previous study concluded that only the minimum retrofit with gas boiler (A1) intervention was found to be financially viable in the absence of government incentives, with a net present value of 65£/m² over a time span of 30 years. Every other intervention still resulted in a negative return of investment over the same time period. However, it is important to recognise the potential risk of future non-compliance with evolving regulatory frameworks. In particular, tightening Minimum Energy Efficiency Standards (MEES) and broader decarbonisation policies may require properties to meet higher performance thresholds in order to be sold or rented. As a result, recently installed gas boilers could face premature replacement before the end of their technical lifespan, leading to stranded assets and additional costs for households. This highlights a key limitation of the A1 pathway: although it provides short-term relief from fuel poverty, it may not represent a future-proof solution in the context of the UK's transition to low-carbon heating.

It should also be noted that, across all retrofit scenarios presented, domestic hot water (DHW) demand is assumed to remain constant. This reflects a simplifying assumption adopted in the original case study, where the focus was placed on space heating demand and fabric performance. In practice, however, a range of interventions could significantly reduce the energy demand associated with hot water generation. These include the installation of low-flow fixtures, optimisation and insulation of hot water distribution pipework, improved storage efficiency, and the adoption of wastewater heat recovery systems. While such measures would not necessarily reduce the hot water demand at the point of use, they can substantially reduce the energy required at the hot water generator. As a result, the scenarios presented here may be considered conservative in terms of total energy demand and associated running costs, particularly for electrified heating systems.

Since every scenario was simulated under both heat generation assumptions of either a condensing gas boiler (GAS - 1) or an air source heat pump (ASHP - 2), we can use the case study as a demonstrator for fuel poverty risk assessment under different energy retrofit and heat generation scenarios, in line with the approach outlined in chapters 3 and 4.

In order to do so, all calculations have been updated to align with the price structure highlighted in Table 7, including both price per unit of energy and standing charges. Subsequently, each scenario has been aligned with the income decile groups introduced in chapter 3, to assess if each specific combination of household income and retrofit level would result in fuel poverty risk.

Similarly to the approach implemented in Table 8, the case study has been mapped against the 16 Ofgem archetypes, matching with categories C7-C9 in the third income decile group (D3), therefore an increased attention is given to this decile in the table and discussion below.

3.1. Calculations with single electricity tariff

Table 13, below, shows the summary of all scenarios assessed under the assumption that a single electricity tariff is applied to cover all electric loads. The price structure highlighted in Table 7 is used for the calculations, under the assumption that each scenario using electric heating (either directly or through the use of an ASHP) would disconnect from the gas network, therefore avoiding any related standing charges.

TABLE 13: FUEL POVERTY RISK WITH SINGLE ELECTRICITY TARIFF

Decile	Annual Income	EB	EB ASHP	A1: Min Gas	A2: Min ASHP	B1: Med Gas	B2: Med ASHP	C1: Deep Gas	C2: Deep ASHP	C4: Deep HPDHW	C5: Deep DE
1	15948	YES	YES	YES	YES	NO	YES	NO	YES	YES	YES
2	16874	YES	YES	YES	YES	NO	YES	NO	YES	YES	YES
3	22366	YES	YES	NO	YES	NO	NO	NO	NO	NO	YES
4	27380	NO	YES	NO	NO	NO	NO	NO	NO	NO	NO
5	31868	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6	36663	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7	42040	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
8	48358	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
9	56456	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
10	71077	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

A few key takeaways from this analysis are:

- It is possible to note how deciles D1-D3 would be currently classified in fuel poverty in the existing building, energy retrofit on the building while maintaining the same energy source (gas) would improve the fuel poverty risk, with minimum retrofit taking D3 out of fuel poverty, and deeper retrofit scenarios completely eradicating it;
- Simply swapping the heating system for a heat pump in the current scenario would exacerbate the situation, by also pushing D4 into fuel poverty;
- Combining different retrofit scenarios with ASHP would ease the burden, with scenario A2 presenting similar fuel poverty risks to the existing building, and scenarios B2 and C2 slightly reducing it (but not eradicating it, primarily due to DHW needs);
- When focusing on D3, as the most likely/appropriate type of occupation for this building, we can see how a minimum retrofit scenario still using a gas boiler would take this household out of fuel poverty risk, however if an ASHP is coupled with the minimum retrofit, the household would still be classified in fuel poverty, and therefore require controlled electricity tariffs.

Table 15 shows the different electricity prices that would be required to either (A) match the same overall energy costs compared to the use of a high efficiency condensing gas boiler, or (B) ensure the household is not at risk of fuel poverty, particularly focusing on D3 as the most likely for the house type, and D1 to completely eradicate fuel poverty.

TABLE 14: ELECTRICITY PRICES SUMMARY TABLE WITH SINGLE ELECTRICITY TARIFF

	EB	EB ASHP	A1: Min Gas	A2: Min ASHP	B1: Med Gas	B2: Med ASHP	C1: Deep Gas	C2: Deep ASHP	C4: Deep HPDHW	C5: Deep DE
Electricity price to match gas costs (£/kWh)	-	0.18	-	0.17	-	0.16	-	0.16	0.17	0.08
Electricity price for D3 to avoid fuel poverty (£/kWh)	-	0.20	-	0.24	-	0.32	-	0.33	0.34	0.22
Electricity price for D1 to avoid fuel poverty (£/kWh)	-	0.14	-	0.16	-	0.22	-	0.22	0.23	0.15

From this summary we can see how, for an ASHP to match the same overall energy costs of a condensing gas boiler, electricity prices would need to range between 16 and 18 p/kWh, depending on the retrofit scenario. However, this would not ensure the household would not be considered in fuel poverty, as seen in Table 13.

