C R E D S

The missed opportunity – ignoring the evidence on energy demand reduction

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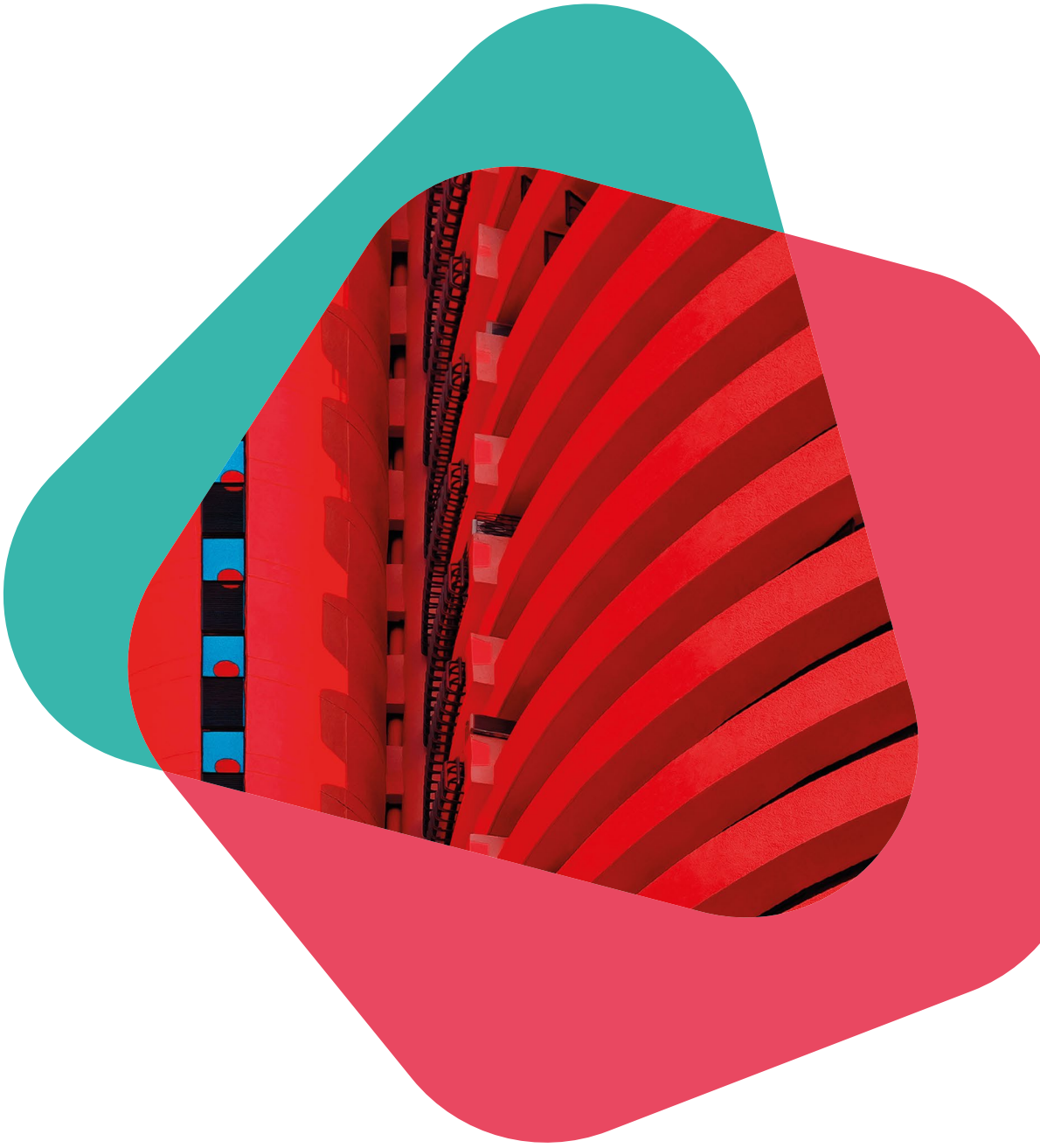

About this report

Reference

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Introduction

Energy demand reduction is a crucial strategy for addressing major challenges facing society today, including climate change, energy security, economic productivity, and public health. Over the past five years, the Centre for Research into Energy Demand Solutions (CREDS) has conducted research that provides a comprehensive evidence base to explore these issues. The research includes a study of key energy efficiency technologies, the benefits of electrification, broader social interventions that reduce energy demand, and the wider implications for the economy as a whole, including impacts on energy prices, and public health.

CREDS has provided the most comprehensive assessment to date of the role of energy demand in meeting the UK's net-zero climate target – the Positive Low Energy Futures project. Following this report (Barrett et al., 2021), the Governmental Office for Science (GO-S) launched a substantial cross-departmental study titled A Net Zero Society (GO-S, 2023). This study worked with CREDS to provide another set of possible pathways to reduce energy demand, involving extensive consultation with different government departments and external stakeholders.

Both studies showed the substantial potential to reduce energy demand, which is essential to meet climate targets cost-effectively and in a timely way without risking missing legally binding climate targets. The CREDS research and GO-S study have demonstrated the potential to reduce energy demand significantly.

