Social and distributional impacts of decarbonisation and climate adaptation in the UK

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Executive summary

- This report was commissioned before the coronavirus emergency. The research and conclusions do not reflect the social impacts that this may have on delivering climate related goals.
- Report provides meta-analysis of current research into distributional and social impacts of decarbonisation of electricity, mobility and heat, as well as adaptation and resilience. The aim of the report was to provide a comprehensive and holistic analysis of these areas with respect to social and distributional impacts, to help develop more targeted policy responses that take account of sequencing issues and flag unintended consequences.
- Academic literature provides a number of good case studies of 'justice' issues with regards to energy but is mostly retrospective and there has not been enough work linking these mostly siloed pieces of research into a systematic research agenda.
- Focus from Treasury and Committee on Climate Change (CCC) on income and carbon abatement (respectively), but lines between social policy and energy policy is increasingly blurred. Treasury review explicitly excludes co-benefits, and costs of adaptation.
- A priority area identified by several institutions regards the lack of data on behavioural response from consumers to new technologies (such as heat pumps).
- Lack of evidence on social impacts of mobility and electric vehicles.
- Regional impacts currently assessed in terms of devolved states, but more nuanced evaluations of urban and rural areas need further attention.
- Risk that costs of electric vehicles (EVs) early adopters will be subsidised by those who cannot (costs of purchasing EVs, and access to on-street parking or charging infrastructure), but depends on the timeframe over which costs of infrastructure are spread over.
- Risk that rural areas will pay more due to lack of access to gas grids.
- Recommendations for further refinement of the framework used to classify social and distribution impacts, incorporating overlaps and allowing for interactions and sequencing.

1. Introduction/aim of report

The UK faces challenges towards reconfiguring its systems to provide key services of transport and energy provision, while meeting its commitments towards decarbonisation and meeting net-zero by 2050. This report, at its core, is based on the notion that the concepts of fairness and equity needs to be at the centre of these strategies. This is not only regarding fairness for the current generation, but also of future generations.

The nature of the work is exploratory and to an extent speculative. The primary reason for this is that the decarbonisation strategy the UK will take is not fully realised at this time, and different pathways towards achieving decarbonisation will have different impacts and considerations. However, the aim of this work was exploratory research to assess the extent of the work being done in relation to social and distributional impacts.

This exploratory research is timely given multiple government workstreams which have implications for fairness, including: the upcoming net zero review by Treasury, the distributional impacts framework currently being finalised by Ofgem, the ongoing analysis by the CCC for the UK's 6th carbon budgets, and the Just Transition Commission launched by the Scottish Government. However, it is worth noting that the work was conducted prior to recent developments due to the COVID-19 pandemic. As such, the viewpoint that this report represents was in line with trends and assumptions prior to lockdown in the UK, and potential the challenges for finance and governance that may result from this.

The report proposes a holistic approach to considering social and distributive impacts. A preliminary framework for considering these impacts is proposed, and populated with potential issues that can arise in these areas. This framework is then used to identify and classify current work on social and distributional impacts. In doing so, the report helps identify key research gaps, and the growing evidence base used for considering these kinds of impacts. The meta-analysis also makes some propositions about sequencing and interrelations of certain types of goals and impacts (such as choices around the decarbonisation of heat, use of hydrogen networks and implementation of carbon capture and storage), and makes proposals for further refinement of the framework.

The remainder of the report proceeds as follows. **Section 2** outlines the main trends considered in the report with regards to each area of sustainability and adaptation, and defines

the main types of social and distributional impacts. **Section 3** then presents the main results of the report in terms of the meta-analysis of existing and ongoing research/work into these themes. **Section 4** then discusses these findings, in relation to main gaps, the question of who pays, and interactions and interdependencies observed. Finally, **section 5** concludes, outlines limitations of the work and then suggests avenues for further work.

2. Potential social and distributional impacts associated with decarbonisation of electricity, heat and mobility in the UK

This section of the reports outlines key assumptions and definitions.

Section 2.1 outlines the key trends that are expected to unfold for the three different areas of decarbonisation, for mitigation and adaptation.

Section 2.2. then defines vulnerability, drawing on the existing language used by the regulators, and then wider considerations that can also be considered under a vulnerability lens.

Section 2.3. then describes and defines four key categories of social and distributional impacts.

The final part of this section then combines these categories with the key trends and goals, producing a table of potential issues which can arise in each of the sectors. These interactions are then represented in **table 1**.

2.1. Key Trends/scenarios

At this point in time, how exactly decarbonisation will unfold in the UK is uncertain. What is certain is that there are no 'silver bullets', and due to the complex and multi-faceted nature of energy transitions, it will likely include a combination of multiple technological and social innovations. These combinations are not necessarily homogenous, and will vary depending on various factors, including geographical location. Whilst are there remaining questions regarding what the eventual portfolio of technologies will look like, there is some consensus over the main technologies being considered, and the general direction of travel. This section outlines the main trends and potential solutions in three areas of decarbonisation: electricity, transport and heat. The final part of this section also outlines the main areas of importance for climate change mitigation and adaption in the UK.

2.1.1. Decarbonisation of electricity

With regards to electricity, the main generation technologies being considered in future scenarios are offshore and onshore wind, solar PV, nuclear. The energy scenarios will be finalised by the CCC in May or June of this year. One of the main contentions between these technologies and the amount of capacity of each on roll out relates to the extent to which electricity supply is centralised or decentralised. Centralised energy supply normally operates under a contractual arrangement between a consumer and an energy utility, and the utility and the District Network Operator (DNO). De-centralised energy supply has the potential to operate under a different model, where a person can generate their own electricity, and does not need to purchase from an energy utility. However, most consumers will still connect to a central grid in order to compensate for intermittency and to balance supply and demand. It also opens up more possibilities as 'prosumers' can chose to sell the electricity they generate, either on retail markets or other arrangements such as peer-to-peer networks.

Of the main technologies considered, nuclear and offshore wind are entirely centralised. Onshore wind can be both centralised and de-centralised, but has historically tended to be commissioned and operated by utilities. Finally, solar PV has been pre-dominantly decentralised, with a boom in household installations following the introduction of the Feed-in-Tariff in 2010. Similarly, what is worth noting is that development of the electricity mix in the UK has, historically, been predominantly policy led (or policy determined). The design of the Renewables Obligation, Feed-in-Tariff and Contracts for Difference (and which technologies they favoured) had significant implications for how generation capacity changed over the last 20 years. Therefore, it is sensible to assume that the extent to which these technologies are favoured as we head towards net-zero will also be determined by the policies implemented in the near future. A final consideration is the use of carbon capture and storage (CCS), but this is still relatively unproven (in the UK) even though it is included in all CCC scenarios for the 6th budget.

Another key theme that links to technology choice is storage and capacity to account for intermittency of supply, as a proportion of electricity generated from renewable technologies increases over time. Beyond simply increasing the amount of storage, and potential to use EVs as batteries which can buy or sell electricity back to the grid to alleviate spikes in electricity demand, other measures will be introduced to manage electricity demand. The main theme is the overall 'smartening' of electricity distribution and demand. This strategy

involves multiple aspects, but mainly centres on the continued roll-out of smart meters to homes, introduction of smart appliances for domestic purposes, and the smartening of the distribution grid. Working together, these innovations can help reduce spikes in demand occurring at peak times and help manage intermittency. Associated with this is the types of tariffs that can be offered, as a flexible energy market based on volatility in prices associated with intermittency can automatically switch off non-essential appliances at peak times (such as a fridge), or switch on when there is an energy surplus (e.g. a washing machine). The most current policy reform package introduced in the UK is the Capacity Market, which has been designed to support more active demand management in the electricity market[1].