In order for that to happen, we would first need to identify the income decile group in which the household is situated. As an example, a D3 household would need a controlled electricity tariff of 0.20 p/kWh to be considered outside of fuel poverty, if a ASHP was installed in the existing building, but would only need a 24 p/kWh tariff, if the minimum retrofit scenario was applied, very similar to the current electricity prices, and likely achievable through a suitably designed incentives scheme.

However, if the household falls into the D1 decile, as it would be expected, unit prices would need to be significantly lower in order to avoid fuel poverty, as low as 14p/kWh. This phenomena is highlighted in Table 8 as irrelevant hypotheticals or outliers, as a D1 household is unlikely to occupy this kind of dwelling, although it is important to consider this as a possibility of happening either in misplaced/unoptimized social housing allocation, or changing circumstances in long-term occupations, when some might find themselves in fuel poverty not due to their income or the quality of their accommodation directly, but because they are occupying a dwelling too large for their needs.

3.2. Calculations with Dual tariff (heating tariff)

When considering controlled energy tariffs to avoid the risk of fuel poverty, it is possible to assume the use of a dual tariff, where a controlled electricity price is offered only for the electricity used for heating and domestic hot water purposes, as seen previously in Table 8. To this extent, Table 15 below analyses a scenario in which a dual tariff approach is applied to the case study, with electricity unit prices for heating and DHW only being reduced down to 18p/kWh.

TABLE 15: FUEL POVERTY RISK WITH DUAL TARIFFS SCENARIO

Decile	Annual Income	EB	EB ASHP	A1: Min Gas	A2: Min ASHP	B1: Med Gas	B2: Med ASHP	C1: Deep Gas	C2: Deep ASHP	C4: Deep HPDHW	C5: Deep DE
1	15948	YES	YES	YES	YES	NO	NO	NO	NO	NO	YES

2	16874	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO	YES
3	22366	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO
4	27380	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5	31868	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6	36663	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7	42040	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
8	48358	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
9	56456	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
10	71077	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

In this scenario we can see how, risk of fuel poverty is maintained unaltered across heating sources, with D3 particularly falling in fuel poverty in both “existing building” scenarios and being classified as not at risk of fuel poverty if a “minimum retrofit” scenario is applied.

Table 16 offers again a summary of all controlled electricity prices required under a dual tariff approach in order to either achieve cost parity with natural gas (ranging between 15 and 18p/kWh), or to take deciles D3 and D1 out of fuel poverty; note how in this scenario a very small reduction of electricity prices from the current 26p/kWh to 23p/kWh would suffice to take D3 out of fuel poverty if coupled with a “minimum retrofit” scenario.

TABLE 16: ELECTRICITY PRICES SUMMARY TABLE WITH DUAL ELECTRICITY TARIFF

	EB	EB ASHP	A1: Min Gas	A2: Min ASHP	B1: Med Gas	B2: Med ASHP	C1: Deep Gas	C2: Deep ASHP	C4: Deep HPDHW	C5: Deep DE
Electricity price to match gas costs (£/kWh)	-	0.18	-	0.17	-	0.15	-	0.15	0.16	0.08
Electricity price for D3 to avoid fuel poverty (£/kWh)	-	0.17	-	0.23	-	0.35	-	0.36	0.38	0.21
Electricity price for D1 to avoid fuel poverty (£/kWh)	-	0.08	-	0.13	-	0.19	-	0.20	0.21	0.11

3.3. Calculations with PV panels

Lastly, it is important to consider the potential positive impact of on-site electricity generation through solar photovoltaic panels installed on the roof. Compatibly with the available space, the previous study estimated a total annual generation capacity of 2692 kWh for the case study. This is only a fraction of the overall electricity consumption in each scenario, and since electricity will not necessarily be generated during times in which is needed (most of the electricity will be generated in the summer during daytime), assumption needs to be made on how such electricity will be used. Table 17 shows results under the assumption that all electricity generated will be exported to the grid, at an average price of 4p/kWh, representative of the currently available exporting tariffs through major energy suppliers.

TABLE 17: FUEL POVERTY RISK UNDER PV PANELS SCENARIOS – SELF CONSUMPTION 0%

Decile	Annual Income	EB	EB ASHP	A1: Min Gas	A2: Min ASHP	B1: Med Gas	B2: Med ASHP	C1: Deep Gas	C2: Deep ASHP	C4: Deep HPDHW	C5: Deep DE
1	15948	YES	YES	YES	YES	NO	YES	NO	YES	YES	YES
2	16874	YES	YES	YES	YES	NO	YES	NO	YES	YES	YES
3	22366	YES	YES	NO	YES	NO	NO	NO	NO	NO	YES
4	27380	NO	YES	NO	NO	NO	NO	NO	NO	NO	NO
5	31868	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6	36663	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7	42040	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
8	48358	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
9	56456	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
10	71077	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

As it can be seen, this contribution would be minimal toward the overall energy prices of the household, due to the low export tariff, and would not contribute to any significant changes, therefore we can assume that a photovoltaic system with no significant self-use or increased exporting tariffs (from a local community energy scheme for example) would not be beneficial in reducing the risk of fuel poverty, even when combined with an ASHP.

However, a varying amount of electricity is normally self-consumed within buildings, to directly cover for electricity needs. This is even more true when the heating demand is also covered by electric technologies (such as heat pumps). Various studies³⁴ show the ratio of self-consumption varies depending on both generation and consumption profiles, but on average can reach 45% in the UK. In the current scenario, given the absence of a battery and the characteristics of the building, a conservative figure of 25% is assumed for the case study. Table 18 shows a summary of fuel poverty risks under the assumption that 25% of the electricity generated by the PV panels is self-consumed, while the remaining 75% is exported to the grid at a 4p/kWh export tariff.

