CENTRE FOR RESEARCH INTO
ENERGY DEMAND SOLUTIONS

Energy Use for Zero Carbon

Presentation to Oxford Energy Network

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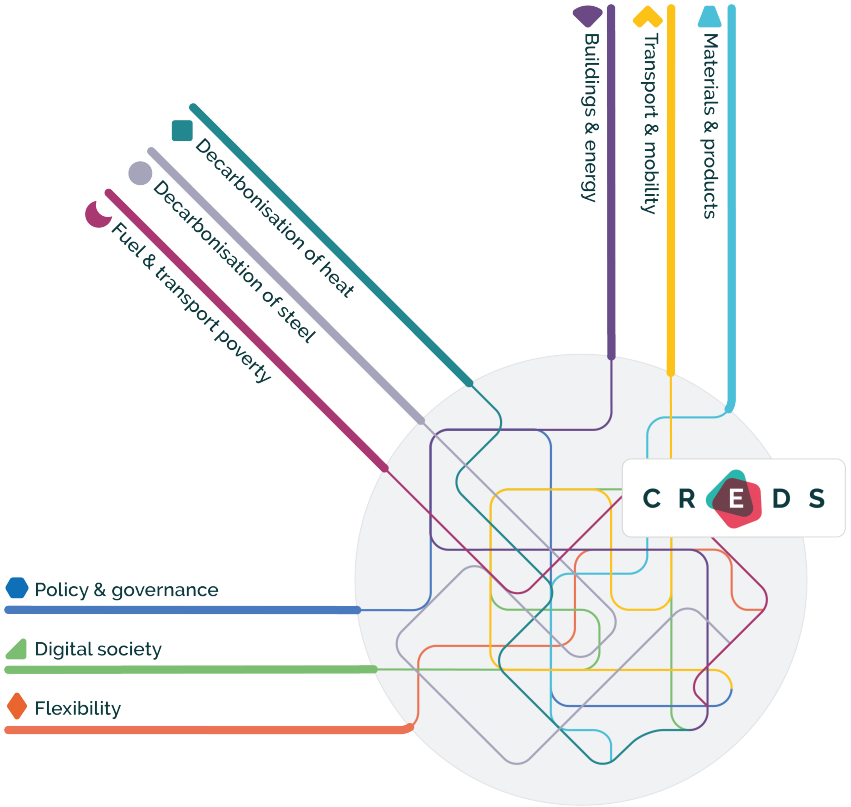
Centre for Research into Energy Demand Solutions (CREDS)

CREDS is:

- A UKRI funded Centre, from April 2018 to March 2023, with a budget of £19.5 million.
- A distributed centre, involving more than 20 universities, led from Oxford.
- Hub for UK energy demand research.

CREDS research programme

- Three sectoral themes: Energy & buildings, Transport & mobility, and Materials & products,
- Three cross-cutting themes: Flexibility, Digital society and Policy & governance,
- Three challenges: Decarbonisation of heat, Fuel & transport poverty, and Decarbonisation of steel



CREDS Research findings

Demand reduction	Multiple benefits	Flexibility	Pandemic learnings	Buildings & heating
Energy systems	Equity	Digitalisation	Affordability crisis	Transport & mobility
Engaging people	Policy & governance	Local action	Tools & data	Materials & industry

For more information see https://www.creds.ac.uk/creds-research-findings/

CREDS Research findings

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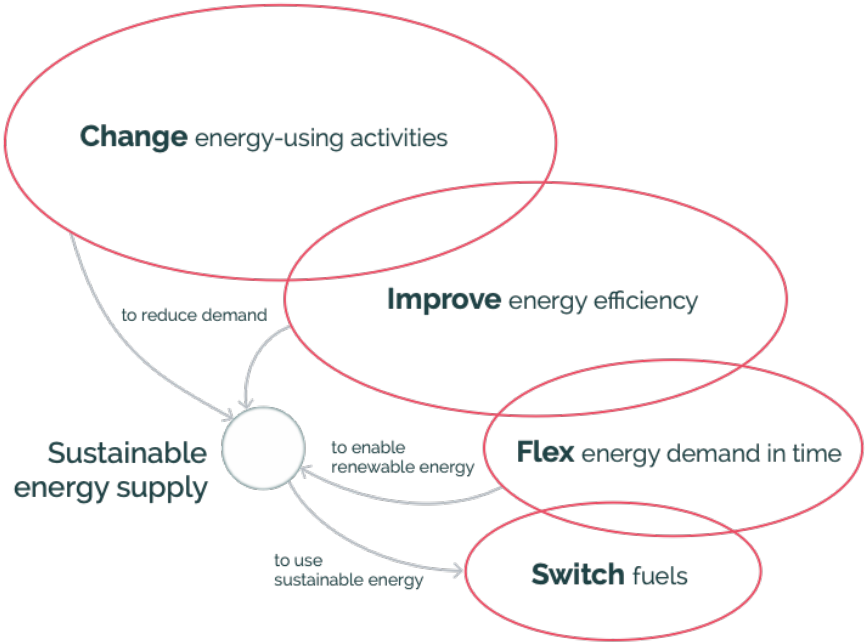
High Level Messages from CREDS Research