The UK Government has now published its analysis on how it intends to achieve its interim targets on the way to net-zero by 2050, titled Powering Up Britain – Energy Security Plan (Department for Energy Security and Net Zero [DESNZ], 2023). This report has a lengthy annex titled the Carbon Budget Delivery Plan, which lists the strategies and policies that the government has selected to achieve these targets (DESNZ, 2023a). There was an opportunity in this plan for the UK Government to ensure that these strategies would avoid relying on unproven technologies and missing their legally binding climate targets.

This report considers whether the UK Government has recognised the wealth of evidence on energy demand reduction strategies provided by CREDS and GO-S in guiding the selection of policy options to achieve the UK's interim climate targets. The report explores the role that energy demand reduction strategies have played in the government's strategy and whether there is a missed opportunity to substantially reduce the UK's energy demand.

Positive Low Energy Futures

One of the ground-breaking projects to emerge from CREDS was Positive Low Energy Futures (PLEF; Barrett et al., 2021). PLEF provides the most comprehensive assessment to date of the role of reducing energy demand to meet the UK's net-zero climate target. The study brings together 17 energy demand modelling experts from within CREDS to provide extensive detail on the possibilities to reduce energy demand in every sector. These sectoral reductions in energy demand are brought together into a whole-system modelling approach, to understand the potential contribution of energy demand reduction to support climate action in the UK. The analysis explores four different levels of ambition in energy demand reductions, ranging from the least ambitious 'ignore' scenario (based on currently planned policies), to the ambitious 'transform' scenario (based on widespread technological, social, infrastructural, and institutional change).

Other research in CREDS also recognises that reducing energy demand is not without significant challenges. These include affordability of new technologies, significant shifts in social practices, and vested interests wishing to maintain the status quo. However, the scenarios generated in PLEF demonstrated that the UK could transform its use of energy, halving current demand by 2050 while enhancing quality of life. Substantial reductions are possible across all sectors (see Figure 1).

The energy system needs to completely decarbonise while expanding the electricity system to provide mobility, heat, and new industrial processes. The challenge is enormous. It requires high levels of societal acceptance of new technologies and presumes that the very real technical hurdles of building out a new infrastructure in a relatively short period of time will be overcome. The PLEF scenarios show that without energy demand reduction, power generation would need to increase by three-fold. Our 'transform' scenario can help moderate this challenge with a modest increase in the power sector in comparison.