TABLE 18: FUEL POVERTY RISK UNDER PV PANELS SCENARIOS – SELF CONSUMPTION 25%

Decile	Annual Income	EB	EB ASHP	A1: Min Gas	A2: Min ASHP	B1: Med Gas	B2: Med ASHP	C1: Deep Gas	C2: Deep ASHP	C4: Deep HPDHW	C5: Deep DE
1	15948	YES	YES	YES	YES	NO	YES	NO	NO	NO	YES
2	16874	YES	YES	NO	YES	NO	NO	NO	NO	NO	YES
3	22366	NO	YES	NO	NO	NO	NO	NO	NO	NO	YES
4	27380	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

³⁴ E. McKenna, J. Pless, S. J. Darby, Solar photovoltaic self-consumption in the UK residential sector: New estimates from a smart grid demonstration project, Energy Policy, Volume 118, 2018, Pages 482-491, ISSN 0301-4215, <https://doi.org/10.1016/j.enpol.2018.04.006>.

5	31868	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6	36663	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7	42040	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
8	48358	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
9	56456	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
10	71077	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Key takeaways from this assessment are:

- Installing PV panels with a 25% level of self-consumption would have a significant positive impact on each scenario assessed, helping to reduce, if not completely eliminate, the risk of fuel poverty even while maintaining the current electricity tariffs, without any controlled price cap.
- Although the contribution from the PV panels is not enough to push D3 out of fuel poverty in the assumption of installing an ASHP in the existing building, it's possible to see how combining the PV panels with a “minimum retrofit” intervention would place D3 out of fuel poverty.
- A higher percentage of self-consumption will further improve the results and push lower deciles out of fuel poverty.

Finally, Table 19 shows a summary of required controlled electricity tariffs under a dual tariff setup, and in combination with a PV system with 25% of self-consumption, in order to either match the energy costs of the existing building, or avoid fuel poverty risks .

TABLE 19: ELECTRICITY PRICES SUMMARY TABLE WITH PV PANELS SCENARIOS – SELF CONSUMPTION 25%

	EB	EB ASHP	A1: Min Gas	A2: Min ASHP	B1: Med Gas	B2: Med ASHP	C1: Deep Gas	C2: Deep ASHP	C4: Deep HPDH W	C5: Deep DE
Electricity price to match gas costs (£/kWh)	-	0.23	-	0.22	-	0.22	-	0.23	0.24	0.12
Electricity price for D3 to avoid fuel poverty (£/kWh)	-	0.21	-	0.27	-	0.41	-	0.43	0.45	0.20
Electricity price for D1 to avoid fuel poverty (£/kWh)	-	0.11	-	0.17	-	0.25	-	0.26	0.28	0.11

In this scenario, price matching against the use of a gas boiler could be reached with controlled tariffs ranging between 22 and 24p/kWh, with some exception of the sole use of direct electric heating, which would still require significantly lower tariffs as seen in C5 (primarily due to the need for Domestic Hot Water).

From a fuel poverty perspective, the D3 decile would be lifted out of fuel poverty in each scenario, with the only exception of installing a heat pump on the existing building, for which a controlled electricity tariff of 21p/kWh would still be necessary. The sole use of

solar panel with a 25% self-consumption assumption would not be sufficient to lift D1 out of fuel poverty except in the case of a deep energy retrofit, however it would only require a controlled electricity tariff of 17p/kWh in order to do so under a “minimum retrofit” scenario. It is however important to keep in mind that given the nature of the case study, a D1 income household is highly unlikely, and would highlight separate potential issues, such as misallocation of social housing.

This chapter has demonstrated how a bottom-up, case-study-based approach can be used to assess fuel poverty risks under different combinations of retrofit depth, heat generation technologies, electricity tariff structures, and on-site renewable generation.

The results show that fabric-first interventions consistently deliver the most robust reductions in fuel poverty risk, particularly for the most representative income decile group (D3), even when conventional gas heating is retained. However, as stated at the beginning of the chapter, the previous study demonstrated that only “minimum retrofit” is to be considered financially viable in the absence of government funding.

By contrast, a direct transition to electric heating via heat pumps, when not supported by sufficient retrofit depth or appropriate electricity pricing, can exacerbate fuel poverty. This is seen in Table 13, and how a direct switch from a gas boiler to a heat pump in the existing building would push even the D4 decile into fuel poverty.

The analysis further highlights the critical role of tariff design: controlled single or dual electricity tariffs significantly improve affordability outcomes and can enable heat pump adoption without increasing fuel poverty, or lift households out of fuel poverty altogether. Especially when paired with minimum retrofit measures, small reductions in electricity pricing down from the current 26p/kWh to 23p/kWh could lift D3 households out of fuel poverty.

Finally, while rooftop PV systems offer limited benefits under low export tariffs alone, modest levels of self-consumption substantially enhance outcomes and reduce reliance on aggressive tariff reductions. As seen in Table 18, a suitably sized PV system, with a limited 25% self-consumption would lift a D3 household out of fuel poverty without the need of any controlled electricity prices.

An extension of the controlled tariff approach presented in EMAX could involve the introduction of flexible, threshold-based electricity pricing. Under such a model, households would receive a defined allocation of electricity at a reduced unit cost, reflecting essential energy needs for space heating, hot water, and basic electrical loads. Consumption beyond this level would be charged at standard or higher rates, maintaining an incentive for energy efficiency and demand reduction.

A key consideration in implementing such an approach is the definition of the appropriate consumption threshold for each household. This would need to account for dwelling characteristics, occupancy levels, and vulnerability to fuel poverty. The EMAX framework provides a suitable basis for this calibration, as it already links energy demand, income, and affordability thresholds across different consumer archetypes. By combining these elements with available building and demographic data, it would be possible to develop dynamic and equitable tariff structures that support vulnerable households while reinforcing efficient energy use.

