

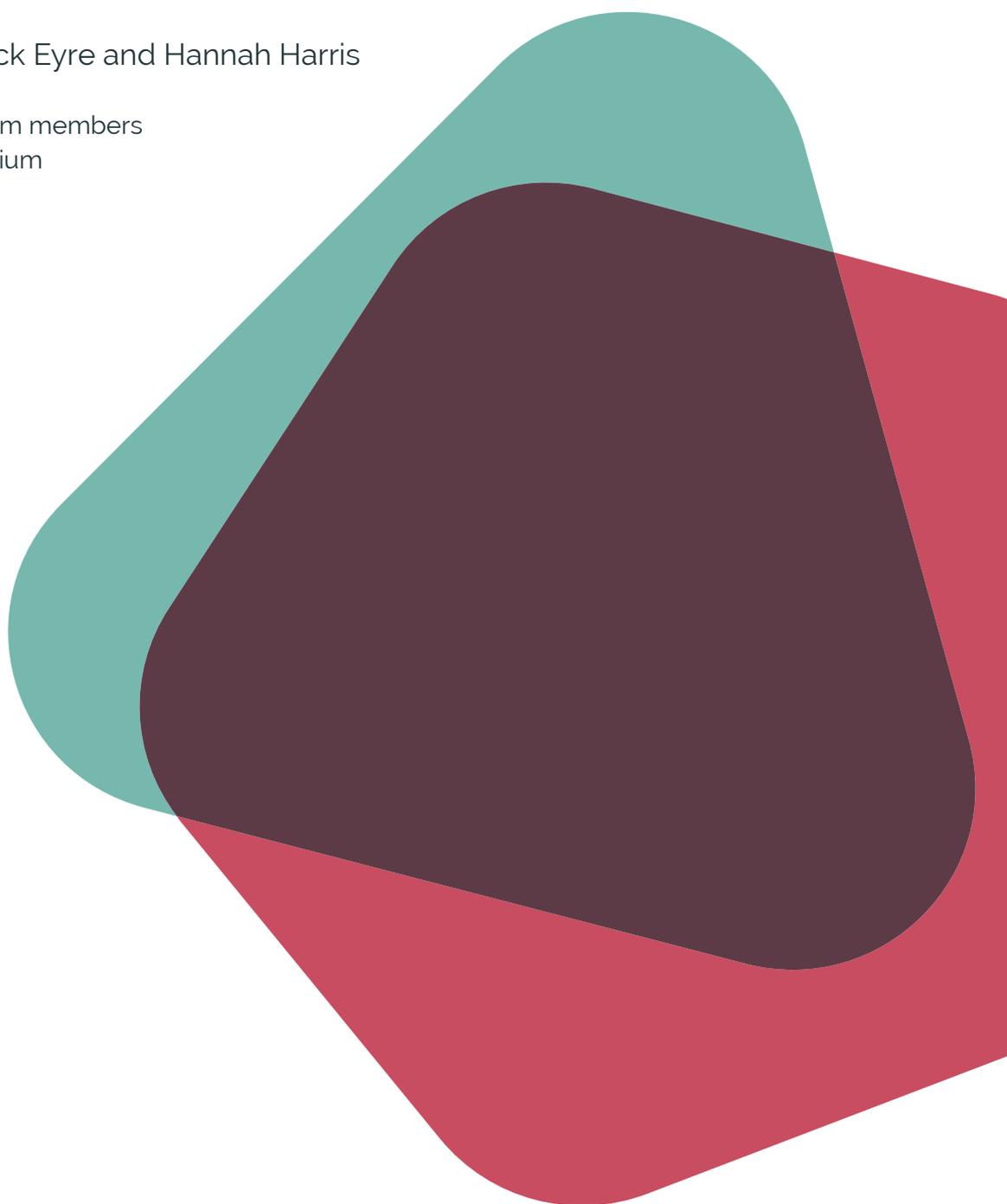


CREDS Annual Report: October 2021 to September 2022

November 2022

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With contributions from members
of the CREDS consortium



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1. Introduction

The Centre for Research into Energy Demand Solutions (CREDS) was established as part of the UKRI Energy Programme in April 2018 and has been running for 4.5 years, with funding of £19.5M over 5 years from EPSRC and ESRC. Its mission is to make the UK a leader in understanding the changes in energy demand needed for the transition to a secure and affordable, net-zero society. We are a team of over 140 people based in 24 UK organisations.

The aims of the Centre are:

- to develop and deliver internationally leading research, focused on energy demand
- to secure impact for UK energy demand research in businesses and policymaking, and
- to champion the importance of energy demand.

This is CREDS' fourth annual report covering the period from October 2021 to September 2022. The [first annual report](#) was published in November 2019, the [second annual report](#) in December 2020 and the [third annual report](#) in December 2021.

2. CREDS Governance, management, knowledge exchange and impact

2.1 Governance and management of CREDS

The Mid-Term Review (MTR) last year (2021) recommended that we put additional focus in areas such as international engagement, impact and career progression. We developed an action plan, which was agreed by UKRI and the CREDS Advisory Board, which has now been completed. We have adjusted the core teams' work plan and allocated the remainder of the Flexible Fund to these areas. See section 2.4 for Impact activities, 2.3 for International and 4 for ECRs and careers.

The Advisory Board (AB), which includes stakeholders from industry, policy and academia met three times in the year (November 2021, March & July 2022). We seek guidance from them on key strategic issues and the Board continues to provide valuable guidance and approves the use of the Flexible Fund. This year it also supported the synthesis project. An Extraordinary meeting of the AB was held on 22nd July via Microsoft Teams, to comment on the products being developed within the synthesis project and the energy price crisis briefing.

The Executive Committee (consisting of the Director, Centre Manager and Theme and Challenge leaders) has continued to meet every six weeks. The Executive is the strategic decision-making body for CREDS, under our Consortium Agreement.

The CREDS core team of 11 staff is based in Oxford and they lead the programme management, engagement, knowledge exchange, communication and equality, diversity and inclusion (EDI) activities of the centre.

We communicate within the consortium on a regular basis and have sent 24 internal newsletters (Consortium Updates) during the period. We have had three Whole Centre Meetings (WCM) of all staff in the consortium – one in October 2021 online covering Equity, Diversity and Inclusion in CREDS (Interim WCM7), one in December 2021 (WCM8) online and one in September 2022 (WCM9 in Oxford) which was the first in-person meeting since 2019 and showcased the findings from all themes. Event reports are available on request. The Advisory Board are invited to all WCMs in addition to the whole consortium.

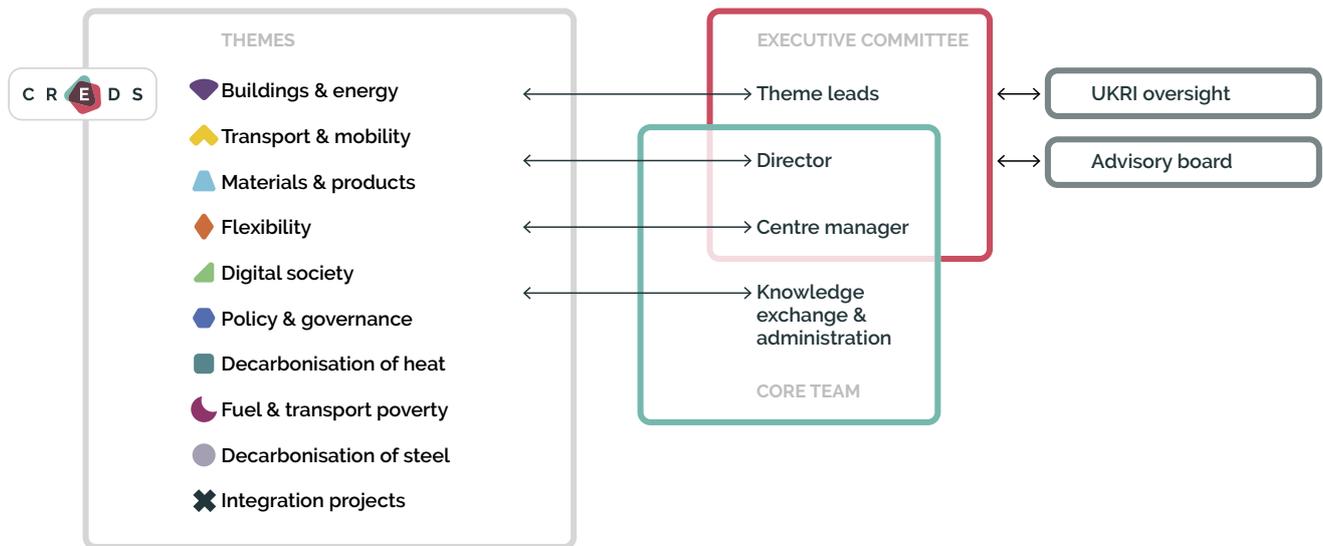


Figure 1: Organisational structure of CREDS

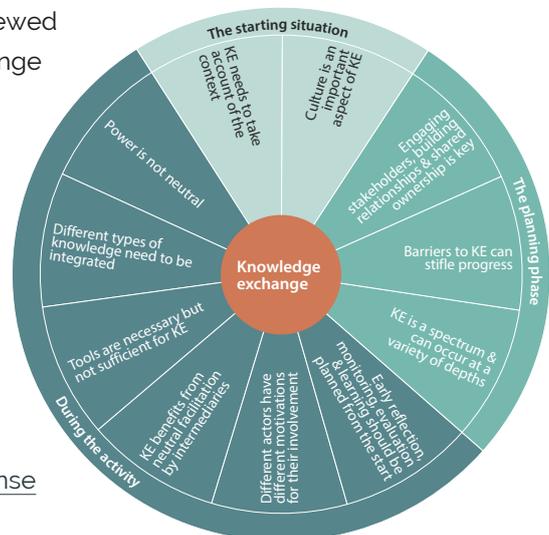
The Centre has an active working group to develop and implement its plan for Equality, Diversity and Inclusion (see section 4) and this includes career progression for Early Career Researchers (ECRs) and the studentship programme. Data archiving is covered within section 5 on the Flexible Fund.

