

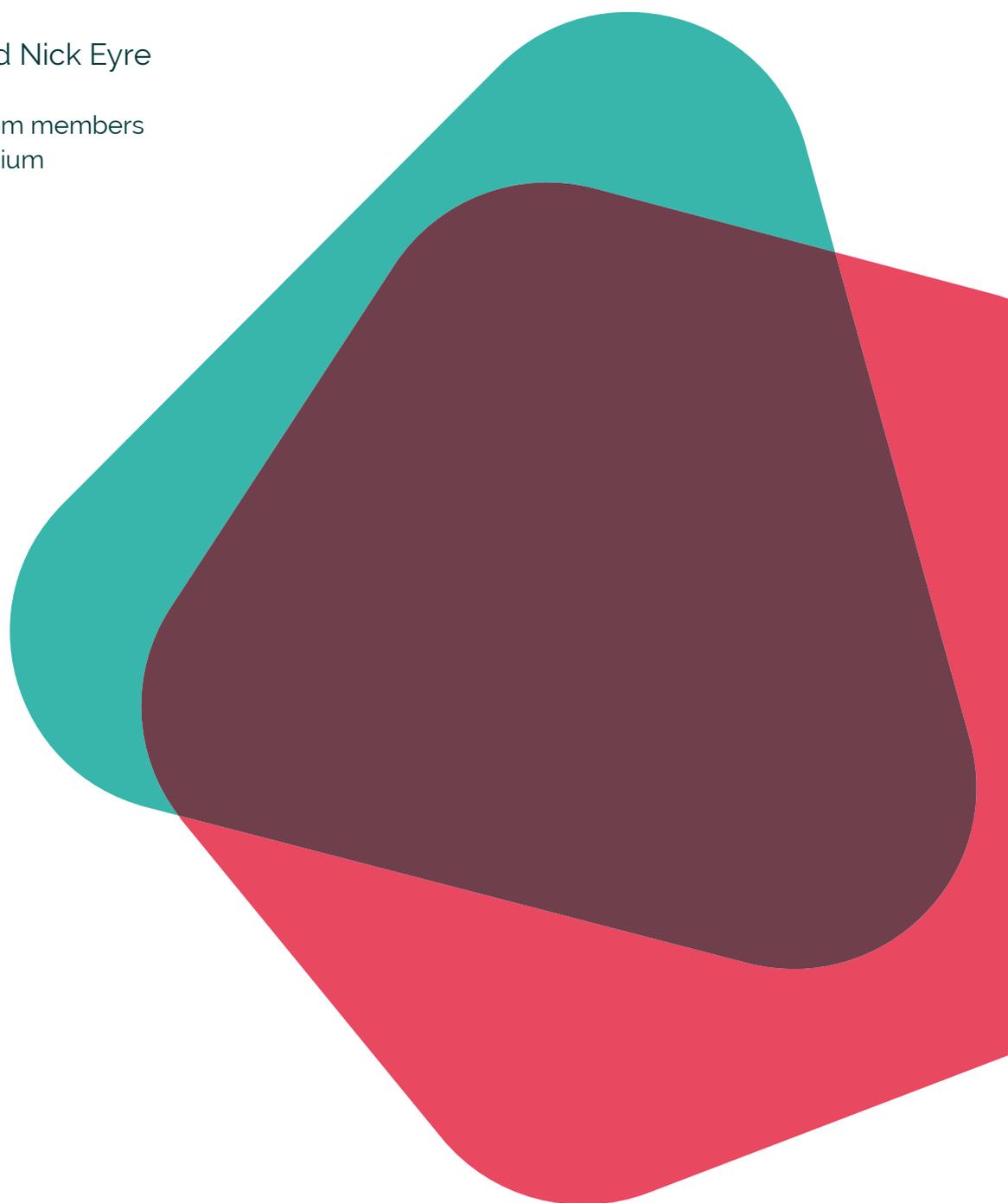


# CREDS Annual Report: October 2020 to September 2021

November 2021

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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 3.5 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 now a team of over 140 people based in 26 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' third annual report covering the period from October 2020 to September 2021. The [first annual report](#) was published in November 2019 and has been viewed 177 times. The [second annual report](#) was published in December 2020 and has been viewed 108 times.

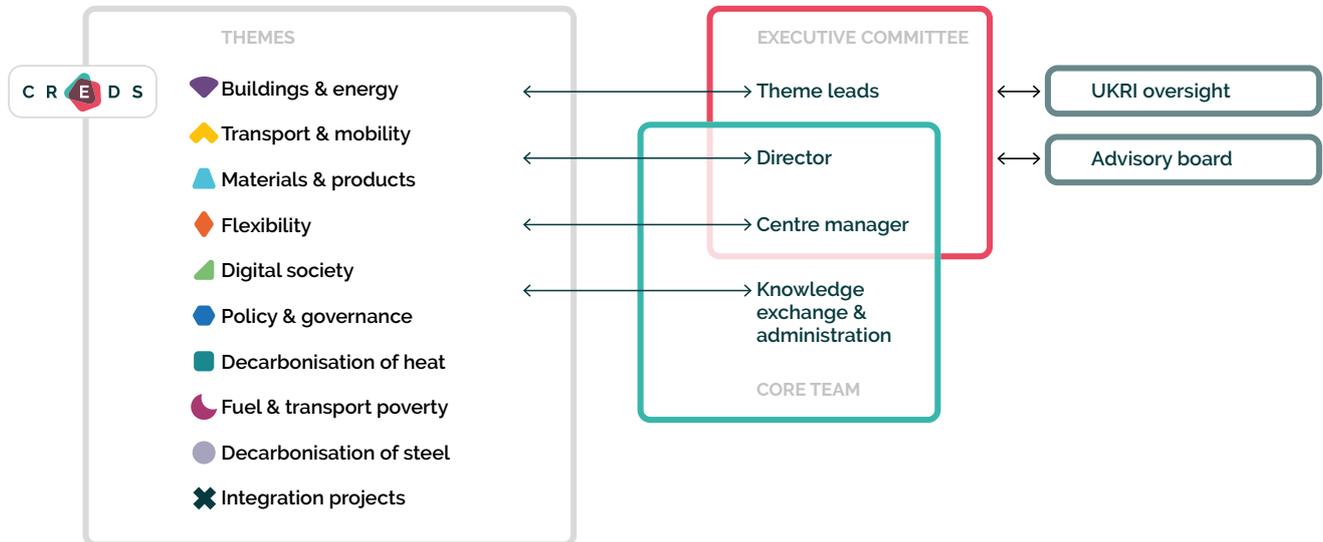
## 2. CREDS governance, management and knowledge exchange

### 2.1 Governance and management of CREDS

The Mid-Term Review (MTR) and evaluation was an important activity for CREDS this year. In January 2021, we submitted a report describing CREDS' activities up to September 2020, appendices listing all the outputs including publications and 16 case studies. Using this evidence and an online survey of the CREDS Advisory Board, an expert panel appointed by UKRI reviewed progress to date and reported in March 2021. The overall score the panel gave CREDS was a 5 (out of 6), which is unusually high for a major investment. The panel concluded that "CREDS is delivering excellent research outcomes but there are some minor recommendations for continuous improvement. Funding should be continued." The panel made some recommendations for further improvements and requested an action plan within three months to address them. The action plan was submitted in July 2021 and is being implemented.

The governance and management systems of the Centre continue to evolve. The Collaboration Agreement between the 15 universities that were part of the original proposal has been maintained and new universities have been added this year (Strathclyde and Stirling) as 'Accession' partners to accommodate the Final Project ([Energy use in a net-zero UK – lessons from lockdown](#)) which completes the allocation of the Flexible Fund. We now have 26 institutes in the consortium split across 10 themes including knowledge exchange within the core team (Figure 1). The Advisory Board including stakeholders from industry, policy and academia meets twice a year (November 2020 and March 2021). We seek discussion on key strategic issues and the Board continues to provide valuable guidance and approve the use of the Flexible Fund. This year it also supported the MTR. An 'Extraordinary meeting' of the AB was held on 30 June via TEAMS, to discuss the action plan from the MTR and sign off the proposal for the Final Project.