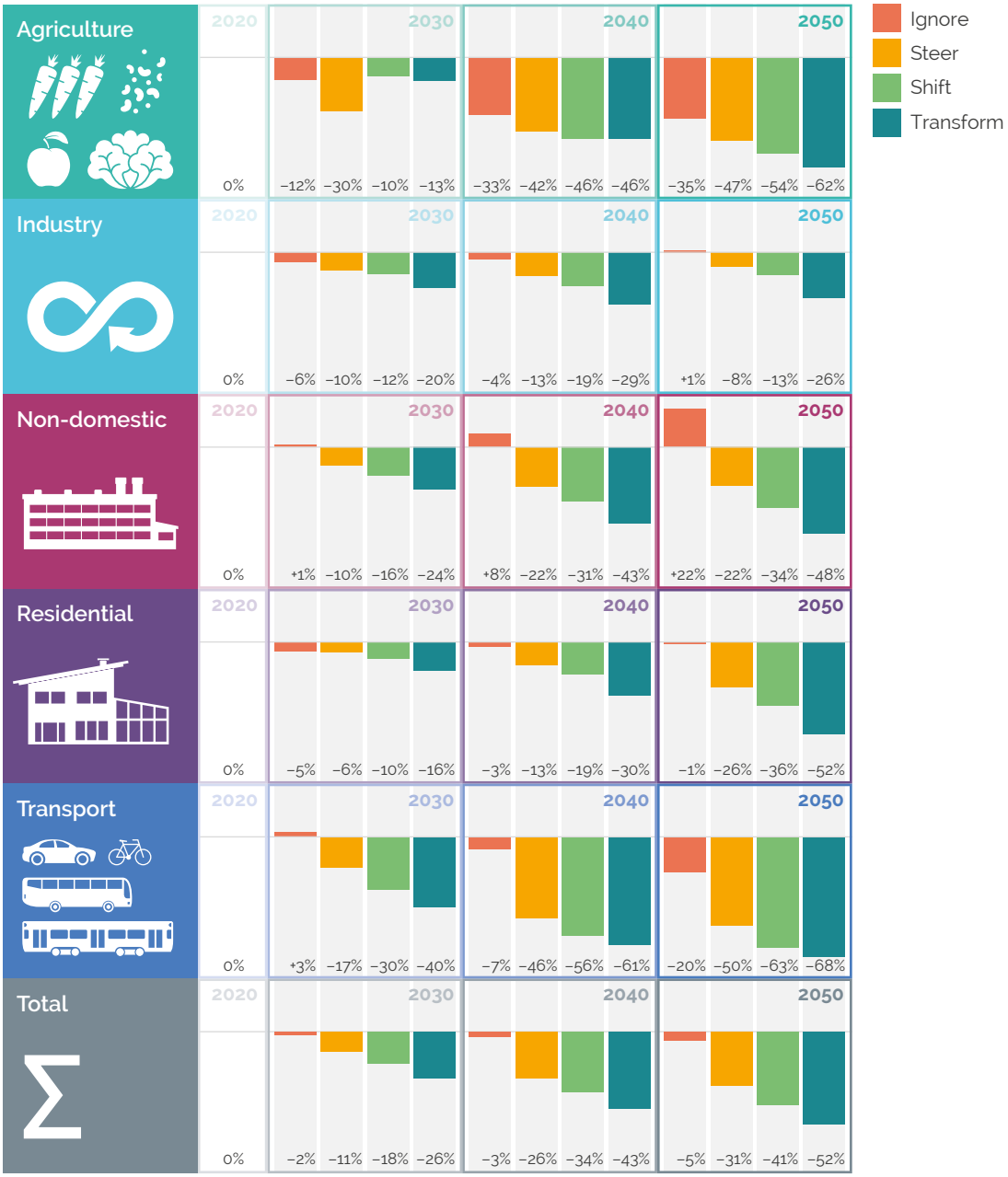

Figure 1: Energy demand reduction potential (Barrett et al, 2023). This chart shows the scale of change required across the different sectors in response to four possible levels of action: Ignore (5% energy demand reduction), Steer (31% reduction), Shift (41% reduction) or Transform (52% reduction).

Net Zero Society report

The Net Zero Society study by the Government Office for Science employs a consistent methodology that was developed in collaboration with CREDS, resulting in several possible pathways for the UK to reduce energy demand to various extents (GO-S, 2023). While not directly offering policy recommendations, the study suggests that a combination of energy-efficient technologies and societal changes can be effective in achieving this goal. However, different sectors require different approaches: for instance, domestic buildings could benefit from the adoption of heat pumps and retrofit strategies, while mobility requires larger social changes to reduce travel demand, coupled with the widespread deployment of electric vehicles. In the case of nutrition, societal changes that encourage healthier eating habits could make a significant contribution to reducing energy demand, while in the materials and products sector, decreasing material use and improving resource efficiency are crucial.

The study showcases four scenarios in which energy demand is reduced between 18% and 50%. It provides strategic insights into the risks and opportunities associated with various pathways to achieving net-zero, and policymakers can use the evidence and scenarios to develop and refine specific policies tailored to reducing energy demand in a more detailed manner.

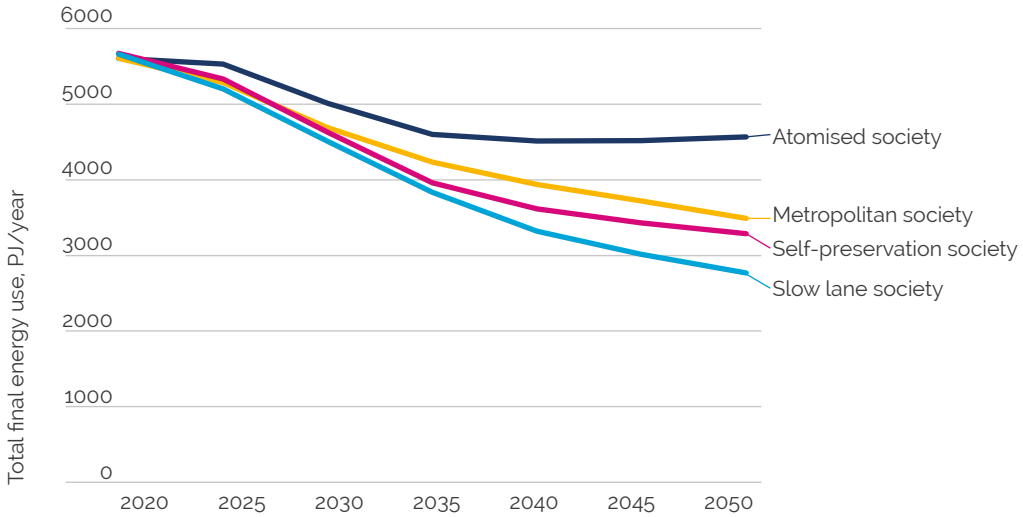

Figure 2: Net Zero Society scenarios, Source: GO-S Report

A comparison – our approach

In this section, we examine whether the UK Government has acknowledged the significant evidence presented in the two reports regarding the imperative to reduce energy demand. Our analysis delves deeply into the subject matter, providing a thorough evaluation of the government's adoption (or lack thereof) of energy demand reduction policies and strategies. We have employed a qualitative methodology to interpret the level of ambition for each energy demand intervention, ensuring a comprehensive assessment.

Our approach – an example

The determination of inclusion is based on the highest ambition demand reduction policy among the scenarios within each modelling exercise. The purpose of comparison is to identify gaps where energy demand reduction policies or measures have not been directly considered by the modelling exercise, rather than to provide a comprehensive assessment of an individual scenario's level of ambition. Additionally, a measure being fully included does not necessarily mean that it has been included to its full potential, but rather that it is presented relative to the other modelling projects analysed.

The PLEF study provided the highest level of ambition among the scenarios for the policy. The GO-S study partially implemented this policy and the policy was entirely absent from the UK Government strategy. We evaluate each energy demand reduction policy against five levels of ambition:

Fully implemented	Mostly implemented	Partially implemented	Mentioned but not included	Excluded entirely
				

The scenarios are colour coded:

Go-Science study	UK Government strategy	PLEF study
		

An example:

Policy option: High taxation on more than one car per household

Go-Science study	UK Government strategy	PLEF study
		

The results

The results can be seen for each individual sector below. These include mobility, homes, industry, material and products, and nutrition. Before providing the sector level analysis, the overall results are shown below.

