Rethinking Energy Demand

Heating and Cooling of Buildings

Policy Briefing

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GEF GREEN EUROPEAN FOUNDATION

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Introduction

This policy briefing is published in January 2023, in the midst of winter and a cost-of-energy crisis in Europe. The energy crisis follows a summer of record high temperatures across Europe that increased demand for cooling.

Ensuring everyone has living space that they can maintain at temperatures safe for human health should be a government priority. This is particularly important at times of high energy prices. Heating and cooling also accounts for around half of all energy consumption and 38% of carbon emissions across Europe,[1] so is a priority area for climate action. Retrofit[2] is certainly an essential part of the solution, including both whole house insulation (the lighter end of retrofit) and a full rollout of deep retrofit including heat pumps and solar hot water systems. However, retrofit alone should not be seen as the 'fix'. Much wider policy changes will be required due to short- and long-term constraints on energy availability.

This policy briefing draws from the earlier 'Rethinking Energy Demand' report (October 2022)[3] and from the expert interviews conducted for that report. The earlier report considered the need and means to sufficiently reduce energy demand. This policy briefing invites policy makers to extend their thinking beyond the immediate crisis towards a longer-term strategy for delivering the human need for thermal comfort whilst eliminating carbon emissions. It is often assumed that this needs at least the same amount of heat as provided now, with a focus on finding different energy sources and technologies. This report challenges this assumption and others that define the current 'need' for heat, before exploring how to meet a new definition of need with less energy overall.

This policy briefing is for policy makers, campaigners and active citizens, and intended as a guide to the policy challenges and options around heating and cooling. The scope includes space heating and cooling as well as hot water provision in homes and other buildings, but excludes the commercial cold chain, refrigeration and industrial process heating. This briefing presents relevant case studies and policy proposals in distinctive 'Policy' boxes, a list of which is given at the end.

The 2022 energy crisis has driven action by governments across Europe to reduce reliance on Russian gas. This led to a European Union target to reduce energy use by 15% between August 2022 and March 2023.[4] A variety of measures are being adopted to support this, from highly visible initiatives such as turning off the lighting of the Eiffel Tower and the Brandenburg Gate to directives to reduce office temperatures and calls on the public to reduce home energy usage.[5] The UK government's response has been slower, with delays to a public information campaign and limited insulation and deeper retrofit programmes following a decade of inaction. With two-thirds of UK homes under-insulated,[6] the need for stronger leadership is clear.

However, this report takes a broader look, beyond the immediate crisis, to think differently about the need for space heating and cooling in the future. Retrofit is a time-consuming process that requires significant investment and long-term commitment. There is also a risk of a rebound in energy use, especially if prices fall. A deeper questioning of habits, lifestyles and priorities could help to ingrain and extend the practices and thinking adopted this winter. This requires a whole range of policies that take a broader view of how our human need for thermal comfort may be met both now and in the future, as is discussed in this briefing.

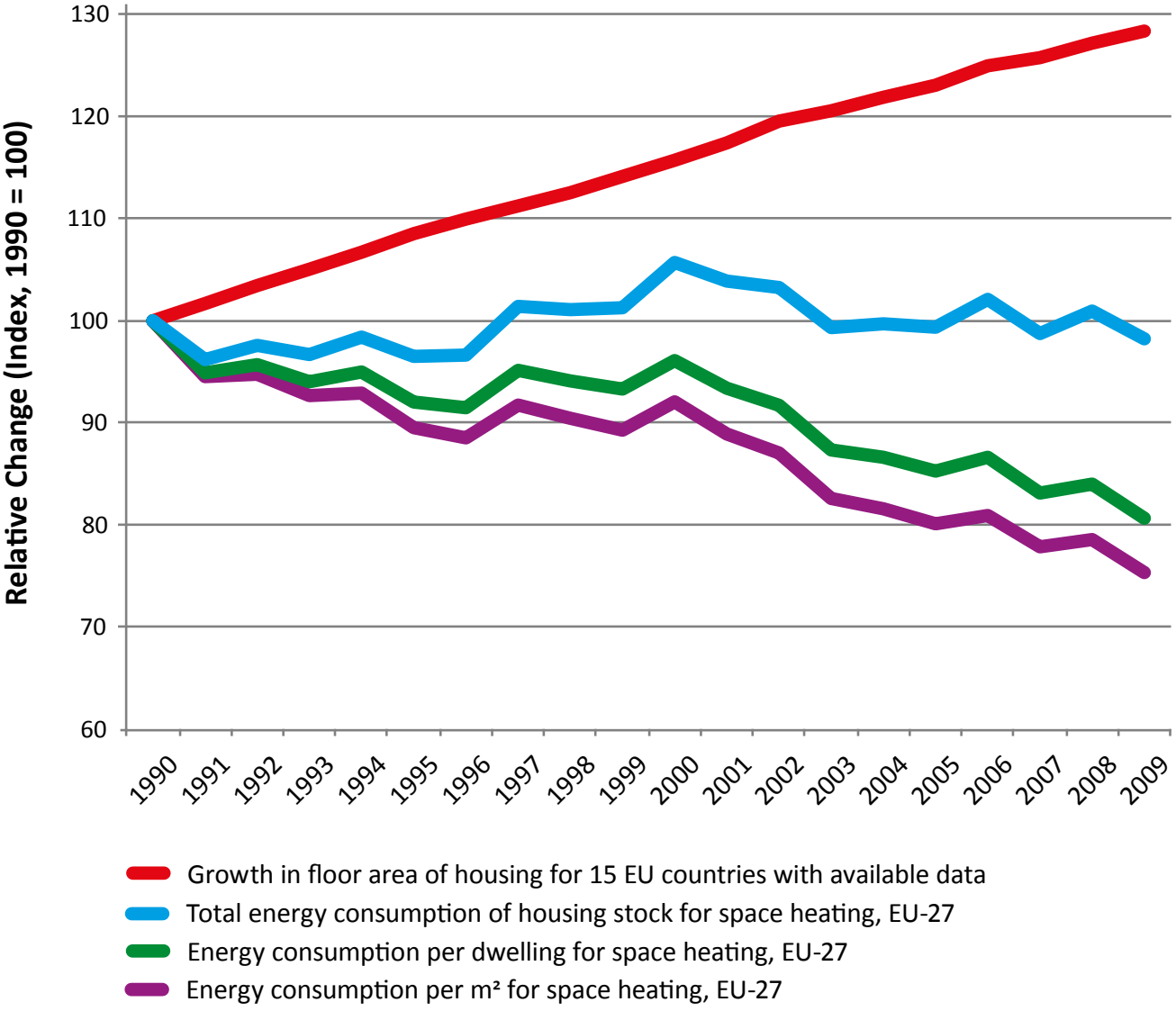
1 IEEE European Public Policy Committee (2018) 'Heating and Cooling Future of Europe and Interactions with Electricity'. *IEEE*.
2 'Retrofit' is sometimes used to refer to house insulation only, but this report uses it to refer to adding energy efficiency measures and renewable energy to existing buildings.
3 Essex, J, Sims, P, and Storey, N (2022) 'Rethinking Energy Demand'. *Green European Foundation* and *Green House Think Tank*.
4 Rankin, J (2022) 'EU agrees plan to reduce gas use over Russia'. *The Guardian*.
5 O'Carroll, L, et al. (2022) 'What are European countries doing to cut power consumption'. *The Guardian*.
6 Rowlatt, J (2022) 'UK must move faster to insulate homes – climate chief'. *BBC News*.

Section 1: Context

Energy for Heating Homes is Not Reducing

The total energy used for heating homes in the UK increased by a quarter between 1970 and 2010, despite a nearly 25% reduction in heat loss per dwelling. Since 2015, no reductions in annual carbon emissions from buildings have been observed.[7] This is due to two main factors: firstly, average internal winter temperatures increased by 4.9°C (partly due to more central heating) and, secondly, the total amount of space being heated increased as more homes were built.[8] Together these have negated the impact of the uptake in insulation during this period. The doubling of the difference between the average winter internal and external temperatures has roughly halved the effectiveness of the insulation in reducing *overall* heat loss. Similarly, Figure 1 shows that, between 1990 and 2012, the increase in housing floor area across Europe completely offset the reduction in energy demand per dwelling and per m² of floor area.

Figure 1: Energy Consumption for Space Heating and Floor Area of EU Housing, 1990-2009[9]



7 zu Ermgassen, SOSE, et al. (2022) 'A home for all within planetary boundaries: pathways for meeting England's housing needs without transgressing national climate and biodiversity goals'. *SocArXiv*.

8 Palmer, J, and Cooper, I (2012) 'United Kingdom housing energy fact file 2012'. *Department of Energy & Climate Change*, pp.44, 55. Heat loss reduced from 376W/°C to 287W/°C per dwelling between 1970 and 2012.