2.2 Support for the impact journey

CREDS considers that there is a strong link and clear journey from research, promotion and engagement, knowledge exchange and impact and this is the process that we support and encourage the whole consortium to follow.

CREDS has developed the following guidance and support for researchers for their own engagement, knowledge exchange and impact work.

1. [Guidance on pathways to impact](#)
2. Knowledge exchange in energy demand. Academic peer-reviewed conference paper (Downing C., Higginson S., Wilkins T., Kobusinge R., Simon H., Jenkinson K. (2021) The role of knowledge exchange in energy demand policy innovation. Conference paper 2-119-21 in Proceedings of eceee Summer Study 2021)
 - [The role of knowledge exchange in energy demand policy innovation](#) – Open access version (available at the end of the page)
 - [eceee recorded presentation](#) (open access recording of presentation)
 - [Blog Using knowledge exchange to help research make sense](#)



3. Impact training with Cultivate Innovation (Mike Colechin). All CREDS' themes are currently undertaking this training, bespoke to each theme and will result in an impact plan per theme for two periods – i) the short-term: the remaining time within CREDS and ii) longer-term legacy work: future projects that use the outputs and findings from CREDS to generate impact. This training has been funded from the core teams' budget.
4. Impact spreadsheet for recording activities that may in the future lead to impact or, have already led to impact.
5. Research to impact journey – a suite of guidance notes that is being developed and will be made available in a few months. There will be an overarching guide that describes the framing and concept and three additional guidance notes. The first, Promoting CREDS research is already available and includes 'How to prepare a communications and engagement plan'. The next two (Knowledge Exchange and Impact) are in draft.

We also ran a workshop **When does our research really make a difference? Come and share your impact stories**, at eceee in June 2022 that discussed and gathered experiences and knowledge about how researchers have made an impact with their research and shared this learning with the group.

2.3 Engagement and knowledge exchange

Engagement with UKRI has included twice-yearly meetings and regular emails including sharing big news stories. These are in addition to the WCMs and Advisory Board meetings where UKRI are also invited.

Wider engagement, impact and championing of energy demand has continued to be a major part of work this year and these activities are provided in detail in the Communications and Engagement Plan 2022.

Engagement with other consortia has strengthened with the Cross-consortium Engagement Meeting (CEM) run by CREDS and UKERC in October 2022. This resulted in a project on mapping the UKRI energy research investments being funded and activities. Challenges and next steps for EDI was discussed at the meeting on 6 October, 2022. There is also an ECR cross-consortium Net Zero conference planned for 30 November to 1 December 2022 in Manchester.

When new research has a strong message for one of our main audiences and when it supports our key messages of energy demand reduction, we endeavour to undertake more comprehensive promotion and engagement work. This is normally with support from the core team and a bespoke promotion plan is developed that specifies the purpose of the engagement and the activities. The promotion planning process is where we determine which promotional tools would best reach the desired audience (e.g. blogs, policy briefs, webinars, social media campaign).

One of the tools we use is [case studies](#) of which there are now 18. Case study #17 on the Place-Based Carbon Calculator (PBCC) received additional funding from BEIS and DfT recommend use of PBCC by Local authorities in their [Transport decarbonisation: local authority toolkit](#). A [Case study #18 on Food Footprints](#) has been added.

This year, CREDS hosted or assisted in the following 18 events (see section 2.3 for international events):

	Title	Date	Speakers	Attendees
1	The role of energy demand reduction in achieving net-zero in the UK	06 October 21	<ul style="list-style-type: none"> • Jillian Anable CREDS • John Barrett CREDS • Chris Stark Committee on Climate Change • Rebecca Willis Lancaster University • Caterina Brandmayr Green Alliance 	328
2	CREDS EDI Spotlight – Inclusive Leadership: Positive Cultures	15 November 21	<ul style="list-style-type: none"> • Nick Eyre CREDS • Zaffie Cox EPSRC • Aradhana Tugnait Leeds Dental Institute • Major General Tim Cross Nottingham, Reading and Cranfield Universities 	23
3	CREDS EDI Spotlight – Diverse Voices: Fitting in and standing out	18 November 21	<ul style="list-style-type: none"> • Anuja Saunders CREDS • Clara Barker University of Oxford • Fraser Stewart University of Strathclyde • Komali Yenneti Wolverhampton University 	20
4	BEIS/CREDS workshop – buildings, heat & comfort: Lessons from the pandemic	19 November 21		24
5	Lectures and practicum sessions of the modelling auditing group – Reading	28 January 22	<ul style="list-style-type: none"> • Samuele Lo Piano Reading University 	30
6	Lectures and practicum sessions of the modelling auditing group – Reading	04 February 22	<ul style="list-style-type: none"> • Samuele Lo Piano Reading University 	30
7	Evidence to Climate Change Committee on net-zero governance by CREDS staff	02 February 22	<ul style="list-style-type: none"> • Greg Marsden, Jacopo Torriti, Jan Webb, Peter Mallaburn and Kay Jenkinson CREDS 	
8	Excess? Is it reasonable to put a limit on how much energy we use?	09 February 22	<ul style="list-style-type: none"> • Jillian Anable and Noel Cass CREDS 	245
9	Parliamentary launch of the PLEF to MPs, peers and senior civil servants to the APPGs on Net Zero and Intelligent Energy and PRASEG	28 March 22	<ul style="list-style-type: none"> • John Barrett CREDS 	c.35

	Title	Date	Speakers	Attendees
10	PLEF presented to departmental Chief Scientific Advisors including DfT, BEIS and Defra	9 March 22	• John Barrett CREDS	c.17
11	CREDS online workshop: Future societies – digitalisation and energy demand	16 March 22	• Anders Andrae Huawei • Tim Foxon CREDS • Noam Bergman CREDS	20
12	Post pandemic Futures and Mobility	22 March 22	• Greg Marsden CREDS • Jillian Anable CREDS • Philippe Christ International Transport Forum • Petra Meier University of Glasgow • Iain Docherty Stirling University • Jonathan Bray Urban Transport Group	156
13	BEIS workshop on flexibility in domestic buildings	09 May 22	• Michael Harrison BEIS • Jacopo Torriti CREDS	c.25
14	CREDS EDI Spotlight – neurodiversity in academia	12 May 22	• Anuja Saunders CREDS • Ginny Russell University of Exeter • Elizabeth Blakelock Citizens Advice	31
15	BEIS workshop on energy advice aspect of smart meter data	13 May 22	• Sam Balch BEIS • Peter Mallaburn CREDS • Tadj Oreszczyn CREDS	c.10
16	Archiving your data – UK Data Service training session for all CREDS project leads	25 May 22	• Maureen Haaker UK Data Service • Anca Vlad UK Data Service • Cristina Madger UK Data Service	48
17	CREDS Whole Centre Meeting 9	28–29 September 22	• Speakers from across all themes	103
18	Policy options for a fair and equitable transition to net-zero	11 October 22	• Mari Martiskainen CREDS • Stuart Dossett Green Alliance • Kirsty Austin DoT • Jennifer Dicks Cambridge Econometrics • Jack Wilkinson-Dix Energy Saving Trust	227

Part of the impact and championing objective of CREDS is to share the findings of our research with policy-makers through two routes – consultations and direct relationships.

We submitted **consultation responses** on the [Net Zero Review](#) in November 2021 and in February 2022 CREDS researchers submitted [written evidence](#) to the House of Lords Committee on Climate Change and the Environment on net-zero and mobility. This was followed by an invitation to [Prof. Jillian Anable to give oral evidence](#) to the Committee. A blog, by researcher Noel Cass, offers a [reflection on the evidence session](#).