An additional dimension that supports the EMAX framework is the increasing role of demand-side flexibility in managing both energy costs and system constraints. Emerging operational models, such as time-of-use tariffs and smart control of heating systems, already demonstrate how peak demand can be reduced by temporarily shifting or modulating loads for example, by pre-heating buildings ahead of peak periods and relying on the building's thermal mass to maintain comfort. This approach is particularly relevant for electrified heating systems, including heat pumps and heat batteries, which can be operated flexibly without compromising occupant comfort if buildings retain sufficient heat over short periods.

Integrating this flexibility into tariff design further strengthens the case for differentiated electricity pricing, as it enables lower-cost energy to be aligned with periods of lower grid demand or higher renewable generation. In this context, flexibility is not only a tool for reducing system costs, but also a mechanism to improve affordability for households, reinforcing the potential of EMAX to support both decarbonisation and fuel poverty reduction.

Overall, the case study illustrates that eradicating fuel poverty in social housing requires an integrated strategy combining targeted retrofit depth, income-aware tariff structures, and selective deployment of low-carbon technologies, reinforcing the importance of locally informed, bottom-up policy design.

PART 3 - Conclusions

The analysis demonstrates that the CMAX and EMAX frameworks are closely aligned and reinforce one another, offering a coherent, evidence-based approach to tackling fuel poverty while enabling an affordable and realistic pathway to net zero. The findings also integrate with the 2022 study between Lewes & Eastbourne councils and the University of Brighton (lead engineer Marco Picco), that concluded minimum retrofit and solar PV are an optimum pathway.

In summary minimum retrofit, lower energy tariffs, and smart tariffs give best chance to reduce fuel poverty and cost of living.

The key findings of this report are that

- Motivations and barriers vary significantly across income decile groups, so any national or local strategy must reflect these differences rather than assume a uniform approach
- Minimum retrofit is the only option consistently shown to be cost-effective under current financial constraints
- Energy price reduction is essential. Bringing electricity costs to circa 15p/kWh and enabling dynamic tariffs during periods of surplus generation will have a greater long-term impact on fuel poverty than retrofit alone
- Households in income decile groups 1–3 will require a blend of grant support and tailored lower energy tariffs, as these groups cannot afford capital expenditure and available grant budgets are limited
- Grant funding should be tightly targeted – not just by income but by health risk – so homes with the greatest vulnerability receive priority
- Public Health teams should help identify households at highest risk of cold-related illness and mortality, ensuring limited support is used to prevent the most severe outcomes
- EMAX should be adopted as the national methodology for tariff-setting, delivered by Ofgem using the extensive data it already collects and manages. Tariffs could be tailored for consumer archetypes and income levels, with the most vulnerable getting the cheapest tariffs; this could also replace the need for winter fuel payments as the neediest are getting the right support
- Within this a fair-use energy threshold should be established for every dwelling archetype. Consumption above this point should attract higher tariffs, with protections for vulnerable residents
- Also within this, there could lower tariffs for heating and domestic hot water, with higher tariffs applied to all other uses

- Heat should be prioritised over electric vehicle charging during periods of constrained supply, reflecting the importance cold homes has on direct health. Poor health does not result from not having a car charged
- Heat batteries should be actively promoted. They offer lower capital costs than heat pumps, can be rapidly scaled in UK manufacturing, have a long shelf life, require less skilled labour for installation, and importantly provide a valuable flexibility to the grid when there is excess energy available
- A mass roll-out of solar PV should be implemented to reduce bills, support grid decarbonisation, and take pressure off national generation capacity. This was advocated in the 2022 study, and has been taken forward by the Warm Homes Plan
- Roll out of retrofit, solar PV and green heat should be led by a national public sector entity. At the very least this will include procurement of materials so that cost efficiency gains are maximised. It should follow the successful conversion of heating to natural gas in the 1970s which was led by a public sector entity. Installations will be carried out by the local supply chain, but they will be drawing off the framework set up by the national public sector entity.
- The right blend of solutions for buildings should be under-pinned by independent empirical assessments to ensure residents and investments are not compromised
- Significant investments in public transport and active travel can help limit EV-related electricity demand, preserving affordable grid capacity for heating and other priority uses (e.g. critical industry)

Overall, a blended strategy for electrification is required with cheaper energy being the primary drive for the change we require. For the heating solutions, heat pumps will not be suitable or affordable for every home, so heat batteries will provide a scalable, low-cost alternative for a large proportion of the housing stock. Any heating solution will be supported by rooftop solar PV.

This will be underpinned by a smarter dynamic tariff system that will enable a fairer and more efficient approach to energy use. The technology exists and the regulatory framework is in place so the objectives of the policies of fuel poverty and net zero could be released much quicker than their current projections.

If full electrification of our homes cannot be achieved, then consideration should be given to partial electrification and re-examining decarbonising part of the gas network and the expansion of the heat network sector through geothermal. This is outside the scope of this paper but is an issue that should at least be considered when taking forward the conclusions of this paper and not assume that full electrification should come at any cost if that is not possible.

ANNEXES

Annex 1 – CMAX Methodology

The approach taken can be explained in the flow diagram below (Figure 15). It is looking at what income a household has available to spend on retrofit, what are the optimum retrofit measures that can be fitted within this budget, and if this is aggregated over a defined area what is the total cost and impact to that area.

Input data is coloured pink in the flow diagram and an explanation of each is given below and in Section 3.