- Energy demand reduction, renewables and electrification are mutually reinforcing components of the energy transition;
- The potential for reducing energy demand is very large;
- Reducing demand contributes to climate, affordability and security goals;
- Buildings, transport and industrial energy use raise some different challenges;
- It is a social as well as technical challenge;
- Public policy will be critical.

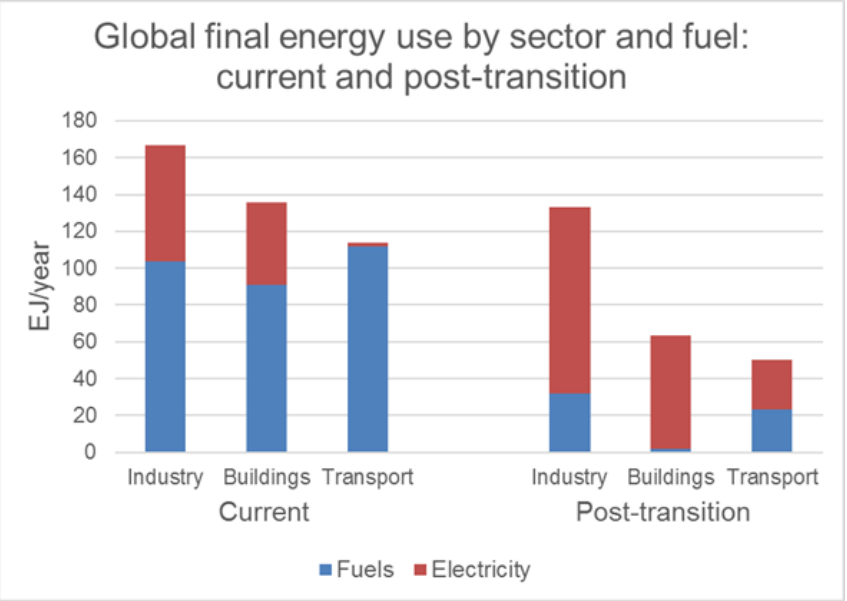
Energy systems (1)

- Energy use influences, and is strongly affected by, the wider energy system.
- Future supply will be dominated by variable renewable energy.
- Direct use of fossil fuels needs to end. This will be largely via electrification.
- Reduced demand and increased flexibility can both reduce costs and improve system security.
- There are policy, technical and social challenges to making this happen.



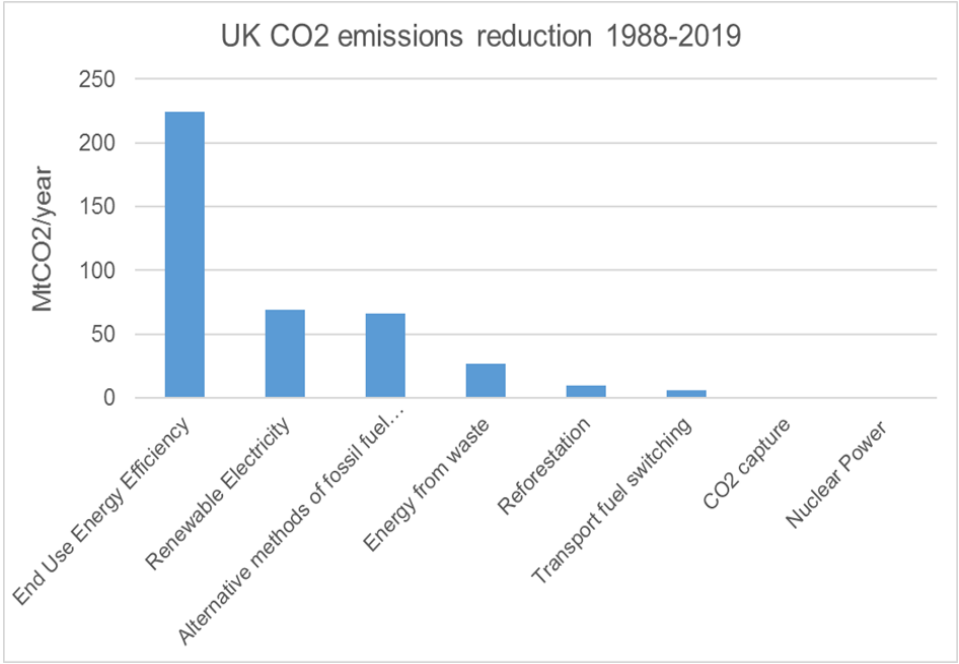
Energy systems (2)