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. This year, meetings have been wholly online due to the pandemic. Without exception, decisions have been made by consensus.



**Figure 1:** Organisational structure of CREDS

The CREDS core team is based in Oxford, and consists of the Director, the Centre Manager, three Knowledge Exchange Managers, a Government Affairs Manager, a Web and Communications Manager, a Designer, two Centre Administrators and a Data Manager. Some of these posts are part-time. We recruited 1 new staff member for the core team during the year – an Equality, Diversity and Inclusion Manager (Anuja Saunders) which adds capacity to implement the EDI plan and address new issues as they arise more effectively. The stability of core team staffing in the last year has been helpful in enabling the smooth management and administration of the Centre and continuing knowledge exchange throughout the pandemic.

Our internal communication within the consortium is regular with 18 newsletters (consortium updates) sent during the period. We have had one Whole Centre Meeting (WCM) of all staff in the consortium in March (WCM7) online – an event report is available on request. The Advisory Board are invited to all WCMs in addition to the whole consortium.

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.

## 2.2 Engagement, knowledge exchange and impact

CREDS considers that there is a strong link and clear journey from:

- communications and dissemination through
- engagement and two-way knowledge exchange to
- impact

and this is the process that we support and encourage the whole consortium to follow. The core team follow the principle that where possible, there is engagement both before and after the publication of an academic paper and that the paper is not considered to be the end of the work. This is particularly true for applied research, which is the majority in the energy demand field. To unpick what makes effective knowledge exchange and to support researchers to do more knowledge exchange, members of the core team carried out an extensive literature review of 80 papers on knowledge exchange from 8 disciplines ([ecccc conference proceedings](#)). The review revealed that selecting appropriate stakeholders and developing the right messages, for the right people, at the right time is key and, in addition, that the two most important factors in successful knowledge exchange are the individual relationships between people and having a clear strategic direction (what is the purpose of the engagement?). The paper ends with combined lessons that could be used by researchers, UKRI and policy-makers to guide and support their own 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.

Engagement 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. The extensive series of case studies that were developed for the MTR illustrates some of the engagement and impact work that CREDS has completed. Case study 17 is new since the MTR and we have a further 3 case studies in preparation. Since case study 17 on the Place-Based Carbon Calculator (PBCC) was written (see [section 3.2](#)) there was a follow-up bespoke webinar for a cross-Whitehall group of civil servants that has resulted in major additional central government funding for the PBCC.

### Case studies

1. [We are the ones that we seek – Equality Diversity & Inclusion](#)
2. [Leaders of tomorrow – Early Career Researchers](#)
3. [Visiting International Programme](#)
4. [Shifting the focus towards energy demand](#)
5. [Engaging with civil servants to improve impact](#)
6. [Taking 3DStock](#)
7. [e-bikes could slash transport emissions](#)

8. [Shared mobility: the case for fewer cars](#)
9. [LGA guidance on actions for transport](#)
10. [Top ten tips for reducing your carbon footprint](#)
11. [Transforming UK Government energy and resources policy](#)
12. [Supporting the Climate Change Committee](#)
13. [Winners & losers of energy policy reform](#)
14. [Innovation forums to tackle the climate emergency](#)
15. [Is working from home better or worse for the environment?](#)
16. [Watts the deal?](#)
17. [Enough is enough – the time for climate action is now](#)

When new research has a strong message for one of our key audiences and when it supports our key messages of energy demand reduction, the core team endeavours to undertake more comprehensive promotion and engagement work in collaboration with researchers. A promotion plan is developed that specifies the purpose of the engagement.

A number of major reports were published and promoted this year that are in addition to the large number of academic papers published:

CREDS produced and promoted a [briefing paper](#) to support the [Industrial decarbonisation policies for a UK net-zero target](#) report in December 2020. This fed into the CCC's sixth carbon budget advice to government and was covered in [Business Green](#) with an interview (subscription needed to access article). To date, there have been 431 views of the report on the CREDS site.

[Resource efficiency scenarios for the UK: A technical report](#) (launched on 26 March, 2021). An accompanying [report was produced and promoted by WRAP](#). WRAP led the promotion, supported by CREDS on social media. There was coverage in a selection of media, including the Radio 4 Today programme, [Business Green](#) (subscription required), [Drapers Online](#), [MRW Magazine](#), [Resource Magazine](#), and [Sustainable Packaging News](#). This is a good example of collaborative working with the WRAP team and good connections made for future working. To date, there have been 641 views of the report on the CREDS site.

A report on energy retrofit was written in collaboration with the Federation of Master Builders [Building on our strengths: A market transformation approach to energy retrofit in UK homes](#) and launched on 22 July, 2021. The report launch attracted coverage in [The Times](#), [Total Contractor](#), [Glass Times](#), [RCI Mag](#) and [Scottish Housing News](#). The report calls on the Government to work with builders and their supply chains so that energy retrofit is integrated into every appropriate project. Further activities include participation at COP26 in the UK Green Building Council's Virtual Pavilion event. To date, there have been over 200 views of the report on the CREDS site.

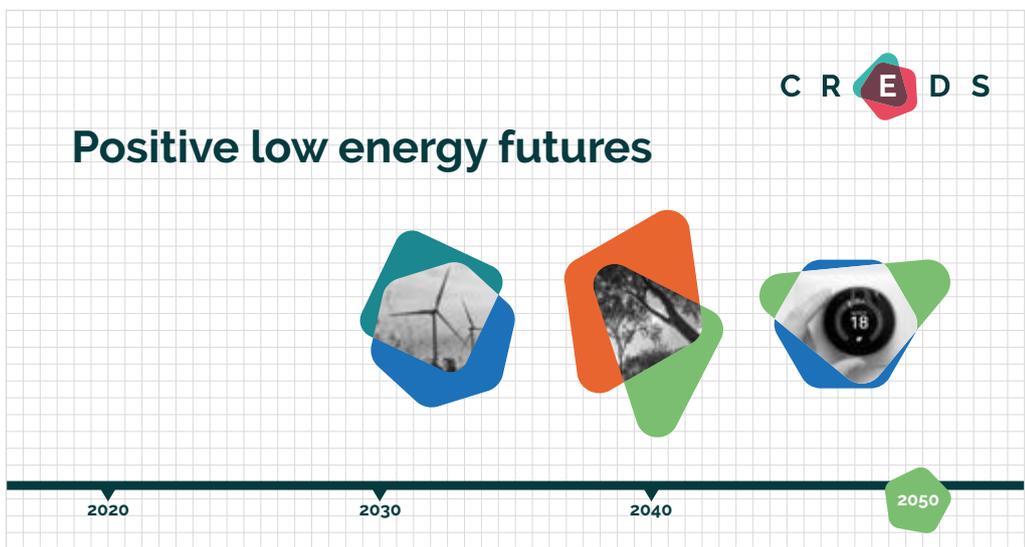


At a crossroads: Travel adaptations during Covid-19 restrictions and where next?

(Published 24 March, 2021). Promotion was undertaken for this report and its accompanying briefing. A news release was sent out to our media list, added to the site and promoted on social media with accompanying visuals. The report was published in full in Energy World in June, 2021. To date there have been 1, 170 views of the briefing on the CREDS site.