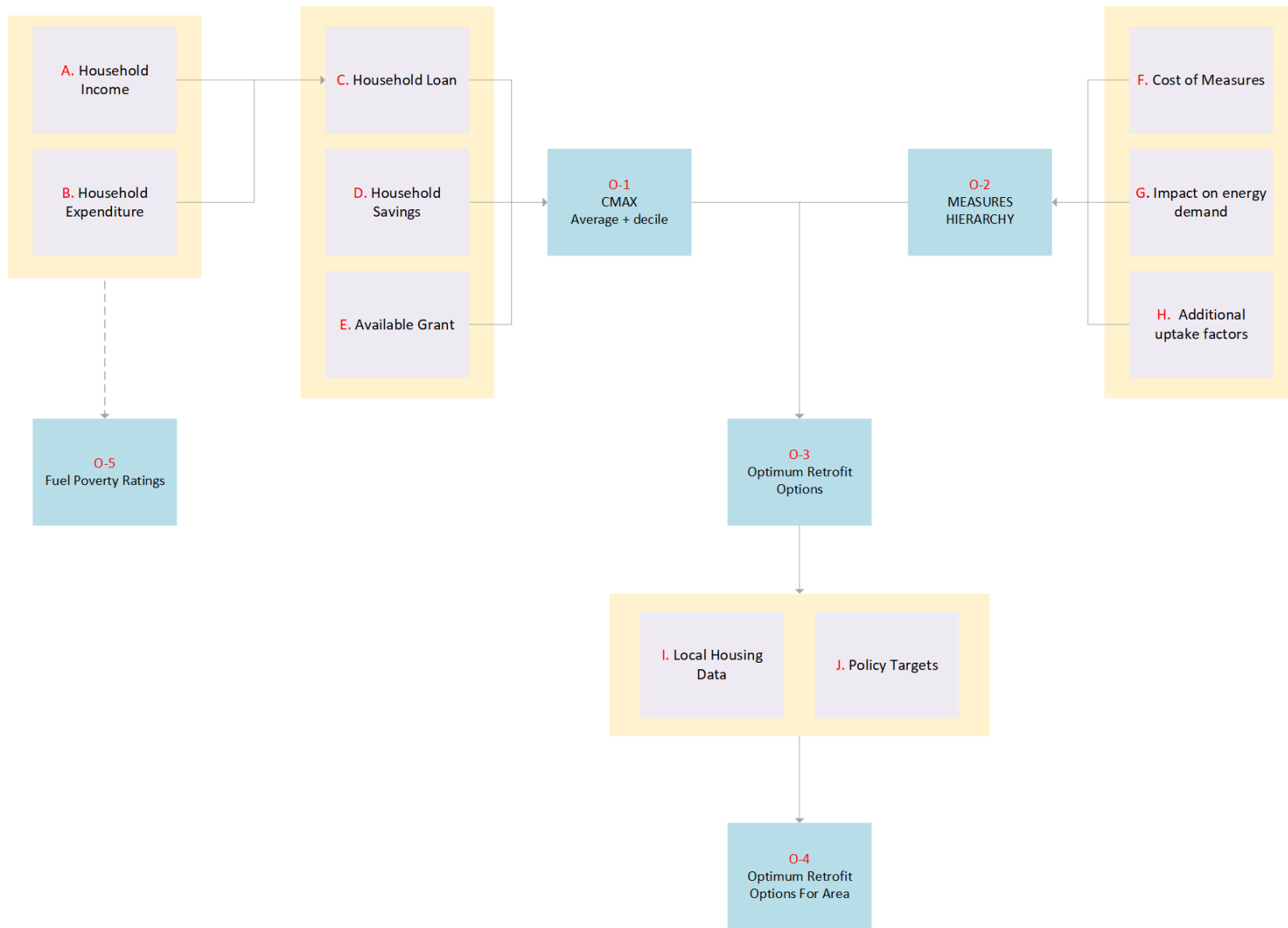


FIGURE 34- METHODOLOGY FOR OPTIMUM RETROFIT

- A. This is the income available to all occupants in a home that are over the age of 18 and broken down by deciles. It is gross income before any housing costs are deducted and averaged over the UK. The data can be split by household occupant.
- B. This is all expenditure households will incur, including housing costs, food, transport and recreation. It is broken down by decile and averaged over the UK.
- C. Taking the balance from A and B above, and using historical financial data to ascertain what (i) the typical size of loan is taken across the different decile groups, (ii) what the interest rate and payback period is and (iii) what households are willing to spend money on, a capital figure for retrofit measures can be obtained.
- D. Using historical financial data, we can see how much savings households will have which can supplement any capital budget obtained from a loan (C above).
- E. Grants could be available to help low-income households, or those in the lowest deciles. Grants are limited so will only be able to help a small number of households, but they could be targeted to help the most in need.
- F. Data has been compared from construction sources on all of the retrofit measures available. This effectively gives a look up table when considering how to spend any available budget. Further detail is given in Section 2.
- G. Each of the potential retrofit measures are graded on their potential to reduce energy demand. Further detail is given in Section 2.
- H. Other factors will determine if a retrofit is viable, including their complexity, disruption to the flow of a house, and desirability. Further detail is given in Section 2. This will help to produce the measure hierarchy, item O-2 in the flow diagram.
- I. This input is only required if looking at an area-wide retrofit scheme. The housing data looks at the profile of homes in the area looking at archetypes by decile, and what their EPC is.
- J. Policy targets change over time and Section 3 introduces different policy approaches