Many of the themes have ongoing, direct relationships with policy influencers and civil servants within these organisations e.g. the research team on the Positive Low Energy Futures (PLEF) team have ongoing relationships with BEIS energy modellers, Government Office of Science and the Climate Change Committee (CCC). CREDS delivered a workshop in February 2022 for CCC's governance team to inform their preparation of the [CCC's annual progress report](#) which, for the first time, included discussion on governance aspects of the net-zero transition. The workshop featured presentations from three CREDS academics, plus several others on the discussion panel.

The core team has established more **strategic, collaborative relationships with two policy teams** in the department for Business, Energy and Industrial Strategy (BEIS) – i) housing retrofit and ii) business energy use, and also with the CCC. This gives us early insights into the policy development process and puts researchers at the heart of the policy process. For example, this year we have provided advice directly to policy teams on the energy affordability crisis, energy advice and standards, consumer use of smart meters/in-use performance metrics and flexibility metrics.

We also sought to strengthen our **relationships with Business and Industry stakeholders** this year and have regularly met with the Association of Decentralised Energy (ADE) and attended the ADE's Business Sector Conference on 3 March, 2022. We also met with UK Industrial Decarbonisation Research and Innovation Centre (IDRIC) and attended IDRIC's Industrial Partner event in June 2022. Finally, we participated in a meeting with Labour's frontbench energy team on green energy storage on 15 June, 2022. A meeting with IMechE has resulted in follow on work to produce a joint guide on energy demand reduction for SMEs.

Digital marketing

One of the many tools we use to promote the findings of CREDS is through our digital media channels (social media and website).

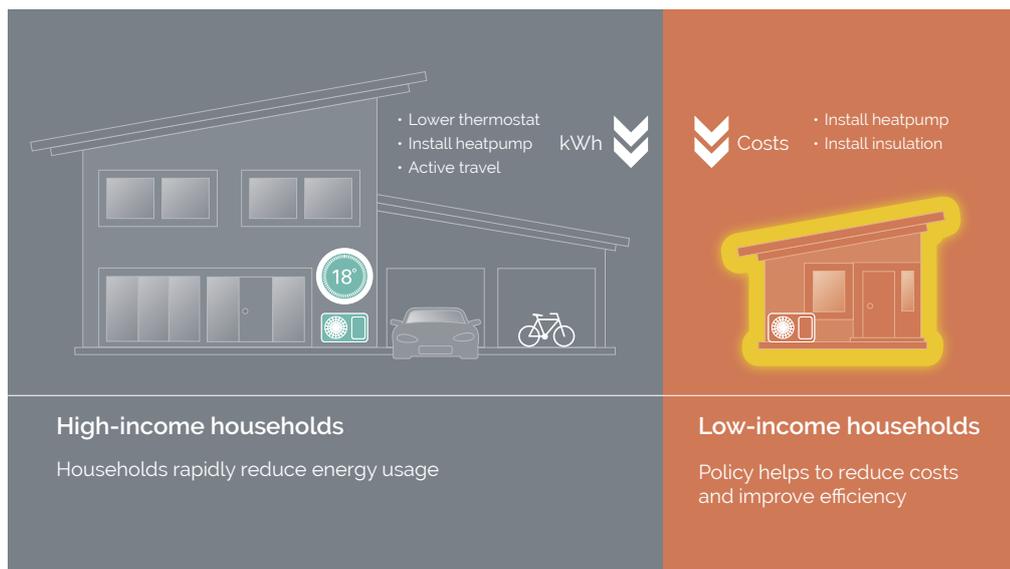
Digital newsletters were sent every month during 2022. There were 833 subscribers to the newsletter by the end of September 2022, up from 732 last year.

There were 2,855 Twitter followers by September 2022, an increase of 610 throughout the year.

Briefings published and promoted this year

We have developed a number of briefings designed to provide a resource to a non-academic audiences, including:

- The [Energy price crisis briefing](#) (30 August, 2022). This briefing was developed in response to the current situation of high energy prices following the war in Ukraine and inflation in the UK economy and is a statement of CREDS' position on the energy price crisis. It is intended as a briefing for people who work on energy use issues, rather than a general audience, providing this community with a summary of the position and what could be done.



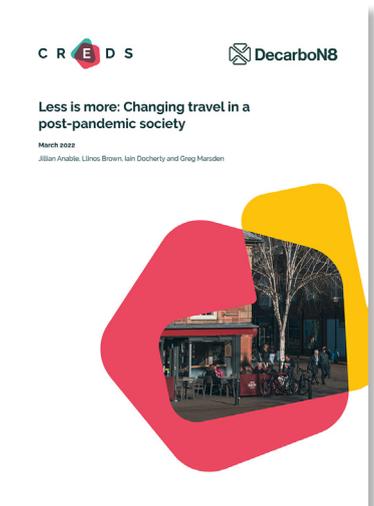
- [Policy options for net-zero Steel](#) (10 March, 2022)
- The [Energy use impacts of 5G](#) (28 Feb, 2022) led to interactions with i) civil servants from DCMS' 5G testbeds & trials team (attended by core team) and ii) representatives of Mobile UK (trade association).
- [Reducing the UKs Food footprint from demand side action](#) (linked to PLEF) was produced to coincide with Veganuary (11 January, 2022) and hosted on both the CREDS main site and PLEF site. Information was sent to selected policy contacts, including in Defra and industry organisations such as the Food & Drink Federation.

Reports published and promoted this year

A couple of major reports were published and promoted this year in addition to the large number of academic papers published (see Research Fish for a full list).

- The findings of the transport theme's, [High energy consumers' project](#) was launched via a webinar in February, 2022. Participants included 83 academics, 53 national/local government and 18 businesses. Lead author Noel Cass was subsequently invited to address a Transport for the North event. The [Curbing excess report](#) received 1083 views by September 2022.

- On 16 March, 2022 the [Less is more](#) report was launched (transport theme, Covid-19 Transport, Travel and Social Adaptability Study (TRANSAS) longitudinal survey analysis) and led to a request from DfT for a bespoke departmental workshop. The report received 4066 views by September 2022 and is our third most popular report to date.



Blog, report and briefing analysis – total to date

There have been 121 blogs in total to date, from September 2018 – September 2022.

The top blog views to date are:

1. [Why we built a place-based calculator](#) **2052** (June, 2021)
2. [New retrofit standards, new roles, existing policy, do they all fit together?](#) **1881** (August, 2020)
3. [You can't always get what you want: a reflection on Climate Assembly UK's deliberations on decarbonising passenger transport](#) **1743** (September, 2020)
4. [Rearranging elephants on the Titanic – Jillian Anable's keynote presentation from UTSG Annual Conference](#) **1650** (July, 2019)
5. [A New Green Shovel? Options for the transport stimulus package](#) **1195** (June, 2020)
6. [All crises are not made equal: what does Covid-19 tell us about the public's capacity to change behaviour?](#) **903** (July, 2020)
7. [Cumbria mine: is there a technical need for new coal mines in the UK?](#) **912** (March, 2021)
8. [Getting home insulation right](#) **870** (November, 2018)
9. [The secret life of boilers – part two: how to burn less natural gas at home](#) **866** (June, 2020)
10. [Don't throw money for heat decarbonisation out of the window](#) **815** (April, 2019)

Report/briefings views to date

We have produced 44 reports and 25 briefings to date and the top ten most viewed are listed in order:

1. [Shifting the focus report](#) **6986** (July, 2019)
2. [E-bike carbon savings briefing](#) **5285** (May, 2020)
3. [Less is more report](#) **4066** (March, 2022)
4. [Positive low energy futures report \(CREDS and PLEF site combined\)](#) **3915** (October, 2021)
5. [Shared mobility – where now, where next?](#) **2602** (September, 2019)
6. [At a crossroads: Travel adaptations during Covid-19 restrictions and where next?](#) briefing **1266** (March, 2021)