2.1.2. Decarbonisation of transport/mobility

Decarbonisation of transport is the sector that, at the time of writing, is perhaps the most certain in terms of future trajectory. This is mainly due to the fact that electric vehicles for personal mobility have already been supported by policy measures to support early adoption and infrastructure roll out. These policies were launched as part of the 2008 industrial strategy, where the UK positioned itself as an early adopter of EVs in order to attract international manufacturers to build factories in the UK and create jobs. The Government's Road to Zero Strategy states that petrol and diesel cars will no longer be sold after 2035. The CCC's recommendations for the 6th carbon budget (period 2033-2037) include 100% uptake of EVs in all of its scenarios. To support this strategy, the continued development of infrastructure is needed, including expansion of electricity capacity and grids to support the increase in demand.

Other aspects of transport are less certain, with regards to large vehicles and public transport. This is potentially to be made up of combinations of electric vehicles and hydrogen fuel cells. Some progress is already being made with regards to public transport, including roll out of electric busses in certain regions, such as Brighton.

2.1.3. Decarbonisation of heat

The decarbonisation of heat is currently the least certain option with regards to the future portfolio of technologies used. Government has committed to providing a clear pathway for heat de-carbonisation by the mid 2020s. The main options being considered are the

[1] The capacity market was not originally designed to accommodate demand management but has since been revised to do so.

electrification of heating (using heat pumps) and the development of hydrogen gas networks. Other options are combined heat and power, district heating networks. These technologies are likely to be implemented with regional variability, providing bespoke solutions based on capabilities. Each have advantages and disadvantages, for instance, hydrogen networks are being favoured by network operators and utilities as they can use existing infrastructure and maintain a more centralised market, and would potentially offer a cheaper solution for consumers. However, they are dependent on the development of CCS as a technology and are most likely to be developed in more industrial regions of the UK such as the North East due to potential availability as CCS will be developed in these areas. Similarly, heat pumps offer advantages in that they can be rolled out in more rural locations which would not have access to hydrogen networks, but require higher capital costs for consumers and potentially higher operational costs, and require expansion of electricity capacity and improving networks to handle increased demand in more rural locations.

The other aspect of decarbonisation of heating is improving the efficiency of the existing and new building stock. The process of retrofitting housing is currently supported by the ECO, which has been extended in recent policy developments. A related issue to heating is that of indoor cooling/air conditioning. However, while this is an overlapping consideration of decarbonisation of this sector, it will be considered in the next section of adaptation and resilience.

2.1.4. Adaptation and resilience

Adaptation and resilience are linked to the future impacts of climate change in the UK, and the preventative measures which need to be taken to alleviate the impacts of these changes. The main issues considered by the CCC in its impact assessments are flooding and urban heating. These issues are geographically dependant, where some communities will be more adversely affected. Coastal erosion and sea level rise are also considerations, but these are likely to play out on a longer time frame than the aforementioned issues. One consideration here is regional variations in costs of reinforcing the network, and cross regional subsidies e.g. some regions paying for water resources in other regions. This could therefore lead to issues regarding willingness to pay, as there are regional differences, and socio-economic variations.

2.2. Vulnerability

Currently, the way in which vulnerability is used by regulators pays more attention to individuals and households. To identify risk factors for vulnerability regulators flag three key areas:

- **Personal characteristics** e.g. health, disability – speech impairment, being a child, low confidence, low awareness, non-English speaking
- **A customer's situations** e.g. which includes social factors as per the CCC definition in the broadest sense– being unemployed, no internet, being a full-time carer, leaving care, experiencing relationship breakdown, living alone, experiencing bereavement, being on a low income.
- **Wider circumstances** – e.g. living in a rural area, living off the gas grid, fuel type e.g. electricity only (in some circumstances), housing type (ownership/housing quality e.g. living in cold energy inefficient homes, living in private rented accommodation, multiple occupancy) – having certain meter types e.g. prepayment, dynamic tele-switching meters, smart/non-smart meters. These are also all 'environmental factors' in the broadest sense.

These factors correspond roughly to the categories used by the CCC to describe types of social vulnerability.

- Personal

  e.g. age, health

- Social factors

  e.g. physical or social isolation, income, ethnic minorities, homeless, information use language and local knowledge

- Environment

  e.g. housing types

However, beyond social vulnerability, the CCC also considers another aspect of vulnerability and impacts which relate more broadly to regions and communities, called **Spatial Distribution**. A wider definition of vulnerability also enables analysis of the impacts on people as citizens as well as consumers. This is particularly important in times of radical uncertainty and when looking at long-run impacts. Building on this concept, the next section of the report defines categories of social and distributional impacts which account for this wider view of vulnerability, which is argued is important for making current and future strategic decisions about climate related goals.

2.3. Categories of key social/distributional impacts

Having introduced more comprehensive definition of vulnerability, this subsection outlines the main categories of social and distributional impacts related to decarbonisation and mitigation/adaptation. These categories seek to link potential effects of changes to the main considerations of vulnerability, thereby looking at impacts though a vulnerability lens. Four main types of social and distributional impact are identified, which can be applied across the different domains[2]. These are:

- *affordability*,
- *inclusion and access*,
- *spatial distribution* and
- *intergenerational impacts*.

Table 1 then links these categories of impacts to the trends identified in decarbonisation and adaptation. In doing so, the table shows a range of potential issues which arise with regards to these different sectors.

2.3.1. Affordability

Affordability relates to the costs incurred by or resulting from potential decarbonisation strategies. These can be short term and immediate or taking place on a longer time frame. One main aspect regards how costs of supporting decarbonisation are distributed, which applies to levies, taxation and other socialised costs. This is how the general population is affected by costs, and links to vulnerability since low income groups are affected more by such costs if they are regressive.

Beyond socialised costs of supporting transitions, affordability also captures the personal costs incurred on people in order to participate. This relates to the costs of new technology (such as smart appliances) and practical or lifestyle changes, which may also incur costs.

This can therefore capture the costs passed on to consumers through levies, such as those attached to fuel bills. The other dimension of affordability also links to access, whereby the material cost of some measures needed, has unintended impacts. For example, for

[2] **Box 1** also outlines safeguarding as another important consideration, albeit beyond the scope of this report.

decarbonisation, the costs of buying new smart appliances may then exclude some from participation in more exclusive time of day tariffs.

Issue for consideration:

- Does this involve customers/households having to afford to buy something new? If so likely to be a barrier to those on low incomes. Exceptions may be as mentioned for those living in social housing where landlords have been proactive in some cases in paying for new technologies. Also, in the case of energy efficiency and smart technology consider variations for Scotland and Wales where they have better developed and more whole house energy efficiency programmes. New builds may be an exception too depending on standards adopted.

2.3.2. Inclusion and access

Relates to the ability of a person to access the benefits of decarbonisation. There are aspects of access which are overlapping and captured by both affordability and spatial distribution, but also additional considerations which do not link to these issues. These relate to personal characteristics (such as cognition, mental health, confidence), and situational characteristics (such as lack of internet access, renters versus owners). These situational characteristics relate to the environmental factors associated with different types of consumers and households. A key example here is access to street parking and charging infrastructure to people living in blocks of flats.