- Heating and light vehicles will be largely electrified.
- Electrification enables a 40% increase in end use efficiency.
- Electricity cannot be used in all applications. Some future fuel choices are uncertain, e.g. in steel and aviation.
- Tens of TWh of storage will be needed, far exceeding what can be provided by batteries. Thermal and chemical storage are the most realistic options.



The potential for reducing energy use (1)

- Over 30 years, energy efficiency has played the largest role in reducing UK emissions
- It has delivered more emissions reduction than renewables and switching to gas combined.
- Policies have been weakened substantially in the last decade.



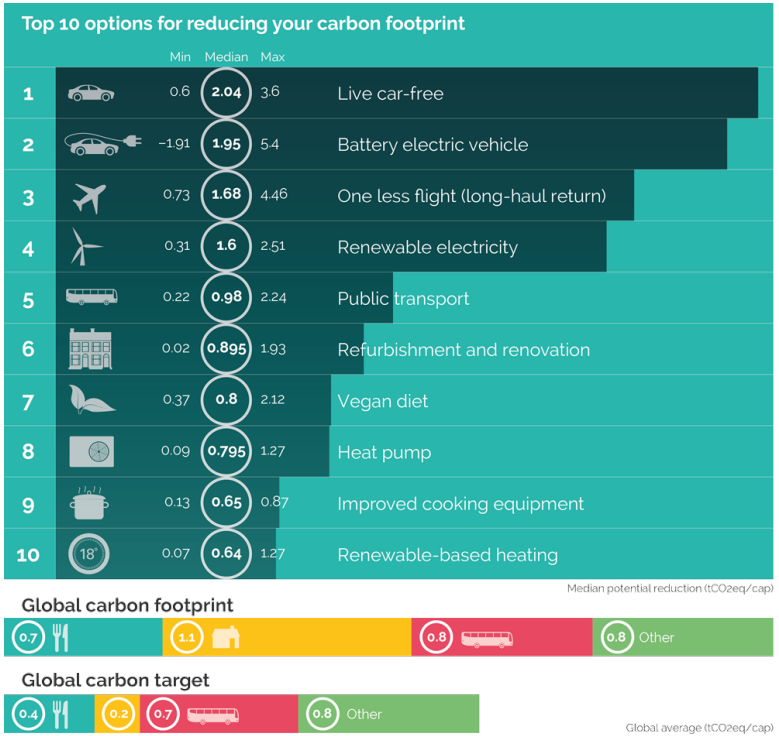
The potential for reducing energy use (2)

- Energy demand can be reduced significantly in each of transport, buildings and industry.
- Total demand can be halved by 2050 to well below the current global average.
- Half of this could be achieved by 2030.
- All plausible net-zero scenarios include substantial demand reduction.