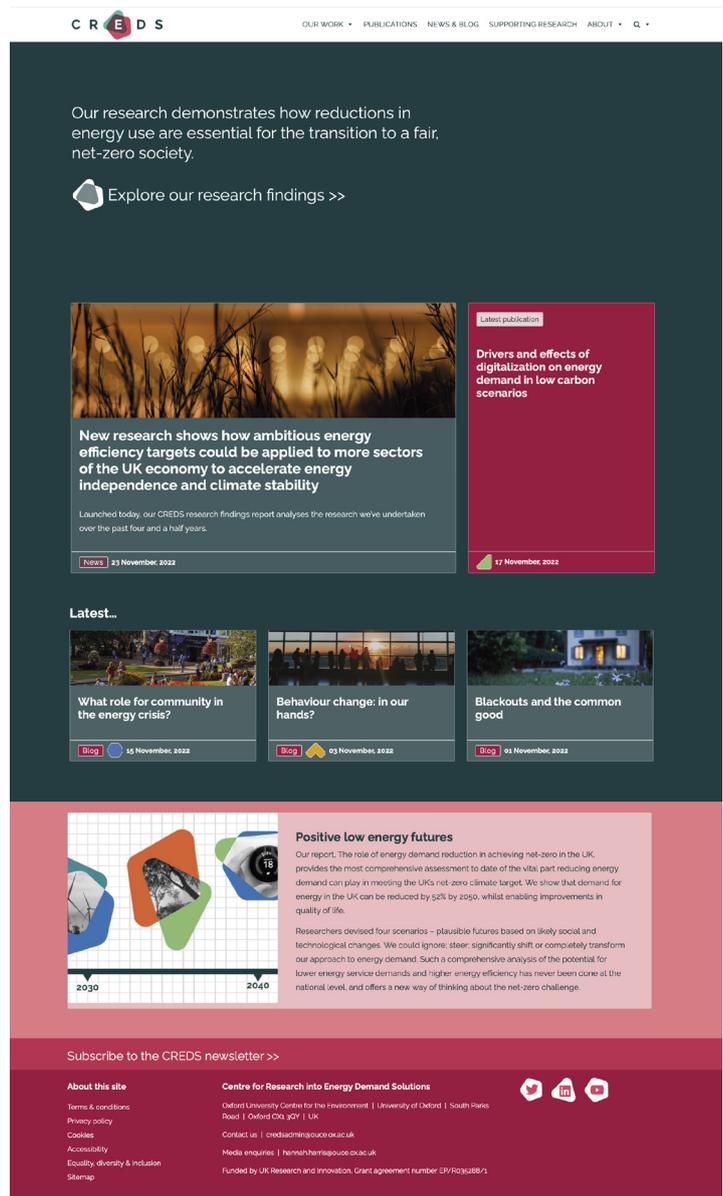
7. [Curbing excess 1083](#) (February, 2022)
8. [Resource efficiency scenarios for the UK 965](#) (March, 2021)
9. [Existing and future technologies for retrofitting the UK housing stock 865](#) (June, 2021)
10. [Positive low energy futures briefing 830](#) (October, 2021)

Website developments

In early 2022 we made a few design changes to improve the usability and findability of content on the website, specifically for researchers. A new section labelled 'supporting research', designed for CREDS members to access guidance materials, was added. We also now include preprints on the website.

We redesigned the CREDS homepage to reduce energy usage and become a best practice example:

- There is now no hero image. Images are big energy eaters. Instead, a clear sentence about who we are is shown in more accessible language.
- There is now less content on the homepage. Previously we would pull in six of the latest content posts (blogs, news etc) – these queries used a lot of energy. Three is not only better for efficiency, but also simplifies things for the user. When there is less choice, there is less cognitive load (the strain a user experiences when he/she has to think too much just to get something done or make a choice).
- We also changed the image type throughout the site to WebP (lowers page load).



2.4 Impact and championing of energy demand

In addition to engagement and knowledge exchange activities to proactively promote the work of CREDS to non-academic audiences (broadcasting and relationships going out from CREDS) we also monitor the effect that this promotion has in terms of actual impact (what we can see coming back as a result of our communications). This can be complex in terms of conceptually ensuring that there is 'cause and effect' and hence we aim to record this in a way that is transparent.

We only claim impact from CREDS where there is a direct linkage between the person or material that originates from CREDS and the source of the impact. We include invitations for interviews and quotes for the media as these have come as a direct result of our promotion work of particular studies.

A few of our impact highlights from this year include:

Research findings that have influenced UK and international policy development

- We hope that the efforts that we've made (although we have not direct evidence) to keep energy demand in policy discussion will have contributed to the u-turn in the Autumn Statement on energy efficiency action (Energy Efficiency Task Force). Most particularly the new goal of a 15% reduction in energy use in buildings and industry.
- CREDS provided written and oral evidence to the House of Commons Committee on BEIS inquiry into decarbonising heat in homes.
- Less is More report (based on data from the Covid-19 Transport, Travel and Social Adaptability Study (TRANSAS)) was launched in March 2022 and led to a request from the Department for Transport for a bespoke webinar to brief staff, a presentation at the International Transport Forum Roundtable and the report was also cited three times in the CCC's annual progress report. It was also cited in the Scottish Government consultation, especially in the Annex.
- Nish Rehmatulla provided analysis on shipping carbon emissions to the Clydebank Declaration - a global initiative led by the UK Department for Transport, encouraging governments to establish maritime 'green corridors' decarbonised from end to end.
- The Positive Low Energy Futures (PLEF) work featured in the weekly meeting of Chief Scientific Advisors in March 2022. John Barrett gave a short presentation and answered questions from CSAs. PLEF has led to continuing engagement between John's team and the Government Office for Science (GO-Science).
- Ben Sovacool presented on the equity and justice implications of European decarbonisation with content from CREDS/FAIR, to the European Parliament's Committee on Employment and Social Affairs and the Committee on the Environment, Public Health and Food Safety.
- The Steel and Materials and Products teams' work was cited in the Parliamentary Office of Science and Technology (POST) Research Briefing on Green Steel (POSTnote) and CREDS researchers were also peer reviewers. The review of the energy impacts of 5G has been cited in a recent POST note on the energy use of ICTs.
- Christian Brand was cited in Women's Budget Group policy report Towards gender inclusive and sustainable transport systems.
- There were multiple citations from Christian Brands' work during COP26 in WHO policy document

- [COP26 Special Report on Climate Change and Health](#), ISBN: 978-92-4-003672-7.
- COP26: [Seven reasons global transport is so hard to decarbonise](#).
- COP26: [Centring cycling in the climate discussion](#) by Lucas Snaije.

Press coverage

- Jacopo Toritti provided findings in relation to work on time of use tariffs in the MailOnline.
- Nick Eyre was quoted in the New York Times in relation to energy conservation.
- Tadj Oreszczyn was quoted in the New York Times in relation to overheating in UK homes during the August heat wave. He was also interviewed by the Canadian Broadcasting Corporation and Live on BBC News Channel about the energy price cap, in addition to providing data and general information to BBC researchers.
- Stefan Bouzarovski also provided comments on energy price cap for articles in The Guardian, The Telegraph, The Independent in August 2022.

TV & radio

- Nick Eyre was on the Q&A session on BBC R4 You and Yours in relation to energy prices.
- John Barrett was interviewed on C4 news covering energy prices.
- Nick Eyre was interviewed on BBC Newsnight talking about turning down thermostat to beat Putin.
- Jacopo Toritti spoke to 5Live/Naga Munchetty about the energy consumption of appliances.
- Jillian Anable was interviewed on the environmental impact of SUVs for BBC Radio 4s programme Antisocial.
- Gesche Huebner spoke on an episode of the BBC World Service Climate Question podcast on [climate change and mental health](#).
- Jillian Anable comments on COP negotiations for BBC Radio 5 Live (Replayed on BBC Radio 1 and numerous local BBC stations). She says: "Wonderful words can be said, pledges can be made, and not fulfilled. What we can take from this COP is a greater sense of urgency."
- The Big Green Money Show with Deborah Meaden on [BBC Radio 5 Live](#) (September, 2022). Jillian Anable advised members of the public about the environmental pros and cons of buying an electric vehicle. It was also on BBC Radio Scotland and various local BBC stations.

There have been many other media interactions on local radio such as for BBC Leeds and BBC Berkshire.

2.5 International activities

Visiting International Programme (VIPs)

We have revived the international visitor programme since Covid. Yael Parag (Israel) visited in September 2022 and gave talks on i) radical policy options (for a webinar and podcast), ii) energy security and the energy trilemma in Edinburgh and iii) the changing roles for individuals and organisations in the net-zero transition for the Oxford Energy Network. She also visited various academics in UCL and Edinburgh and was interviewed by Bloomberg UK on energy advice (offline copy available).

International engagement

Following the MTR recommendations, we have expanded our work on international engagement with a series of webinars entitled 'CREDS in Conversation'. We also sponsored the eceee (European Council for and Energy Efficient Economy) conference 2022 Summer Study, where we ran two plenary sessions, 3 workshops and gave 11 paper presentations.

Further international events are planned, including one on Digitalisation for Sustainability, in December 2022.

	Title of event	Date	Speakers	Attendees
1	Making mass retrofit a reality: A webinar from CREDS and Buildings & Cities	20 October, 22	<ul style="list-style-type: none"> • Nick Eyre CREDS • Faye Wade, Jan Webb, MBE Edinburgh University • Erwin Mlecnik, Henk Visscher TU Delft • Kate Simpson ICL • Veronika Schropfer Architects' Council of Europe • Lord Deben Climate Change Committee. 	137
2	Webinar and Panel Discussion: IPCC finding on Energy Demand Reduction	11 May, 22	<ul style="list-style-type: none"> • Yacob Mulugetta Climate Compatible Growth • Joyashree Roy Jadavpur University • Felix Creutzig TU, Berlin • John Barrett CREDS • Patrick Devine-Wright University of Exeter 	179
3	International Reading Rooms and podcast on Price Elasticity	18 May, 22	<ul style="list-style-type: none"> • Jose Luis Ramirez- Mendiola, Jacopo Torriti, Anna Alberini 	
4	eceee conference 2022 Summer Study	6–10 June, 22	<ul style="list-style-type: none"> • More than 15 	<400
5	Realistically radical policy options	7 September, 22	<ul style="list-style-type: none"> • Magnus Bengtsson Hot or Cool • Yael Parag Reichmann University • Yamina Saheb OpenExp • Stuart Capstick CAST Centre • Tina Fawcett University of Oxford 	159

3. Research progress

During this period, CREDS staff have authored over 100 publications, and these outputs are listed in Research Fish.