The Positive Low Energy Futures project (previously Low Energy Demand Scenarios) provides the most comprehensive assessment to date of the role of reducing energy demand to meet the UK's net-zero climate target. The study brings together 17 energy demand modelling experts from within CREDS to provide extensive detail on the possibilities to reduce energy demand in all the major energy service demands (mobility (transport), shelter (residential and non-domestic buildings), materials (industry), food and products (appliances)) using the Shift, Improve, Avoid framework. These sectoral reductions in energy demand are brought together into a whole-system modelling approach using UK TIMES (see Figure 2). The key message is that energy demand reductions of 50% are possible, 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 needed and the installation of expensive Carbon Dioxide Removal (CDR) technologies.



The report was launched on 6 October (<340 people at the webinar launch event) and included a high-profile panel of Caterina Brandmayr (Green Alliance), Chris Stark (CEO of the Climate Change Committee) and Rebecca Willis (Lancaster University). An additional session straight after the launch webinar to 'ask the authors' enabled detailed technical interaction with the audience. A detailed promotion plan for the project was delivered including the completion of a [short animation](#), a social media campaign (including gifs and imagery) and blogs. In addition, a [microsite](#) has been developed to house the report and supporting content (policy brief, blogs, explainers, data and animation). Extensive media relations were carried out, including issuing a news release and supporting materials under embargo several days before the event and coverage included BBC News and New Scientist (online and print editions). Within one week, 451 unique users had visited the report site resulting in 104 downloads of the report and 13 downloads of the policy brief. By the end of October, this increased to 159 report downloads and 816 unique visitors.

Promotion planning can also take place at a more macro level such at the theme level or, as a synthesis activity across multiple themes such as the Covid Spotlight that highlighted all the Covid-related work within the CREDS consortium. The promotion activities include, but are not limited to: digital marketing, website content (blogs etc) and events.

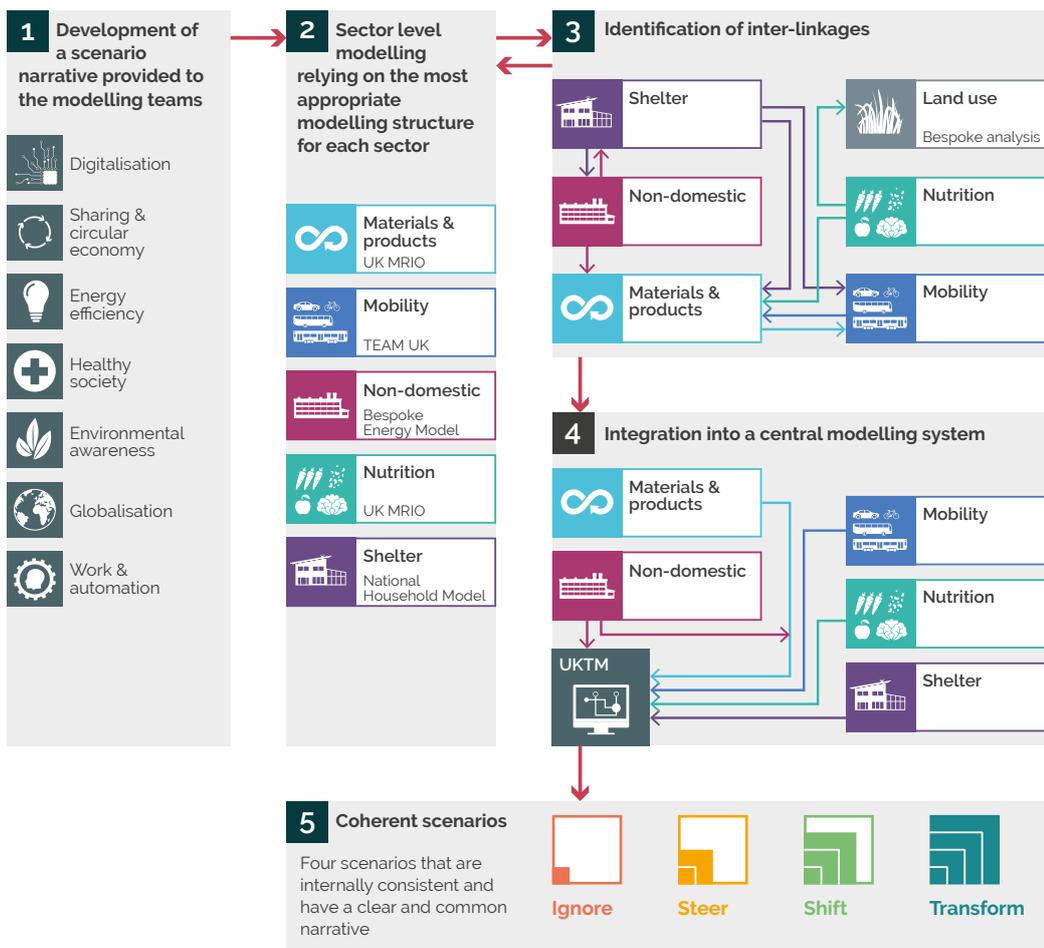
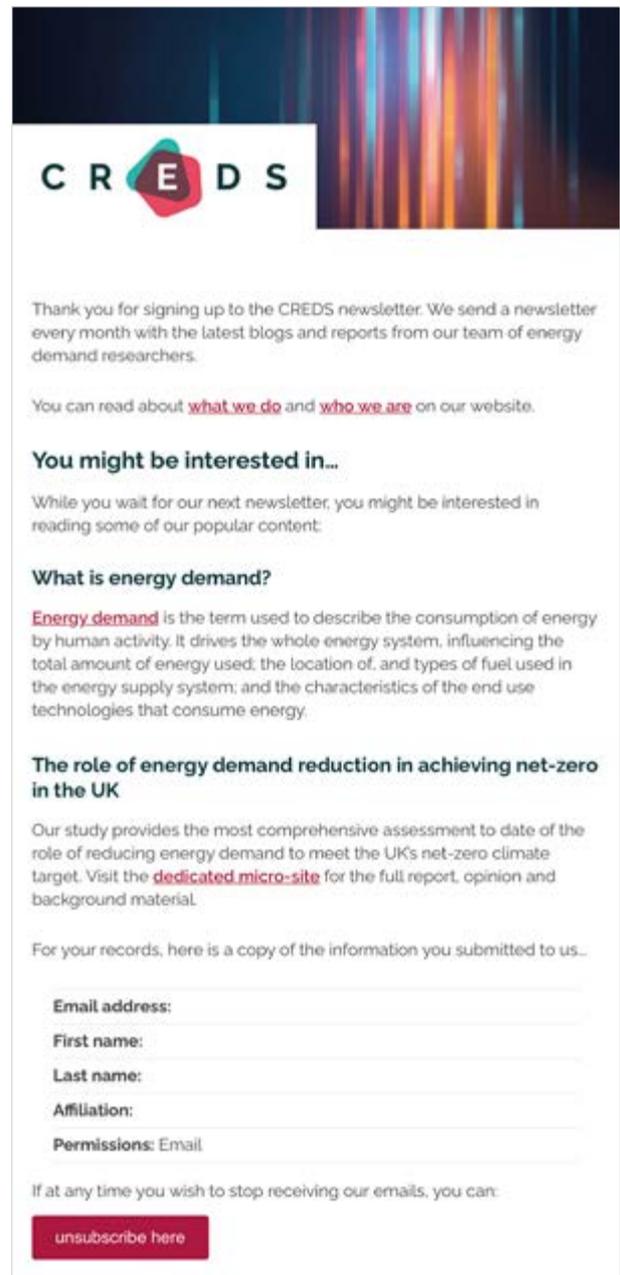


Figure 2: The low energy demand modelling framework

**Digital marketing** includes the external newsletter and social media activities (Twitter and LinkedIn). There has been an excellent increase in Twitter followers and there are currently 2,245 followers, an increase of almost 1000 new followers over this year. All new content on the CREDS site (blogs, reports, papers etc) is shared via social media.