Issues for consideration:

- Does accessing the benefit/or the proposed change require disruption to a person's life/home? Customers may be less open to change, or less able to make the changes where they require them to do things differently to access the benefits.
- Does accessing the benefit involve customers understanding and engaging with new information/making choices/taking proactive action? If so, certain groups will miss out.
- Are there usability challenges in accessing the benefits? E.g. even if the customer had the technology/service, would they physically be able to use it?

2.3.3. Spatial distribution

Primarily relates to geographical differences between different communities and the implications that may come along with that. Some decarbonation solutions will be only be available to certain regions, such as the development and access to hydrogen gas grids. This also incorporates spatial issues associated with communities, such as overall access to employment, which types of employment, and if they are associated with high polluting industries, which will have to change due to transition. This aspect can also relate to different devolved authorities (Scotland, Wales etc.). This also encompasses differences and challenges between urban and rural communities, and 'deep rural' areas such as Orkney in Scotland.

Issues for consideration:

- Does geography provide different opportunities for participation in energy transitions. This may be in terms of community wide implications such as employment opportunities and access to different energy solutions.

2.3.4. Intergenerational impacts

The intergenerational impacts refer to the longer term social and distributional impacts that come about from certain decarbonisation strategies. Primarily this relates to implications to health and lifestyle which may arise from decarbonisation, and the effects to ecosystems which are attributed to climate change.

Another consideration is the implications that strategic choices made now may lock-in these solutions and produce outcomes which are not easily reversed. In this way intergenerational impacts may then include a wider set of characteristics which relate to the other types of distributional impacts on future generations (such as the costs/affordability of heating options for subsequent generations). These impacts can also be more generalised than specific sectors (e.g. heat) and can be associated to factors such as carbon pricing. How the costs of carbon pricing are socialised will affect who pays for decarbonisation and will have distributional impacts on different income groups.

Finally, this also captures how adaptation may be influenced by changes in climate, which may exacerbate existing issues (such as flooding) or create new issues, such as coastal erosion and sea level rise.

Issues for consideration:

- Are there particular groups at risk in the future?

Box1: Safeguarding

Safeguarding also important!

- This refers to implications around data, privacy and protecting vulnerable groups.
- Consider not just the intended use of any technology for low carbon transition but also wider use/unintended uses.
  - E.g. in the case of smart meter data and energy, companies want to maximise their profits and minimise their risks. Greater data on energy profiling will enable them to do this, potentially resulting in some groups of customers excluded from new deals or impacting wider credit scores.

Issues for consideration:

- Will it make existing safeguarding issues harder or easier?
- How will the market/competition as it stands encourage business to behave?
- What's the worse-case scenario?

Table 1 – Potential social and distributional impacts arising with respect to decarbonisation and adaptation

		Distributional and social impacts for individuals, households & communities			
		Affordability	Access/inclusion	Spatial Distribution	Inter-generational
Climate related goals	Decarbonisation of electricity	• Income taxation Vs. Energy Bills • Fuel Poverty – costs of decarbonisation pushing more people into fuel poverty • Carbon pricing affecting costs of energy • Cost of the 'smart kit' – new appliances • More complex tariffs with possible penal TOU rates leading to self-disconnection at times • Newer appliances that work alongside the smart meter • Design of regulations affecting costs	• Access to broadband • Ability to interact with 'smartening' of energy, new tariffs and appliances. • Options for decentralised energy supply/Access to local electricity production	• Creation of green Growth jobs helping empower regions and communities • Re-skilling and inclusion of workers from currently high polluting industries • Expansion of the grid needed to support other areas of decarbonisation (EVs, heat pumps) • Options for peer-to-peer electricity trading • Regional availability of broadband • Availability of local resources for distributed energy provision (wind speeds, planning permission, direction of roof slope affects availability of PV) • Fewer opportunities for smart energy in rural areas	• Lock-in to new electricity systems • Centralised vs. decentralised electricity supply • Air quality • Ecosystem impacts • Regional job losses due to shifting away from high polluting industries
	Decarbonisation of transport	• Cost of EVs – many people buy second-hand cars • First adopters gain while are subsidised by those who cannot access • Subsidy schemes • Cost of public transport	• Availability of charging points (off-street parking) • Option to install charging points on rented property • Access to public transport in rural communities • Ability to manage transition to new technologies (EVs), accessibility of public transport for vulnerable groups	• Local communities will struggle with grid expansion, to support EVs on the grid and to support public transport • Important for infrastructure (charge points). • Important for improving public transport. • May not even have public transport • Resources available at local level to drive development.	• Lock-in to new infrastructure supporting either EVs and/or hydrogen • Air quality • Ecosystem impacts
	Decarbonisation of heat	• How efficiency schemes are funded (how progressive) • Fuel Poverty – currently increased due to payment of schemes through bills • Affordability of efficient housing • Affordability of energy efficiency improvements • Carbon pricing • District heating potential monopoly – need price regulation	• Proximity to hydrogen producing networks • Ability of those in private rented property to make improvements (landlord tenant divide) • Ability to interact with 'smartening' of energy • Fuel poverty affecting vulnerable groups more • Ability to access district heating solutions	• Choices around use of hydrogen as replacement for gas or electrification of heating is likely to be regionally distributed and based on location and proximity to heat networks • Regional bespoke solutions	• Lock-in to new infrastructure for electric heating solutions • Indoor air quality issues in housing stock due to building design • Air quality • Ecosystem impacts • Locked into long term price deals that may not be competitive
	Adaptation / resilience	• Personal impacts • Properties in areas liable to flooding cheaper • Cost of sandbags/preventative gear • Cost of insurance • Cost of replacing belongings after flooding • Costs of fans for cooling in urban areas	• Some impacts will affect vulnerable groups more • Urban heat is more likely to be an issue in low income residencies (blocks of flats)	• Ability of certain regions to fund adaptation • linked to how to flood prone an area is to extreme weather, storms and floods. • Water rich versus water poor geographical areas - water transportation	• Impacts of flooding, sea level rise, drought and urban heat on future generations

3. Existing and ongoing research into the distributional and social impacts of climate goals in the UK

3.1. Data collection

This section of the report represents findings published and ongoing work into social and distributional impacts related to decarbonisation and climate adaptation in the UK.
The aim of this research was to provide an overview of a very wide scope topic, and given the relatively short timeframe of this research, inclusion of material had to be bounded in order to be feasible. The research followed a selective sampling strategy, identifying current major workstreams engaging in the policy process with regards to decarbonisation and adaptation. Additional work was then identified via a snowballing process, and by a wider literature search. Publications were also only included after 2010, as they were deemed most relevant. Publications were also included specifically if discussing the UK. With regards to academic literature, this list is not intended to be exhaustive, but through cross validation of interview participants looks to identify the most important actors and institutes.

The data collected was through a combination of desk-based research and semi-structured telephone interviews. Interviews were needed to discuss ongoing and unpublished work in this area. This included several upcoming workstreams looking into distributional impacts in the public sector organisations/departments:

- Treasury – net zero review
- Ofgem – distributional impacts framework
- CCC – 6th carbon budgets
- Just Transition Commission

A limitation of this research related to the relatively short time frame, was that it was not possible to talk to a representative from BEIS about the clean growth strategy or Defra's air quality group.