- 104** All Publications
- 30** Collaborations and partnerships
- 28** Further funding
- 189** Engagement activities
- 67** Influence on policy
- 33** Influence on business
- 24** Artistic images
- 3** Data & other

In this annual report, we have focused on showcasing the findings from each theme rather than describing the project activities within each theme now research in many of the themes is nearing completion.

3.1 Buildings

Our buildings and energy research has looked at how to shift the UK built stock to net-zero by 2050 in the most cost effective, resilient, acceptable and practical way, maximising co-benefits and minimising unintended consequences. There is a significant resource of untapped energy-saving opportunities in UK homes, with technical potential exceeding 50% and a cost-effective potential exceeding 25% by 2035. We have found that the majority of the long-term energy saving comes from moving to high-efficiency heating systems (like heat pumps), rather than from insulation.

Heat pumps are the key decarbonising technology for buildings

Decarbonising energy use in buildings will rely on the deployment of heat pumps. However, there are policy, technical, public acceptance and cost challenges to be overcome to achieve roll out at the level and speed required to meet net-zero goals. Successful building retrofit and renovation for energy efficiency requires attention to be paid to timings, bespoke/building-specific requirements, and complementary objectives, i.e. more than just carbon reduction.

Getting heat pumps to work as efficiently as possible is one of the greatest opportunities and challenges to UK decarbonisation. During cold weather, improving the efficiency of heat pumps from average to good efficiency could save as much energy as insulating all UK solid walls. Heat pumps could be used flexibly to help manage peak electricity demand, but more standardisation of the heat pump stock would be required.

Heat pumps powered by renewable electricity challenge the 'fabric first' approach. With offshore wind and PV costs reducing, and with heat pumps needing only a quarter of the energy of gas boilers, it is becoming cheaper to generate decarbonised heat than to save it. This may limit the need for 'deep' retrofit, with insulation prioritised where it is particularly cheap (e.g. during normal refurbishment/extension) or where it is essential for health and comfort and for the efficient operation of heat pumps.

Hybrid appliances which combine a gas boiler with a heat pump could be a low disruption, low-cost pathway to net-zero, reducing energy demand by 60% (compared to current gas boilers), and also reducing peak electrical demand by 10 GW (compared to air source heat pumps).

Health impacts of energy efficient homes can be considerable

Energy efficiency can result in considerable health benefits, particularly for vulnerable people. A substantial number of UK homes experience temperatures that are judged as too low for the health of the vulnerable. Older dwellings, detached homes, single occupancy and living in the North of England are all associated with the lowest share of hours at the recommended temperature threshold in the bedroom, living room, and hallway.

However, greater attention is needed to avoid unintended health consequences, such as installing measures that impact ventilation in regions with high levels of radon.

Performance gaps can be addressed

Data, its analysis and visualisation from monitored buildings during construction and in occupation can help UK buildings transition to net-zero. Much of the data is already being collected or can now be collected at minimal cost. It is now practical and cost effective to use thermal cameras on-site to identify building defects during construction and therefore help to reduce the performance gap.

Energy Performance Certificates must be improved

Energy Performance Certificates (EPCs) are a key policy tool and their usefulness can be considerably enhanced by linking them with data about actual energy use in buildings. In particular, this could be of use in the non-domestic buildings sector.

3.2 Transport and mobility

Our transport and mobility work shows that the energy used in the UK for transport (vehicles, trains, aviation) can be reduced by 60% by 2050, compared to current levels. This would make it easier to reach the UK's net-zero target, and would limit the amount of investment required for new energy and road infrastructure. Moreover, policies that target high-energy travel options (e.g. long-distance travel) are seen as the fairest, most acceptable solution.

Most high-carbon travel is done by a small number of individuals

We found that a small number of people are responsible for a large proportion of personal transport-related carbon emissions: 11% of English car users are responsible for 44% of miles driven, while the majority of flights (75%) are taken by 15% of people. Our analysis shows that carbon footprints are so unequally distributed that policies targeted at 'high consumption' activities affecting the behaviour of a small number of people would have a greater impact than 'blanket' policy approaches. Policies should also signal preferred travel behaviours that support the UK's net-zero goals. Fares for high-carbon air travel and low-carbon rail journeys should reflect their relative impacts.

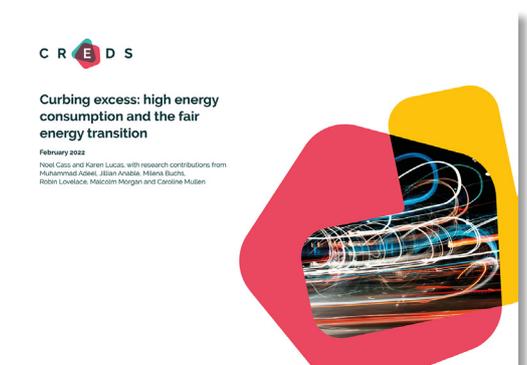
Targeting the highest-carbon travel behaviours is seen as fair

We show that public debate on fair and sustainable consumption will be needed to establish the acceptability of any policies that target travel choices, particularly for addressing 'excess' travel consumption. Our work suggests that people and policymakers are not aware, for example, of the full climate impacts of aviation. Voluntary behaviour change has been ineffective, so structural change, regulation and economic signals are needed to incentivise the switch to lower-carbon travel options. Affordable access to low-carbon travel alternatives (notably public transport) would support the wider shift to active travel and electric vehicles (EVs).

Our workshops tested policy ideas for reducing travel demand and we found that people supported regulation and even rationing-with-choice, as the fairest options, with protections for vulnerable groups. Business flights, excessive car mileage and the most environmentally damaging vehicles were seen as valid targets for tax or regulation.

Policy opportunities for greatest impact

Travel energy demand is much more unevenly distributed across income groups than housing energy demand. For maximum impact on emissions, policymakers should focus more on reducing long distance car use and frequent flying than on household energy in the shorter term.



Carbon emissions from aviation are much bigger in absolute and relative terms than is typically acknowledged. Policy changes such as a frequent flyer levy would affect a small number of people but could have a significant benefit for carbon reductions.

We commissioned surveys to look at travel patterns before, during and post-pandemic. We could see the impact of reduced travel demand and were able to identify new travel behaviours that policies could encourage to deliver multiple benefits for health, congestion, net-zero and air quality. Our analysis showed that the biggest and most sustained change was an increase in walking, and a reduction in cars in two- to one-car households. By Autumn 2022, car travel and public transport use has still not returned to pre-pandemic levels.

Helping communities to plan for change

The [Place-based Carbon Calculator](#) (PBCC) is a free online, area-based carbon footprint tool for England, using data about household and travel energy use. It shows the composition of carbon footprints in small areas, and is being used by local authorities (as recommended by the Department for Transport) and community-based groups to plan the most effective ways to reduce their carbon emissions.

3.3 Materials and products

Our materials and products research has found that delivering net-zero in industry will require a combination of improved material resource efficiency, energy efficiency improvement and new zero-carbon industrial processes. Our research has found that, in the short term, materials efficiency has the greatest potential, with new processes contributing more towards 2050.

Energy demand reduction has a significant role to play in industrial decarbonisation

Our research has found that it is possible to reduce industrial energy demand in the UK by 24% by 2050 compared to 2020 levels. This will need to be part of a comprehensive strategy that also involves fuel switching and the development of new technologies to address key industrial processes. The majority of these changes come from variations in the way we use materials and products, with a more limited role for further energy efficiency in existing processes. From detailed system sectoral studies of food and steel, it is clear that that net-zero compatible industrial energy systems cannot be achieved without demand-side action.

Historically, a significant portion of UK industrial energy demand reduction has been achieved by outsourcing of manufacturing. However, this strategy does not reduce overall global Greenhouse Gas Emissions. There are also numerous benefits for the UK to maintain industrial capacity.

Our research concludes that energy demand needs to be prioritised in both public and policy discourse, but that may require effective and 'positive' framings of the value of 'demand reduction'.

Benefits of demand reduction spill over beyond 'energy'

Our research found that demand-side actions have spill over benefits beyond 'energy'; In the nutrition scenarios, the main benefit of reducing levels of demand came from the associated reductions in non-energy emissions; in the steel sector, reducing demand results in emissions reductions from both energy and process emissions reductions.