We evaluate the inclusion of 135 different possible policy interventions. There is clearly crossover between some of them and a need for specific interventions to be included to allow others to succeed. Our analysis is qualitative and designed to consider whether energy demand reduction options are being considered. This is not a quantitative analysis of energy demand.

Mobility

Emissions from transport have almost flatlined over the past three decades. At 30%, transport is now the largest sector for CO_2 emissions across the economy (this includes domestic transport, aviation and shipping) (DESNZ, 2023). A strategy of technology regulation to improve the efficiency of fossil fuelled vehicles did not produce the reductions anticipated as a result of manufacturers gaming the test cycles and a significant switch to the sale of larger and heavier vehicles. Coupled with increases in travel demand – particularly in the freight sector – transport has been left facing a steep reduction pathway.

The indicative pathway for transport set out in the carbon budget delivery plan is at the low end of the ambition envelope set out by the Department for Transport (DfT) in July 2021. 72% of the ambition has been deemed as not likely or not necessary, leaving other parts of the economy to pick up the gap (Marsden, 2023). The shift in ambition comes from the fixing down of plans to legislate for the phase out of fossil fuel vehicles which, while ambitious, fall behind the steeper reduction pathways which had been set out in 2021. The 2021 Department for Transport's Decarbonisation Plan also included scenarios where road traffic was substantially below the pre-pandemic levels throughout the period to 2040 (DfT, 2021). More recently however, it appears that traffic reduction has been put aside with the recent National Networks Planning Policy Statement consultation stating that "continued absolute traffic growth is likely under all scenarios" (DfT, 2023; p. 21).

On reviewing the policies which have been modelled and quantified in the Carbon Budget Delivery Plan (CBDP; DESNZ, 2023a), the overwhelming balance of policies focus on the technology transition, across all sectors including domestic, maritime and aviation. This is important, as without this transition there can be no zero-emission transport system. However, it is clear that the pace of the transition, coupled with the time which existing technologies will stay in the fleet, does not deliver reductions on the scale required. Very few of the potential policies which could be deployed to transform the way we travel have been quantified. Transforming the way we travel offers opportunities to improve fairness as well as reducing the volume of journeys which need to transition and the scale of the fleet which needs to shift as set out earlier. The CBDP suggests that further mitigation will come from the Local Transport Plan process where local authorities will set out their strategies and investment plans later in 2024. It is not clear how much of the emissions savings from these local actions have already been factored in to the baseline however, as the projections of road traffic growth are based on past performance, which would include levels of spending on local transport similar (or greater) than those currently planned.

Some of the policies which have not been assessed in the CBDP have been examined elsewhere. The National Road Traffic Projections, for example, look at a behaviour change strategy with greater home working, localisation and more home deliveries (DfT, 2022). However, this is seen to be an exogenous scenario and not something which policy will bring about. It is not the core scenario of traffic growth around which the DfT is planning. So, the sector recognises that many of the opportunities in PLEF and GO-Science scenarios do exist and could play a role. However, there is not sufficient interest in or appetite for a programme of comprehensive demand shifts, meaning that they do not feature in emissions reduction plans. The rowing back of transport ambition on decarbonisation suggests that Government currently sees it as preferable to leave these off the table. There are many opportunities being missed.

Study			Ambition level				
Go-Science	DESNZ	PLEF	Fully	Mostly	Partially	Mentioned	Excluded
							

Modelled EDR net-zero policies, assumptions and targets	Go-Science	DESNZ	PLEF
Interventions impacting modal choice and trip length			
Rapid action to reduce private car use alongside increases in supply of alternatives (shared mobility, public transport, active travel including e-bikes and other micro e-mobility)			
Gradual/rapid change in travel patterns, mode choice and occupancy levels leading to relatively fast transformations and new demand trajectories			

Modelled EDR net-zero policies, assumptions and targets	Go-Science	DESNZ	PLEF
Concerns relating to health, quality of life, energy use and environmental implications drive social change to promote status of more sustainable modes of transport and low traffic neighbourhoods and demote single-occupancy car travel, fossil fuelled vehicles, unnecessarily long distances and speeding			
ICT facilitates rapid behavioural change by making cost and energy use transparent to users, changing everything from destination choice, car choice and models of 'ownership', driving style and paying for travel, including in the freight sector			
Substitution of shopping and personal business trips by home delivery			
Changes in work patterns and business travel fuelled substituting disproportionally impactful long commuting and business trips by digital technology			
Introduction of a four day working week			
Businesses are made much more accountable for their emissions (including commuting)			
Changes to structure of retail – retail and leisure blend together as more 'mundane' shopping is done online but coffee and experience = local leisure			
Devolution/ localisation – changes to planning system and desire to work and play more locally			
No more development on greenfield sites (consistent with the 'no new homes' scenario)			
Integrated transport authorities in all urban/city regions (one network; one timetable; one ticket)			
Public acceptance for new regime of 'pay as you go' pricing linked to environmental impacts			
Eco-levy applied to the whole system – the more you travel and the more polluting modes you use, the more you pay – includes air travel (frequent flier levy)			
Renewed focus on localism and 'proximity principle' in planning – e.g. local shopping, local schools, local leisure travel			
Road transport assumptions			
Much more radical market transformation of passenger vehicle fleet to EVs than currently assumed as it will include rapid phase out of sale of high-polluting vehicles			
It becomes socially unacceptable to drive kids to school. Much scope for change here as access to schools by car is restricted, short journeys are switched to alternative modes			