There are now 732 subscribers to the CREDS newsletter. A change was instigated in May 2021 to send more regular, shorter newsletters (one a month, rather than one per quarter) and this has resulted in a noticeable increase in sign-ups. New registrants also now receive a welcome email providing them with introductory content to read about CREDS (what is energy demand page of website and link to the positive low energy futures report).

**Website content.** The CREDS website has become, by design, a predominantly blog focused site with regular requests for blogs sent to CREDS members (see Figure 3). 31 blogs were published this year and 20 news posts – averaging almost one new blog or news post per week. Five blogs made it into the top 20 most popular pages of the year (two last year). The blog about the Place-Based Carbon Calculator received 283 views on the day it was launched and has received over 1.5k views to date in total. During this year 35,534 unique users visited the site – 8.5k more than last year which saw 10k growth compared to 2018-2019 which is an excellent result.



**CREDS** OUR WORK + PUBLICATIONS NEWS & BLOG SUPPORTING RESEARCH ABOUT +

## Research to transform the energy demand landscape

**Changing our way of living – why and how?**

While changes to our lifestyle are crucial, they do not often enough translate into policy. How could personal carbon budgets contribute to those changes?

**Blog** 02 November 2021

**Latest publication**

**Energy efficiency: What has research delivered in the last 40 years?**

03 November 2021

**From shock to change: Energy use in a net-zero UK – lessons from lockdown**

**News** 03 October 2021

**Making mass retrofit a reality: A webinar from CREDS and Buildings & Cities**

**Events** 31 October 2021

**The UK can more than halve its energy demand by 2050 and improve quality of life**

**News** 05 October 2021

**CREDS interdisciplinary energy demand studentships call Q&A**

**News** 29 September 2021

**Re-thinking the zero carbon energy transition**

**Blog** 29 September 2021

**The contribution energy demand reduction could make to tackling the climate emergency**

**Blog** 28 September 2021

**Positive low energy futures**

Our report, The role of energy demand reduction in achieving net-zero in the UK, provides the most comprehensive assessment to date of the vital part reducing energy demand can play in meeting the UK's net-zero climate target. We show that demand for energy in the UK can be reduced by 50% by 2050, whilst enabling improvements in quality of life.

Researchers devised four scenarios – plausible futures based on likely social and technological changes. We could ignore, steer, significantly shift or completely transform our approach to energy demand. Such a comprehensive analysis of the potential for lower energy service demands and higher energy efficiency has never been done at the national level, and offers a new way of thinking about the net-zero challenge.

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Figure 3: CREDS website home page, 03 November 2021

This year CREDS hosted the following events – all our events were online webinars this year due to the pandemic:

<b>Table 1: CREDS events</b>			
<b>Date</b>	<b>Number of participants</b>	<b>Presenters</b>	<b>Webinar Title</b>
06 October	87	Kay Jenkinson, Peter Mallaburn	Policy and impact: how does research make a difference?
20 October	38	Sarah Higginson, Kay Jenkinson	Delivering successful impact (& monitoring it) in CREDS
04 November	37	Stuart Galloway, Jonathan Bowes	Decarbonising heat demand: a Scottish case study
04 November	92	William Gale, Peter Taylor	Towards more sustainable steelmaking
17 November	127	Steph Parker	Making government policy: what does a 'Policy Professional' do?
1 December	116	Neil Simcock, Kirsten Jenkins, Mari Martiskainen	Identifying the vulnerable: energy poverty, transport poverty and beyond
14 January	55	Sarah Royston	Inadmissible evidence? The role of social sciences and humanities in EU energy policy
26 May	34	Nick Eyre, Greg Marsden, Tadj Oreszczyn, Steve Sorrell, Jen Dicks	Covid-19 spotlight for policy-makers – Energy demand reduction is critical if UK is to reach net-zero. How might CREDS and policymakers/ researchers like you convey this message more powerfully in future?
27 May	53	Nick Eyre, Llinos Brown, Tadj Oreszczyn, Bernardo Caldarola, Hector Pollitt	Covid-19 spotlight for researchers – Energy demand, social and political attitudes have changed dramatically and quickly. What have we all learned from the pandemic that might help us get to net-zero?
7-11 June	n/a	CREDS presented 13 papers	eceee 2021
18 June	Invited audience (21)	Gavin Killip, Tina Fawcett	Federation of Master Builders facilitated workshop with builders to discuss content for the new report (launched on 20 July by FMB)
28 June	231	Malcolm Morgan and Jillian Anable	Launch of Place-based Carbon Calculator
6 July	76	Robert Lowe, Lai Fong Chiu, Baltazar Solano-Rodriguez, Daniel Scamman, Tiziano Gallo Cassarino, Nick Eyre	Strategic Directions for Decarbonising UK Heat: A System Architecture Perspective'
28 July	Invited audience (34)	Nick Eyre, Halima Begum, Sarah Higginson	Racial Injustice roundtable, workshop with The Runnymede Trust
30 September	Invited audience (20)	Rob Gross, Jim Fleming, Sara Walker, Dan Taylor, Clare Downing, Sarah Higginson, Amber Sawyer	A joint CREDS/UKERC cross-consortia meeting to discuss ways of working across the different consortia

Part of the impact and championing objectives of CREDS is to share the findings of our research with policy-makers and one of the important ways that we do this is through responding to consultations. This year, CREDS has responded to 10 consultations on the topics of heat pumps, decarbonising heat in both homes and commercial buildings, zero emission vehicles, impact of the pandemic, diversity and inclusion in STEM and decarbonising aviation and shipping. More than 21 members of CREDS wrote the responses, demonstrating the breadth and depth of commitment to sharing findings from research with those outside of academia and for championing energy demand.

The other main route to reach policy influencers and civil servants is through direct relationship building. Many of the themes have ongoing close relationships with staff within these organisations as demonstrated by some of the case studies, for example Department for Business, Energy & Industrial Strategy (BEIS), the Climate Change Committee (CCC), and the Department for Transport.

The core team has established more strategic, collaborative relationships with two key energy demand teams in BEIS – housing retrofit and business energy use. This gives us early insights into the policy development process and puts researchers at the heart of the policy process, for example by contributing directly to Ministerial briefings and influencing consultation papers before they are released. We are discussing similar relationships with the CCC and the BEIS clean heat team for 2022 and will be considering how our overall relationship with government can best develop to benefit the programme.

## **2.3 International activities**

### **Visiting International Programme (VIPs)**

Two of our International visitors (Fatima Khushnud and Max Kleinebrahm) visited before Covid-19 in early 2020. However, the other international visitors could not visit because of Covid-19 but work with them has continued remotely. Yael Parag (Israel) and authors from Theme 6 have had a paper on personal carbon trading published in Nature Sustainability and a further publication is in preparation on carbon rationing for an international report. Petra Hoffman (Netherlands) and authors from Theme 6 have written a paper for Buildings and Cities on comparing Scotland and The Netherlands governance for retrofit at scale. Max Kleinebrahm (Germany) and authors from Theme 4 have had a paper published on modelling long-term dependencies in occupancy behaviour in Energy and Buildings. Selin Yilmaz (Switzerland) and Yohei Yamaguchi (Japan) have participated in the reading rooms workshop series and a paper is in preparation on spatial variation of demand flexibility.

Following the MTR recommendations, we are looking at our international research work and engagement again with the aim of strengthening this area. This will be covered in the Communications and Engagement Plan that will be completed in the next few months.

### 3. Research progress

During this period, CREDS staff have authored over 110 publications.

- 115** All types of publication
- 12** Collaborations and partnerships
- 35** Further funding
- 275** Engagement activities
- 94** Influence on policy
- 35** Influence on business
- 9** Artistic images
- 11** Data & other

The credibility of CREDS as an organisation rests on the insights from our research and the reliability of these results. Most of our research outputs are published as articles in peer reviewed academic journals, mainly international journals with high standards. In these cases, there is an automatic check on accuracy and research quality through the peer-review process.

