UK Energy Research Centre

Energy Demand Reduction

An Energy Data Centre Introductory Guide

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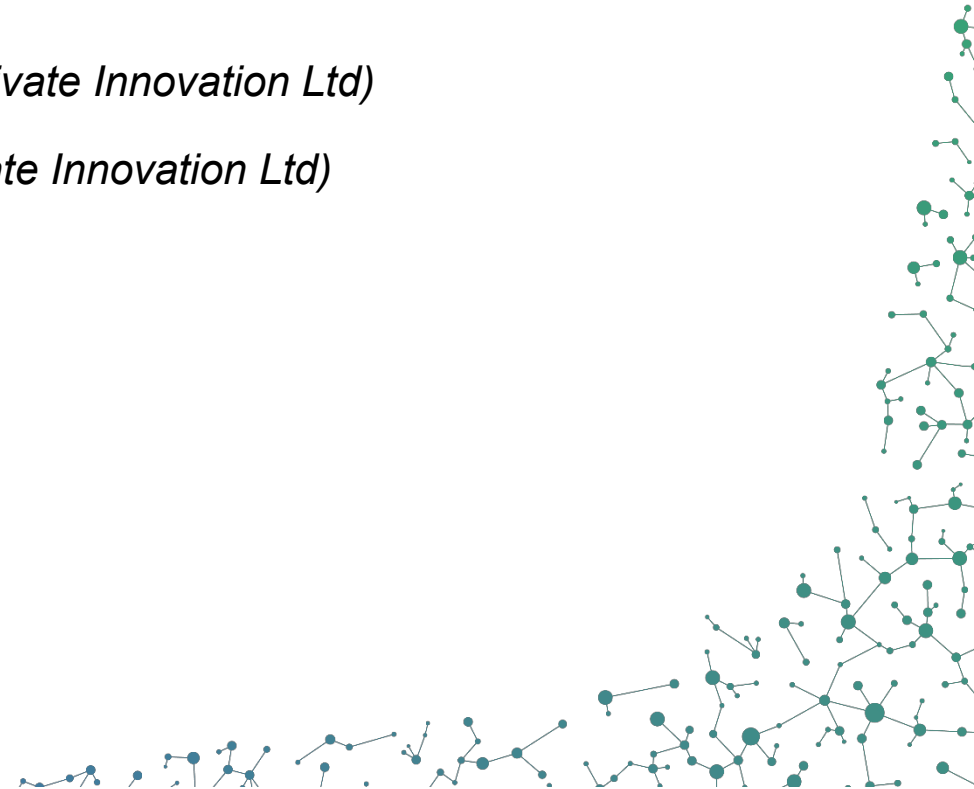


Introduction to UKERC

The UK Energy Research Centre (UKERC) carries out world-class, interdisciplinary research into sustainable future energy systems.

It is a focal point of UK energy research and a gateway between the UK and the international energy research communities.

Our whole systems research informs UK policy development and research strategy.

UKERC is funded by UK Research and Innovation.

Document Purpose

This document is an introductory guide to the topic of ‘Energy Demand Reduction’. It highlights the main concepts, policies and technologies which influence this topic area in the UK, and is written for those with limited prior knowledge of energy demand reduction. This document will not cover all relevant issues in this area but will serve as a starting point for those looking to research further.

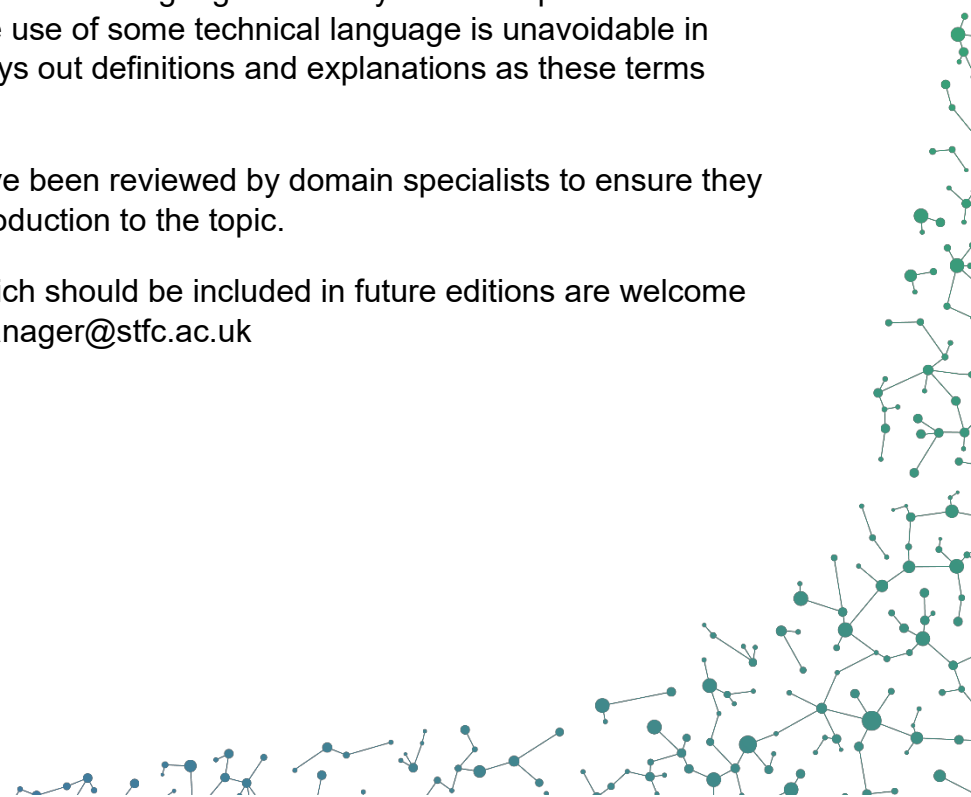
The ‘research and innovation’ section is based largely on projects which can be found in the UK Energy Research Centre - Energy Data Centre’s (UKERC EDC) projects database. This section is not exhaustive and focuses on publicly, rather than privately, funded research; as such, it will not cover all research in this area.