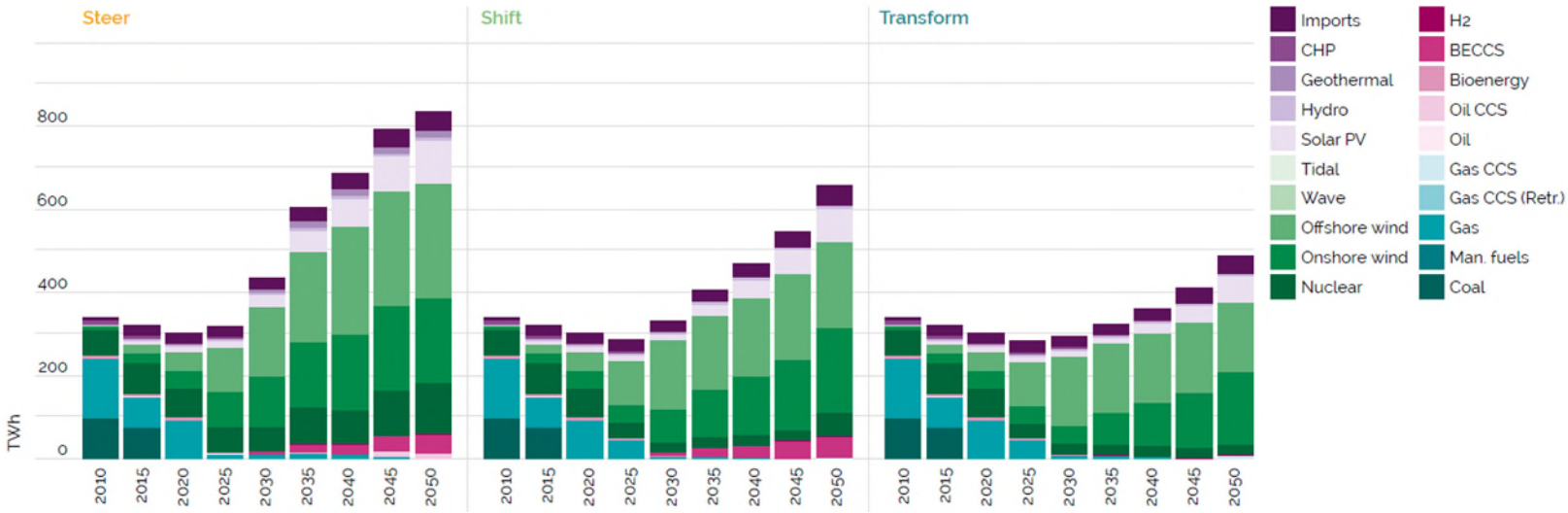
Large scale demand reduction – how do we do it?

There are three components:

- Well-established energy efficiency measures, e.g. insulation, heat recovery, improved control.
- New efficiency options enabled by electrification - EVs, heat pumps etc.
- Changes in the system in which energy is used - mobility, materials, comfort etc



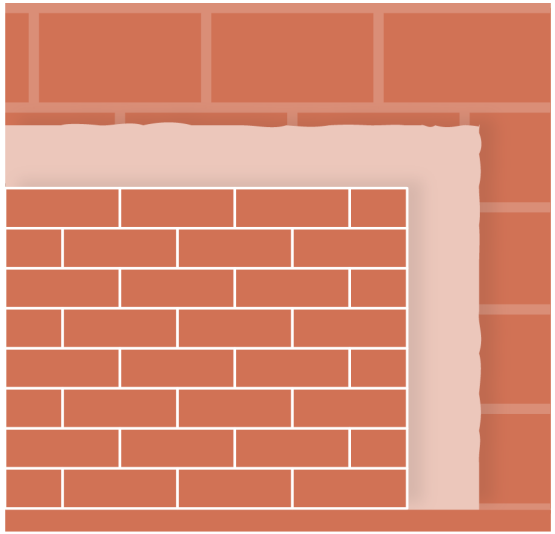
Implications of demand for energy infrastructure



- Electricity supply in net-zero scenarios in 2050 can range from <500 TWh to >800 TWh
- Major implications for the highest capital costs technologies – nuclear and BECCS

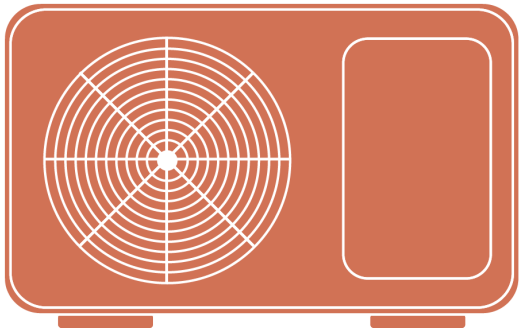
Buildings and heating (1)

- The potential for reducing energy use in buildings exceeds 50%.
- Future uncertainties include heating practices, indoor clothing trends, cooling demand and uptake of energy service business models.
- Improved fabric and heating technology remains critical for reducing building energy use.
- Retrofit is a long-term challenge. It requires attention to skills, supply chains, innovation and wider goals than carbon reduction.