We also choose to publish results in other ways, for example as project reports and briefings. These formats allow more rapid publication and targeting of audiences who do not read academic papers. All publications are reviewed internally and, for major CREDS reports, we have commissioned expert external reviews. In either case, responsibility for accuracy ultimately rests with the authors and the manager of the individual project.

We also publish blogs by individual CREDS researchers and others. The topics are chosen for relevance to CREDS areas of work and likely interest, and many are based on CREDS research. They are opinion pieces; content is checked by CREDS staff for clarity, but blogs express the views of the individual author and we do not seek to censor them.

### 3.1 Buildings and energy

All projects are progressing well within the theme mostly through leveraging additional external funding. In the [health project](#) we are working on evaluating health status and energy performance of housing using a number of different datasets

1. The English Follow-Up Survey (EFUS), Health Survey for England (HSE), English Longitudinal Study of Aging (ELSA), National Energy Efficiency Data-Framework (NEED) and Meteorological Office data. A paper using the EFUS data has been prepared and a paper looking at health and indoor temperature with the Health Survey for England has been published in the BMJ. Data matching with ELSA – will begin next quarter now that access to the NEED has been granted following the Data Sharing Agreement between BEIS and National Centre for Social Research (NatCen).
2. Biobank data – this work is complete and a paper has been published.
3. Developing the underlying evidence base for the NHM-Health – access to this data has been delayed.

New research in the sub-project on the performance gap can be undertaken due to leveraging income from the BEIS-funded SMETER project. The algorithm to produce digitally generated in-use building efficiency certificates continues to be developed and a paper has been drafted on Heat Transfer Coefficient (HTC) estimates.

There is a significant extension of funding for the Green Homes Grant (GHG)-SMETER evaluation using in situ methods and the theme have worked to support BEIS with their development of a new in-use energy performance metric, providing significant input and delaying publication plans. In addition, further BEIS funding has been secured for the evaluation of the Green Homes Grant Finance Innovation Fund. This will allow for interviews with institutional and high-street mortgage lenders on products to support owner-occupied investment in energy efficiency in UK housing

One project is investigating the creation of a [Demand Side Management rating](#) for properties in support of policy and occupant choice (a flexibility rating) by analysing of the cooling of 4 properties with heat pumps and data from around 200 homes aiming to account for technical and social factors.

The 3Dstock model has received funding from the Active Building Centre to support the development of a Welsh version and funding from BEIS for a non-domestic building stock model (BEES2) for England enabling it to be a major research and policy tool in the future.

There is significant engagement and support outside of research within this team with George Bennett now employed at BEIS following a secondment, regular meetings with BEIS and MHCLG to provide one-to-one advice to key staff on smart meter data, in-use efficiency ratings and issues around the performance gap and advice to the NHS on achieving net-zero.

## ECR projects

### **How can compact combi hybrids (heat pump/boilers) contribute to decarbonising and reducing heat demand?**

The project will investigate whether the [Compact Combination \(CoCo\) Hybrid technology](#) that combines a gas boiler and an air source heat pump (ASHP) in one wall-mounted, compact appliance offers a potentially attractive transition technology. The project started in August 2020 but the data from Bosch was delayed and hence analysis of the data will now be undertaken as part of the CREDS Final Project. The main deliverable has been completed that did not require access to the Bosch database with a paper about English stock modelling of different heating system scenarios.

### **DeViz (Defect visualisation via thermography)**

This project uses thermal imaging as a behaviour change and monitoring tool for site supervisors and to encourage a zero-defect culture. The project team has been recruited and piloting of the methodology occurred through the summer focused on which camera types would be best and how to heat building areas to provide the correct conditions for thermal defect identification. A training schedule and data collection methods are planned and due to be piloted in October 2021.

## **3.2 Transport and mobility**

Work is now underway or, complete on all projects under this theme, resulting in many outputs. Although there have been some delays in two of the original projects and the early career researcher (ECR)-led projects, the theme has produced outputs that were not originally planned. More than ten academic papers have been published this year.

The project on [High-end consumers](#) (Excess) is on track with the fieldwork (30 interviews and four workshops) completed and analysis is almost complete. A book chapter on 'Social divisions in energy consumption in the transport sector: personal car ownership and use' is close to publication in the Research Handbook on Energy and Society. Peer reviewed papers have been published on [Trends in air travel inequality in the UK: from the few to the many?](#) and [Sustainable welfare: how do universal basic income and universal basic services compare?](#) Another book chapter on 'Transport and energy justice' is under review. Strong links have been established with the work in Theme 8 on transport poverty. The project on [Long-distance travel](#) has also been completed. Three papers are currently being drafted. In addition, unplanned work on non-CO<sub>2</sub> emissions from aviation has been undertaken.

Research on flexible mobility has progressed well. The project on [Flexing passenger mobility](#) is complete and its implications for EV charging are being linked with work in Theme 4 on patterns of domestic energy use, with one paper under review. The work on [Modelling flexibility](#) has been delayed to allow for a staff secondment to BEIS and reallocation of some effort to the integration project on Positive Low Energy Futures. Two published journal papers on the emissions impacts of active travel are already securing very high impact.

The project on Governing radical change is beginning and on track. The Commission on Travel Demand planned inquiry is delayed due to Covid-19. It is focusing on travel adaptations due to the pandemic. Monthly evidence exchanges are being held with key stakeholders.

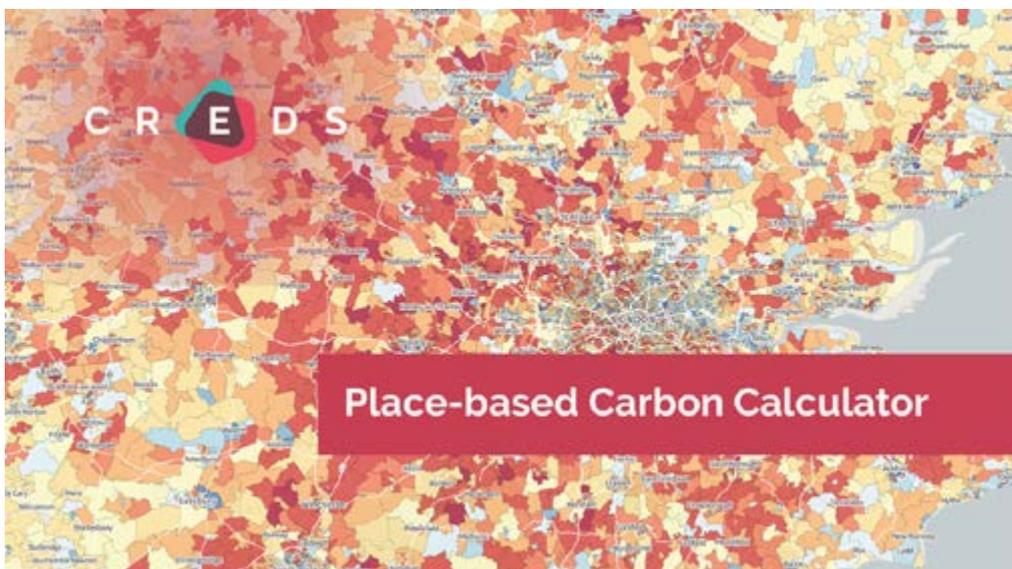
The impact acceleration project (co-funded by DecarboN8) has been completed. This work was commissioned by the Local Government Association. Seven briefing notes for local authorities on transport decarbonisation were developed and seven webinars for local government officers and elected members were delivered with total attendance exceeding 1000.