When referring to the role of UK Governments, the document focuses on policies rather than regulations or specific funding packages. Policies help to give a broad sense of Governments’ direction without getting into the technical details which may: a) distract from the key messaging of the document and b) be subject to frequent change.

This document avoids using technical language or acronyms where possible and is written in plain English. As the use of some technical language is unavoidable in such documents, this guide lays out definitions and explanations as these terms arise.

The contents of this guide have been reviewed by domain specialists to ensure they are a useful and accurate introduction to the topic.

Suggestions about factors which should be included in future editions are welcome and should be sent to EDCManager@stfc.ac.uk



1. Overview

The UK is facing an energy crisis on three fronts: climate change, energy security, and affordability. Energy demand reduction is fundamental to improving the UK's performance on all three. Research has shown that reducing energy use could meet half of the required greenhouse gas emissions reductions needed by 2050 for the UK to become a Net Zero society (EDRC, 2023). Lower energy demand reduces the scale of energy supply decarbonisation needed, and is essential if the UK is to meet its carbon emission reduction goals. By 2050 we have the potential to halve our energy demand in transport, housing and nutrition (CREDS, 2022). All the National Energy System Operator's (NESO) 'Future Energy Scenarios' expect substantial energy savings through demand reductions by 2050 (NESO, 2024). The ability to control energy demand is also viewed as a key component of enabling flexibility in the energy system, something that will become increasingly important as more intermittent renewable energy supplies are installed (EDRC, 2024). Some academics have noted that a disproportionate amount of focus, funding and effort is placed on supply side solutions to energy decarbonisation, and that rebalancing this effort is therefore essential. Reducing energy demand is not, however, without its challenges, and the different solutions for doing so vary between sectors. To effectively enact demand reductions, efforts and coordination would be needed from government, utility companies, NGOs and others.

2. Government direction

The different tiers of government in the UK, from central government, through the devolved administrations, to local government, each have certain powers within their jurisdictions to incentivise or mandate energy demand reductions, such as changing energy efficiency standards for homes. The UK Government and the devolved administrations have each published strategies for achieving net zero, and have each detailed energy demand reduction targets to different extents. Several local authorities have also published plans to reduce energy consumption in their areas through Local Area Energy Plans (LAEPs), trying to promote the local co-benefits of demand reductions.

2.1 The UK Government

All the policies described below are subject to change following the recent 2024 General Election in the UK. The UK Government's approach to energy demand reductions largely focuses on improving energy efficiency across housing, industry and transport. The Heat and Buildings strategy (BEIS, 2021) sets out the Government's ambitions to improve the heat efficiency of the UK housing stock, a

measure with significant potential as discussed in the UKERC Heat Landscape Document.

In the Net Zero Strategy (BEIS, 2021) the Government seeks to support improvements in material supply chains as well as increasing energy efficiency in industry, since materials represent significant embodied energy demand. This strategy also discusses efforts to accelerate the transition between transport modes, from highly energy intensive cars to more active and shared transport methods (e.g. bikes and trains). However, there is an emphasis on energy efficiency improvements in the transport sector, prioritising a shift towards electrification to achieve this. It also presents a role for digitalisation and smart energy management in both residential and commercial settings, allowing greater demand side flexibility and taking pressure off the electricity grid. Finally, it discusses the public information campaigns the government will use to help consumers adopt lower energy demand behaviours.