Buildings and heating (2)

- Choices between the 3 three main zero-carbon heating infrastructures - hydrogen, heat pumps and district heating – have major implications for the wider energy system.
- High reliance on hydrogen is not likely.
- Potential savings from high-efficiency heating exceed those from improved insulation.
- A ‘fabric first’ strategy is applicable only where it is cheap, or needed to ensure health, comfort or heat pump efficiency.



Transport and mobility (1)

- Transport energy use could be reduced 60% by 2050. This requires shifting travel modes and as well as using zero-carbon fuels efficiently.
- Transport is the critical sector for reducing oil use.
- Pathways which focus solely on electric vehicles limit the speed of demand reduction.
- Aviation and other long-distance trips are largely for leisure and by higher-income groups. They form a large share of transport energy use, and are where changes to travel patterns are most important.

Transport and mobility (2)

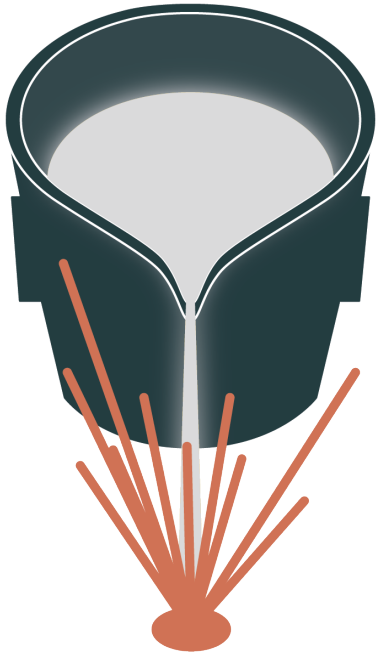
- Only 15% of private cars are in use at any one time, and 30% do not move on any given day. There is therefore a large potential for car sharing.
- There is declining car use by young adults.
- Lower energy travel solutions are highly location dependent.
- In urban areas, walking and cycling can be significant modes, reducing congestion, energy use and carbon emissions.
- Public transport, in particular buses, can also play a substantial role in reducing energy use.

Industry and materials (1)

- Moving to net-zero industry will require improved material and energy efficiency and new zero-carbon processes.
- Energy efficiency has historically contributed most to falling industrial energy use; Materials efficiency has the greatest short-term potential, with new processes contributing more towards 2050.
- Using all these approaches, it is possible to reduce UK industrial energy use by 24% by 2050.
- Sectoral studies of food and steel show achieving net-zero industries requires demand-side action.

Industry and materials (2)

- A materials strategy is needed, covering production, use of secondary materials, product light-weighting, new business models and circular consumption.
- Construction accounts for 50% of UK material use, and is critical to resource efficiency improvement.
- Increased scrap steel use could allow greater use of electric arc furnaces.
- Steel decarbonisation via hydrogen direct reduction requires early support for R&D and demonstration.



Multiple benefits (1)

- Reducing energy demand has many benefits, including for energy security, jobs, comfort, air pollution, diets and active lifestyles.
- Many of these offer major health benefits.
- Reducing and electrifying motorised transport, in particular, will help reduce air pollution.
- Energy efficient buildings can reduce the risk of cold homes and ill-health.

International Energy Agency (2015) Capturing the Multiple Benefits of Energy Efficiency

Multiple benefits 2

- Energy efficiency investment has a high propensity to create jobs locally.
- Energy and resource efficiency both tend to increase economic growth.
- These benefits may be a big driver for energy demand reduction.
- There are potential disbenefits, e.g. from poor ventilation, and multiple barriers.
- Energy efficiency decisions are therefore complex.

Fawcett, T. and G. Killip (2019) Journal of Cleaner Production 210: 1171-1179.

Engaging people (1)

- People are critical as users, citizens and workers.
- Two crucial transitions – to heat pumps and electric vehicles - depend on shifts in consumer purchases.
- Relying on consumer behaviour to lead the transition will not work. It requires changes to infrastructure, regulation and incentives.
- Changing the ways that energy is used also requires personalised information and advice, particularly for vulnerable people.

Engaging people (2)

- Some energy savings will require changes to social norms.
- People have a role as citizens. This might be catalysed by processes such as citizens' assemblies.
- The transition has big implications for jobs, as major new industries emerge. This will require improving skills, particularly in construction.
- And effective change will depend critically on people believing that it will be fair.

Governance & policy (1)

- Energy policy focusses on energy supply, even when the benefits of a demand focus would be larger.
- UK policy needs strengthening: not just in energy, but also for the drivers of energy use in transport, the built environment and materials.
- Current institutions are inadequate to deliver these changes. Governance reform is needed.
- A combination of regulation, incentives and information is needed, and emphasis on public engagement and trialling new policies.