Other interviews were conducted with academic institutions/NGOs. Participants were identified in accordance to their involvement in key areas of research or upcoming/ongoing research in these themes. This is important due to the relatively long delay between ongoing academic work and publication. It is also important to include NGOs (CSE, NEA, CA) in

order to include a range of viewpoints. All interviews were conducted over the telephone and are represented in **Table 2** - **Appendix A.**

3.2. Results of meta-analysis

The results of the meta-analysis are represented in **table 3**. This is a 'heat-map' style representation of the publications and projects included where the most populated cells are the most well researched. The results show that affordability of electricity and heat are the most well researched areas, followed by access and spatial distribution of these same aspects of decarbonisation. The results show that mobility is less well researched in general than these other two aspects of decarbonisation. There is also relatively little work on the intergenerational impacts of these specific areas of decarbonisation. Finally, adaptation and resilience were less well researched overall (with regards to social and distributional impacts) than decarbonisation.

The full list of publications, along with a short collection of key points is found in **Appendix A**. The abbreviated definitions from section 2.3 along with definitions for timeframe and materiality of the work are found in **table 4** (in **Appendix B**). Current and ongoing research is found in **Appendix C**. Details on current projects is variable, this is mainly as some of these projects are supported by telephone interviews, while some are identified through desk-based research and snowballing. These projects are represented in terms of how they coincide with the key interactions of social and distributional impacts introduced in **section 2** and **table 1**. Publications are represented numerically, which correspond to **Appendix B**. Projects are represented by numerals (I, II, III…) which correspond to **Appendix C**. Some excluded papers, which are not about the UK specifically are included in **Appendix D.**

		Distributional and social impacts for individuals, households & communities			
		Affordability	Access/inclusion	Spatial Distribution	Inter-generational
Climate related goals	Decarbonisation of electricity	1, 2, 3, 4, 5, 6, 7, 12, 17, 18, 19, 20, 21, 24, 28, 29, 30, 34, 35, 36, 37, 46, 48, 49, 50, 56 **I, II, III, IV, V, VI, VIII, X, XI**	18, 19, 20, 22, 27, 29, 30, 34, 35, 46, 48, 49, 51, 52 **I, II, III, IV, V, VIII, X, XI**	7, 11, 18, 19, 20, 23, 26, 27, 28, 34, 35, 39, 40, 42, 46, 53 **I, II, III, V, XI**	39, 35, 42 **VII**
	Decarbonisation of transport	8, 19, 20, 21, 35, 37, 37, 41, 56 **I, II, III, VI,**	8, 19, 20, 35 **I, II, III**	8, 19, 20, 26, 35, 41, 42 **I, II, III,**	35, 42 **VII**
	Decarbonisation of heat	2, 4, 5, 6, 7, 9, 12, 15, 17, 18, 19, 20, 21, 24, 28, 29, 30, 31, 32, 34, 35, 36, 37, 43, 44, 45, 48, 49, 50, 55, 56 **I, II, III, IV, VI, VIII, X, XI, XII**	9, 15, 18, 19, 20, 22, 27, 29, 30, 32, 34, 35, 44, 45, 48, 49, 51, 52 **I, II, III, IV, VIII, X, XII**	7, 18, 19, 20, 23, 26, 27, 28, 34, 35, 40, 42, 53 **I, II, III, XI, XII**	31, 35, 42, 54 **VII**
	Adaptation/ resilience	10, 13, 31	10, 13, 33	10, 13, 33	10, 13

Table 3 – Publications and ongoing research into distributional and social impacts

4. Discussion

This section of the report discusses the main findings of the analysis in terms of:

- Key research gaps
- Costs of delivering climate goals (who pays?)
- Interdependencies/interactions

4.1. Key research gaps

In this section, five main gaps are discussed more thoroughly (4.1.1.), while a larger number of additional gaps are also identified (4.1.2.).

4.1.1. Main gaps

1. Lack of quantitative data on behavioural response and adaptation of consumers to new technologies

It is unknown how people will respond to new heating systems and more flexible models for energy use. Specifically, there is a lack of quantitative data which links behavioural change to social demographics. The lack of data on behavioural response was emphasised by Ofgem and Treasury as being a major barrier towards a more comprehensive approach to different types of vulnerabilities. This is primarily because there are no suitable data sets which link demand to social demographics. The best example of a completed project was the customer led network revolution (2010-14), which did a lot of work linking social demographics. The main conclusion of this work was that there is more variation within social groups than between them. The only correlation (a small one) was between energy demand and income. However, even this project used MOSAIC data[3] and is low resolution. There is an ongoing project which is in this area, the Energy Systems Catapult 'living lab', which allows for trials of new technologies. There is also ongoing work being done at the University of Reading into demand. This data is being used by Ofgem as part of their distributional impacts framework.

[3] Mosaic is Experian's system for geodemographic classification of households. It applies the principles of geodemography to consumer household and individual data collated from a number of government and commercial sources.

2. Lack of data on transport/mobility and social impacts

There is overall a lack of existing work linking social and distributional impacts to transport and mobility. A key work stream in this area is the ongoing FAIR project as part of UK CREDS. UK CREDS is focussed on research to transform the energy demand landscape, and is very much academically dominated. However, since FAIR only started in January, there are no codified outputs so far. A key notion that this project introduces and then develops is the notion of 'transport poverty'. The project includes multiple workstreams including quantitative and qualitative research. Quantitative work on modelling impacts is carried out by Jenifer Dicks at Cambridge Econometrics, while geographical mapping of different regions is to be carried out by Paul McKensie. Additional qualitative workstreams are looking at the differences between urban and rural areas, but a limitation of the work is that it is not looking at 'deep rural' areas, and more focussed on areas more closely proximate to urban regions.

Another project looking into transport and social and distributional impacts is EnergyRev. This is another large consortium, but with more collaboration with industry. EnergyRev is about research and innovation on local energy systems. it includes local generation and technology innovation, includes a number of significant demonstration projects and involves a range of partners. However, the project is relatively new, and there is only one publication so far which is about transport.

3. Limited work on co-benefits

According to the CCC, where additional benefits occur as a result of GHG emission reduction, they are called 'co-benefits' of abatement, and it is important that they are taken into account in considering the overall costs and benefits of abatement. Reductions in GHG emissions will be accompanied by a range of other effects. For example, reduced combustion of fossil fuels will reduce emissions of other air pollutants, with significant health benefits. If agricultural emissions are reduced by people reducing their over-consumption of red meat, these healthier diets will also yield health benefits. And health may also be improved if reduced vehicle use in urban areas leads to more active travel, better public transport, and

more green space in cities. Accordingly, ‘co-benefits’ captures one aspect of what this report calls intergenerational impacts.

However, in much of the work on distributional impacts, there is a lack of consideration of these co-benefits. Treasury explicitly is not looking at this aspect. The CCC intended to include co-benefits in its analysis for the 6th carbon budgets, but decided that the tools available to include them are not currently good enough, so then excluded these factors. The just transition commission are intending to look into these effects. This is expected to be done through qualitative work. However, details on how these are being considered is still limited due to being at an early stage of the projects/research.

4. Limited work linking the costs of decarbonisation against the costs of adaptation

In a similar manner to co-benefits, there is limited attention to contrasting costs associated with decarbonisation and potential impacts, and the costs and impacts of adaptation. Moreover, there seems to be a general lack of research looking into the social and distributional impacts associated with adaptation more generally. There is some research on impacts of urban heating and access to cooling. This lack of research findings may be to do with a limitation of the research design, however, associated with the snowballing strategy used to collate data.