Modelled EDR net-zero policies, assumptions and targets	Go-Science	DESNZ	PLEF
No more road building or airport capacity expansion; some roads re-purposed for shared, public and active mobility			
Social norms change: single occupancy car use, large cars and flying less acceptable			
Increased internet shopping increases the use of vans, which somewhat offsets the positive effects of decongestion from fewer cars on the road			
Electrified car fleet is reduced substantially as driving licence uptake is down with transition to 'car usership'			
Single occupancy car use becoming socially unacceptable and parking charges and infrastructure designed to encourage vehicle sharing			
But taxi and shared fleets increase – all electric by 2030			
Large and heavy ICE, PHEV and HEV cars gradually phased out in 2020s; only BEVs (for cars and vans) from 2030 (2025 in Transform demand case)			
High taxation on more than one car per household			
Big investment in and standardisation of charging infrastructure across the nation			
HGV – renewed push for consolidation centres around big cities and towns – reduced miles travelled			
Road freight – much improved logistics, vertical integration e.g. Amazon – improves load factors for long and medium distance freight			
Last mile delivery regulated to require zero emission vans or e-cargo bikes			
Increase in LCV (van) fleet due to more online shopping – electric only sold from 2030			
HGV zero emissions vehicles			
Fossil fuel ICE cars (not vans) banned from urban centres by 2030; all cars banned by 2035			
End the sale of ICE 'L-category vehicles' in 2022			
Efficiency improvements to ICE new sales and PHEVs			

Modelled EDR net-zero policies, assumptions and targets	Go-Science	DESNZ	PLEF
Autonomous vehicles by 2050 only in niche local applications and some long distance fixed routes. Limited impact			
Active travel & public transport			
Doubling investment in public transport, walking and cycling – including e-bikes and on-demand services enabled by ICT			
Substantially expanded bus fleet will be largely electric (but not all – coach, mini)			
Further electrification of railways			
Re-regulation of buses and railway under public control			
Construction of high-quality cycling networks of segregated cycleways in all urban areas and along all single carriageway roads radiating within e-bike range (about 15km) from major settlements			
Aviation & shipping			
Pricing of aviation (esp. frequent fliers)			
International aviation and shipping included in domestic carbon budget. No use of offsets. But flying less = more domestic surface leisure and business travel.			
Rapid scale up of alternative aviation fuels for domestic & international aviation			
Zero emissions aircraft in 2035			
Aviation efficiency improvements			
Domestic maritime decarbonisation			
Airport operations net-zero			

Domestic buildings

Energy demand from the residential sector has declined. Between 2000 and 2021 there was an 11% reduction in energy demand, representing an annual average reduction of 0.5% (DESNZ, 2023). This has been achieved while the number of housing units in the UK has increased by 17% over the same period (ONS, 2022). Therefore, there has been a more significant reduction per housing unit in the UK of 26% over the same time period (annual average reduction of 1.2%).

Two broad options exist that are common features of all residential net-zero pathways; these include the decarbonisation of supply (reducing the CO_2 per kWh) and measures to reduce energy demand. The decarbonisation of supply requires two strategies. These include the rapid roll out of renewables to replace fossil fuels combined with the electrification of home heating. The electrification of homes includes the replacement of gas boilers with heat pumps and has two substantial benefits. Firstly, it allows home heating to be provided by renewables as opposed to fossil fuels. Secondly, heat pumps offer substantial improvements in energy efficiency that can reduce energy demand.

There is an acknowledgment across all future pathways that heat pumps will play an instrumental role in reducing energy demand in the residential sector. The variation between the pathways depends on the speed and level of ambition of this goal. The PLEF scenarios have maximum installation rates of 1.5 million heat pumps a year in the 2030s with the Department for Energy Security and Net Zero (DESNZ) pathway aiming to install 600,000 a year from 2028 onwards. The Government Office for Science have adopted the UK Government assumption.

There is a need for a stronger recognition of the benefits of short-term reductions in energy demand through the more rapid replacements of gas boilers with heat pumps. The figure used by PLEF was selected as it represented the maximum rate of replacement to install condensing boilers that was achieved predominately in the 1970s and 80s. Therefore, there is a historical precedent that unpinned the analysis.

The same pattern can be seen when comparing retrofit strategies across the different scenarios. All scenarios recognise the need to improve the fabric of buildings to reduce heat loss, however the level of ambition varies. There is no technological breakthrough needed to insulate homes and there is evidence of previous policies and strategies that have delivered significant improvements. It is simply the case of introducing well-designed supporting policies that have longevity to ensure market certainty.

The most significant variation between the UK Government's Carbon Budget Delivery Plan and the Positive Low Energy Futures scenarios relates to questioning the need for future housing. This involves more fundamental shifts such as increasing the occupancy of under-occupied homes, conversion of redundant offices to small apartments while also ensuring the more rapid roll-out of solar energy.