9 European Environment Agency (2012) 'Trends in Heating Energy Consumption and Energy Efficiency of Housing, EU-27'.

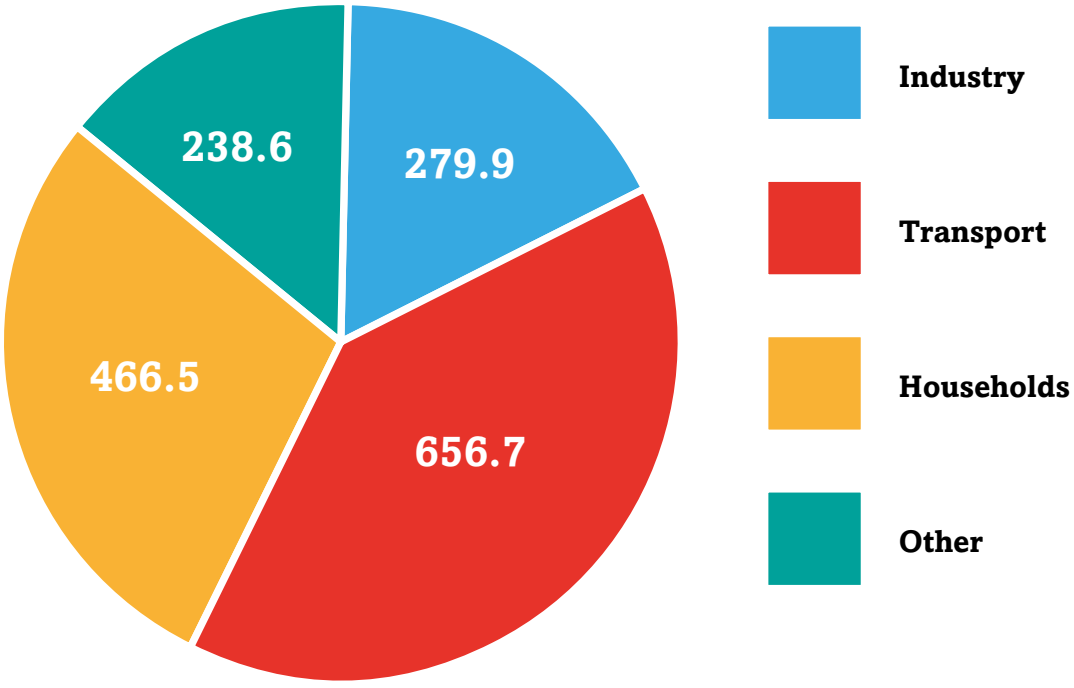
Government Responses Focus on Technology, not Demand Reduction

International climate scenarios for delivering 1.5°C do not incorporate significant changes in energy demand.[10] Similarly, national climate models tend to under-represent the potential to reduce energy demand.[11] Policies to decarbonise heating and cooling tend to over-emphasise technological solutions, as in the European Union's Heating and Cooling Strategy.[12]

This technical approach risks change being too slow (as outlined in the October 2022 'Rethinking Energy Demand' report [13]) and it must also take into account Europe's 'fair share' of the minerals and rare earth metals needed for renewable energy infrastructure.[14] This 'fair share' may need to be lower than currently projected to limit the ecological damage of mining.[15] Taking these constraints into account, the rollout of renewables and heat pumps to the domestic sector should be prioritised over non-essential industry. This could be undermined if incentives to industry mean they secure funding for retrofit before poorer homes and community buildings.

There is also a risk that industry will be prioritised before homes because 70% of total energy use in the UK is not by households, as shown in **Figure 2**. The equivalent average figure across the EU is 74% with a range from 87% in Luxembourg to 65% in Estonia.[16] Yet, consideration needs to be given to which sectors within industry are sufficiently necessary in delivering wellbeing – current (high) energy use should not dictate retrofit priority. Looking specifically at heating, domestic buildings account for around half of the carbon emissions (see **Table 1**), and their heating has large direct impact on wellbeing. If all sectors are considered together when rethinking demand, the need to prioritise domestic retrofit becomes clear.

Figure 2: Breakdown of UK Energy Consumption (TWh) by Sector (2017 data for energy, not just heat)[17]



10 Warszawski, L, et al. (2021) 'All options, not silver bullets, needed to limit global warming to 1.5 C: A scenario appraisal'. *Environmental Research Letters* 16(6), p.064037.
11 Pye, S, et al. (2021) 'Modelling net-zero emissions energy systems requires a change in approach'. *Climate Policy* 21(2), pp.222–231.
12 European Commission (no date) 'Heating and cooling' (accessed: 16 Jan 2023).
13 Essex, J, Sims, P, and Storey, N (2022) 'Rethinking Energy Demand'. *Green European Foundation* and *Green House Think Tank*.
14 Green European Foundation (2021) 'Metals for a Green and Digital Europe' (accessed: 16 Jan 2023).
15 Sonter, LJ, et al. (2020) 'Renewable energy production will exacerbate mining threats to biodiversity'. *Nat Commun* 11, 4174
Eyre, N, and Killip, G (2019) 'Shifting the focus: energy demand in a net-zero carbon UK'. *Centre for Research into Energy Demand Solutions*.
16 Odyssee-Mure (2019) 'Final energy consumption by sector in EU'.
17 Eyre, N, and Killip, G (2019) 'Shifting the focus: energy demand in a net-zero carbon UK'. *Centre for Research into Energy Demand Solutions*.

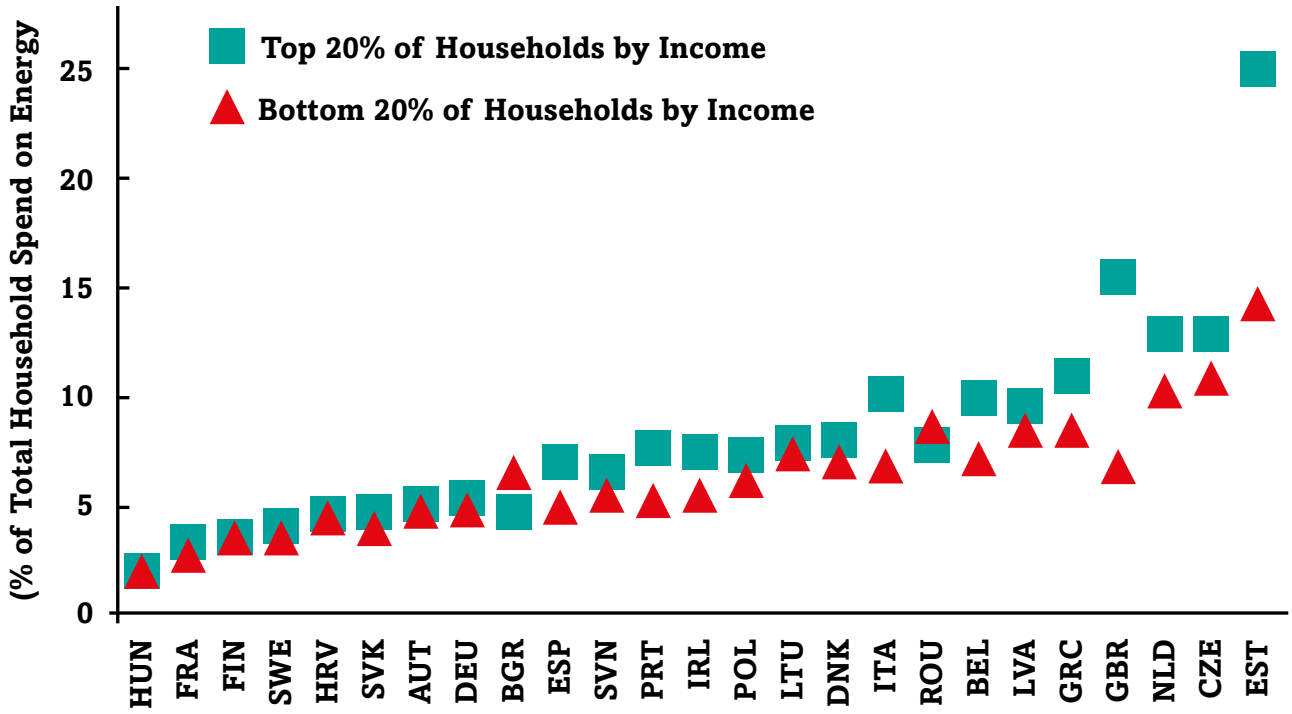
Table 1. Split of Carbon Emissions of Heat between Domestic and Other Buildings[18]

GHG emissions/ $MtCO_2e$	Gas	Oil	Solid fuel	Electricity	Total	*Percentage of total*
Domestic	61	9	3	14	87	*48*
Services	15	3	0	19	37	*20*
Industrial	18	7	5	28	59	*32*
Total	94	19	8	61	182	*100*

The Inequality of Keeping Warm

Higher energy prices typically hurt poorer households more than rich ones. The Progressive Economic Forum estimated that in 2022 spending of disposable income on energy in the UK hit lowest income households hardest: 47% for the poorest 10%, over twice the figure for the richest 10%.[19] The Social Policy Research Unit at York University calculated that 63% of UK households could be at risk of fuel poverty once the £400 rebate scheme from the UK government ends in March 2023.[20] Comparing household spending on energy across Europe shows that inequality is now greatest in Estonia and the UK, followed by Italy and Belgium (see **Figure 3**). In the EU, the Social Climate Fund partially addresses the inequality issue but falls short compared to a Universal Energy Allowance.[21]

Figure 3: Burden of Domestic Energy Costs Across Countries
(% of Total Household Spend on Energy for Top 20% (Q5) and Bottom 20% (Q1) of Households by Income)[22]



18 Department of Energy & Climate Change (UK) (2012) 'UK emissions from heat'.
19 Progressive Energy Forum (2022) 'New PEF Research Shows Energy Price Guarantee Failure'.
20 Bradshaw, J, and Keung, A (2022) 'Rising Fuel Poverty'. *University of York*. Fuel poverty is defined as over 10% of net income after housing costs spent on fuel.
21 European Parliament (2022) 'Deal on establishing the Social Climate Fund to support the energy transition'.
22 Ari, A, et al. (2022) 'Surging Energy Prices in Europe in the Aftermath of the War: How to Support the Vulnerable and Speed up the Transition Away from Fossil Fuels'. *IMF*.