2.2 Devolved governments

The Scottish Government's demand reduction focus is on heat, with details given in their Heat and Buildings Strategy (2021). They put particular emphasis on heating efficiency improvements not just to reduce energy demand but also tackle fuel poverty. In their Climate Change Plan (2020) they also highlight the need for improved energy efficiency in transport and industry.

The Welsh Government's Net Zero Strategic Plan (2022) puts an emphasis on public engagement and behaviour change to achieve energy demand reductions. Similarly, they emphasise the need for community-centred and community led approaches to reductions, highlighting the link between demand management and social value.

The Northern Ireland Executive plans to support its population to decrease energy demand through public information campaigns. This includes information around home insulation and heating efficiency.

2.3 Local authorities

Several local authorities, although by no means all, have published LAEPs that outline various energy demand reduction measures. Some highlight their role in community engagement, using this to advocate for community-led behaviour change campaigns. Others establish a variety of neighbourhood-level energy-sharing schemes as well as integrating smart energy systems across buildings to manage demand. Others set out to aid the deployment of energy efficient technologies in local businesses, especially SMEs which can struggle developing their own demand reduction plans.

3. Solution Framework

Demand reduction solutions can take many forms, but generally solutions can be split under three headings: avoid, shift, improve. This framework was originally developed as a tool for improving transport sustainability, but can be applied to a variety of sectors.

- **Avoid** unnecessary uses of energy by, for instance, extending the lifespan of products to reduce the energy needed for manufacturing.
- **Shift** to lower intensity forms of energy use, for example integrating some homes into district heating networks rather than having individual boilers in each building.
- **Improve** the energy efficiency in current modes of energy use, this could include improving the fuel efficiency of cars, or electrifying them.

This framework encourages the research community to consider demand side solutions beyond the technical (which would largely fall under 'improve') and consider the role that elements such as policy and behaviour change might play. To implement solutions of each type requires a combination of policy, regulation and incentives, as well as collaboration between a variety of actors (government, NGOs, businesses, etc.). As such, some research looks at the underlying governmental, social and organisational factors needed to make demand reduction solutions viable. Some solutions could be placed under multiple categories, the category allocation used here is simply indicative rather than definitive.

Another key distinction that some researchers make is between consumption-based energy demand and territorial energy demand, this can impact demand reduction approaches. Solutions that seek to minimise UK territorial energy demand might look different to those taking account of global energy consumption. For example, heat in buildings is the largest single use of energy in the UK, so tackling heating efficiency might be a priority for reducing domestic demand. However, as the UK is a net importer of goods that each have embodied energy demand from their production, reducing our consumption of these goods would reduce our overall energy demand. As the UN requires countries to account only for their own domestic emissions, often it is the former approach that takes priority in governmental efforts.

4. Research and innovation

There are numerous energy demand reduction research projects across the main energy use sectors in the UK: transport, residential and commercial, manufacturing, and nutrition. We can consider each of these under the avoid, shift, improve framework.

4.1 Transport

- **Avoid** – some research is considering the ways we might combine transport and land use planning to: reduce the distances that needs be travelled, and prioritise less consumptive transport modes. Compact cities are a particular area of interest as research seeks to more fully understand their environmental impacts and potential. Similarly, studies into the impacts of remote or 'teleworking' seek to understand the overall impacts on consumption of this substantial paradigm shift in the workplace. Some are seeking to innovate by developing demand responsive transport systems, facilitating an improved 'sharing economy' for travel and logistics. This includes algorithms that can applied to high energy demands over large geographies, but also by working to understand stakeholder needs.
- **Shift** – researchers are seeking to understand the barriers for mode shifts towards more public and active transport, including work on transport cultures and political-economic systems. Some also seek to understand the potential for more fringe technologies in this transport mix such as light weight electric vehicles, e.g. electric bikes and e-scooters. Cutting edge solutions are also being explored such as drone delivery systems and the potential role of energy efficient autonomous vehicles.
- **Improve** – energy efficiency in the current transport mix has long been a topic of research, and as a result internal combustion engines have become significantly more efficient over the last 50 years. However, there have been "rebound effects" associated with this efficiency as cars have become larger and journeys longer. Some research seeks to better understand this relationship and so deal more proactively with rebound effects, encouraging eco-driving and making cars smaller and more lightweight. Moving towards electric cars also provides energy efficiency improvements and some studies, often focussed on economics, explore how we can accelerate this transition. An additional demand reduction advantage of electric vehicles could be smart charging or vehicle-to-grid charging to reduce peak demand and even act as short-term energy storage. This relates to broader efforts to understand how digitisation might contribute to energy demand reductions in transport, stretching from home charging to shipping port management.