There is a need for a far-reaching material consumption strategy

Our research has concluded that a comprehensive material consumption strategy is needed including improvements in production processes, use of secondary materials, lightweighting of products and innovative business models. It also needs to challenge existing material consumption patterns, where they are not circular.

The construction sector is the most important sector for resource efficiency improvement

The construction sector accounts for 50% of material use and relies on materials that currently have limited, short-term, production mitigation options, in particular steel and cement. It is therefore the most important sector for resource efficiency improvement. Energy demand reductions can be achieved through changing both planning laws and building regulation. Significant reductions could be achieved through the promotion of material efficiency in buildings and infrastructure.

3.4 Flexibility

Research from our flexibility team conceptualises and measures flexibility and assesses the impact of flexibility-related interventions. A distinctive and original feature of our approach is that it conceptualised the introduction of flexible technologies, new pricing regimes and the transformation of social-temporal orders within a single frame.

How flexibility is conceptualised is important

Current conceptualisations of flexibility 'fix' a particular interpretation of normality, supposing that certain needs exist and should be met. Instead, we treat flexibility as a feature of how multiple practices hang together, and of changing relations between them. Flexibility in organisations is made at the intersection of organisational and institutional processes, which define the scope for adaptation.

Flexibility interventions are not a win-win for everyone

Estimations of the distributional effects of Time of Use tariffs (ToU) differ based on income and location, with high-income groups in London benefiting and high-income groups in Scotland paying more because peak electricity demand period for an average residential household in the Greater London area takes place 60-90 minutes later compared to the North-East England area. This research was cited by Ofgem's final Impact Assessment on [Electricity Retail Market-wide Half-hourly Settlement](#) and used as input for Ofgem's Electricity Network Access and Forward-Looking Charging Review. It has been estimated these reforms will save UK residential customers GBP2-5bn up to 2045.

Histories of supply and demand balancing matter when it comes to flexibility

Infrastructural legacies and previous methods of balancing supply and demand are layered over time and influence contemporary connections between social practices, the timing of energy demand, and flexibility. Flexibility is positioned at the intersection of supply and demand and is a feature of service provision which changes over time.

Modelling spatial and temporal variability

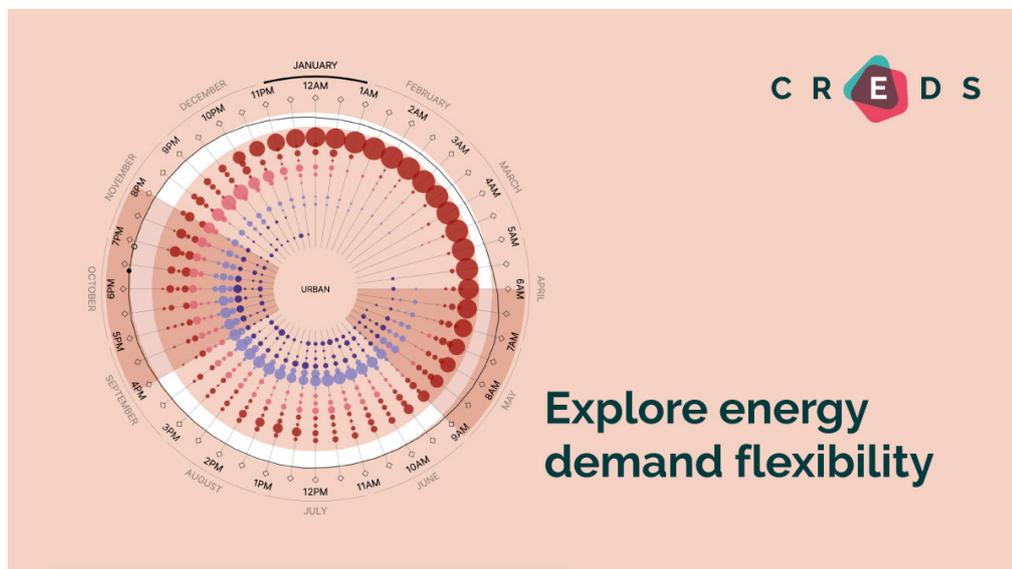
A model was developed to try and overcome limitations in spatial and temporal disaggregation of national and regional energy demand data. Our model provides accurate simulations of the spatial and temporal variability of anthropogenic heat emissions (as a proxy to energy use) across London.

New flexibility metrics

New metrics for analysing the time of day variability of both price and non-price elasticity of energy demand. These metrics can provide more granular insights into the changing degree of flexibility throughout a given day and more accurate estimates of total flexibility potential. Our work has provided evidence for a new demand side flexibility service to be launched later in 2022 by National Grid ESO.

Outreach efforts

We have also reached out to audiences using novel activities, such as our [reading rooms](#), [photo essay](#), [planned Gallery](#), and [data visualisation](#) to illustrate some of our key findings around timing of energy demand and everyday life.



3.5 Digital society

Our digital society research has found that digital technologies have the potential to enable large energy savings in three ways: first by using digitalisation to optimise energy control, secondly by substituting information for material goods and services, and thirdly by enabling sharing of material goods. However, policy interventions will be needed to steer digitalisation in directions that have this benefit.

The energy impacts of digital technologies vary widely between different applications, contexts and users

The use of digital technologies and services to substitute for material goods and services is now widespread, for example e-healthcare, e-music, e-books, teleworking and video-conferencing. Our research finds that there is no strong evidence that substituting physical goods (such as e-books) with digital services delivers significant energy savings. While energy savings can occur under certain conditions (e.g. if user devices are energy efficient, long-lived and intensively used), these savings are highly sensitive to user behaviour, socio-economic context and other variables.

Digital technologies have the potential to enable large energy savings but policy steering is needed to capture benefits

Digital technologies can enable energy savings in multiple areas. New digital platforms can facilitate the sharing of material goods, for example by car sharing, ride-sharing, bike-sharing, peer-to-peer exchange of goods and food-pairing apps. In many cases, sharing business models are community-based and depend on upon the desire of users to contribute to the development of their local community.

However, there is only limited evidence for the achievement of those savings in the past. Claims that energy savings exceed the direct energy use of ICTs lack a firm empirical foundation, and expectations of future savings may be overoptimistic unless these are encouraged by specific policy interventions.

Digital technologies have both positive and negative effects

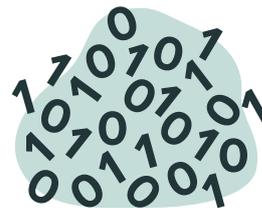
Digital technologies have made a major positive contribution to increasing economic growth and providing benefits to consumers. However, there are also trade-offs to consider, including the negative effects for users (e.g. the security implications of smart devices) and to society (e.g. generation of e-waste), in addition to the additional energy consumption. These trade-offs need to be anticipated and managed going forward.

Digital technologies are associated with large rebound effects

Continuing improvements in the energy efficiency of digital technologies, coupled with broader improvements in performance and utility can encourage large direct and indirect rebound effects. Evidence from a number of applications (e.g. teleworking, video streaming) suggest that these effects may lead to a net increase in energy consumption. However, with the right policy and market mechanisms in place, digital solutions can deliver significant energy savings.

2021

11.4 GB
per smartphone,
per month



2027

41 GB
per smartphone,
per month



3.6 Policy and governance

Our policy and governance research team has found that there are unexplored policy opportunities to support the switch to a net-zero economy. Faster and deeper cuts to carbon emissions can be achieved by expanding the scope of energy policy, introducing new policy tools, finding 'non-energy' policy opportunities and by transforming multi-level governance & policy evaluation.

There is a need for better retrofit policy

Current UK buildings policy – for both domestic and non-domestic buildings – are insufficient to meet the challenge of climate change. We've concluded that significant changes in governance, policy, culture and practice are required.

An energy performance metric applied to commercial buildings in Australia has driven improvements in energy efficiency. Our research concluded that a similar approach could work in UK non-domestic buildings.

Successful retrofit for energy efficiency needs to pay attention to the opportunities offered at trigger points such as when a building changes hands. Retrofit must align to building-specific requirements and should acknowledge that retrofit must satisfy multiple objectives (e.g. comfort as well as running costs).

New funding models for retrofit – such as a salary sacrifice scheme – could open up new routes for homeowners to improve domestic energy efficiency, but these approaches need to link financial services, project management and evaluation.

Cultural and structural change is needed regarding skills

The UK construction sector currently operates in a low-skills equilibrium. A cultural and structural change is needed to value and encourage the high-level skills required to produce low-energy buildings. Timing is critical: necessary changes to education and training must be accompanied by industry reform *at the same time* so that there is demand for these newly-skilled professionals.

Multi-level governance offers routes to action on net-zero

Focusing attention on policy institutions and how they might innovate could offer new routes to action on net-zero goals. Our comparisons between UK nations and cities provide lessons and examples of better practice.

Future 'City Deals' and similar local/regional funding initiatives would benefit from incorporating cross-sectoral measures to address climate change challenges.