Thermal Comfort as a Basic Need

Humans need to maintain their internal body temperature to survive and this becomes more difficult in extremes of heat and cold, particularly when physically inactive. This means that indoor temperatures need to be controlled to a level that is safe for health. As such, heating and cooling sufficient to avoid temperature extremes can be seen as a basic human need; however, the amount required varies when taking into account different levels of mobility, health, geography and local climate conditions. By contrast, other energy intensive activities such as flying and long-distance driving can be seen as relative luxuries. These should be constrained to ensure all basic energy needs can be met.

Policy A: Universal Energy Allowance

A Universal Energy Allowance would be an amount of energy provided free of charge or at a lower cost to all homes. Once homes have been retrofitted, this allowance would ensure every household is able to meet its basic energy needs. Although the allowance would be available to all, for the vast majority of people it would be claimed on a household basis as part of an energy supply contract. Each household would be allocated a set amount of energy based on the number of occupants.

The monthly allowance could vary between summer and winter, but is likely to only meet a proportion of most household energy use. The cost of free units should be funded by higher energy prices for energy above the allowance. Such an increase in energy prices beyond the basic allowance would help discourage excessive energy consumption. This could be increased in multiple steps [a rising block tariff] but this may create additional complexity for diminishing gain. To be truly universal it needs to accommodate different ways of sourcing energy [e.g. living off grid or nomadically], and be combined with increased support for vulnerable households with higher energy needs.

Section 2: Rethinking Heat

Taking a Sufficient Approach: Avoid-Shift-Improve[23]

Reducing energy demand for heat has to go far beyond the retrofit of buildings, restructuring of pricing and addressing fuel poverty, which are all well documented. To sufficiently reduce demand requires coordinated interventions to reconsider the appropriate temperatures to which buildings are heated and cooled alongside revised building standards. It also requires a reconsideration of cultural norms and an exploration of how a commoning of energy and the implementation of wider economic policies could help to avoid a rebound effect (see **Section 6**).

However, the European Commission's current approach is centred around efficiency, technological improvements and circularity – without significant focus on changing lifestyles and reducing demand. In the EU, whilst the Fit for 55 policies are a crucial first step to achieve the 1.5°C target of the Paris Agreement, they are insufficient to achieve the required target of reducing high-income footprints in the EU by 91–95% by 2050. This is because current policies are framed in terms of individual action without a holistic vision of what constitutes sustainable ways of living.[24] Similarly, UK energy policy, which focuses on energy supply options rather than a systemic approach, should be reversed and demand-side solutions given at least equal weight.[25]

The Avoid-Shift-Improve hierarchy of sufficiency is useful for prioritising efforts to transform the energy demand of heating and cooling buildings. This could be summarised as:

1. Avoiding the need for heat by stopping increasing the area of space that is heated and cooled (**Section 3**) and by reducing the amount of heating and cooling of these spaces (**Section 4**).

2. Shifting culture and daily practices including through sharing and repurposing space, with greater use of community buildings and public space, and shifting what people wear *inside* as temperatures change *outside* (**Section 4**).

3. Improving building energy efficiency and end fossil fuel heating and cooling. This requires two very different types of building thermal improvement to be made simultaneously:

- Draught proofing and basic insulation improvements (**Section 4**)
- Scale-up and accelerate 'deep retrofit' and accelerate rollout of technology solutions such as heat pumps (**Section 5**).

23 Essex, J, Sims, P, and Storey, N (2022) 'Rethinking Energy Demand'. *Green European Foundation* and *Green House Think Tank*, Figure 1, p.23.

24 Timmer, V, et al. (2022) 'How to Talk with Policymakers About 1.5°C Degree Lifestyles'. *ZOE-Institute for future-fit economies*, *OneEarth Living*, *Hot or Cool Institute* and *Climate Outreach*.

25 Eyre, N, and Killip, G (2019) 'Shifting the focus: energy demand in a net-zero carbon UK'. *Centre for Research into Energy Demand Solutions*.

Section 3: Repurposing Buildings Instead of Building More

Experiencing a cost-of-living crisis offers the potential to open up the discussion on how our societies manage energy to address the climate crisis.

Stop Building More

Repurposing spaces (as discussed above), retrofit (**Section 5**) and changing temperature norms (**Section 6**) will not reduce overall energy use whilst it is still offset by building and heating ever more homes and other buildings (see **Policy B**). Whilst the EU Energy Performance in Buildings Directive (EPBD) has reduced final energy use/m^2 in buildings, the number and size of buildings is still rising[26] which is increasing the overall need for heating and cooling.

This means shifting housing policy away from the dream of single (detached) houses outside or on the outskirts of a city, which require more energy to heat and cool (see **Policy C**).

Policy B: Restrict New Construction

Planning restrictions on new builds could be introduced for certain classifications of indoor space. Restricting new building would force existing buildings to be better utilised, refurbished and converted to new uses. Such restrictions would also redirect skills, materials and labour towards retrofit activities and limit the emissions peak expected to arise from the rapid increase in construction activity to build renewable energy infrastructure.

Policy C: Set a Maximum Space for New Homes and Legalise Micro-Housing

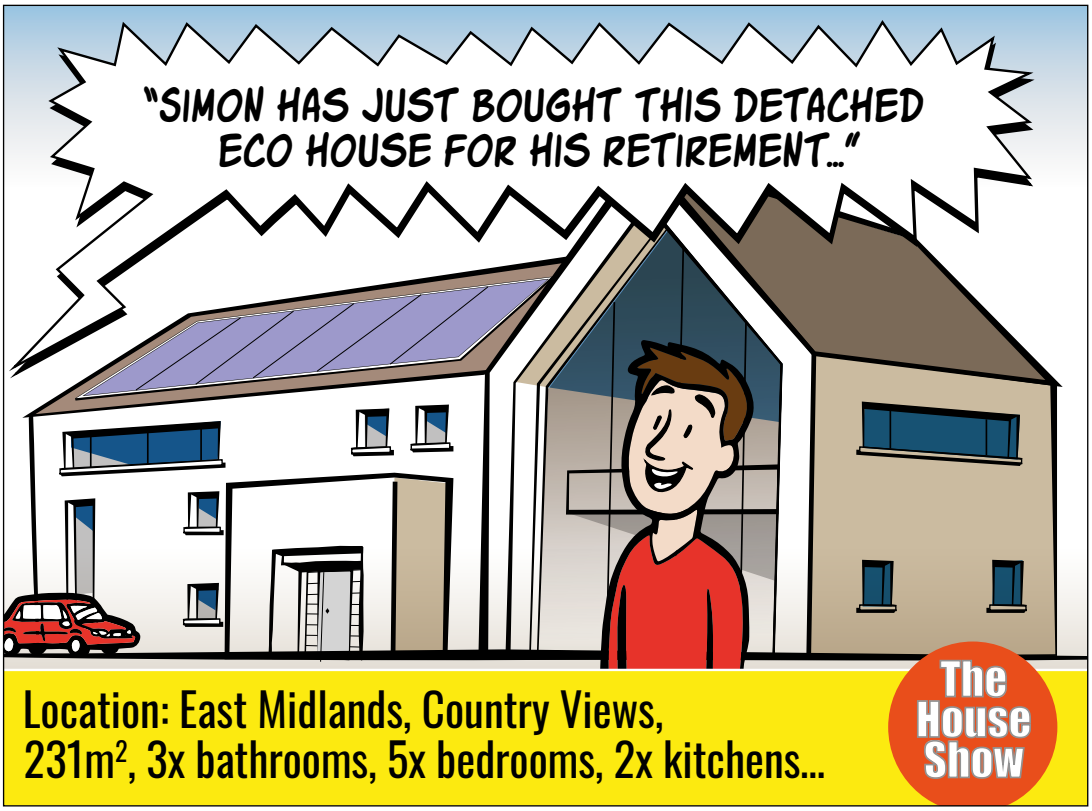
Minimum space standards for new housing continue to be set at levels that are higher than researchers are advising from the point of view of energy use.[27,28] *In addition to setting a maximum space for new homes, this set of planning policies prioritises multi-family buildings over single-family homes in new developments and permits micro-housing alongside communal space and facilities.* [29]