4.2 Commercial and Residential

- **Avoid** – avoiding energy demand in commercial and residential settings can include things like reducing temperature set points. Reducing set temperatures in homes requires social buy-in which can be a challenge, this represents a key area of research. Some modelling work seeks to understand how these kinds of demand reductions might affect the whole energy system as well as the wider economy.
- **Shift** – heat is the biggest use of energy in UK homes, and most of that heat is currently provided by burning fossil fuels on site. Switching to different

forms of heat production can drastically reduce the energy demand associated with that heat through solutions such as heat pumps and heat networks. However, it is important to note that these only reduce overall energy consumption when solutions are well designed and implemented. Some research is investigating what opportunities there are for accelerating the roll-out of these technologies by addressing barriers which are largely concerned with economic and policy support. Other studies are seeking to understand how behaviours may change with the introduction of these technologies, and the impact they may have on the energy system at large.

- **Improve** – given it is likely that 80% of existing buildings will still be in use in 2050, retrofitting to improve their thermal efficiency will be an essential part of reducing energy demand, as will setting out more stringent insulation standards for new-builds. Retrofits face barriers due to issues of construction skills shortages, financing and awareness, issues that some research seeks to address. While research into domestic demand improvements used to focus on improving the performance of our appliances (enhancing the efficiency of boilers for example) it has recently shifted towards a data-centric approach. Many buildings now have smart metering and management systems which collect high frequency, high resolution data. Particularly for larger buildings, this data can unlock insights into potential energy savings and some studies are looking at digital innovations that may help with this. Data analytics and digital twins are just some of the methods being assessed in the research. Accompanying these studies is research into how building data can be made more open while protecting the privacy and security of our buildings and homes.

4.3 Manufacturing

- **Avoid** – energy demand can be avoided in the manufacturing sector by extending the lifespan of products and integrating practices with models of circular and sharing economies. There are many projects and research centres seeking to understand how different elements of industry and society can be transitioned to a circular economy. Some of these look at the manufacturing techniques and materials that best align with this economic structure, others look at the role of tools like digitalisation to help manage such an economy.
- **Shift** – using recycled materials in manufacturing can also help to reduce whole system energy consumption, however recovering materials from waste can be a challenge. Research is especially focused on how such recovery can be carried out for the critical materials used in advanced technologies. Recovery of such materials from waste can not only help reduce energy consumption but also help address concerns about the security of supply chains. However, this is not true of all such materials and research is needed to identify where recycling can be most effective. Some research is also investigating how chemical compounds can be produced from agricultural

waste with other work exploring the potential role of bio-derived and bio-inspired advanced materials in manufacturing systems.

- **Improve** – industry has dramatically improved the energy efficiency of its processes over the last 50 years, however, many of the demand reduction benefits of these improvements have been counteracted by increased production. Some research still seeks to improve manufacturing energy efficiency, often through the use of more energy efficient materials and increased electrification. However, other research seeks to understand the other measures efficiency improvements need to be paired with to achieve overall energy demand reductions.

4.4 Nutrition

- **Avoid** – reducing the total amount of consumed calories at a system level will also reduce energy demand and this can be achieved through reducing calorie consumption in line with daily needs, and reducing food waste. Reducing calorie consumption often falls under the remit of nutrition science and social epidemiology, however there is an increasing awareness of the environmental impact of such objectives. As such, some researchers are looking at how we can more effectively understand and communicate the co-benefits of this and other energy demand reduction measures. Food waste reduction is another area which attracts transdisciplinary attention, with investigations finding that a mixture of policies, information campaigns, and behavioural interventions can have positive impacts.
- **Shift** – the impacts of shifting diets are complex, as are their impact on energy demand reductions. However, it is commonly understood that moving away from ruminant meat to other forms of protein can help reduce energy consumption in food production. In recent years, meat consumption in the UK has decreased substantially, but the causes of this are difficult to understand. Some research is investigating the diverse factors which influence such dietary choices and how we might encourage a further move towards less energy intensive diets.
- **Improve** – we can improve the energy efficiency of our food consumption by making full use of our food resources and making improvements in the efficiency of our culinary appliances. Some research is looking at how food waste can be reused in some manufacturing processes improving the overall product energy efficiency. Other research is investigating the relative efficiencies of fresh and processed foods, taking into account production, storage and transport.

4.5 Political and social research

Many of the solutions listed above will require some degree of Government intervention to incentivise the diverse actors involved. While there are intrinsic benefits to energy demand reduction, there is often a question mark over governments' social licence to use this approach. Some research seeks to understand the conditions for such interventions, and the extent to which governments already have and can cultivate such a licence. Other researchers are seeking to understand how demand reduction can become integrated into Government policy more broadly. Parts of this research are focused on how we account for carbon in our consumption, including from imported goods. Finally, some are seeking to understand the impacts of place and specific place-based interventions on the success of energy demand reduction efforts, highlighting the special role of local government in this context.

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