Governance of net-zero buildings needs innovative institutions. We show that current structures are not working and a more collective approach can deliver net-zero buildings. For example, Scotland has a more comprehensive and planned approach to energy efficiency than England, but both traditions lack the urgency to meet carbon targets.

Ambitious governance is needed

Our research identified some novel opportunities to tackle climate change and reduce energy demand. By expanding the scope of energy policy, introducing new policy tools, finding 'non-energy' policy opportunities and by transforming multi-level governance & policy evaluation, faster and deeper cuts to carbon emissions can be achieved.

Acting on the timely evaluation of climate and energy-related policies could help to increase the pace and scale of innovation in this area.

Framing policy discussions around energy sufficiency (what is 'enough' and who determines this) would move beyond the focus on technological advances to consider the broader challenges of a successful energy transition. It would also allow those who currently do not have adequate energy services to increase their demand.

New types of services could unlock energy efficiency and sources of lower carbon energy, but would need policies that protect consumers and support innovation. Our work has identified policy changes that would empower local authorities to offer bespoke services for net-zero carbon buildings. Our research suggests that peer to peer trading communities could be used to optimise the supply and demand of locally-generated energy.

Energy demand unlocks the transition to net-zero

A shift to a more efficient energy system reduces energy demand overall, with positive consequences for the journey to net-zero energy. This benefit of moving to energy sources like wind and solar which directly produce electricity compared to fossil fuels which produce heat, means that the shift can be smaller in scale than generally expected.

There is a fundamental 'asymmetry' in the way policy and investments deal with energy demand and supply. Energy demand as a solution to challenges such as net-zero or fuel poverty is irrationally neglected in favour of changes to energy supply. We do not yet understand the causes and reinforcing mechanisms underlying this asymmetry.

3.7 Decarbonisation of heat

Our decarbonisation of heat research, with its focus on a System Architecture perspective, highlights the importance of emergent system features, such as evolvability, flexibility, robustness and feasibility in energy system decarbonisation. Our research reviewed a wide-range of models and found that that no one modelling approach captures all of these features.

There is a need to focus on resilience and flexibility

Our research found that there is a need to move away from the current focus on cost of the energy system towards more consideration for resilience and flexibility of the energy system. This would allow the system to withstand shocks better, such as, those arising from the abrupt reorganisation of supply chains, trading systems and geopolitical structures, during the transition to net-zero.

Empirical and qualitative research should be undertaken alongside modelling work

In any complex and dynamic situation, there are gaps in modelling capacity and these are unavoidable. We conclude that empirical and qualitative research should form a prominent part of the energy research portfolio along-side energy modelling and this constitutes a powerful reason for adopting an overarching System Architectural perspective on energy.

Three technologies could be used to achieve heat decarbonisation in the UK

Our research found three major technologies that could be used to achieve heat decarbonisation – hydrogen, individual heat pumps, and district heating. All are technically feasible, although *high hydrogen* systems appear to be the least cost-effective. This is due to the availability of more energy efficient and cost-effective alternatives, and the need for high value hydrogen in other parts of the energy system, such as industrial processes.

Our research also found that policy makers and other stakeholders' do not have a unified or, a single perspective on the selection of technologies in the light of system goals, particularly, the goal of equity. It is therefore important that sustained and structured stakeholder engagement between the energy modelling community and policy makers/energy system stakeholders is maintained.

Model development

A novel outcome of our research is a set of clearer conceptual distinctions between flexibility, resilience and evolvability, and descriptions of how each can be operationalised using energy system models.

3.8 Fuel and transport poverty – FAIR

Our fuel and transport poverty research has found that energy and transport poverty is caused by a mix of reasons including financial and infrastructural inequalities such as low incomes, poor housing quality, use of expensive technology such as prepayment meters, lack of public transport and 'forced' ownership of personal cars.

Our research suggests that vulnerability to energy and transport poverty is deep-rooted in the structure of societies, extending beyond only the energy and transport domains. We also found that fuel and transport poverty impact on people's broader quality of life, for example, living in a cold home and lacking sufficient travel options can have detrimental effects on health, education and life opportunities.

North-south and urban-rural divide

Our research found a clear north-south and urban-rural divide. In the energy poverty domain, one of the surprising findings was the high degree of energy poverty in peri-urban areas, possibly due to higher energy costs and lower Energy Performance Certificate (EPC) values. The transport poverty showed high values in inner-city areas outside of London, possibly as a result of poor accessibility and car ownership scores.

The greatest vulnerability to double energy poverty was found in isolated rural communities that have a high proportion of residents who are disadvantaged in socio-economic and demographic terms.

Net-zero policy can be designed to have positive outcomes on those in fuel and transport poverty

Our research found that decarbonisation policies, if designed and delivered appropriately and fairly, can grow the economy and reduce vulnerability to fuel and transport poverty, though there can be winners and losers. Low-carbon technology adoption will cluster in more affluent households unless there is sufficient government support for people vulnerable to fuel and transport poverty to adopt low-carbon technologies. Without this government support, higher income homes will benefit from the energy and cost saving opportunities of low-carbon technologies, while vulnerable households may get left behind.

Equity and redistribution should therefore be taken account in policymaking. A net-zero carbon economy, delivered in the right way, has the potential to reduce fuel and transport poverty while helping to grow the economy and employment across the country.

Priorities for policy were identified

Our research participants gave the following priorities for policies to improve energy poverty:

- Regulations requiring landlords to improve the energy efficiency of their homes
- Increasing the level of support under the Warm Homes Discount scheme
- Ensuring that new homes are much more energy efficient.

Policies to improve transport poverty were:

- Making bus and train fares and ticketing simpler and cheaper
- Restoring bus services post-Covid
- Resourcing local authorities so that they can install electric vehicle charging.

3.9 Decarbonisation of the steel industry

Our decarbonisation of the steel industry research has found that key policy options for the government to drive green steelmaking include

- Lowering industrial electricity prices (the UK has the highest in Europe),
- Removing discrepancies between the cost of greenhouse gas emissions for steelmakers based on the level of their emissions associated with electricity consumption, and
- Implementing a carbon border adjustment mechanism.

Short and long-term options for decarbonisation

In the steel sector, our research shows that retrofit options have the highest short-term mitigation potential, whilst the most likely options for complete decarbonisation are hydrogen direct reduction of iron and electric arc furnaces, which have lower carbon emissions and costs than carbon capture and storage-based options if low-carbon electricity is used. Over a typical project lifetime, this could already be a lower cost option than blast furnace relining if steel producers are exposed to the full cost of their carbon emissions over a reasonable timescale. Acting soon is important, as once a decision is made to reline a blast furnace and return this to service, carbon-intensive ironmaking would be locked-in for a decade or more. Increased scrap use in steelmaking is potentially attractive as it makes greater use of electric arc furnaces, but requires better quantification of its whole system benefits and integration with other process options.

Our research also shows that ultra-high temperature heat pumps could provide meaningful cost reductions when used to preheat process gases, while reducing energy demand and air pollution.

Need for financial support to the UK steel industry

Our research concludes that unless the government provides significant financial support to the UK steel industry and improves the policy environment around green steelmaking, UK steel manufacturers will struggle to decarbonise their operations while maintaining international competitiveness. UK steel producers and manufacturers interviewed for our research felt that they cannot decarbonise their operations without government assistance, pointing to energy costs, international competition, and the significant investment required.

There is a serious risk of UK steel production being moved overseas, considerably reducing the control that we have over decarbonisation and security of supply. If this occurs, the costs of reaching net-zero emissions from UK steel consumption could be needlessly high in terms of stranded assets and job losses.

Policy recommendations for green steelmaking

Our research concludes that the government should consider socialising the cost of renewable levies and network maintenance, or moving them from electricity to gas, and lay out steps to expose industry to the full cost of its greenhouse gas emissions while preventing carbon leakage (such as developing a carbon border adjustment mechanism, to be phased in as emissions trading scheme free allowances are phased out). There is a need to foster internal demand for steel produced by decarbonised routes and work towards consensus between the stakeholders involved in the process, rather than government expecting industry to act and vice versa.

Our research also concludes that the government should provide funding towards the development of a zero emissions steel plant based on green hydrogen, direct reduction of iron, and electric arc furnaces. This could be a collaboration between the public and private sectors.

4. Approach to Equality, Diversity and Inclusion

Our aim is to foster an inclusive culture within the Centre, which promotes equality, values diversity and maintains a working and social environment in which the rights and dignity of all our staff, students, partners and stakeholders are respected. This fulfils our legal obligations under the Public Sector Equality Duty but goes further than the legal requirements.

Previous work on Equality Diversity and Inclusion has covered a policy and [action plan on Equality, Diversity and Inclusion \(EDI\)](#) that was published in April 2019 and the [EDI Annual report](#) and briefing paper in June 2020.

We keep EDI visible in the consortium with sessions at every WCM, items in the internal newsletter (the Consortium Update) and external newsletters, items on the website and EDI working group meetings.