This will also help to shift the construction industry from prioritising new-build to becoming retrofit dominated, focusing on improving what is already built. This will in turn reduce the need to produce so much high-carbon material including steel, cement and bricks.[30]

Redistributing Space and Empowering Tenants

Instead of building more, our societies could better share and utilise existing buildings. For example, living space is currently unequally distributed: the poorest often live in crowded spaces whilst other people under-occupy larger homes. By 2011 the most spaciously housed decile of the population of England had five times the rooms per person than the lowest decile.[31] A Hot or Cool 1.5-Degree Lifestyles report calls for reductions in housing space per person such as from 41m^2 to 27m^2 in Finland and from 39m^2 to 24m^2 in the UK.[32] Co-housing provides users with a shared space

26 European Commission (no date) 'Energy performance of buildings directive' (accessed: 16 Jan 2023). This is currently undergoing revision, led by Ciarán Cuffe MEP.
27 Department for Communities and Local Government (UK) (2015) 'Technical housing standards – nationally described space standard'.
28 Akenji, L, et. al. (2021). 'Towards a Fair Consumption Space for All'. *Hot or Cool Institute*.
29 Kichanova, V (2019) 'Size Doesn't Matter: Giving a Green Light to Micro-Homes'. *Adam Smith Institute*.
30 Essex, J (2014) 'How to Make Do and Mend our Economy'. *Green House Think Tank*.
Blewitt, J, and Cunningham, R (Eds) (2014) *The Post-growth Project: How the End of Economic Growth Could Bring a Fairer and Happier Society*. Green House, pp.71–105.
31 Dorling, 2015, cited in zu Ermgassen, SOSE, et al. (2022) 'A home for all within planetary boundaries: pathways for meeting England's housing needs without transgressing national climate and biodiversity goals'. *SocArXiv*.
32 Akenji, L, et. al. (2021). 'Towards a Fair Consumption Space for All'. *Hot or Cool Institute*.



(e.g. for laundry, offices, guest rooms and dining rooms) to minimise the need for private space and reducing resource consumption.[33]

There are also other challenges to address. It is common for residents in a block of flats to have limited or no control over a shared heating system, and some tenancy contracts are inclusive of energy bills which removes the financial incentive to use less energy. These wider systems also need to be addressed to facilitate collective change to lifestyles and to ensure that landlords and tenants have a shared incentive to reduce energy use. The same applies to rental of office, retail and other commercial space (see **Policy E**).

Policy D: Incentivise Downsizing and Multiple Occupancy

Policy options include a property tax proportional to m² per person, or per m² of heated or cooled commercial space. Such an approach would apply sufficiency principles to indoor space allocation. Other measures should restrict the ownership of second homes and incentivise bringing empty homes back into regular use. This could sit alongside progressive energy pricing (see **Policy A***) to incentivise downshifting. Similarly, the Universal Energy Allowance can be expected to further encourage co-habiting.*

Policy E: Incentivise Energy Efficiency Measures by Private Landlords

Minimum energy efficiency standards should be enforced, and energy performance certificate (EPC) loopholes and over simplifications be addressed.[34] Taking this further, a tax levied against landlords based on the number of EPC ratings below the optimum would provide financial incentive to invest in retrofit.

33 Saheb, Y (2022) 'Beyond Efficiency and Renewables: Sufficiency Matters to Limit Global Warming by the End of the Century to 1.5°C'. *OpenEXP*.

34 The Domestic Minimum Energy Efficiency Standard (MEES) Regulations in the UK set minimum energy efficiency levels for rented homes, with enforcement delegated to councils – Department for Business, Energy & Industrial Strategy (UK) (2017, updated May 2020) 'Domestic private rented property: minimum energy efficiency standard - landlord guidance'.

Sharing and Repurposing Indoor Spaces

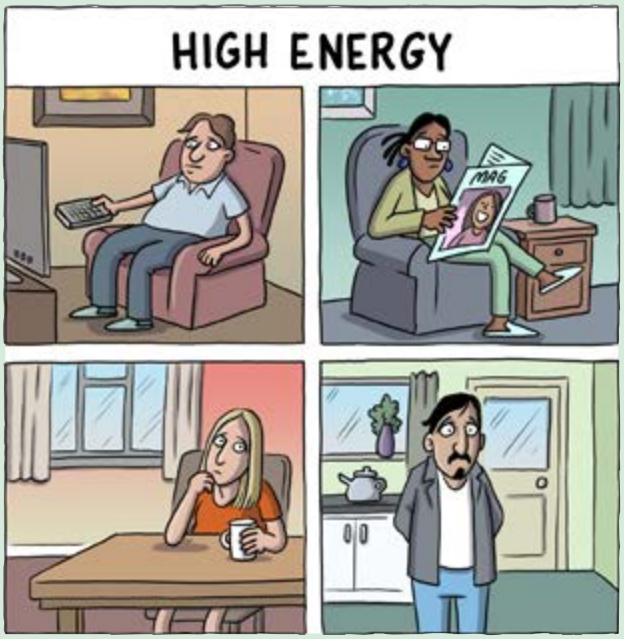
Addressing the cost-of-living crisis should start with the retrofit of all community buildings and other public spaces in order to provide the social infrastructure that is critical for ensuring sufficient comfort for all. Reversing the loss of community spaces associated with increasing loneliness (see **Box 1**) in parallel with the retrofit of community buildings (see **Policy F**) could help address the current challenges of cost of living and the climate impact of home heating.

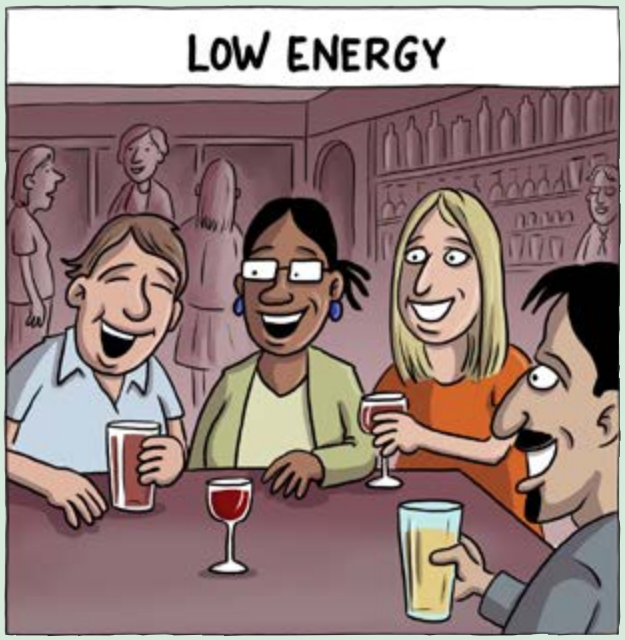
Increasing the occupancy of community buildings would reduce the need to heat individual homes and reduce excessive energy use because less floor area is being heated overall and community buildings can be retrofitted faster than all homes. Bringing diverse groups of people together can also foster increased understanding and a sense of community. Similarly, repurposing existing buildings to serve as work hubs could support increased local working rather than long-distance commuting. However, to avoid the negative associations of the provision of warm spaces with fuel poverty, this aspect should be seen only as a short-term aim. The longer-term goal should be to foster the expansion of space for the purpose of building community, with sharing warm space and associated energy saving as a co-benefit (see **Box 2**).

Such an approach would lead our societies to better value and utilise all shared spaces. This should not only be libraries, schools, health centres, places of faith, and government and community

Box 1: Decline of Public Spaces and Increase in Loneliness in the UK

Responding to the current cost-of-living crisis by strengthening community hubs would also help address the social crises around loneliness and care. Research in the UK found that 43% of people do not feel part of the community where they live, with the lack of community facilities given as the second highest reason for community decline.[35] Similarly, post-Covid research found that **95%** of young people in the UK feel lonely: a **6%** increase in a year.[36] Over the years there has been a decline in community buildings, with more non-domestic buildings becoming privately owned or only accessible by club members. This includes a number of public spaces: loss of pubs and village halls, consolidation of cinemas to larger urban centres, and a reduction in community and youth centres.





35 London Post (2022) 'UK Communities on the brink of decline as two fifths feel disconnected'.

36 Co-op Foundation (2022) 'New research reveals youth loneliness on the rise'. Co-op Foundation researchers spoke to 2,000 10–25-year-olds from across the UK for *'A Friend in Need'*.

centres, but also shared local office space for home workers to meet, shared workshops, and pubs as places to drink together rather than at home. Increasing the utilisation of indoor public space could reduce energy use and could be seen as an indirect '*commoning* of warmth' alongside social benefits (see **Policy F**).