5. Limited research on intergenerational impacts of specific decarbonisation pathways

The final consideration is there appears to be little work considering the sector specific intergeneration impacts of decarbonisation and adaptation. To an extent this is to be expected as certain intergenerational impacts such as overall changes to health attributed to decarbonisation are not sector specific. There could be unintended outcomes of certain choices, for example, increased uptake of hydrogen networks could potentially lead to a decrease in air quality due to higher levels of NOx, a particle which has direct health implications such as breathing issues, and is attributed to formation of smog, acid rain and is a significant greenhouse gas. Therefore, it is essential that there is increased attention to long term implications of certain strategic choices, before we become locked-in to new ‘sustainable’ options, only to find there are adverse unintended consequences of those decisions.

4.1.2. Other gaps

- A clear assessment of social groups vulnerable to the transition: workers, consumers, communities, small businesses etc.
- A clear assessment of how the transition can be designed to deliver positive social impact for these and other groups
- Clear operational guidance on how the just transition can be translated into action by governments, business, investors, communities (e.g. something more hands-on than the ILO guidance). The just transition commission is working towards providing this guidance for Scottish government, and LSE is producing guidance for investors. However, a co-ordinated approach, specifically with the UK government in mind is currently absent.
- Differentiation of types of businesses being considered.
- Limited use of customer archetypes to date by Ofgem. But there are terms of reference which require them to use a distributional framework going forwards.
- Currently the Ofgem distributional impacts framework is static (providing a snapshot), rather than dynamic.
- More nuanced consideration of regional impacts.
    - in CCC modelling scenarios (currently limited to devolved authorities – England, Scotland, Wales).

4.2. Costs of delivering climate related goals

In this section the costs associated with delivering climate related goals are considered, in terms of who pays (affected demographics) and how do they pay (mechanism). Broadly speaking the actual costs of decarbonisation depends on the funding mechanism in place. Until policy mechanism are decided then it will not be possible to make a substantive comment, 'the devil is in the details'. Some publications go as far to state this explicitly and use it as a disqualifying statement for considering impacts in a substantive way. However, it is possible to speculate regarding certain types of funding mechanism used, potential alternatives and the implications this will have. How the costs of decarbonisation are distributed is a contested topic, politically and within literature. Ultimately, this depends on the mechanism implemented and to what extent costs are socialised. Most of the mechanisms which have been put in place to date are regressive, meaning that low income

groups are disproportionally affected. This applies to levies which have been applied to fuel bills to support new electricity capacity. There are a number of publications that argue for moving away from having costs included on energy bills as this leads to more progressive outcomes [17]. For instance, it has been demonstrated that socialising costs of decarbonisation through income taxation leads to more progressive outcomes (**figure 1**).

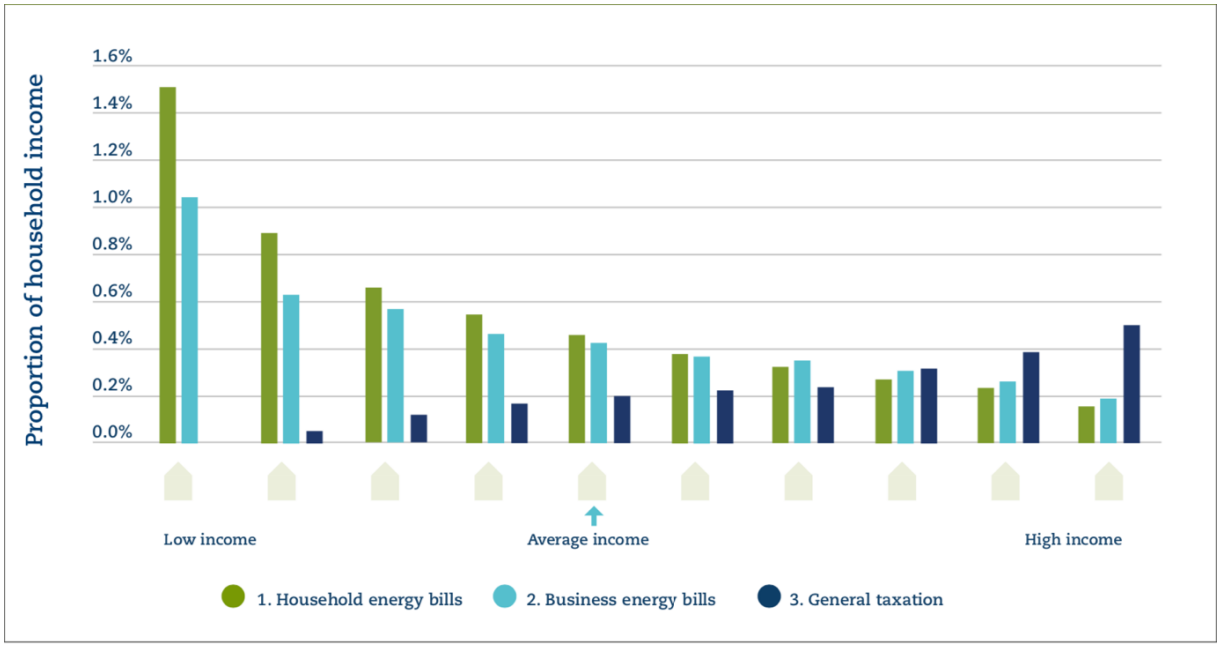

Figure 1 - Proportion of household income required to meet different energy policy funding approaches. Source: [17]

However, whether supporting transitions are included in general taxation or other mechanisms also has implications regarding political risk. Generally speaking, if such policy mechanisms are supported through taxation they become more influenced by the Treasury, and are subject to more frequent reviews, which could have negative implications for climate policy as other issues can be regarded as more important in the short term, which may lead to significant reductions in ambition of decarbonisation efforts. This is especially true in the current situation and the economic recession likely to be incurred through the current situation with COVID-19.