FIGURE 15 – METHODOLOGY FOR OPTIMUM RETROFIT

Annex 2 – CMAX Calculations

Flowchart Reference	Row Reference		Median	1	2	3	4	5	6	7	8	9	10	Notes - Source Data & Calculations
		Loan												
A	a	Average household disposable income	36,663	15,948	16,874	22,366	27,380	31,868	36,663	42,040	48,358	56,456	71,077	1
O-5	b	Maximum monthly energy bill for fuel poverty threshold	306	133	141	186	228	266	306	350	403	470	592	2
B	c	Average household weekly expenditure	623	307	318	430	483	569	607	696	753	878	1,195	3
	d	Average household annual expenditure	32,412	15,948	16,520	22,344	25,126	29,562	31,554	36,187	39,161	45,677	62,150	4
	e	Annual spare budget	4,251	0	354	22	2,254	2,306	5,109	5,853	9,197	10,779	8,927	5
	f	Monthly spare budget	354	0	29	2	188	192	426	488	766	898	744	6
	g	% used for savings	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	7
	h	Amount used for savings	30	0	2	0	16	16	36	41	64	75	62	8
	i	Monthly budget available for retrofit	325	0	27	2	172	176	390	447	702	823	682	9
	j	Minimum loan threshold (needs to be at least 50)	50											
	k	Years of loan (max 15)	5	5	5	5	5	5	5	5	5	5	5	10
	l	Interest rate	4	4	4	4	4	4	4	4	4	4	4	11
C	m	Loan capital available	16,289	0	0	0	8,144	8,144	19,004	21,719	38,009	43,438	35,294	12
		Savings												
	n	Saving based on wealth statistics - household financial wealth	40,990	0	1,100	1,300	3,500	7,600	16,100	29,100	47,000	85,800	218,400	13
	o	% of savings to be used	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	8.4%	14
D	p	Amount of savings to be used	3,427	0	92	109	293	635	1,346	2,433	3,929	7,173	18,258	15
		Grant												
E	q		0											
		Total												
O-1			19,716	0	92	109	8,437	8,779	20,350	24,152	41,938	50,611	53,552	

- 1 Table 3. The effects of taxes and benefits on household income, disposable income estimate, UK, 2023/24. ONS. Decile 1 N/A so use same figure as expenditure
- 2 Uses fuel poverty definition of 10% of income, then split by month.
- 3 Table 3.1, Row 386. Workbook 1 - Expenditure by Household Characteristics. ONS
- 4 Above weekly expenditure multiplied by 52

- 5 Annual expenditure minus income
- 6 Annual spare budget divided by 12
- 7 Workbook 1 has an entry but low sample rate so used UKEA savings data, table S14, ONS. Took average over last 20 years.
- 8 % multiplied by spare monthly budget
- 9 Monthly surplus minus savings amount

- 10 Personal loans average upto 5 years. Money supermarket.
- 11 Average mortgage from 2005. Source Bank of England. High was 6.4%, Low was 1.3%.
- 12 This is a PMR calculation based on interest rate, loan length and monthly budget available. Average loan improvement loan is £12,298.42. Money Supermarket

- 13 House of Parliament research report number 10210
- 14 Used above entry and assumed this rate as this is what people are comfortable setting aside.
- 15 % multiplied by savings amount.

How is CMAX calculated

Row **a** is obtained from national data with the exception of Decile 1 which was not available, so the income figure was made the same as outgoings.

Row **b** is 10% of the figures obtained for **a** to understand what a monthly bill for each Decile would be. This is for information only as actual expenditure is included in **c**.

Row **c** is taken from national data

Row **d** takes the figures from **c** and multiplies it by 52 (as it was a weekly figure) to get the annual figure. National data is comprehensive and includes all expenditure by households

Row **e** is figure **a** minus figure **d**

Row **f** is figure **e** divided by 12 so we have a monthly figure of what spare budget is available

Row **g** is taken from national data, and the amount people typically save from their income. Averaged data from the last 20 years.

Row **h** multiplies the % figure from **g** with the spare monthly budget from **f** to understand how much will be used for savings.

Row **i** is figure **f** minus figure **h** so we know what spare budget from regular income is available for retrofit

Row **j** sets a reasonable minimum load repayment amount to avoid using too small a figure

Row **k** is the number of years a loan could be taken out for – using figure **i** to make monthly repayments. The length of loan used is based on a typical length of a personal loan from Money Supermarket data. Even green loans attached to mortgages would unlikely exceed this length.

Row **l** is loan interest rate using Bank of England data that has been averaged since 2005.

Row **m** calculates how much capital can be raised using the above variables. Firstly, if figure **i** is less than **j** then no loan is taken out as the amount of budget available each month is too small. If it is larger, then it takes this amount and uses it as the monthly repayment amount in a standard PMR calculation, with the loan length being **k** and interest rate **l**.

Row **n** is the first step to see how much savings would be available to top up the capital amount found by **m**. Figure **n** is total savings available for each Decile. Uses data published by House of Parliament research which in turn uses national data. For the Median figure, Decile 10 was discounted as this was viewed as an outlier.

Row **o** is a repeat of **g** and is the % amount people would be willing to take out of their long-term savings to convert to working capital for retrofit.

Row **p** is the % figure **o** multiplied by **n**

Row **q** is how much grant is available for each Decile. This has been set to zero for now as grant programmes are still being developed but once there is certainty a figure can be included. Grants are only likely to be available for Deciles 1 to 3.

The final CMAX figure is **m** plus **p** plus **q**

Annex 3 – Criteria for CMAX ranking

	Score	1	2	3	4	5
Range of effectiveness (U value reduction)	Criteria	Less than 0.5	Between 0.5 and 1	Between 1 and 1.5	Between 1.5 and 2	Greater than 2
Complexity	Criteria	Works involve (i) alterations to over 50% of the walls (internal or external) (ii) will significantly disrupt the airflow and ventilation of the original building design or (iii) any modifications to any structural component	Works involve (i) alterations to between 25% and 50% of the walls (internal or external) (ii) will disrupt the airflow and ventilation of the original building design or (iii) any minor modifications to any structural component	Works involve (i) alterations upto 25% of the walls (internal or external) (ii) will disrupt the airflow and ventilation of the original building design or (iii) any minor modifications to any structural component	Works involve (i) disruption to the airflow and ventilation of the original building design	Does not require an energy specialist
Disruption	Criteria	Works could last weeks and involve some disruption to the movement of residents	Works could last at least a week and involve some disruption to the movement of residents	Works take between 3 and 7 days and may involve disruption to the movement of residents	Works take up to 3 days and may involve disruption to the movement of residents	Works take up to 1 day with minimal disruption to the movement of residents
Desirability	Criteria	Not a favourite measure with residents	Residents are slightly against	Residents are neutral	Residents are slightly in favour	Strong favourite measure with residents
Cost	Criteria	Over £15,000	Between £8,000 and £15,000	Between £3,000 and £8,000	Between £1,000 and £3,000	Less than £1,000