Study			Ambition level				
Go-Science	DESNZ	PLEF	Fully	Mostly	Partially	Mentioned	Excluded
							

Modelled EDR net-zero policies, assumptions and targets	Go-Science	DESNZ	PLEF
No new house building (transform)			
Reduced average living space per person			
1 million retrofits per year			
130,000 Solar Thermal retrofits per year			
100% LED lighting			
High levels of energy efficiency in any new construction			
Heat pumps for any new builds where possible			
Boilers over 20 years old replaced with heat pump			
Heat pump replacing gas boilers			
Gas boiler ban implemented			
Improved gas boiler efficiency			
Internal temperatures set to 18 degrees			
If occupancy in building is low, internal temperatures set to 16C			
Reduction in appliance energy usage in the home (e.g. shift from gas to induction hob)			

Modelled EDR net-zero policies, assumptions and targets	Go-Science	DESNZ	PLEF
Mortgage lenders to support homeowners to improve domestic energy efficiency to EPC band C where practical			
Minimum EPC of rented & social housing homes increases to band C			
Heat network development			
Greater integration of biogas into the gas network			

Industry, materials & products

Industrial emissions have fallen in the UK over the past 20 years predominately for two reasons; efficiency improvements and the outsourcing of energy intensive industry to other countries (Hardt et al., 2018). This has resulted in the UK being a net importer of emissions. When emissions embodied in imports is considered, the UK has not reduced its emissions to satisfy UK consumption. Efforts to reduce industrial emissions include fuel switching to less carbon intensive options (electrification, for example), energy and material efficiency as well as resource consumption strategies. This refers to strategies that reduce the need for excessive consumption by promoting product longevity and switches from goods to services, for example. These strategies aim to minimise energy demand and promote sustainable practices.

Studies conducted by CREDS and GO-Science have highlighted the need for a sector-level approach, as strategies can vary significantly from one sector to another. Within these studies, a total of 56 strategies have been identified. Surprisingly, a significant number of these options are either completely ignored or inadequately addressed in the government's strategy. Out of the 56 strategies, 15 are entirely overlooked, 15 are merely mentioned without implementation, and 21 are only partially considered. Most notably, the government's attention is disproportionately focused on fuel switching, while neglecting critical aspects of the construction sector, which happens to be the largest consumer of materials in the UK. This oversight is concerning, considering the growing body of evidence pointing towards potential improvements in this sector, including reducing demolition rates, exploring material substitution options, increasing the utilisation of secondary materials, and proactive planning for future infrastructure needs.

This analysis underscores the necessity of adopting a more comprehensive approach to energy demand reduction that extends beyond simple fuel switching in industry sectors. It calls for a holistic examination of the entire supply chain, encompassing both upstream and downstream considerations of products. By embracing this broader perspective, the UK can better address the complexities of emissions reduction and pave the way for more effective and sustainable solutions.

Study			Ambition level				
Go-Science	DESNZ	PLEF	Fully	Mostly	Partially	Mentioned	Excluded
							

Modelled EDR net-zero policies, assumptions and targets	Go-Science	DESNZ	PLEF
Lightweight design: Less material use by design, avoiding emissions associated with material production			
Goods-to-services: Higher use rate from sharing economy-type approaches means less goods required and emissions savings from reduced production			
Product longevity: Longer life products means less new production and reduced emissions. May be offset to some extent by more repair and maintenance activity			
Material substitution: Emissions-intensive materials substituted by less emissions intensive alternatives that provide a similar service			
Waste and recycling: Reducing waste and increasing recycling rates avoids the need for virgin production			
Clothing & textiles: Reduce supply chain waste through a 5% efficiency improvement in fibre and yarn production, dyeing and finishing sold to UK consumers			
Clothing & textiles: Dispose of less clothes and reuse more			
Clothing & textiles: Dispose of less carpets and rugs and reuse more			
Clothing & textiles: Dispose of less clothes and recycle more			
Clothing & textiles: Use clothes and leather products (shoes, luggage etc.) for longer			
Clothing & textiles: Dispose of less carpets and rugs and recycle more			
Packaging: Reduce weight of metal, plastic, paper and glass packaging sold to consumers			
Packaging: Prevent waste of metal, plastic, paper and glass packing sold to consumers.			
Vehicles: Reduce steel (up to 45%) and aluminium (up to 20%) consumption in car manufacturing through car weight-saving measures			

Modelled EDR net-zero policies, assumptions and targets	Go-Science	DESNZ	PLEF
Vehicles: Reduce all other materials used in car manufacturing through lightweighting strategies by 25%.			
Vehicles: Yield improvement (metals) in car structures sold to UK consumers through cutting techniques			
Vehicles: Steel fabrication yield improvement in cars sold to UK consumers			
Vehicles: Reuse discarded steel products in vehicles sold to UK consumers (up to 30% of discarded steel)			
Vehicles: Shift from recycling to refurbishing for vehicles sold to UK consumers (can reduce material use by 15%)			
Vehicles: Car clubs			
Vehicles: Use cars for longer (33% increase in average use life)			
Electronics & appliances: Reduce steel without material or alloy changes in computers and electronics sold to UK consumers			
Electronics & appliances: Sharing appliances used less frequently – using steel products (vehicles, industrial equipment, construction and metal goods) more intensely could reduce final demand by nearly 30% across all products)			
Electronics & appliances: Sharing hand-held power tools			
Electronics & appliances: Using electronics for longer			
Electronics & appliances: Re-manufacturing/refurbishing reduces material and energy manufacturing inputs			
Furniture: Reduce steel inputs in furniture (lightweighting)			
Furniture: Dispose of less furniture & reuse more			
Furniture: Dispose of less furniture and recycle more			
Other machinery, electrical equipment & metal products: Reduce steel without material or alloy changes in fabricated metal products sold to UK consumers			
Other machinery, electrical equipment & metal products: Reduce steel without material or alloy changes in other machinery and equipment sold to UK consumers			