Governance & policy (2)

- Electric vehicle support is justified, but not sufficient. Road building, bus re-regulation and aviation growth also need attention.
- Support for supply chains and skills development in retrofit is needed.
- Delivering heat pumps targets will require incentives, regulation and enforcement.
- Energy intensive materials sectors need policies to promote both material efficiency and new processes.

Thank you

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Spare slides

CREDS Key achievements

Changing the terms of debate:

- Energy use as central to the energy transition
- Demonstrating the scope for demand reduction in the UK.

Developing people:

- Building capacity in energy demand research across disciplines.

Contributing practical solutions:

- Responding to stakeholder needs,
- Developing methods, models and tools,
- Professionalising knowledge exchange.

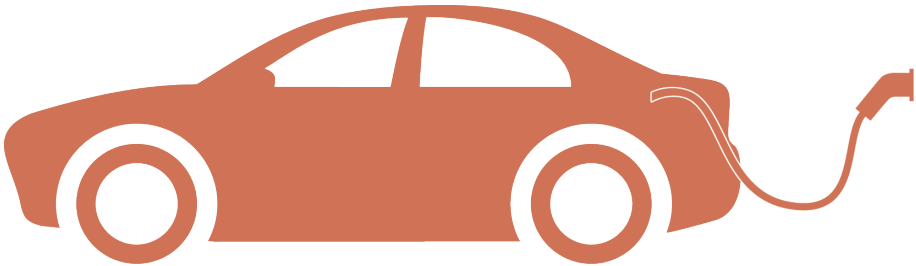
More than 400 publications. Plus research findings usable by stakeholders.

Equity & justice (1)

- There are major inequalities in energy use. High income groups use more energy. Low-income households spend a higher income share on household energy.
- Fuel and transport poverty matter, overlap and affect households disadvantaged in other ways.
- Ensuring access to key services will be essential and requires policy change.
- The current energy affordability crisis mainly affects lower-income households.

Equity & justice (2)

- Travel demand is highly-income dependent, especially long-distance travel and aviation.
- Incentives for electrification provide little help for low-income households.
- Policy design for zero-carbon heating needs to account for higher capital and operating costs.
- Households differ in their capacity to use smart technology and provide demand response, so ‘smart’ is not a ‘win-win’ for everyone.



Demand flexibility 1

- Flexible electricity demand can help address supply variability.
- Local energy storage and re-timing of energy-using activities are both potential sources of demand flexibility.
- The patterns of activity in energy use are driven by social and institutional factors.
- Interventions to achieve demand response need to take these into account.

Demand flexibility (2)

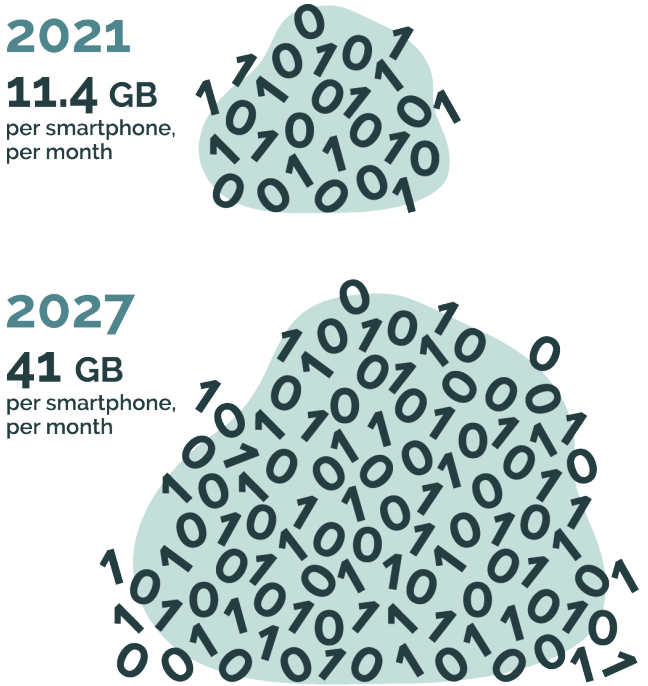
- Smart meters are an essential, but not sufficient, enabler of demand response.
- Electric vehicle batteries offer a large potential for within day flexibility.
- Heat pumps exacerbate seasonal imbalances, but coupled to heat storage in buildings, can contribute to diurnal balancing.
- Some current flexibility business models are driven by electricity system needs, and better user engagement is needed.