Box 2: Community Buildings – for Work, Socialising, Warmth and Wellbeing

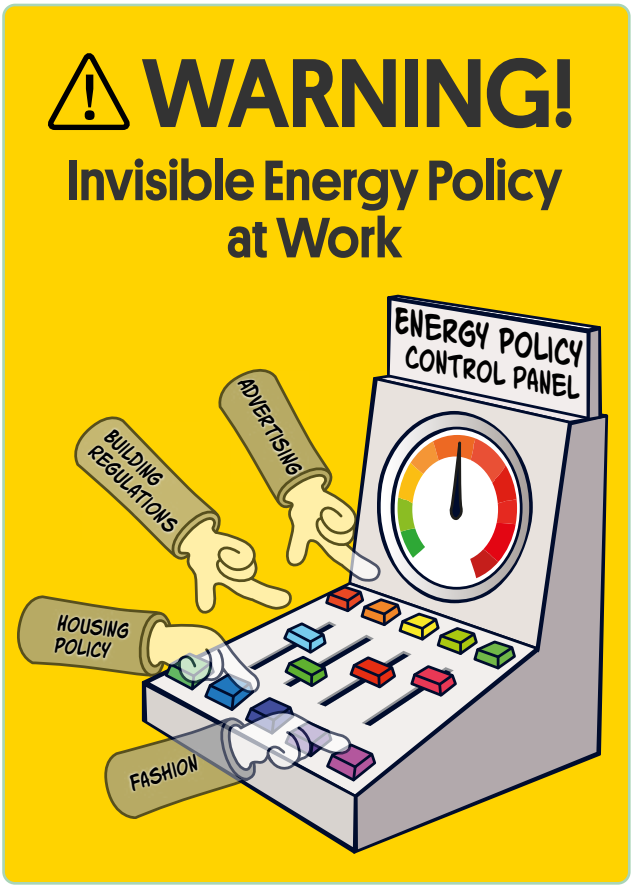
During the 2022/2023 winter, UK charitable organisations and councils are publishing local listings of *warm hubs* as 'warm, safe places where residents can gather during the cost-of-living crisis'.[37]

This focus on a shift to utilising public over private space could form just one part of a wider motivation to rebalance the public/private split in the economy. A reversal of the trend towards commercially owned and run social spaces – from sports clubs and gyms to shopping malls – which centre consumerism in people's lives, could also create more community-focused spaces. An increase in collective provision would be facilitated by both increased taxation to finance better services and reduced consumption of private goods (thus freeing up resources – such as goods or raw materials – to make a revived public sector possible). Such a shift to more collective provision will enable the redistribution needed as the economy shrinks as it is decarbonised.[38] The way low-carbon lifestyles are communicated should also reflect the need to address existing inequality in access to heating, cooling and indoor space.

Policy F: Increase Access to Warm Community Spaces

Under this policy, existing community spaces will be prioritised for retrofit to make these spaces heat-efficient as well as comfortable to spend time in.

In addition, a stronger approach to corporate responsibility could encourage privately owned businesses (for example sports and social clubs as well as business premises) to make a greater commitment to supporting their local community. One way they could do this is by making their space available to the community at particular times at low or no cost. This would help to bridge the gap between those with the means to belong and those who are currently excluded from these spaces.



37 Warm Spaces and Warm Welcome.
38 See Murphy, R (2022) 'We are entering a new political era. The only problem is that very few politicians seem aware off this'. *Tax Research UK*.

Section 4: Changing Social Practices and Making Energy Policies Visible

Resetting the Thermostat

To meet their citizens' basic needs, along with the needs of future generations, it is crucial that European countries enact policies that reduce the demand for heating in all buildings – whilst addressing fuel poverty for those with not enough heating. To do this, overall demand for heating (and cooling) needs to be reduced rather than just focusing on changing the sources of heat. This means going beyond retrofit, heat pumps and other measures that improve the efficiency of heating. First, expectations around heating and cooling must be challenged. Only then will ways of living shift, and energy demand be significantly reduced.

Increasingly, comfort in buildings is assumed to be simply delivering heating or cooling to reach a set temperature range. This ignores how much space is heated, what type of heat is provided, or the impacts of clothing, occupancy levels or soft furnishings.

'Citizens do not need air conditioning but the right to heat a comfortable home.'

On the cooling side, energy-consumption data suggests the total volume of *deliberately air-conditioned* space is increasing around the world.[41] Office buildings in London are now designed on the basis that they need air conditioning to be sold.[42] The existence of the globally accepted indoor temperature standards for mechanically controlled buildings is the main driver for the proliferation of air conditioning.[43] Anything different is now regarded as uncomfortable even though previous generations might have had varying preferences around the amount of clothing and the warmth or coolness of their rooms. In the past, for example, the siesta in Southern Europe was a form of adaptation to the high temperatures in the middle of the day. Cultural homogeneity has now taken over from this.[44]

Box 3: The CLO: How 18–22°C has been Normalised as a Range for Heating Buildings

Buildings are still being designed to be comfortable wearing one CLO (one layer of clothing), which was originally defined as equivalent to wearing a man's traditional business suit. Research in the 1920s led to the ASHRAE Standard 55 being incorporated into worldwide building standards, based on the CLO and targeting 21–22°C as the optimal temperature assuming this clothing.[39] This is now embedded in building regulations, giving an expectation of this temperature year-round, regardless of outside temperature.[40] Given that this style of clothing is no longer a cultural norm (and never was for women), that there is variation in comfort temperatures between people and the need to reduce amount of space heating, this underlying assumption needs to be challenged. The potential for adapting clothing, and for door curtains and heavy winter window curtains to reduce heat loss, is excluded from such standards.

39 Faulconbridge, J, et al. (2016) 'Standards, design and energy demand: the case of commercial offices'. *DEMAND*.
40 Rinkinen, J, et al. (eds) (2019). *Energy fables: Challenging ideas in the energy sector*. Routledge. Chapter 2.
41 Shove, E, et al. (2014) 'Material culture, room temperature and the social organisation of thermal energy'. *Journal of Material Culture* 19(2), pp.113–124.
42 Cass, N (2017) 'Energy-related standards and UK speculative office development'. *Building Research and Information* 6(46). DOI:10.1080/09613218.2017.1333351.
43 European temperatures have increased far slower than the rate of air conditioning installations.
44 Shove E (2012) 'Energy Transitions in Practice: The Case of Global Indoor Climate Change', in *Governing the Energy Transition*. Routledge. Similarly, the amount of freezer space is increasing, which is tied to a global system of frozen food provisioning.

Policy G: Adopt the Adaptive Comfort Model

This policy proposes adopting the Adaptive Comfort Model in place of the ASHRAE Standard 55 for building regulations. This is an alternative global standard for the design and operation of naturally ventilated buildings and has delivered energy savings worldwide.[45] *It encourages individuals to adapt via clothing appropriate to the temperature (see* **Policies K–M***).*

In 2022 pressure to reduce energy use led to new policies across Europe. [46] In Germany, public buildings have turned down their thermostats to 19°C and outside illuminated advertising must be turned off between 10pm and 6am.[47] Spain has legislated to reduce heating in non-domestic buildings, reflecting earlier experience reducing energy use in Japan (see **Box 4**). In contrast, analysis by Imperial College London showed far less reduction in natural gas use in the UK than across Europe. From September to November 2022 the UK's gas demand was just 0.3% lower than would have been expected pre-energy crisis, after accounting for weather anomalies.[48]

Policy H: Limit Non-Domestic Heating and Cooling

Offices and other non-domestic buildings typically use air conditioning much more than is needed. A maximum temperature to heat to and a minimum temperature to cool to should be introduced, as implemented in Spain in August 2022.

Box 4: New Laws to Limit Heating and Cooling between 19–27°C in Japan and Spain

Spain's response to the combination of limits on European imports of gas and oil and record temperatures, such as 45°C in Grenada and 50°C in Cordoba, has been to bring in new laws to curb heating and cooling in various buildings and premises: administrative, commercial, cultural, entertainment, restaurants and transport. The new Spanish law, introduced in August 2022, limits heating to up to 19°C and cooling to not below 27°C.[49] There are also calls in Spain to rethink working hours, such as re-establishing the culture of a siesta, including physical works on construction sites and to rethink how schools address heat waves.[50]

This follows on from the Japanese government decision in 2005 to no longer heat or cool its buildings between 20 and 28°C. It encouraged its employees to adjust their clothing instead, with Environment Ministers demonstrating seasonal wear on the catwalk.[51]

45 For example: Centre for the Built Environment (no date) 'Adaptive Comfort Model' (accessed: 16 Jan 2023).
46 Short- and medium-term measures to reduce energy use in heat include reducing room temperatures and hot water use whilst installing intelligent thermostats and controlling ventilation – Best, B, et al., trans. Bonhage, A, and Stefan Scheuer Consulting (2022) 'Saving energy as the key to energy security – sufficiency as a strategy'. *Future Earth*.
47 For example, see Osborne Clarke (2022) 'Energy saving requirements are emerging across Europe'.
48 Penman, H (2022) 'UK lagging behind Europe in slashing demand for gas'. *Energy Voice*.
49 Orihuela, R (2022) 'Spain's Curbs on Aircon Become Law in Bid to Restrict Energy Use'. *Bloomberg UK*.
50 Kassam, A (2021) 'Spain to launch trial of four day working week'. *The Guardian*.
51 Shove E (2012) 'Energy Transitions in Practice: The Case of Global Indoor Climate Change', in *Governing the Energy Transition*. Routledge, p.68.