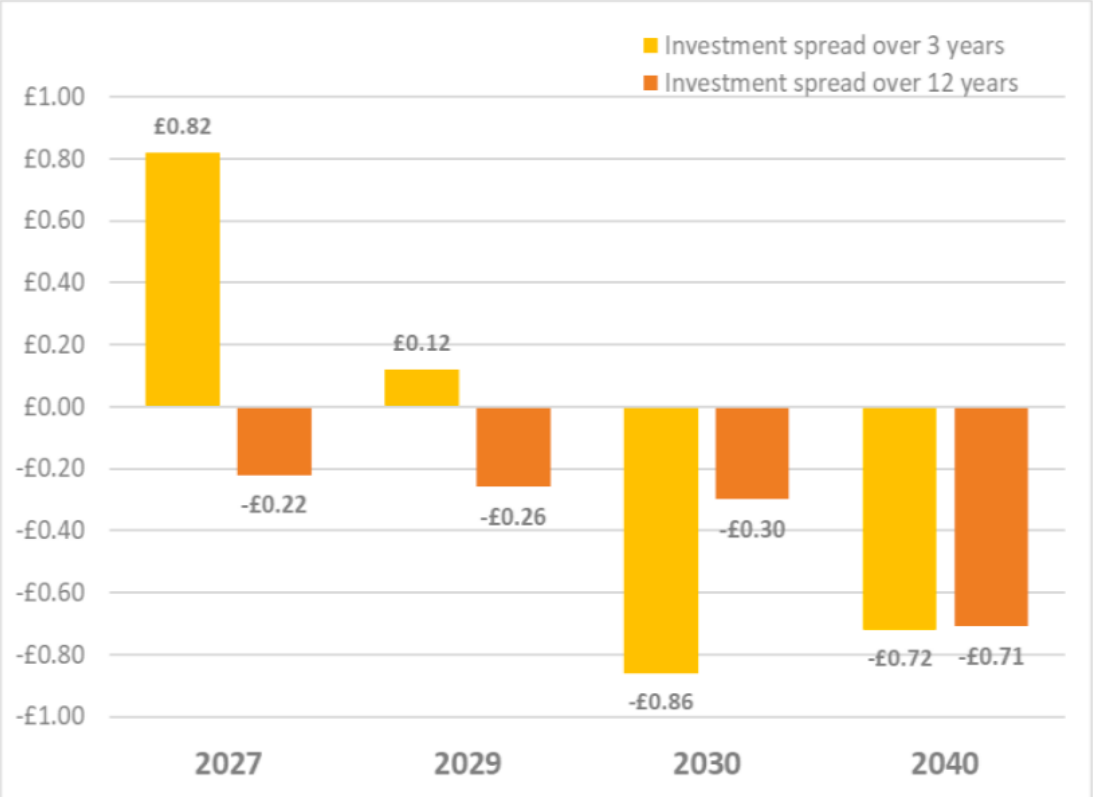

Figure 2 – costs to consumers when investments costs of EV infrastructure are spread over 3 vs. 12 years. Source: [41].

Ofgem's distributional impacts framework has been designed so that it could account for other funding mechanisms. Some have suggested that moving towards taxation would only have a marginal difference for lowest income groups, and another strategy is to implement exemptions for lowest income groups to pay for decarbonisation polices, which has a high material difference for these groups, and only leads to a marginal increase for the rest of customers.

With regards to transport, concerns are that most vulnerable are likely to suffer disproportionality, while also being unable to participate due to the upfront capital costs needed to purchase EVs [8]. This is mainly due to socialised costs of investment and upgrading of grids to accommodate EVs [41]. However, it has been found that the time frame

over which these investments are spread over makes a substantial difference to how low-income groups are affected (**figure 2**).

Specifically, with regards to heating, work carried out by Imperial for the CCC, while not explicitly considering social and distributional costs of heating options, does calculate the cost per household of conversion and appliance for different options. **Table 5** shows a simplfied version of these results adapted from this paper, highlighting that hydrogen and resistive heating (electic heaters) offer the lowest cost solutions per household. The table shows that heat pumps would incur (at minimum) an additional £2000 per household up-front cost. This is important when considering incurred costs for heating solutions and the costs of access.

Action required	H2 heating £3k including gas pipe upgrade	Electric - Heat pump (5kWth)and resistive heating (1 kWth), preheating (3.6 kWth), thermal storage (1.7 kWth)	Hybrid heat pump with natural gas (HP:4 kWth, gas boiler: 10kWth, thermal storage: 1.7kWth)	Small heat pump (£1k/kWth) with supplementary electric heating (£.2k/kWth) (Assume 5kWth for heat pump and 5kWth for electric heating) £6k	District heating £6.8k	Resistive heating £150/kWth (Assume 10kWth)	Hybrid resistive heating with natural gas (RH:4 kWth, gas boiler: 10kWth, thermal storage: 1.7kWth)
Total costs	**£4.0k**	**£6.0k**	**£6.0k**	**£7.5k**	**£7.8k**	**£4.0k**	**£3.6k**

Table 5 – Total costs of conversion and appliance per household for different heating solutions – simplified from [55]

An additional consideration for costs is the implmentation of carbon taxing. It is generally argued that a carbon tax is needed to support decarbonisation [9, 12, 17, 36, 37]. Therefore the design of such as tax needs to reduce social and distributional impacts. It is possible to design a system that leaves lower income and other vulnerable groups better off, through mechanisms such as revenue recycling [36]. Several of our interviewees reported that there was currently not considered to be good levels of cross-departmental coordination.

4.3. Any clear interdependencies / sequencing / pathway issues between different goals and impacts

4.3.1. Sequencing and pathway issues of climate goals

There is a lack of research into social and distributional impacts of mobility, and yet all the CCC scenarios assume 100% adoption of EVs. The implication is that more considerations of the barriers to access, affordability and spatial distribution is needed in order to meet these needs. It has been suggested that the lines between climate and social policy is increasingly converging, and yet the response within government does not seem to be incorporating this in its strategic planning processes to consider a the wider set of issues which may impact upon these goals.

The current uncertainty over decarbonisation of heat is also a major pathway issue. Many have called for the government to produce a roadmap this year (2020), and to produce a full-scale decarbonisation strategy by 2025. Some decisions, such as demonstration projects may have to be implemented before this date, however. A related consideration is the implementation of CCS, since the use of hydrogen networks is dependent on the use of CCS. In addition, all CCC scenarios for the 6th budget include CCS, as it is needed for negative emissions. However, to date, there are limited applications of CCS, with the UK cancelling its £1 billion project in 2015. There is an ongoing project linked to Drax power station in the UK, and applications in Scandinavia. However, considerations of social and distributional impacts of CCS roll-out is under researched, as are the intergenerational impacts.

4.3.2. Refinement of impact categories considering interdependencies

One consideration that comes out of this report, is that the types of social and distributional impacts are inherently linked to each other. It is still important to represent issues separately, in line with the original categories (affordability, access, spatial distribution), as there will be impacts that relate to a category aspect only. An example of a single impact is inclusiveness linked to technical capabilities of elderly people, or people with learning disabilities. This affects ‘inclusion’ of this group and does not relate to affordability or spatial distribution. Another single impact is fuel duties or levies, which affect affordability.

However, while it is important to maintain these analytical categories to capture issues which are not interconnected, it is also necessary to consider the causal relationships that these have,

where one impact may then influence other categories simultaneously, or through sequencing. To represent how these impacts are expected to link to each other, the overlaps have been represented in **figure 3**. Together, the impacts represented in figure 3 all affect 'participation'. This term is used to capture a wider set of issues than 'access and inclusion', that affect the ability to take part in, or reap benefits from the given aspect of decarbonisation or adaptation. An example of an interconnected impact is if the cost of new technology needed for 'access and inclusion' is too high for some, they will be unable to participate due to the 'affordability' of that aspect of decarbonisation. A policy intervention to alleviate this could be to remove up-front capital costs of the new technology, which then allows this group to participate.