Annex 4 – EMAX Tables and Data Sources

Duel fuel	Y
Electricity Standing charge (p) ¹⁰	53.68
Gas Standing charge (p) ¹⁰	34.03
Non-heating tariff (p/Wh) ¹⁰	26.35
Heating tariff (p/kWh) ¹⁰	6.29
Heating & HW % ^{5,11}	81%
Non-heating energy	19%
Heating COP ¹²	0.85
Housing costs ⁶	17%

Average total energy bill	1,794 ^{8,9}
Ofgem price cap 31 Dec 2025	1,755 ¹⁰
Ofgem average consumption	14,200 ¹¹

Energy Bills as % of income. Anything red exceeds current 10% fuel poverty indicator

Income Deciles¹ Before and After Housing Costs⁶

1	2	3	4	5	6 ⁴	7	8	9	10
15,948	16,874	22,366	27,380	31,868	36,663	42,040	48,358	56,456	71,077

User Type ⁷	Homes ⁷ (m)	kWh ⁷	13,237	14,005	18,564	22,725	26,450	30,430	34,893	40,137	46,858	58,994
LU1	N/A	5,000	870	942	942	942	942	942	942	942	942	942
LU2	N/A	6,000	980	1,052	1,052	1,052	1,052	1,052	1,052	1,052	1,052	1,052
LU3	N/A	7,000	1,090	1,162	1,162	1,162	1,162	1,162	1,162	1,162	1,162	1,162
LU4	N/A	8,000	1,200	1,272	1,272	1,272	1,272	1,272	1,272	1,272	1,272	1,272
LU5	N/A	9,000	1,310	1,382	1,382	1,382	1,382	1,382	1,382	1,382	1,382	1,382
LU6	N/A	10,000	1,420	1,492	1,492	1,492	1,492	1,492	1,492	1,492	1,492	1,492
D11	1.20	11,264	1,631	1,631	1,631	1,631	1,631	1,631	1,631	1,631	1,631	1,631
A2	0.67	12,313	1,746	1,746	1,746	1,746	1,746	1,746	1,746	1,746	1,746	1,746
B6	0.92	13,553	1,883	1,883	1,883	1,883	1,883	1,883	1,883	1,883	1,883	1,883
A1	0.58	13,675	1,896	1,896	1,896	1,896	1,896	1,896	1,896	1,896	1,896	1,896
A3	0.88	14,141	1,947	1,947	1,947	1,947	1,947	1,947	1,947	1,947	1,947	1,947
DZ1	N/A	14,600	1,998	1,998	1,998	1,998	1,998	1,998	1,998	1,998	1,998	1,998
H20	3.54	14,820	2,022	2,022	2,022	2,022	2,022	2,022	2,022	2,022	2,022	2,022
DZ2	N/A	16,000	2,152	2,152	2,152	2,152	2,152	2,152	2,152	2,152	2,152	2,152
C7	0.66	16,768	2,236	2,236	2,236	2,236	2,236	2,236	2,236	2,236	2,236	2,236
C9	3.41	17,022	2,264	2,264	2,264	2,264	2,264	2,264	2,264	2,264	2,264	2,264
D10	1.16	17,862	2,357	2,357	2,357	2,357	2,357	2,357	2,357	2,357	2,357	2,357
E14	1.18	18,676	2,446	2,446	2,446	2,446	2,446	2,446	2,446	2,446	2,446	2,446
I21	2.21	19,531	2,540	2,540	2,540	2,540	2,540	2,540	2,540	2,540	2,540	2,540
D12	1.46	20,017	2,594	2,594	2,594	2,594	2,594	2,594	2,594	2,594	2,594	2,594
J23	1.96	20,862	2,687	2,687	2,687	2,687	2,687	2,687	2,687	2,687	2,687	2,687
E13	0.69	21,797	2,790	2,790	2,790	2,790	2,790	2,790	2,790	2,790	2,790	2,790
I22	1.79	23,214	2,946	2,946	2,946	2,946	2,946	2,946	2,946	2,946	2,946	2,946

Standard Elec³

Economy⁷

22.51

Income Deciles¹ Before and After Housing Costs⁶

1	2	3	4	5	6	7	8	9	10
15,948	16,874	22,366	27,380	31,868	36,663	42,040	48,358	56,456	71,077

User Type ⁷	Homes ⁷ (m)	kWh ⁷	13,237	14,005	18,564	22,725	26,450	30,430	34,893	40,137	46,858	58,994
LU1	N/A	5,000	7%	7%	5%	4%	4%	3%	3%	2%	2%	2%
LU2	N/A	6,000	7%	8%	6%	5%	4%	3%	3%	3%	2%	2%
LU3	N/A	7,000	8%	8%	6%	5%	4%	4%	3%	3%	2%	2%
LU4	N/A	8,000	9%	9%	7%	6%	5%	4%	4%	3%	3%	2%
LU5	N/A	9,000	10%	10%	7%	6%	5%	5%	4%	3%	3%	2%
LU6	N/A	10,000	11%	11%	8%	7%	6%	5%	4%	4%	3%	3%
D11	1.20	11,264	12%	12%	9%	7%	6%	5%	5%	4%	3%	3%
A2	0.67	12,313	13%	12%	9%	8%	7%	6%	5%	4%	4%	3%
B6	0.92	13,553	14%	13%	10%	8%	7%	6%	5%	5%	4%	3%
A1	0.58	13,675	14%	14%	10%	8%	7%	6%	5%	5%	4%	3%
A3	0.88	14,141	15%	14%	10%	9%	7%	6%	6%	5%	4%	3%
DZ1	N/A	14,600	15%	14%	11%	9%	8%	7%	6%	5%	4%	3%
H20	3.54	14,820	15%	14%	11%	9%	8%	7%	6%	5%	4%	3%
DZ2	N/A	16,000	16%	15%	12%	9%	8%	7%	6%	5%	5%	4%
C7	0.66	16,768	17%	16%	12%	10%	8%	7%	6%	6%	5%	4%
C9	3.41	17,022	17%	16%	12%	10%	9%	7%	6%	6%	5%	4%
D10	1.16	17,862	18%	17%	13%	10%	9%	8%	7%	6%	5%	4%
E14	1.18	18,676	18%	17%	13%	11%	9%	8%	7%	6%	5%	4%
I21	2.21	19,531	19%	18%	14%	11%	10%	8%	7%	6%	5%	4%
D12	1.46	20,017	20%	19%	14%	11%	10%	9%	7%	6%	6%	4%
J23	1.96	20,862	20%	19%	14%	12%	10%	9%	8%	7%	6%	5%
E13	0.69	21,797	21%	20%	15%	12%	11%	9%	8%	7%	6%	5%
I22	1.79	23,214	22%	21%	16%	13%	11%	10%	8%	7%	6%	5%