Modelled EDR net-zero policies, assumptions and targets	Go-Science	DESNZ	PLEF
Other machinery, electrical equipment & metal products: Steel fabrication yield improvement in fabricated metal products sold to UK consumers			
Other machinery, electrical equipment & metal products: Reuse discarded steel products in industrial equipment sold to UK consumers			
Other machinery, electrical equipment & metal products: Sharing leisure equipment			
Other machinery, electrical equipment & metal products: Reuse discarded steel products in metal goods sold to UK consumers (fabricated metal products, computers, electronics and appliances, and furniture)			
Construction: Package of cement measures (post tensioning, precast systems, reducing cement content of concrete, use of calcined clay and limestone, reducing construction waste and reducing over-design, use of flexible formwork technologies in floor slabs & beams)			
Construction: Bringing vacant properties back into use			
Construction: Increased use of digital design optimisation tools in non domestic construction			
Construction: Designing adaptable foundation to enable future reuse			
Construction: Reuse of existing foundations			
Construction: Greater reuse of structural steel			
Construction: Changes in rail design and specification			
Construction: Elimination of high embodied energy/carbon insulation materials			
Construction: Use of hybrid timber/steel structures			
Construction: Use of cross-laminated timber to replace concrete floors.			
Construction: Achieving close to optimal use of structural steel			
Construction: Increased use of computationally optimal reinforcement products			

Modelled EDR net-zero policies, assumptions and targets	Go-Science	DESNZ	PLEF
Construction: Use of straw bale construction methods for new housing			
Construction: Use of hemp in building applications			
Construction: Increasing reuse of timber, bricks and other materials in construction			
Construction: Use of electric plant on site			
Industrial energy efficiency measures & technology adoption			
Fuel switching in steel production			
Broader industrial energy fuel switching from FF to hydrogen, electricity or biomass			
Reshoring industry			

Nutrition

Like every other sector, the food system needs to be net-zero by 2050. In the UK, the Climate Change Committee (CCC) estimates that 11% of territorial UK GHG emissions are attributable to agriculture and land use, and predict that the sector will be a more significant emitter by 2050 (based on 2016 data; p. 12, CCC, 2018). There is little room for one sector to take a disproportionately larger share of GHG emissions. Mounting evidence shows that the single most effective measure of reducing emissions in the food system will have to come from the demand side (Garvey et al, 2021). This involves shifts in diet that must reduce meat consumption, in particular animals associated with high levels of methane emissions. For instance, 58% of UK agricultural emissions can be assigned to cattle and sheep farming (CCC, 2018). Within the PLEF scenarios, the "business as usual" scenario considers historical trends in the growth of plant-based diets highlighting that the underlying trend is a reduction in meat consumption. If this underlying trend continued then there would be a further 34% reduction in meat consumption by 2050. This is without any policy intervention. The GO-Science scenarios included a range of assumptions, including one around the technical innovation in lab-grown meat and its introduction to UK diets. However, since the assumptions for reducing meat and dairy consumption were less ambitious than those in the PLEF analysis the scale of emissions reductions from this sector were weaker. This further illustrates the extent to which it is meat and dairy demand that is the critical driver of emissions and therefore the appropriate target for sustainable food policy.

However, policy intervention would be required to accelerate this "business as usual" figure from PLEF in line with the UK's climate targets (Barrett et al., 2021). The highest ambition scenario describes a 54% reduction in meat consumption by 2050. Both the PLEF and the GO-Science scenarios, at varying levels of ambition, demonstrated the possibility of shifting diets. These demand-side measures were entirely absent from the UK Government report. Despite the substantial evidence that they can deliver more savings than efficiency improvements in agriculture, they are not even discussed as an option. No link is made to heathier diets, World Health Guidelines and underlying trends in the Government report. An entirely techno-centric option is operated that is not consistent with the evidence. The publication (and subsequent deletion) of a Government report considering the potential for a meat tax is indicative of the current hesitancy of UK Government to engage with issues of behavioural change (Garvey, 2022). This is particularly true of policy oriented around the sustainability of UK food consumption.

Study			Ambition level				
Go-Science	DESNZ	PLEF	Fully	Mostly	Partially	Mentioned	Excluded

Modelled EDR net-zero policies, assumptions and targets	Go-Science	DESNZ	PLEF
Reduced calorie intake			
Dietary shift: Reduction in the number of omnivores			
Dietary shift: Increase in number of healthy diets (lower red meat consumption)			
Dietary shift: Increase in number of vegetarians			
Dietary shift: Increase in number of plant based diets			
Reduction of food waste			
Farm-based energy efficiency (electric tractors, low-energy using machinery etc)			
Trends in the fraction of food consumed outside the home (more takeaways = higher meat consumption)			

Reflections

There is a clear variation between the strategies identified in both the Government Office for Science and the Positive Low Energy Future scenarios compared to the options that form part of the Government's Carbon Budget Delivery Plan. Numerous options to reduce energy demand have been excluded from Government plans despite considerable evidence on their ability to deliver significant energy demand reductions in the near-term and beyond. There is an extremely limited focus on energy demand throughout.