Energy & digitalisation (1)

- Digitalisation allows three broad approaches to reducing energy use, even though these benefits are rarely the primary driver.
- Digitalisation offers improved control options to reduce energy waste.
- Digital services that replace material goods can enable energy savings, especially in manufacturing and travel.
- Some digital platforms facilitate sharing, enabling energy saving.

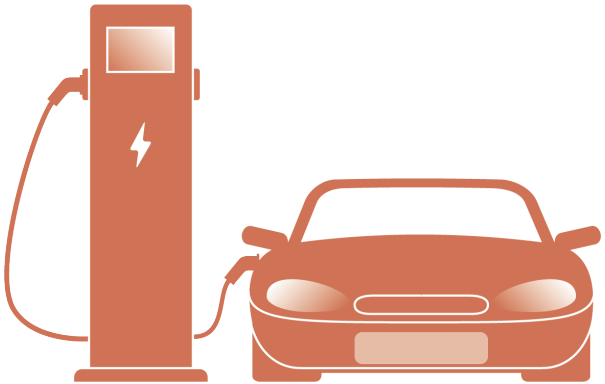
Energy & digitalisation (2)

- Energy efficiency improvement can enable higher consumption, and digitalisation can enable new goods and services, lowering total energy demand reduction.
- Future energy impacts of digitalisation will be a complex mix of these direct and indirect effects.
- With good policy mechanisms in place, digital solutions can deliver significant energy savings.



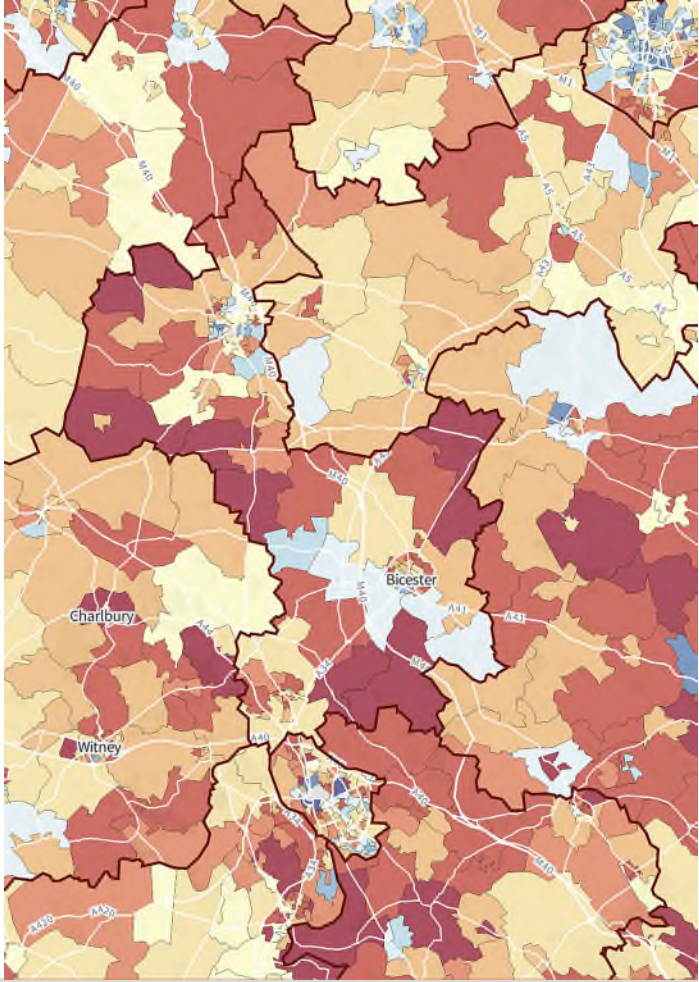
Local action (1)

- Most local authorities have declared a climate emergency, set targets and aim to do more.
- They have key functions in planning, transport and housing, and a key role as facilitators of local action.
- Local actors are best placed to address the huge heterogeneity within and between local areas.



Local action (2)

- Policy changes and funding increases will be needed if local authorities are to contribute more systematically, particularly to net-zero carbon buildings.
- Local and regional public bodies are already leading many local initiatives to provide retrofit projects, heat services, vehicle charging and innovation projects.
- Reliance on piecemeal funding leads to a lack of joined-up approaches.