We have extended the EDI role that was recruited in 2021 from 0.2 FTE to 0.4 FTE to allow significantly more capacity to embed EDI thinking into our ways of working and research. Anuja Saunders, CREDS' EDI Manager, has focused on running the EDI working group, developing and presenting the [Inclusive language guide](#) at the Whole Centre meeting 9 and drafting the Recruitment Best Practice guide.

CREDS launched an EDI spotlight series this year with:

A webinar on inclusive leadership (15 November, 2021) and a second webinar about personal stories of diversity, called 'Fitting in and Standing out' on 18 November, 2021. This was co-ordinated with National Anti-Bullying Week in November 2021, the theme of which was One kind word.

This theme inspired the [Amplify Project](#) – a confidential forum for members of the energy research community to share their own stories of workplace bullying and harassment. Collecting and sharing these accounts will help raise awareness and create a safe and honest way to examine working cultures.

A third webinar completed the series on 12 May, 2022 with a Neurodiversity Spotlight as part of mental health awareness week covering issues such as diagnosing neurodiversity (e.g. ADHD, autism and dyslexia), living with energy-limiting conditions, how to adapt work and workplaces to be more suitable for neurodiverse people and working with a neurodiverse team of people.

Engagement on the topic of EDI has included UKERC cross-consortia meetings (summary of EDI work), advice to Advancing Capacity for Climate and Environment Social Science (ACCESS) project, Climate Coaches session, Citizens Advice Diversity Forum, Accelerating the Decarbonisation of Mobility' Summer School podcast on EDI with the Faraday Institution and [UKERC](#).

We recruited a researcher to scope the agenda on the intersection of racial justice and energy and to help us advocate for funding. Uttara Narayan presented her interim findings at WCMg.

CREDS continues to support career progression for **Early Career Researchers** (ECRs) with the Flexible Fund still supporting both CREDS ECRs and beyond CREDS within the ECR call. There is also an ECR cross-consortium Net Zero conference planned for 30 November to 1 December 2022 in Manchester being led by Sarah Higginson for CREDS' contribution.

We recruited **six students** to start their PhDs in Autumn 2022 (see Table) and have launched our call for students for 2023.

Project number	Title	Student	Supervisor	Institution
1	Office work: Transforming energy demand and practice	Jemma Cliff	Elizabeth Shove	Lancaster University
2	Energy justice and citizenship: Refugee and asylum seeker communities' experiences of energy poverty and infrastructural exclusion in the United Kingdom	Manon Burbidge	Stefan Bouzarovski	University of Manchester
5	Towards an integration of demand- and supply-side policies for deep decarbonisation	Leticia Mueller	Philip Johnstone	University of Sussex
10	Analysing the effect of bus service quality improvements on transport energy demand using micro-scale models	Hussein Amr Mahfouz	Robin Lovelace	University of Leeds
11	Energy demand response business models for low to middle income households in India	Kanika Balani	Tim Foxon	University of Sussex
12	Fairness implications for vulnerable households of energy demand reduction policies in France and the UK, an intersectional approach.	Mathilde Rainard	Milena Buchs	University of Leeds

5. Flexible Fund allocation

The majority of the Flexible Fund was committed in previous years and there are now over 40 projects within this fund.

5.1 Early Career Researcher (ECR) Awards

The eight ECR awards that were funded in 2020 have been integrated into the themes, so are reported in section 3.

The two CREDS ECR projects are progressing well – one is at the stage of writing papers on the topic of clothing, comfort and energy demand and one is carrying out a two-way learning process between ECRs and practitioners on sensitivity auditing to scrutinise a model's uncertainty – multiple workshops have been undertaken and practitioners are developing their skills in assessing modelling uncertainty.

5.2 Data and research quality project and support for archiving

The data and research quality project led by Sarah Higginson has produced a six-video series to support learning on improving the transparency, reproducibility and quality of research ([TReQ tools](#)) and reviewed and summarised the preprint policies of [20 top journals](#) published in by CREDS researchers. All data sources used by CREDS have been collected and collation has begun. A collaboration between UKERC and CREDS to harvest archived CREDS data from UKDS by AI and list it on their database according to IEA categories is underway. Next steps are to produce guidance on how to deposit this data to enable retrieval and run a pilot.

UK Data Service ran a bespoke training session on archiving data for all CREDS project leads in May (48 attended).



5.3 Final Project on 'energy use in the new normal'

This project aims to use research on changes to energy use during the pandemic and the affordability crisis to draw lessons for the longer term. It is structured into five work packages:

- WP1: Heating and comfort
- WP2: Commuting and business travel
- WP3: Space, time and infrastructure
- WP4: Local responses
- WP5: Stakeholder engagement

All work packages are making good progress. In WP1, quantitative and qualitative work is being undertaken to understand changes to heating practices during lockdown and subsequently. WP2 is undertaking further waves of research and stakeholder interviews to understand post-pandemic travel patterns. WP3 is linking a number of existing models and demand scenarios based on other CREDS work to investigate the scope for flexibility using EV batteries. WP4 is focussing on the economic arguments for post-Covid, zero-carbon strategies in two contrasting city region areas of England. WP5 is pulling together findings from across the project which will link to the CREDS-wide development of a package of synthesis findings and materials.

5.4 Impact Acceleration Awards

Progress on the IAA projects is reported in section 3 within their related themes.

5.5 Integration Projects

The Flexible Fund funded four ongoing integration projects, three related to Covid and one to develop low energy scenarios for the UK.

The short and long-term impact of COVID-19 on building energy demand and future decarbonisation, led by Tadj Orecsczyn. Data analysis of the questionnaire and meter data from 1,000 properties has been completed, leading to a full paper on energy use behaviour change during lockdown. Future papers will focus on the change in measured energy use and its relationship to the self-reported behaviour change.

Covid-19 Transport, Travel and Social Adaptability Study (TRANSAS) led by Jillian Anable and Greg Marsden, and co-funded by many partners including CREDS Theme 2, Transport Scotland, ClimateXChange and Liverpool City Council. The third wave of panel data was analysed and culminated in the launch of the 'Less is More' report (March 22) with various requests to present the findings within DfT – see section 2.2. The fourth wave of data was collected in July and delivered in early September. A final wave of data will be collected towards the end of 2022. Results of the survey, including blogs and news are produced on the [dedicated website](#).

The contribution of energy demand in the economic recovery package post-Covid-19

led by Clare Downing. A range of green policies for buildings and Industry and estimated investment values provided inputs into the E3ME macro-economic model scenarios and Cambridge Econometrics ran the scenarios against a BAU baseline of current policies. The results indicate that investing in 'green' rather than 'brown' recovery measures would benefit the economy, have better employment outcomes, drastically improve environmental performance and have important distributional impacts, with low-income households seeing greater relative welfare improvements from these policies. The report [Macro-economic impacts of green policies in the Economic Recovery Package post-Covid](#) was published in December 2021, and was promoted in co-ordination with the communications team at Cambridge Econometrics with a blog: [Energy-demand-reducing measures can play a major role in helping the economy to bounce-back from the long-term impacts of Covid-19.](#)



The Positive Low Energy Futures (PLEF) project led by John Barrett, provides the most comprehensive assessment to date of the role of reducing energy demand to meet the UK's net-zero climate target. The key message is that reductions of 50% are possible through reducing energy demand, without which, meeting climate targets (particularly net-zero in 2050) becomes extremely expensive due to the substantial increases in the size of the energy system and the installation of expensive Carbon Dioxide Removal (CDR) technologies. The report was launched on 6 October 2021 with a [webinar](#), [short animation](#), a [microsite](#), a social media campaign and blogs. There have been almost 4,000 views of the report within the year and over 800 views of the accompanying policy briefing.



An academic paper was published in Nature Energy on 27 June, 2022. This added an international dimension presenting a framework that can be applied by other countries. The same overall message as the main PLEF report was communicated, namely that to fully exploit the potential of energy demand reduction, social changes, not just energy efficiency improvements are needed – changes to the way we eat, travel and heat (and cool) our buildings which could allow us to reduce our energy demand by 52%. We launched a new mini animation to go alongside the Nature Energy paper. There was extensive Twitter activity with over 2,200 views of the mini animation to date. A blog was published in New Energy World on 13 July 2022 and further promotion included meetings with the departmental Chief Scientific Advisors and a range of All Party Parliamentary Groups (APPGs). Further development of the joint working activity with the Government Office for Science on their own low-energy modelling work has continued.

The modelling team were also invited to be members of the Energy Demand changes Induced by Technological and Social innovations (EDITS) network. This wider academic team are looking to update the global energy demand scenarios that were published in 2018 and incorporate work from PLEF.



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 mission is to make the UK a leader in understanding the changes in energy demand needed for the transition to a secure and affordable, net-zero society. CREDS has a team of over 140 people based at 26 UK universities.

CREDS is funded by UK Research and Innovation, Grant agreement number EP/R035288/1

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