There is a common theme in the limited number of options that have been included. The strategies within the Government's Carbon Budget Delivery Plan are almost entirely reliant on a small number of energy efficiency measures delivered by a handful of technologies. This ignores the saturation points to deploying efficiency measures and their potential rebound effects. There is therefore a clear failure to identify strategies that reduce energy demand at the source, by shifting consumption patterns and avoiding energy use.

The lack of recognition of the potential role of energy demand reduction marks a continuation of the historic divide in attention given to issues of energy supply rather than demand. Though there is now a comprehensive and robust evidence base around the potential contribution of energy demand reduction, it is still sidelined within Government energy strategy. The creation of an Energy Efficiency Taskforce was announced in Autumn 2022, setting a target to deliver a 15% reduction in total UK energy demand by 2030 (against 2021 levels; HM Government, 2023. However this marks a £6 billion investment in contrast to the £20 billion allocated for CCUS development (HM Government, 2023a), suggesting the relative balance of priorities within carbon budget delivery efforts. This is despite the fact that energy demand is likely to deliver half of the required reduction in GHG emissions while the contribution of engineered carbon removal technologies is likely to be negligible.

Additionally, the Taskforce target only encompasses domestic and commercial buildings and industrial processes (HM Government, 2023). This excludes the transport sector, in which energy demand is projected to increase significantly over the coming decades. According to the Government's Energy and Emissions Projections (EEPs), demand will also increase against 2021 levels in the residential and industrial sectors, suggesting that the Taskforce target is not yet reflected in this analysis (DESNZ and Department for Business, Energy and Industrial Strategy [BEIS], 2023).

It may be the case that the Taskforce efficiency target and its associated policies are not yet developed enough to be considered "EEP-ready" policy savings (DESNZ and BEIS, 2023). However, there appears to be inconsistency in the current documentation of energy demand strategies and how targets translate into substantive policies that drive real reductions in total energy demand. There is also limited consideration of how planned energy demand reduction activities would contribute to reducing international demand for goods and products generated by UK consumption.

The contribution of energy efficiency versus avoiding/shifting energy demand will vary by sector, for instance, with greater contributions from energy efficiency in reducing demand in the buildings and transport sectors. Nutrition and industrial processes will benefit from more avoid/shift behaviours. The Taskforce target is broadly in line with our scenarios' estimates of the potential of energy efficiency improvements. By omission, this therefore highlights the array of energy demand reduction opportunities, as highlighted in the PLEF and GO-Science analysis, that are currently out of scope of government policy. The predominant focus of the Taskforce is on "the role of the private sector and the stimulation of investment", with a limited stated focus on behavioural change and practices (HM Government, 2023).

The demand reduction options that are considered in Government energy strategy are techno-centric and rarely engage with complex socioeconomic factors which provide a reduced reliance on energy to deliver energy services demand reductions. Many energy demand reduction measures can be readily deployed, without relying on high risk and uncertain rewards from the future development of technologies such as CCS and hydrogen which are currently large assumptions in current national energy and climate policy. 'Ready-made' energy demand reduction options – as outlined in the PLEF and GO-Science analyses – would have the added benefit of reducing energy demand in the short-term. This is disproportionately effective since it is in the near-term that the carbon intensity of the materials, products and services we use are highest, thus having the greatest impact on our cumulative emissions.

Different sectors have a 'common but differentiated responsibility' (and capability) to reduce their energy demand. This means that whilst they all have different pathways, speeds, and methods of achieving energy demand reductions, they should all ultimately be consistent with the overarching net-zero target in the UK. Conservatism on the part of any one sector will eventually shift the burden of mitigation to other sectors. A whole systems and 'whole government' approach to energy policy development is needed. This would incorporate non-energy issues that have an impact on overall energy use, and would mean including government departments not typically responsible for energy issues (for instance DfT).

The Independent Review of Net Zero recommended that Government "significantly expand its public reporting on net-zero" (HM Government, 2023a). The Government responded that the Net Zero Growth Plan which accompanies the CBDP does this (HM Government, 2023a). However, there is a critical gap in up-to-date, quantitative and disaggregated reporting of the impact of recent policies on energy demand. Improving publicly accessible monitoring, reporting and verification of energy demand policies would allow oversight of the balance of measures that are in place, better allowing the identification of gaps. There is also a key gap in incorporating social practices in modelling and planning around energy demand reductions, beyond cost-benefit analysis and econometric modelling as the basis for policy development and decision-making. Recognising the co-benefits of energy demand reductions and potential for value creation from these measures would make energy demand reduction policies both more politically viable and socially acceptable. This could be delivered in practice through integrating social science research into government decision-making, engaging with diverse stakeholders, seriously exploring and evidencing behavioural change campaigns, and developing policies that are sensitive to the socioeconomic context.

By doing so, governments can create more effective and inclusive strategies for reducing energy demand and promoting sustainability.

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About CREDS

The Centre for Research into Energy Demand Solutions (CREDS) was established as part of the UK Research and Innovation's Energy Programme in April 2018, with funding of £19.5M over 5 years. Its aim to understand the role of energy demand change in accelerating the transition to a zero carbon energy system, including the technical, social and governance challenges of demand reduction, flexible demand and use of decarbonised energy. CREDS has a team of over 140 people based at 24 UK universities.

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