Insulation and Draught Busting Now

Efforts could be made to quickly upgrade insulation and eliminate draughts alongside policy interventions that make it more culturally attractive to use less energy. These should not wait for the finance, planning, skills and delivery of more expensive, deeper retrofit, nor for new technologies. The former can happen whilst the latter progress.

To do this, practical measures should include those that are relatively inexpensive and easy to deliver, such as increasing the thickness of loft insulation, installing cavity wall insulation (where still absent and appropriate), measures to eliminate draughts, installing thermostatic radiator valves and so on. The same principles of combining subsidies and incentives for improvements alongside clear messaging to shift culture should be applied to the use of all other buildings. This will require a detailed and varied mix of changes (physical, practice and associated policies) to public sector, office, retail, industrial and commercial premises as well as community spaces, including changes set out in **Policy I**.

Policy I: Stop Excessive Heating of Outdoor Spaces

Ban the use of patio heaters and the heating of un-insulated temporary spaces such as marquees. Shop doors would also be closed by default to prevent the wasteful practice of heating space outside the premises.

Policy J: Implement Retrofit and Behaviour Change Policies Together

A joined-up package of policies that quickly delivers basic minimum energy efficiency standards to all buildings must be linked to incentives, such as a voucher scheme for low-income households and a VAT reduction on DIY roof insulation.[52] *As a package, this will build understanding of retrofit as an essential process and could accelerate demand for deeper retrofit.*

Personal Insulation

In developing policy, rather than starting from current norms, it is possible to expect new behaviours to develop fairly quickly once they start being practised:

'Demand is derived from social practices: it is made and not simply met.'[53]

To maximise energy conservation outcomes, basic energy saving measures should be combined with changes in how people live and dress in different seasons (see **Box 5**).

'One layer of thermal long underwear allows you to turn down the thermostat [by] at least 4°C, saving up to 40% on space heating energy.'

52 The UK government reduced VAT on installation in the 2022 Spring Budget, but this does not include a reduction on materials for DIY-ers. HM Revenue and Customs (UK) (2022) 'Policy paper: The Value Added Tax (Installation of Energy-Saving Materials) Order 2022'.

53 Rinkinen, J, et al. (2020) *Conceptualising demand: A distinctive approach to consumption and practice*. Routledge.

Box 5: Clothing as an Approach to Heating

UNEP recognises the powerful influence of the fashion industry and its responsibility to communicate in ways that match the goal of reducing over-consumption. An additional approach would be for the fashion industry, together with producers of advertising and TV programmes, to lead on demonstrating appropriately warm clothing being worn indoors. The public would be encouraged to adopt this practice, in support of recommendations to reduce indoor home heating to 16°C in line with minimum office temperatures. Kris de Decker calculated that adding a layer of thermal long underwear could enable around a 40% energy saving through turning the thermostat down by 4°C.[54] A key task would be to make this acceptable and common practice. A 1993 report, following escalating energy prices at that time, found that older adults seeking thermal comfort in their homes did use clothing to some extent but that there was greater prevalence of the use of thermostat controls and supplemental heating appliances.[55] Another study in 2015 noted that stylishness and projection of identity through clothing was important in all age groups, hence the need for the fashion and communications industries to work together to support an attitudinal shift.[56]

There is also a need for the fashion industry and TV producers to shift from marketing summer clothing in winter (through programmes such as Love Island which, with its links to social media, has been shown to have a huge direct impact on viewers' purchasing behaviour[57]), and for greater changes to the thermal properties of clothing as the seasons change.

Policy K: Lower Minimum Temperature Guidance for Home Heating

Update guidance on the recommended minimum for home heating to 16°C (rather than 18–22°C), matching UK health and safety guidance for office temperatures.[58] Compared to a typical thermostat setting of 21°C this would significantly reduce heating demand. Education around the need for ventilation to prevent mould is needed alongside recommendations to reduce temperatures to (but not below) this level in the home.[59] Additional guidance may be required for those with medical conditions.

Policy L: Tax Incentives and Public Information for Weather-Appropriate Clothing

A combination of tax incentives and public information can help to align what is seen as fashionable concerning functionally appropriate clothing. For example, thermal layers and jumpers made from sustainable materials could be exempt from VAT. This will be part of a wider policy approach to clothing, aimed at reversing the trend in Europe for the ever-increasing consumption, washing and disposing of clothing, all of which contributes to emissions.[60]

54 De Decker, K (2011) 'Insulation: first the body, then the home'. *LOW-TECH MAGAZINE*.
55 Khan, S, et al. (1993) 'Older adults: clothing preferences for thermal comfort in cold weather'. *Journal of Consumer Studies and Home Economics* 17(2), pp.187–195.
56 Childs, C et al. (2015) 'Old and Cold: Challenges in the Design of Personalised Thermal Comfort at Home', in *Design 4 Health: Proceedings of the 3rd European Conference on Design4Health*.
57 Randell, L (2020) 'Love Island Stars "break rules" by wearing jumpers to film outside in chilly Cape Town'. *Mirror*.
Sherwood, J (2019) 'Love Island: How Amber Gill and Molly-Mae changed fashion'. *BBC News*.
58 Health and Safety Executive (no date) 'Temperature in the workplace' (accessed: 16 Jan 2023).
59 Ginestet, S, et al. (2020) 'Mould in indoor environments: The role of heating, ventilation and fuel poverty. A French perspective'. Building and Environment 169
60 Average carbon footprint/capita for fashion for European countries range from 374kg (UK) and 264kg (Germany) to 146kg (France). Coscieme, L, et al. (2022) 'Unfit, Unfair, Unfashionable: Resizing Fashion for a Fair Consumption Space'. *Hot or Cool Institute*.

Policy M: Advertising Controls to Reflect Seasonal Clothing

Restrict advertisements and TV programmes that reinforce the notion that it is normal to wear shorts and t-shirts indoors in winter, or that depict 'modern living' as wearing summer clothes all year round. Advertisers would be required to ensure that their output portrays people wearing suitable clothing for the weather at the time and location of airing.

Allowed

but encourages energy waste

Not Allowed

because it encourages obesity

Section 5: Retrofit Now!

Whole house insulation (elsewhere sometimes referred to as 'retrofit') and rollout of associated building technologies, such as heat pumps and solar hot water systems, both need to be massively scaled up now and delivered together. This task must prioritise low-income homes and community buildings and be supported with appropriate finance. And crucially it will need a rapid reskilling of workers to accelerate delivery and education of communities so that lifestyles and cultures can adapt with changes to buildings.[61,62]

The prominence of retrofit policies and programmes is inconsistent, and should have a far higher priority across Europe. Whilst a recent index contrasted retrofit progress across Europe, ranking Germany and Netherlands highest, none have sufficient policies in place to deliver the necessary carbon reductions.[63] The lack of action is highlighted by the situation in the UK where serious improvements to building standards and retrofit efforts should have started decades ago and where two-thirds of homes are still under-insulated (see **Box 6**) [64]

This accelerated rollout of deep retrofit should target areas with higher fuel poverty (low-income and less energy-efficient homes) first. Repurposing and retrofit of existing public and community buildings should also be prioritised as this could open up potential to heat fewer buildings overall (as noted in **Section 3**).

The 'fabric-first' approach to retrofit planning is critical, which means upgrading building insulation and wider thermal performance (improved air tightness and reduced thermal bridging) before investing in active technology solutions such as heat pumps. This must be implemented universally, and deal with different tenancy types. For instance, replacement of fossil fuel heating systems requires retrofit of all flats in a block together, not just those in fuel poverty or with particular tenures. And heat networks may be introduced in some circumstances, such as in high-density mixed-use developments and areas with geothermal potential. Such retrofit, of all public buildings as well as homes, for both heating and cooling, requires government leadership with:

- Clear targets and financial incentives with delivery plans that are accelerated and locally specific. The embodied carbon of this work must be factored into planning what is the best 'energy return for energy invested' to make sure these works deliver strong carbon benefits quick.
- A mindset of progressive improvements not (just) one-off changes. It is important that retrofit should precede or be delivered alongside a more rapid rollout of heat pumps (otherwise there is a risk of oversizing heat pumps) and a phase-out of fossil fuel heating (e.g. gas boilers).[65]
- Enabling buildings and lifestyles to better adapt to a future changing climate.
- Strengthening of building codes for new buildings: with a shift to passive forms of building design that remove the need for mechanical heating or cooling systems for new buildings. Air conditioning (including air source heat pumps) should be avoided for new buildings and their size limited in the retrofit of existing buildings. In assessing the benefit of heat pumps, the energy use and emissions of their operation and those embedded in their manufacturing and installation should be fully appreciated.