**Figure 4:** Graphic from the briefing for local authorities on parking

A project to assess the emissions savings potential of e-bikes has been completed, leading to a briefing note that has been widely shared and a peer reviewed publication.

The impact acceleration project to develop a Place-Based Carbon Calculator has been successfully completed, launched with an attendance of over 300 and is available at [www.carbon.place](http://www.carbon.place). The website has had over 13,000 visitors, with very high levels of attention on social media and in the industry press. Project leader Malcolm Morgan did a TV interview as part of a 10-minute news item on the regional BBC programme Look East.



## ECR projects

### Facilitating policy change for low carbon mobility: the role of multilevel governance

This project has been delayed due to the pandemic, but this will allow it to adapt to changes in the local political balance in one case study area. The first stage of network visualisations is complete, as are the majority of interviews. It remains the plan to do face to face workshop sessions. Two conference papers have been presented.

### Decarbonisation of coastal shipping in UK

This project is also delayed due to Covid-19 restrictions on field work. The project plan has been changed to an online analysis of available qualitative data and the virtual interviews. Project lead Nishatabbas Rehmatulla contributed written evidence to an inquiry of the House of Commons Environmental Audit Committee.

Non-academic impact of the theme is high. Particular highlights are the Place-Based Carbon Calculator launch and direct influence in the DfT's Transport Decarbonisation Plan.

## 3.3 Materials and products

All projects in the theme are mostly complete and the remaining time will be spent on dissemination and engagement activities. John Barrett led the Positive Low Energy Futures (previously Low Energy Demand Scenarios) project – see [section 2.2](#), and elements of project were completed within this theme.

Industrial energy demand projections for delivering net-zero emissions have been modelled for the steel and cement industry as part of the Positive Low Energy Futures activities, resulting in reports and an academic paper (revisions submitted). Further work in this area includes developing scenarios for a net-zero UK food system, as part of the project. A paper and article in the Conversation are both published and a policy brief in preparation. Alice Garvey spoke about low-carbon diets on [BBC Radio 5 Live](#), and on the BBC News Channel.

A modelling approach grounded in stock dynamics and material flows has been used to assess a number of energy and resource demand reduction options, such as lightweighting, and material substitution. A new report about [Resource efficiency](#) was produced in collaboration with environmental charity WRAP (March 2021). Through eight complementary strategies, the report sets out how changing the way we use materials as well as energy could deliver an additional 100 million tonnes (Mt) CO<sub>2</sub>e reduction in territorial emissions between 2023 and 2032. See [section 2.2](#).

A literature review on consumption-based mitigation options looked at household-level consumption data to illustrate the distribution of carbon footprints. A simplified figure from the Environment Research Letters paper has been submitted to the Summary for Policy Makers for the next IPCC report due March 2022.



The findings from work on exploring how the use of materials and products throughout the supply chain have been published in a report on [Industrial decarbonisation policies](#) in December 2020 that coincided with the publication of the CCCs recommendations. A blog, [policy brief](#) and downloadable [Industrial decarbonisation policy dataset](#) were also published alongside the report. A blog was written for the CREDS website, and for Business Green in December 2020. Further journal papers including on Science Based Targets, UK and EU supply chains and household energy footprints are published.

The project on reducing energy in construction has been substantially affected by Covid-19 and hence the Living Lab project will no longer go ahead. This work package will be covered by work updating the 2013 Green Construction Board Low Carbon Routemap; the positive low energy futures work and future collaboration with Strathclyde. Working with the UK Green Building Council the project will develop sector-based carbon allowances, targets and actions as part of the [Net Zero Whole Life Carbon Roadmap](#).

There is ongoing engagement with the Cross-departmental Government working group (to discuss monitoring energy / resources and economic implications, policy assessment and analysis). For further information see the [case study on resources policy](#).

### **3.4 Flexibility**

The Theme is progressing well with all six planned projects ongoing.

Work on [Flexibility: past, present and future](#) has been central to a special issue in the [Journal of Energy History](#). Publication of work on fuel switching has been delayed due to staff changes. The project on [Measuring flexibility of demand](#) is on track and has already produced multiple outputs. Research on [Conceptualising flexibility](#) is also on track and the [series of virtual Reading rooms](#) has generated a publication in [Nature Energy](#).

In the other sub-theme, the project on [Flexibility of demand-side technologies](#) is on track with model development ongoing and a review paper in preparation. The project on [Time and price elasticity](#) was delayed but is now making good progress with two outputs being prepared. The project on [Time dependence and institutional flexibility](#) has been delayed by the pandemic but restructured to incorporate the delayed aspects of work on fuel switching, with research now underway.

The theme continues to be deeply engaged with key stakeholders, notably Ofgem, Defra and BEIS. The webinar on 'Distributional effects of time of use tariffs' attracted more than 80 participants, including the Shadow Energy Minister. The Reading Rooms have secured an international audience and engagement.

Three VIPs are hosted within this theme – see [section 2.3](#).

## ECR project

### Using electric vehicles as distributed energy storage systems: a digital twin-based approach

This project has now been completed successfully with a conference paper and digital twin models.

## 3.5 Digital society

Progress has continued well within the theme, with further journal and conference papers produced. Four projects have commenced this year: Digital twins in the built environment, Place-based business models for net-zero, Anticipating future impacts of ICTs on energy consumption, and an extension of the work on long-run trends in ICTs and energy use.

Further work on e-working / teleworking finds that the majority of English teleworkers travel farther each week than non-teleworkers. However, there appears to be a 'tipping point': if people telework three or more times a week, they may achieve net reductions in private travel (commuting and non-work). The results were presented at the ECEEE Summer Study and a journal article on 'Do teleworkers travel less: Evidence from the English National Travel Survey' has been submitted.

Data collection via interviews and focus groups for the digital platforms for the sharing economy work is complete and three journal papers are being prepared – 'Borrowing, energy demand and Covid-19: a model for disruption', was presented at the ECEEE and has been submitted to the ERSS journal and further work has been presented at the RGS 2021 and the IST 2021 conferences.

Research work on the use of ICT for new energy service business models project was completed last year, and a second paper has been written in collaboration with CREDS policy theme (Edinburgh) and was presented at the BIEE'21 Conference. Additional 'Impact Accelerator' funding from Sussex University was received to undertake a series of innovation forums for the Greater Brighton region. The first three Sussex Innovation Forums were held between October 2020 and May 2021 and were attended by 78 people. Findings on business models and local value were presented in meetings with Councillors and council officers from Greater Brighton region, which will inform their plans for a forthcoming Climate Summit. It is hoped that this will lead to further opportunities to feed into their strategic planning for net-zero.

The project on anticipating future impacts of ICT on energy consumption has been published: Fouquet and Hippe (2021) compares historical energy and communication transitions and the long run trends in energy and communication intensity in major European economies since 1850. The paper found that communication transitions tend to be substantially faster than energy transitions, suggesting it may be challenging to achieve both the decarbonisation and digitalisation of economies.

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The expectations for automated vehicles project is analysing data from professional and public Delphi surveys, focusing on the three revolutions (electrification, sharing and automation) as ways to reduce transport energy demand. Papers have been submitted on the challenges of sampling and recruitment of professionals from the professional analysis. Results on public views on owning and using autonomous (and electric) vehicles were presented at the annual Institute of RGS (with IBG) conference. Further analysis is being undertaken.

The work on user acceptance of smart homes is complete, with papers submitted on digital violence and abuse and 'Controllable, frightening, or fun? Exploring the gendered dynamics of smart home technology'. The narrative review of the energy impacts of 5G has been completed submitted to Renewable and Sustainable Energy Reviews

## ECR project

### Social entrepreneurship at the grid edge

This project is investigating how community groups are responding to opportunities for community-led, renewable electricity generation that are appearing 'at the grid edge'. The qualitative research and data collection has been started in both the UK and NL. The project is supporting three undergraduate students who are compiling background documents on the case studies and are expanding the toolkit library. A paper on regulatory sandboxes (with a particular focus on UK & NL) was presented at the BIEE 2021 conference.