Learning from the pandemic (1)

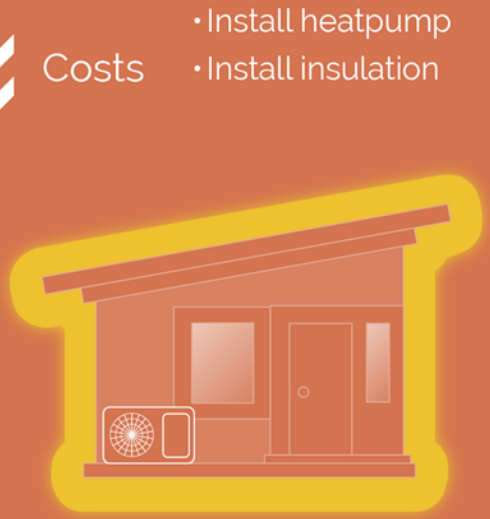
- Covid had profound effects on transport, with less impact in buildings and industry.
- Demand for residential space heating was resilient to changes during lockdown.
- Appliance and hot water energy demand increased.

Learning from the pandemic (2)

- Weekday car use is 10% below pre-pandemic levels. Long term commuting patterns have probably changed.
- Fewer cars are being bought.
- Van use has increased, due to e-shopping.
- There is reduced use of public transport.
- The pandemic has boosted both cycling and walking: The former, largely for leisure; the latter is a more persistent effect.

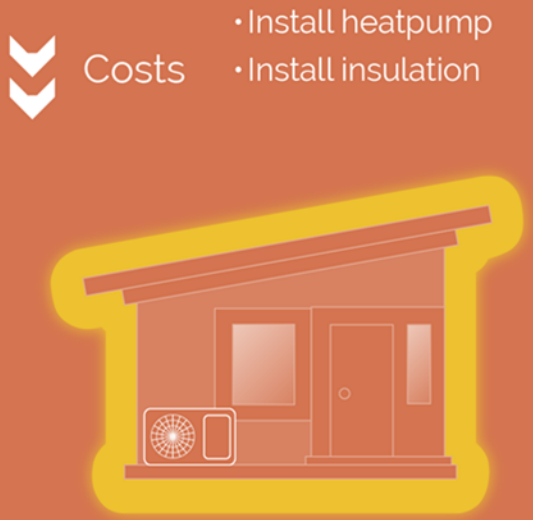
Energy demand in the energy crisis (1)

- Energy affordability is now a critical social and health issue.
- Government plans to date focus largely on limiting prices.
- Improving energy efficiency and support for low-income households are also needed.



Energy demand in the energy crisis

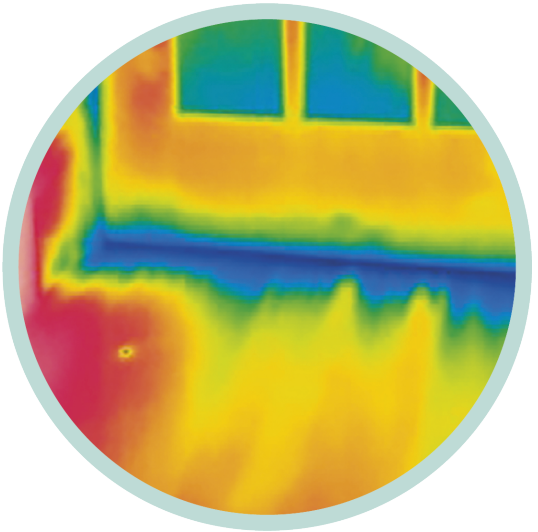
- Saving energy should form a key part of any energy security strategy.
- The combined problems of affordability and energy security energy require reduced energy use.
- High-income households have the most scope to reduce energy use quickly.
- The crises are additional reasons for a long-term energy demand reduction strategy.



CREDS Tools

CREDS has developed tools to:

- Model future UK energy demand,
- Calculate local carbon emissions,
- Model the UK building stock in 3 dimensions,
- Assess options for heat decarbonisation,
- Analyse data on the building performance gap.
- Use smart meter data to improve EPCs,
- Identify building defects using infra-red visualisation,
- Provide a metric for fuel and transport poverty
- Model resource efficiency potential,
- Predict spatial patterns of car ownership,
- Model transport-related energy use.



Tools and data (2)

- Poor data on energy use remains a problem.
- There is a lack of harmonised data on energy and transport use across the UK.
- Data on energy use in industry is inadequate and we have developed a strategy to improve this.