61 Ginestet, S, et al. (2020) 'Mould in indoor environments: The role of heating, ventilation and fuel poverty. A French perspective'. *Building and Environment* 169.

62 Average carbon footprint/capita for fashion for European countries range from 374kg (UK) and 264kg (Germany) to 146kg (France). Coscieme, L, et al. (2022) 'Unfit, Unfair, Unfashionable: Resizing Fashion for a Fair Consumption Space'. *Hot or Cool Institute*.

63 Kilgour, R, et al. (2022). 'Global Retrofit Index'.

64 Rowlatt, J (2022) 'UK must move faster to insulate homes – climate chief'. *BBC News*.

65 The IEA states that gas boilers should be banned no later than 2025 for the EU to be on track for its 2030 climate targets. The current deadlines are 2029 for the EU and 2035 for the UK. IEA (2021) 'Net Zero by 2050'; Ghantous, N (2022) 'Ditching gas boilers for heat pumps will take EU "well beyond next winter"', *Energy Monitor*; and Department for Business, Energy & Industrial Strategy (UK) (2021) 'Heat and buildings strategy'.

Retrofit should be accompanied by a shift in how buildings are heated, which will vary by country and geography. Whilst there will be some increase in use of efficient wood-burning stoves in rural areas, for the most part this will be a shift to electric heating, which is most efficiently delivered through heat pumps. The financial incentives and rate of deployment of heat pumps varies markedly across Europe. In 2020 only a small fraction of households had shifted away from gas- and oil-fired heating systems. There were around 265,000 heat pumps installed in the UK, 3.1 million in France, 2 million in Sweden and 1.1 million in Germany. The scale-up of heat pumps is expected to be significant. For example the UK Climate Change Committee estimates that nearly 19 million heat pumps will need to be installed to achieve net zero in the UK alone.[66] In the UK, rollout of heat pumps is constrained by the higher taxes (in the form of green levies)[67] on electricity than on gas. There is a need to increase the financial incentive to invest in heat pumps. The challenges in adapting daily practices to heat pumps and combining them with wider retrofit and changes in temperature norms are discussed in **Box 7**.

Box 6: UK as an Example of Government Failure to Properly Fund Insulation Measures

UK energy conservation has been starved of funding for a decade.[68] Current support is focused on low-income households and is still but a fraction of that required, with no overall strategy or plan. The latest British Energy Security Strategy barely says a word about demand reduction.[69] The failure of political leadership to properly fund insulation is highlighted by pressure for political action in the UK. Even the UK Conservative Environment Network is calling for mass retrofit of homes.[70] Greenpeace put it like this: *'Unless the government intervenes we will suffer every winter, while companies get richer. Energy companies have made £170 billion excess profits in the last two years. Government advisors have said it would cost just £55 billion to insulate all UK homes.'* [71]

66 Trask, A, et al. (2022) 'The Future of Home Heating: the roles of heat pumps and hydrogen'. *Energy Futures Lab*, *Imperial College London*, p.36.
67 8% of UK energy bills are due to green levies – Seabrook, V (2022) 'Green levies - why scrapping them wouldn't lower your bills as much as claimed'. Sky News.
68 The Green Deal policy introduced by the coalition government in the UK watered down proposals in the ground-breaking New Green Deal report, in a way that would never work. The aim was for a mass energy retrofit of homes through householder loans, procured through a number of big companies. But the interest rate was set at 6%, far higher than available from banks at that time, so the take-up was low and the scheme was quietly shelved.
69 Department for Business, Energy & Industrial Strategy and the Prime Minister's Office (UK) (2022) 'British energy security strategy'.
70 An announcement in August 2022 called for retrofit of 500,000 homes in the UK this winter – Conservative Environment Network (2022) 'Green Tories propose industry-led plan to combat winter gas crisis'.
71 Greenpeace (2022) 'The Cost of Living'. *YouTube*.

Box 7: Heat Pumps will Change How People Live in Buildings

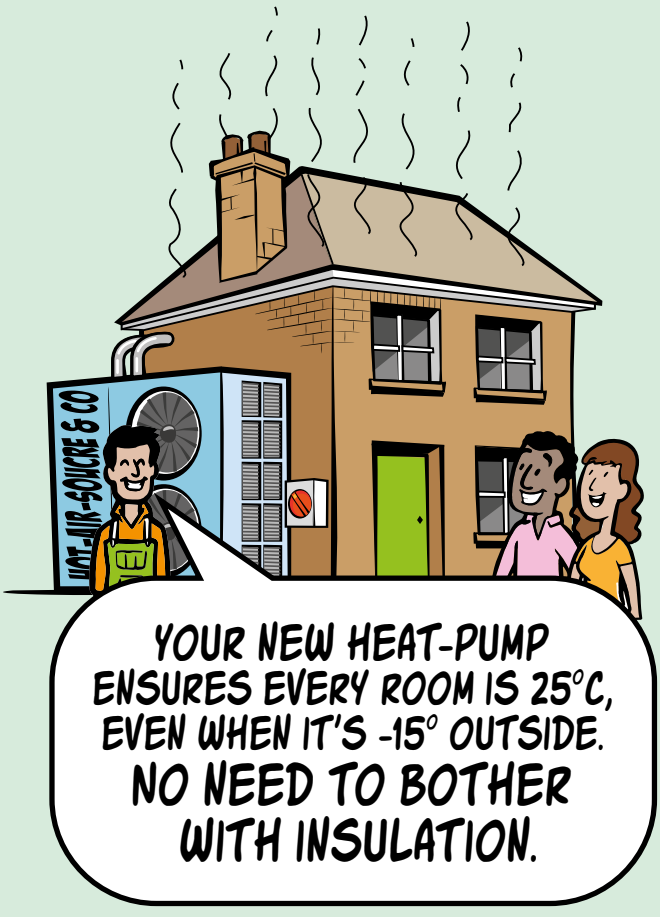
Heat pumps heat differently to conventional central heating systems. Heat pumps are best at generating consistent background heat via warm rather than hot radiators (or under-floor heating), which will result in less radiant heat than households are currently used to. This difference brings challenges:

- Adapting to different heat delivery requires a shift in behaviour and expectations, and changes to the rhythms and patterns of daily life.[72]
- There is a risk that households are not sufficiently informed about the difference in operation of heat pumps compared to gas boilers, so do not adapt their expectations or daily practices, and when it's too hot or too cold may not adjust the pump's settings but instead open windows or use additional heating (e.g. electric fan heaters).

In addition, the electrification of heating is likely to create peaks in electricity demand, so there may be a need to change people's daily practices and heating operation times.[73] Investing in electric cars alongside heat pumps could, in theory, provide storage capacity to power a home at times of peak electricity demand. However, in the longer term a shift towards shared access to vehicles (e.g. car sharing schemes or car clubs) alongside increased active and public travel will reduce the total number of cars.

There are other risks associated with installing and running heat pumps, and simply rolling out mass installation will not necessarily reduce energy demand sufficiently:

- New heating controls (as associated with smart meters or heat pumps) can lead to reduced energy demand in some instances but increased demand in others.
- Heat pump installations tend to be oversized to avoid the dissatisfaction that might result from needing secondary heating.
- Households might invest in a heat pump without first undertaking a full retrofit of the home, so energy demand is substituted rather than reduced.
- If the target room temperature is set the same the overall amount of energy used might be higher as a heat pump takes longer to reach the set temperature than a boiler and so will be turned on earlier. This means that, overall, the home will be heated for longer.



72 Carlsson-Hyslop, A, et al. (2016) 'Research Insights – Transitions in Heat: The arrival and disappearance of gas central heating'. DEMAND.
73 Hammer, C, et al (2019) 'How house hold thermal routines shape UK home heating demand patterns'. Energy Efficiency 12(1), pp.5-17.

Retrofitting housing stock would create alternative employment as damaging sectors are wound down whilst addressing the cost-of-living and climate crises together.[74] This requires a strong support in governance for, amongst others:

- Addressing the skills/labour gap[75]
- Securing the significant finance required
- Strengthening public incentives and support.