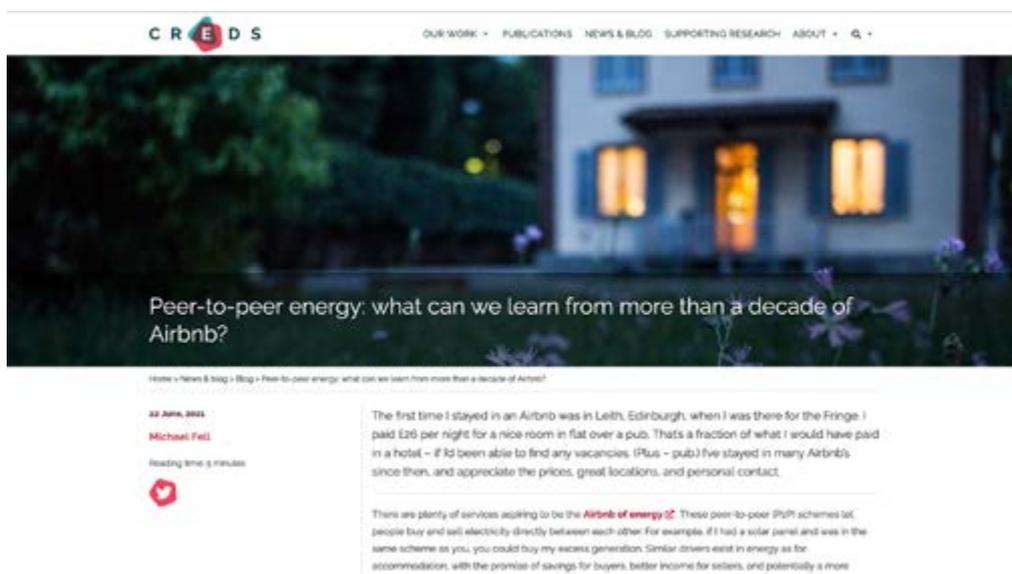
## 3.6 Policy and governance

The theme is progressing well, with all projects now completed or underway and strong outputs, including conference papers, book chapters, journal articles, blogs and consultation responses.

The screenshot shows a webpage from CREDS. The header includes the CREDS logo and navigation links: OUR WORK, PUBLICATIONS, NEWS & BLOG, SUPPORTING RESEARCH, ABOUT, and a search icon. The main heading is 'Building on our strengths: A market transformation approach to energy retrofit in UK homes'. Below the heading, there is a breadcrumb trail: Home > Publications > Building on our strengths: A market transformation approach to energy retrofit in UK homes. The page features a 'Report' section with the title 'Building on our strengths: A market transformation approach to energy retrofit in UK homes' and authors: Gavin Killip, Tina Fawcett, Marina Topouzi, and Faye Wade. The report is dated 11.04.2021. An 'Executive summary' section follows, stating that energy retrofit must become embedded into the everyday practices of builders working in the repair, maintenance and improvement (RMI) market. It notes that policy efforts to develop energy retrofit have not delivered the scale of activity needed to meet climate policy goals, and that opportunities for improving the energy efficiency of the nation's homes are routinely missed because they are not planned for. The summary concludes that a policy mix is needed to help deliver a changed market for retrofit, so that it becomes a normal activity, sought by households and delivered by competent builders, supported by supply chains, intermediaries and other local stakeholders.

The project on Policies for deep refurbishment of buildings was delayed but is now on track. Outputs feature a number of papers which include high-level policy perspectives as well as detailed investigations of particular aspects of retrofit policy from commercial building policy in Australia to training needs in the UK SME building sectors, input to national retrofit standards and a high-profile report for the Federation of Master Builders (see [section 2.2](#)). Work is ongoing on local projects and new policy options.

The projects on devolved and local policymaking in Multilevel governance and energy demand are now largely complete, with published or accepted outputs on policy divergence after United Kingdom devolution, local authority energy service models, local heat and energy efficiency policy. Work on City Deals was promoted and communicated effectively in various formats, with the help of the core team.



Research on peer-to-peer (P2P) energy trading is well-advanced with outputs including a book chapter, board game, case study and other publications in preparation. Work on policy asymmetry was delayed and the last to start, but is now on track with data collection underway and a new team member recruited to add to work on this topic.

Other research and knowledge exchange work includes publications on personal carbon trading in collaboration with a CREDS international visitor, and supporting the development of a new research network on SMEs and energy demand.

Two projects funded under the CREDS ECR call are linked into the theme. The small project on Adding another layer? A future for clothing in heat demand reduction and decarbonisation has successfully completed with the positioning/review paper drafted. This work is going to be taken forward with additional funding in the Final Project. The start date for Old for new? Mapping skills and communication networks for local traditional and off-site modular building energy retrofit has been delayed until October 2021.

The theme maintains a high level of engagement with key stakeholders. The research on multi-level governance has supported numerous inputs to Scottish and UK Governments. The report on retrofit, in collaboration with the Federation of Master Builders, was launched at the House of Commons and continues to be promoted to business and policy audiences including COP26.

### **3.7 Decarbonisation of heat**

The Decarbonisation of heat challenge concentrates on the system architecture of decarbonised heat rather than specific technologies. The work is now close to completion and this year there has been a strong focus on publication and stakeholder engagement.

The review of the literature for how heat can be decarbonised is complete with a review paper published. Early work in the theme on social, regulatory and governance issues has been further developed, leading to a paper on stakeholder expectations and system resilience.

The research on improving energy system models has made major progress. In particular, the UKTM Model (also used by UK Government) has been developed in a way that enables multiple runs to address robustness, rather than merely cost optimisation. In parallel, the same model has been used to address the broader challenges of net-zero as part of the Low Energy Demand Scenarios work. In parallel, the ESTIMO model that provides greater time granularity has been developed and used to illuminate operational issues that will be crucial in a net-zero system. Peer reviewed papers using both models have been published or, accepted.

The work has been used to inform a number of public policy and industry initiatives, notably the BEIS Heat and Buildings Strategy, ENA work on gas decarbonisation and Ofgem's work on RII0-2 and a was the subject of a well-attended public webinar. The work on ESTIMO is expected to inform ongoing work on energy storage for the Royal Society. One of the researchers, Tiziano Gallo Cassarino now has a permanent post at BEIS.

### **3.8 Fuel and Transport Poverty – FAIR**

The FAIR theme is investigating who may be vulnerable to both fuel and transport poverty in the UK's transition to net-zero. The project has conducted a systematic literature review comparing the literature on fuel poverty/energy poverty and transport poverty, specifically examining the socio-demographic groups that are vulnerable to each problem. This has led to the publication of a policy briefing (last year) and academic paper in *Energy Research and Social Science* journal. There were significant delays on recruiting households for interviews with partner Energy Saving Trust (EST) due to Covid-19, but despite this 59 interviews have now been completed remotely, across the UK. The analysis has started but has also been delayed due to Covid-19 related staff sickness which will also delay associated journal articles. A total of 5 papers have been published in 2021 from FAIR team members.

The data collection on visualizing and mapping vulnerabilities has been completed following discussions on creating unified energy and transport poverty indicators for the UK. The modelling stages are moving forward by conducting robustness checks and sensitivity analysis and using EST's unique EPC Scotland dataset for the modelling. The field scoping and meetings with relevant experts and other actors to discuss the types of questions and data that should be collected in the survey has started.