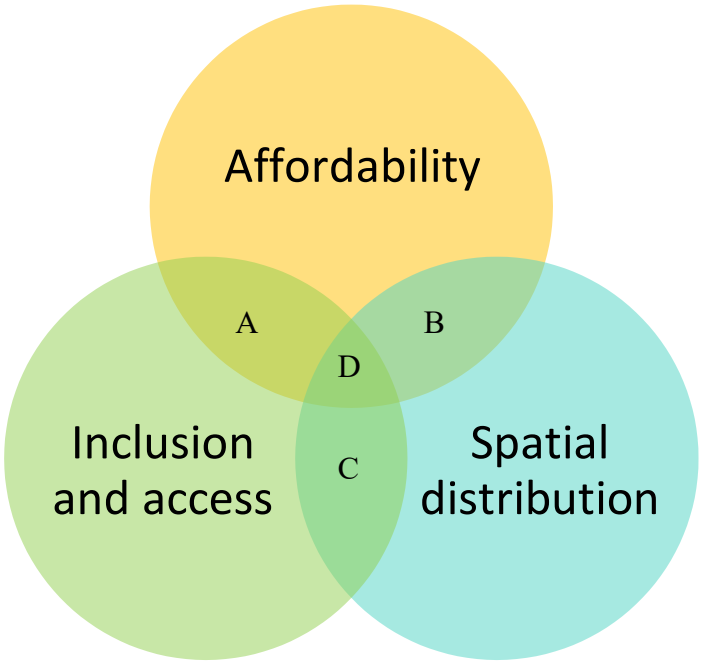

Figure 3 – overlaps and interactions of social and distributional impacts affecting participation

The overlaps in figure three are represented by letters, where A-C are overlaps of two of the original categories, and D is the interaction of all three aspects. For each of the overlaps represented in figure 1, some examples are included below:

A. Costs of participation affecting ability to access. Examples are buying smart kit, cost of EVs etc.

B. Regional differences in employment affecting income distribution and higher instances of low income vulnerability. This also relates to industries lost due to transition, and if re-skilling or provision of new jobs does not occur, which will lead

to lower regional average income levels. Another example is that regions which have a higher risk of flooding will have incurred costs for communities due to damage.

C. Availability of certain solutions due to geographic placement, e.g. availability of hydrogen networks

D. Interaction of all three dimensions. Example would be lack of access to hydrogen network (**C**) means having to buy heat pump (**A**), which is a more expensive form of heating, which makes energy less affordable and may contribute to increased fuel poverty.

The other consideration arising from this way of categorising impacts, is the definition and scope of intergenerational impacts. Rather than simply looking at the impacts which come about in terms of health impacts and change/damage to ecosystems, intergenerational impacts should incorporate the 'participation impacts', and how they lead to sequencing issues in the longer term. By considering temporal aspects related to sequencing, all three of these 'participation impacts' issues could have intergenerational impacts (**figure 4**). A clear example is the linking of spatial distribution to intergenerational impacts. The extent to which certain regions which are economically heavily dependent on polluting industries, are able to manage transitions and create new jobs and welfare, will have huge implications in terms of intergenerational impacts for that region. Another implication is if certain regions become locked-in to a certain 'solution' (e.g. hydrogen vs. electric heating), which will have potential implications further down the line. One dimension is the costs and therefore having an intergenerational affordability impact that varies by region. Another potential issue relates to if hydrogen increases NOx, then having local air quality impacts for regions which adopt this as the main heating strategy.

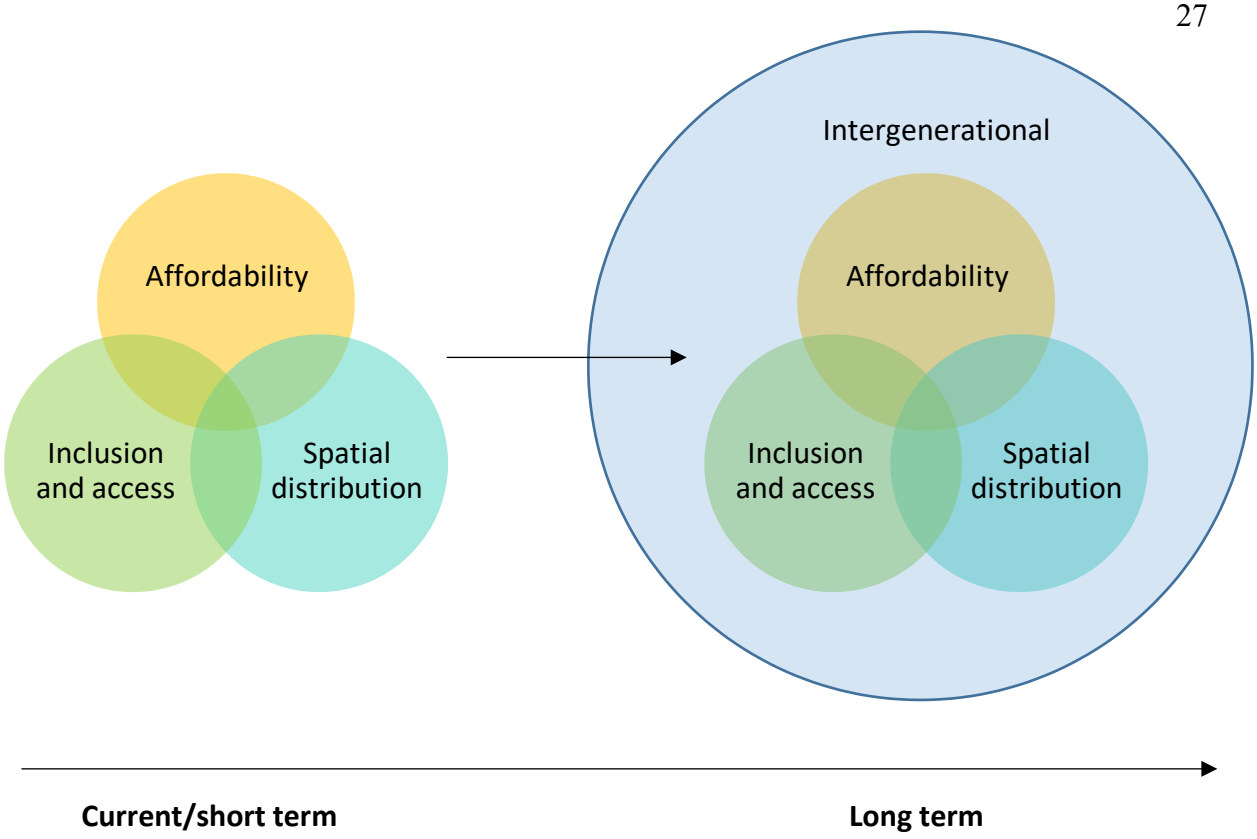

Figure 4 – Illustration of current distributional impacts leading to intergenerational impacts and associated (future) distributional impacts.

5. Conclusion

This report has provided an overview of current work on social and distributional impacts of decarbonisation in the UK and of adaptation.

The main theme of this report is that there is a need to move beyond thinking about households and individuals to communities, regions and geographies in our considerations of vulnerabilities and impacts of energy and adaptation strategies. This is important as increasingly issues are not linked to individuals, more regional impacts which are affected by the energy solutions available, employment opportunities, and regional differences in the impacts of weather events (such as flood plains). The report shows that there is some evidence that thinking is moving towards this direction, particularly in terms of the various just transition projects being launched. However, it is suggested there is still a need for a more holistic and systemic viewpoint where impacts are considered as interrelated, rather

than myopically focussing on one dimension of such impacts without considering the complex and potentially unintended implications that one may have on another.

The report identified five key research gaps: (i) a lack of quantitative data on behavioural response and adaptation of consumers to new technologies; (ii) a lack of data on transport/mobility and social impacts; (iii) limited work on co-benefits; (iv) limited work linking the costs of decarbonisation against the costs of adaptation; and (v) limited research on intergenerational impacts of specific decarbonisation pathways. The results also indicate that there is overall much more attention given to the costs of decarbonisation of energy (electricity and heat) than there is for mobility and adaptation. Overall, this is the most well researched area, with lots of work on energy poverty, although there is more attention given to qualitative research and from a short to mid term perspective.