A first step towards this is for government to invest in training now, so that the number of skilled fitters increases over the next few years. This could include deploying the retrofit expertise of both energy companies (e.g. their gas boiler engineers could fit heat pumps) and community-based energy initiatives.[76]

Policy N: Prioritise Retrofit of Fuel-Poor Households First

Fuel-poor households generally have a low income and are living in energy inefficient housing. Retrofit should be prioritised for low-income housing [owner-occupied and privately rented], social housing, retirement homes, nursing homes and supported-living accommodation. Subsidies directed to those living in inefficient housing [alongside other support measures] would also help to pinpoint homes most in need of retrofitting. Prioritising these households first avoids the potentially regressive implications of relying upon behaviour change alone, as only the most affluent have the financial means to retrofit. However, to make the installation process as efficient as possible, private owners should be offered the opportunity for retrofit at the time it is being undertaken in their geographical area.

Policy O: Government Support to Accelerate Retrofit Programmes

Strong leadership and coordination are critical for:

- *Investing in skills training over the next few years to speed up rollout*
- *Government intervention to prevent 'overselling' of unnecessarily large heat pumps*[77]
- *Focusing the objective on reducing overall energy usage, not just switching from gas to electricity.*[78]

It is important for holistic policy to be developed that links heat pump installation to the sufficiency agenda to ensure that overall demand is reduced and a rebound effect is avoided.

74 Chapman A, Essex, J, and Sims, P (2018) 'Unlocking the Job Potential of Zero Carbon'. *Green House Think Tank*.
75 For example, see Ashden (no date) 'Retrofit: Solving the Skills Crisis' (accessed: 16 Jan 2023).
76 For example, see the Energy4All network for community energy co-operatives, and local groups such as Draught Busters.
77 Currently, the reliance on the private sector means that there is an incentive, both in terms of profit and customer satisfaction, for installation firms to sell oversized heat pumps rather than a combination of heat pumps and behaviour change.
78 The avoidance of secondary heat sources needs to be questioned. Supplementation of heat pumps with low-tech direct heat devices such as hot water bottles, electric blankets or heat pads – used to provide direct heat – may deliver comfort whilst reducing room temperatures, so reducing overall demand.

Section 6: Avoiding Rebound and Embedding Sufficiency

All the efforts set out above will not be sufficient if the energy and carbon saved in a reduced need for heating leads to a spike in home extensions, fast-fashion or flights. That is, unless heat policies are set in a wider context, there is a risk of both direct and indirect rebound (see **Box 8**). A broad joined-up view is needed with complementary policies introduced across different areas.

As outlined in the 'Rethinking Energy Demand' report,[80] adopting an emergency governance approach could enable multiple changes to be made at the same time. The emergency framing works both on a practical level to make change happen fast and on a cultural level to signify the importance of addressing societal norms around energy demand – including the need to be fair both globally, between the global north and south, and within individual countries. Sufficiency needs to become a culturally embedded value.

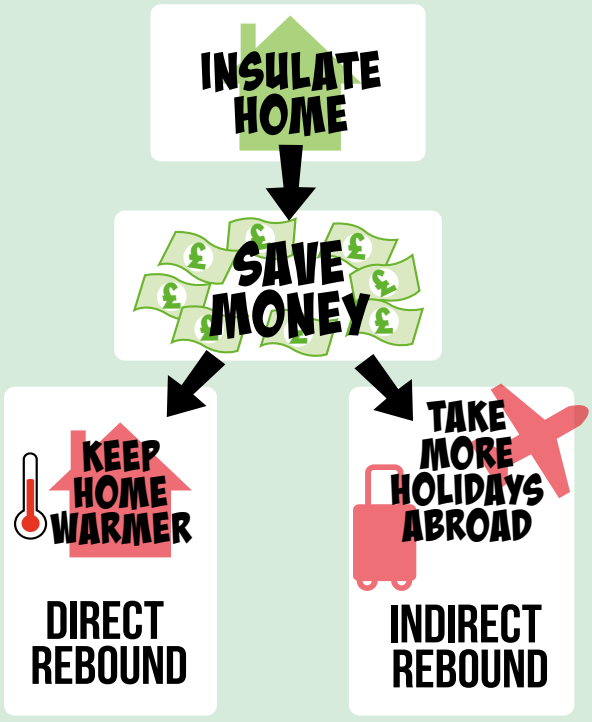
This is difficult when the energy crisis is framed primarily as a cost-of-living and security crisis, focusing on cost and energy supply. The very real issue of those in fuel poverty needing to save money now cannot be ignored; however, changes to ways of living and business practices justified in purely financial terms have greater risk of both direct and indirect rebound effects. Therefore, a wider narrative is needed for the more affluent parts of society to reduce demand to create a different future for all. This will ensure that behaviour changes to reduce demand for heating in the short term and will change the culture and expectations of heat in the longer term. The way retrofit and other energy saving measures are framed influences people's behaviours and therefore impacts on overall energy demand.[81]

The rebound effect comes into play because policies involving people's behaviour do not always work as intended. For example, with increased post-Covid home working there is a risk that increased home energy use (e.g. heating homes for longer hours in winter) could offset carbon reductions from less commuting. So rethinking heat should be part of the transformation of our economy so that our society uses far less energy whilst delivering wellbeing for all. Thermal comfort should be thought of in terms of the wider factors that influence it. This is already the case for public health, which focuses on the causes of

Box 8: The Rebound Effect

An example of direct rebound is that, in the event of energy prices reducing, people will simply revert to former practices, rather than continuing to reduce their energy demand. Or rebound could occur if savings from energy-efficient retrofit lead to a choice to heat homes more. Similarly, even with adopting new technology, there is a risk of continuing unrestricted energy use.

Indirect rebound may occur when cost savings are made through reducing energy usage in the home but that spend is diverted into other energy-intensive activities, such as flying.[79]



79 Marsden, G (2019) 'Rebound', in *Energy fables: Challenging ideas in the energy sector*. Routledge
80 Essex, J, Sims, P, and Storey, N (2022) 'Rethinking Energy Demand', *Green European Foundation* and *Green House Think Tank*.
81 Essex, J, Sims, P, and Storey, N (2022) 'Rethinking Energy Demand', *Green European Foundation* and *Green House Think Tank*, pp.32–33.

Policy P: Joined-Up Government Narrative and Policy Packages: Meeting Basic Needs whilst Discouraging Excessive Consumption

In most countries, there is far greater variation in carbon emissions from the richest to the poorest deciles in overall consumption (e.g. clothing) and travel (notably driving and flying) than in home heating.[82] *Therefore, a Universal Energy Allowance for heating (see* **Policy A***) should be matched by measures to reduce demand for travel and to restrict disposable income in high-affluence groups, which will limit over-consumption. Policies need to be developed as a package to avoid the rebound effect and to ensure that overall reductions are made across the economy and society.*

ill-health (often termed as the 'wider determinants of health') [83] including: obesity, drug and alcohol consumption, poverty, access to education and the environment in which people live. Education, planning and transport policy are often as much invisible energy policies as they are invisible health policies. Policy intervention to change cultural norms must address most public health and energy policy objectives simultaneously.

Policies that are successful in significantly reducing demand for energy (to reach energy sufficiency) must therefore form part of a wider economic transformation that facilitates more equitable consumption of energy and delivers better wellbeing across society. Although many individuals and organisations have some agency in delivering the interventions set out in this briefing paper, there are limits on the action that people can take without leadership and facilitation at all levels of government. A well-meaning minority of people cannot sufficiently rethink heating and cooling energy demand alone.

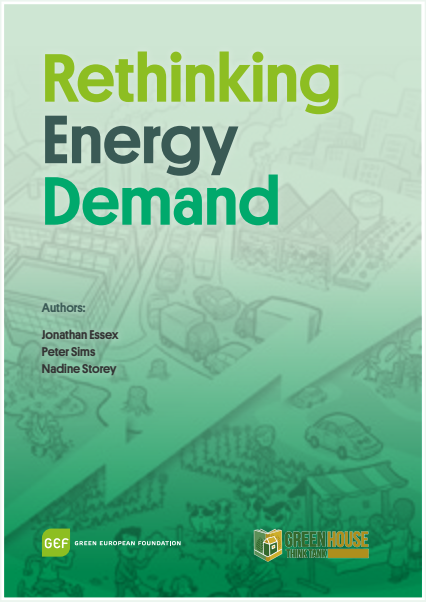
This policy briefing draws from:

Rethinking Energy Demand Report

Published October 2022

greenhousethinktank.org/report/oct-2022

gef.eu/publication/rethinking-energy-demand



82 In the UK, half the population do not fly in a given year whilst 15% of people take three or more flights (together taking 70% of total flights) – a free ride (no date) 'about the project'.

83 Office for Health Improvements & Disparities (UK) (no date) 'Wider Determinants of Health' (accessed: 16 Jan 2023).

List of Policies

The Policy Briefing applies recommendations of the Rethinking Energy Demand framing report published Oct 2022 to the heating and cooling of buildings. It outlines the current context, the need to reduce the number of buildings heated and the amount of heating and cooling needed within them. An economy-wide approach is needed to avoid an energy rebound from building retrofit.

GREEN HOUSE THINK TANK

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