Engagement with stakeholders has continued, linked to the development of a communications plan together with CREDS core team. The engagement of the four UK nations and wider stakeholders continues with EST in ongoing dialogue with e.g. Sustrans Cymru and Scotland, NEA, Community Transport UK, local authority representatives, and the Bevan Foundation. There is continuing discussion with the BEIS Fuel Poverty Team supported by the CREDS Government Affairs manager. The team have written a number of blogs and held webinars e.g. 'Identifying the vulnerable: energy and transport poverty and beyond', 1 December 2020, which was attended by over 115 participants.

Members of the team have been speakers, invited experts and panel representatives at a number of events during the year including: the Fuel Poverty Research Network online conference Delivering Net Zero Workshop, panel member at National Energy Action Warm Homes Week.

There has been engagement internationally with IEA, C40 Cities and the team are members of the EU Task Force, Fair Energy Transition for All and the reference group for EU research on transport poverty feeding into European research agenda for the European Commission.

### **3.9 Decarbonisation of the steel industry**

The work in this theme is focused on integrated strategies to eliminate the dependence of iron and steel production on fossil carbon.

Initial work on stakeholder visions was undertaken early in the year. This identified the main issues as being general concerns about the UK steel industry, decarbonisation technology issues and related potential policies.

The work on technology analysis is quantifying in detail the technology options relevant to the UK. It has estimated the marginal abatement costs for hydrogen-based steelmaking and the implications for increased supply of electricity if green hydrogen is used. This has been published. The model developed has been adapted to incorporate the potential benefits of the steel industry supplying flexibility services and to allow for variable scrap rates. The work has developed a model of high-temperature mine water heat pumps for potential use in industry.

The research on policy has included analysis of materials recycling issues, working with the Materials and Products theme, and considering how policy interventions might encourage greater utilisation of ferrous scrap and reuse of steel. It has investigated the options available to decarbonise the industry, considering how policy interventions might encourage greater secondary steel production and drive the adoption of CCS and hydrogen. The work has engaged stakeholders from across the steel and energy industries, which has been considered in the paper being prepared.

## 4. Approach to Equality, Diversity and Inclusion

CREDS has adopted a policy and action plan on [Equality, Diversity and Inclusion \(EDI\)](#) that was published in April 2019. 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 fulfills our legal obligations under the Public Sector Equality Duty but goes further than the legal requirements.

We keep EDI visible in the consortium with sessions at every WCM (covering the responsible bystander, unconscious bias, career progression, feedback from the EDI working group, staff survey), items in the internal newsletter (the Consortium Update) and external newsletters, items on the website and EDI working group meetings.

In addition, we submitted evidence to the All Party Parliamentary Group on Diversity and Inclusion in STEM inquiry on [Equity in the STEM Workforce](#) that was referenced six times in the final report (published July 2021) and was cited as an example of good evaluation practice. We have also published the activities on EDI as a case study [We are the ones that we seek: Equality, Diversity and Inclusion in CREDS](#).

A year after publishing our EDI plan we reviewed the progress in implementing it and published the [EDI Annual report](#) and briefing paper in June 2020. The main challenge to CREDS is that many aspects of EDI are determined at the institutional level, which means the Centre's influence is limited, although we are sharing what we have learned with the institutions that are part of the consortium.

Some of the actions within the plan have had to be delayed (such as work to promote better career progression for researchers) due to resource constraints, since all the EDI working group are voluntary including those within the core team. To address this, we used the Flexible Fund to resource an **EDI post** (one day per week – 0.2 FTE). We advertised the post openly and it attracted a very strong field. We interviewed in March 2021 and appointed Anuja Saunders. This provides us with additional capacity and expertise to monitor and develop the EDI plan.

We are aiming to raise the profile of EDI in the energy research community by holding a series of events on this topic starting with linking to National Anti-Bullying and Harassment week in November.

CREDS continues to support career progression for **Early Career Researchers** (ECRs) by holding two induction meetings for new PIs and funding for three small projects for ECRs within CREDS (See [section 5.1](#)). In terms of defining what an ECR is typically, we found that it was so many years (3.5 or 7) post PhD e.g. for fellowships, but this was too restrictive for us so we have defined suitable criteria for each call we made based on clear criteria that were considered to be fair and equitable and diverse. This has included – those who haven't yet held a grant larger than £100K, those on fixed term contracts (ie. NOT permanent contracts), and the broadest 'if you think you are one, you are'. Our work with ECRs is described in a case study, [The leaders of tomorrow](#).

CREDS launched its Studentship programme for eight PhDs on 3 August and held an information webinar on 17 September. Applications close at the end of October and the studentships will start from September 2022. Feedback will be provided to all applicants and in addition, successful students will follow an adapted ECR induction programme once they start.

## 5. Flexible Fund allocation

### 5.1 New commitments

The main commitments from the Flexible Fund were made in earlier years to allow for efficient use of resources. There was a small amount of budget remaining from the ECR call that we have used to fund three projects for ECRs within CREDS. One project is funding two paper writing activities on the topic of clothing, comfort and energy demand, one is a capacity building activity for CREDS ECRs developing messaging and outreach materials for young people and the third project is carrying out a two-way learning process between ECRs and practitioners on sensitivity auditing to scrutinise a model's uncertainty.

A further project, led by Sarah Higginson on data and research quality across the consortium has been funded under the Flexible Fund. It will promote processes that produce transparent, reproducible, high quality (TReQ) data and research, map existing energy data and carry out awareness and capacity-building work within the consortium and beyond in the EDRN (Energy Demand Research Network). Video guides for researchers in the use of TReQ approaches are in preparation.

In the early part of the year, we reviewed the status of the remaining Flexible Fund budgets. Following extensive discussion within the CREDS Executive and Advisory Board, we decided to combine various remaining sections of the Fund (for Integration projects, Gap projects and Final project) into a single budget for use in a targeted Final project and that this should have a strong focus in the final two years of CREDS on energy use in the new normal. A special meeting of the CREDS Executive in November 2020 brainstormed the scope and approach, agreeing to an open call and a workshop for all interested CREDS staff. We then requested expressions of interest (EoI) from across the consortium. We received five responses, which were reviewed by members of the Executive and feedback provided to proposers. The project ideas were all presented, and discussed in parallel breakout groups, at a virtual open meeting of CREDS on 25 February 2021.

The unconflicted members of the CREDS Executive assessed the position on 4 March 2021, discussed the broad fit of the different Eols. We agreed a single project, using key aspects of all the Eols, with the following five work packages:

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

The Advisory Board agreed with the proposed outline, approved funding of up to £762,000 for the project, and asked for detailed plans, with a view to approval by the Advisory Board outside the usual meeting cycle. This was followed by detailed discussion with the proposers of the Eols, the development of detailed project plans, and agreement of the project in June 2021.

This project fully commits the Flexible Fund.

## **5.2 Progress with existing commitments**

### **5.2.1 Early Career Researcher (ECR) Awards**

The eight projects have been integrated into our existing themes and progress is reported in [section 3](#).

### **5.2.2 Impact Acceleration Awards**

Progress on the projects to support work with local government to develop seven decarbonising transport briefs and to develop a carbon calculator for transport for local authorities is set out in [section 3.2](#).

## **5.4 Integration projects**

The Flexible Fund has also funded our four ongoing integration projects, three related to Covid-19 are described below and one to develop low energy scenarios for the UK (see [section 2.2](#)).

- The short and long-term impact of Covid-19 on building energy demand and future decarbonisation, led by Tadj Orezczyn. Data analysis of the questionnaire and meter data from 1,000 properties has been completed, leading to a pre-print 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 received in August 2021, with preliminary results already presented to stakeholders. Further data on attitudes has now been received, which will inform a segmentation analysis for the DfT Chief Scientific Advisor. A third wave of policy interviews is planned for October 2021. The work has informed two book chapters and CREDS report – see [section 2.2](#).
- 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 is in preparation.



## 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.

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