Standard Elec³

Economy⁷

22.51

Average FP for archetypes

10%

1 Table 3. The effects of taxes and benefits on household income, disposable income estimate, UK, 2023/24. ONS. Decile 1 N/A so use same figure as expenditure.

2 <https://assets.publishing.service.gov.uk/media/67e3eae39c9de963bc39b482/consumption-level-review-march-2025-methodology.pdf>

3 <https://assets.publishing.service.gov.uk/media/67e3eae39c9de963bc39b482/consumption-level-review-march-2025-methodology.pdf>

4 [Average household income, UK - Office for National Statistics](#)

5 Nesta states 78% <https://www.nesta.org.uk/project/finding-ways-to-deliver-cheaper-electricity-by-rebalancing-levies/how-different-households-use-energy/> Ofgem suggests 81%

6 Table 3.1, Row 386. Workbook 1 - Expenditure by Household Characteristics. ONS

7 https://www.ofgem.gov.uk/sites/default/files/2024-02/Ofgem_archetypes_update_2024_FinalReport_v4.1.3.pdf.

DZ1 is DESNZ March 2025 average energy use for standard electricity and DZ 2 is DESNZ March 2025 for economy 7. LU1 to LU6 are categories of low energy use to reflect new build standards.

8 Addition of 2024 weather adjusted gas bill, Table 2.3.5, and electricity bill Table 22.5. and electricity bill <https://www.gov.uk/government/statistical-data-sets/annual-domestic-energy-price-statistics>

9 [National Energy Efficiency Data-Framework \(NEED\): Summary of analysis, Great Britain, 2025](#)

10 [Energy price cap explained | Ofgem](#)

11 <https://www.ofgem.gov.uk/information-consumers/energy-advice-households/average-gas-and-electricity-use-explained> .Have not included in table as close to archetype A3.

12 Heating for gas would normally have a COP of no greater than 0.9 but this is relative to other forms of heating as the vertical axis is energy used not heat needed.

Is the load threshold for most direct or resistive electric heating, and the consumption that leads to the Ofgem price cap figure

Annex 5 – Summary of EMAX Scenarios

		Electricity Standing charge (p)	Gas Standing charge (p)	Non-heating tariff (p/Wh)	Heating tariff (p/kWh)	Heating COP	Number of target archetypes in fuel poverty	Average FP rating for archetypes
A	Baseline Gas + Electric	53.68	34.03	26.35	6.29	0.85	5	10%
B	Baseline reduced energy prices only	53.68	34.03	15.00	4.10	0.85	0	7%
C	Baseline reduced energy and standing prices	25.00	25.00	15.00	5.60	0.85	0	7%
D1	ASHP baseline high COP	53.68	N/A	26.35	26.35	2.70	8	10%
D2	ASHP baseline low COP	53.68	N/A	26.35	26.35	2.20	9	11%
E1	ASHP reduced energy prices split tariffs - high COP	53.68	N/A	19.00	15.00	2.70	0	7%
E2	ASHP reduced energy prices split tariffs - low COP	53.68	N/A	17.00	13.00	2.20	0	7%
E3	ASHP reduced energy prices single tariff - high COP	53.68	N/A	16.50	16.50	2.70	0	7%
E4	ASHP reduced energy prices single tariff - low COP	53.68	N/A	14.50	14.50	2.20	0	7%
F1	ASHP reduced energy and standing prices, split tariffs high COP	25.00	N/A	20.00	16.00	2.70	0	7%
F2	ASHP reduced energy and standing prices, split tariffs low COP	25.00	N/A	19.00	14.00	2.20	0	7%
F3	ASHP reduced energy and standing prices, single tariffs high COP	25.00	N/A	18.00	18.00	2.70	0	7%
F4	ASHP reduced energy and standing prices, single tariffs low COP	25.00	N/A	15.80	15.80	2.20	0	7%
G	Heat battery baseline, split tariff	53.68	N/A	26.35	13.00	1.00	0	12%
H1	Heat battery reduced energy prices, split tariffs	53.68	N/A	20.00	8.00	1.00	0	8%
H2	Heat battery reduced energy prices, single tariffs	53.68	N/A	10.00	10.00	1.00	0	8%
I1	Heat battery reduced energy and standing prices, split tariffs	25	N/A	15.00	10.00	1.00	0	8%
I2	Heat battery reduced energy and standing prices, single tariffs	25	N/A	10.00	10.00	1.00	0	7%

Average

17.0

13.4

CLEAR Futures is a collaboration of Lewes and Eastbourne Councils with AECOM and Robertson delivering sustainable infrastructure and services to the UK public sector.

CLEAR Sustainable Futures is a JV between AECOM and Robertson Capital Projects delivering the activities of CLEAR Futures