As a whole, transport is less well researched than other areas of decarbonisation, but two active projects, FAIR as part of UK CREDS and EnergyRev are working on these areas, with an attention to social and distributional impacts. However, the time frame of these is more on mid-to-long term and not on the intergenerational impacts associated with transport. In addition, both of these projects are still in early phases, so there is not much in terms of codified outputs (e.g. publications) at this stage.

Overall there is significantly less attention paid to the regional impacts that transition will have on livelihoods and regional community wide impacts. Again, the work on just transitions and some of the CCC modelling provides the best current known examples considering these themes.

The findings of this report suggest that there is opportunity for further work in this area. The main area in this regard is advocating a systemic approach towards social and distributional impacts, and the links between all four types of impacts considered in this report. As suggested in the discussion section of this report, to add more nuance, the areas of intersection of these impacts could be used to further specify which areas need more attention. Potentially, these implications could help theorising and conceptual development linking academic work on energy justice, as currently the field lacks over overall conceptual framing linking many different case studies as more focussed aspects of justice theory.

The report also suggests that the framing of just transitions is a discourse in a more systematic way also offers benefits for policymakers and academics. For academics it could

help move research away from historical based/risk aversion, and a siloed approach to research in key areas to a more systematic framing of the issues involved. The challenges of dealing with multiple variables requires a framework that can cope with a more fluid situation, and highlights the need to move beyond a technocratic analysis, which will help engage some audiences which are currently unsighted on impacts.

Another opportunity for further work is continued engagement with recently launched projects as they develop, with regards to EnergyRev and FAIR (CREDS) these are large projects with a number of people working on different aspects. In particular, speaking to modelling of impacts being done by Cambridge econometrics, and geographical mapping, both as part of FAIR should be engaged with. Both of which agreed to discuss the work but were not available within the timeframe of this report. A final area for potential further work would be to incorporate safeguarding into the framework and its consideration of social and distributional impacts.

There were several limitations of the report. It was conducted over a relatively short timeframe (20 days), which meant that certain people were unavailable to speak to. This was exacerbated by national university strikes ongoing throughout the period of the research. The short timeframe also meant that the amount of research that could be included in this report was limited by feasibility issues. Consequently, the research included in the report is not exhaustive, and may be limited by the sampling strategy used to collate data. Most significantly here is that snowballing was used to find additional work, which may have had implications for the amount of work found on social and distributional impacts associated with adaptation. This is to be expected to some extent, mainly because thinking about decarbonisation is normally somewhat siloed without linking to climate change adaptation as well. The most systemic thinking is from the CCC, but even they tend to treat adaptation as a separate workstream to carbon abatement. What this means for the research is that projects and people do not always link across these areas, so since the focus was predominantly on decarbonisation there may be aspects of adaptation which are missed by this strategy. However, this is important and more work should focus on linking decarbonisation to adaptation. Doing so could link to work on co-benefits and would help explain intergenerational impacts. Another final limitation is that this does not include commercial data in some of these areas. This presents a potential opportunity, if industry share this (e.g. on EVs) to better understand the challenges presented in this report.

6. About Sustainability First & Acknowledgements

6.1. About Sustainability First

Sustainability First is a think tank and charity that promotes practical, sustainable solutions to improve environmental, economic and social wellbeing. We are a trusted convenor on public utility issues and have a strong track record of bringing stakeholders together in multi-party projects in the public interest.

This Research Report follows an earlier paper by Maxine Frerk for Sustainability First 'What is fair? How do we pay for the energy system of tomorrow?'. Sustainability First's major Fair for the Future Project is also exploring the issue of fairness in energy and other essential services through: developing and testing the concept of a 'Sustainable Licence to Operate' for utilities; and getting a better grip on the measurement and pricing of social and environmental risks in key utility sectors.

The pandemic is bringing vulnerability issues, such as those explored in this report, to the fore in unprecedented ways. In the light of corona, Sustainability First is also carrying out extensive work on how to ensure recovery from the crisis is smart, fair and green. More details can be found in our Bridging corona to a sustainable future work programme. As part of this, we plan to host a series of webinars in the summer of 2020 to help kick-start the discussion about the different affordability solutions that we may need to address the problems arising from the pandemic, and prepare for the future, medium to long-term. These webinars will provide a forum for organisations and individuals to present and discuss new ideas about how we might ensure all consumers have access to essential water, energy and communication services.

If you would like more details about our work, please contact info@sustainabilityfirst.org.uk

6.2. Acknowledgements

Sustainability First would like to warmly thank The Nuffield Foundation for funding the research for this report.

The Nuffield Foundation is an independent charitable trust with a mission to advance social well-being. It funds research that informs social policy, primarily in Education, Welfare, and Justice. It also funds student programmes that provide opportunities for young people to develop skills in quantitative and scientific methods. The Nuffield Foundation is the founder and co-funder of the Nuffield Council on Bioethics and the Ada Lovelace Institute. The Foundation has funded this project, but the views expressed are those of the authors and not necessarily the Foundation.

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Appendix A – List of telephone interview participants (table 2)

Interview	Name	Affiliation	Date
1	Rebecca Ford	EnergyREV/Strathclyde	20/02/2020
2	Ofgem		26/02/2020
3	Treasury		26/02/2020
4	Tom Hargreaves	UCL	03/03/2020
5	Committee on Climate Change		04/03/2020
6	Simon Roberts	CSE	04/03/2020
7	Chaitanya Kumar	Green Alliance	04/03/2020
8	Stew Horne	Citizens Advice	09/03/2020
9	Michael Fell	CREDS/EnergyRev/UCL	10/03/2020
10	Just Transition Commission		11/03/2020
11	Mari Martiskainen	CREDS/Sussex	12/03/2020
12	Peter Smith	National Energy Advice	13/03/2020
13	Timur Yunusov	Reading	16/03/2020
Calls with Sustainability First Associates			
A	Martin Hurst	Sustainability First	12/02/2020
B	Maxine Frerk	Sustainability First	13/02/2020
C	Zoe McLeod	Sustainability First	17/02/2020
D	Judith Ward	Sustainability First	18/02/2020

Appendix B – Bibliography of publications

Key definitions		
Term/concept	**Definition**	
Affordability	Issues arising from the costs of supporting or participating in energy transitions. This may be the overall costs of energy or the personal capital costs of buying	
Access and inclusion	Issues relating to inclusion and accessibility to aspects of transitions. This captures a wider set of inclusion barriers beyond costs and spatial distribution, including, personal characteristics (e.g. age, disabilities) and environmental factors (e.g. type of property lived in).	
Spatial Distribution	Primarily relates to the regional differences of some communities and households and the implications this has for participation. Also captures the effects of transitions on regions which have high proportions of employment from highly polluting industries and the implications this may have for displacement of work.	
Intergenerational	The issues that current decisions about the rate and direction of the energy transition will have on future generations.	
Time frame	Short	Immediate to short term effects (0-5 years)
	Medium	Leading up to the 2030 carbon budgets (5-10 years)
	Long	After 2030
Materiality	High Medium Low Don't' know	This category is difficult to generalise due to the differences between the different sectors considered. Generally speaking, materiality is considered high, medium or low relative to the impacts on vulnerable groups. If not clear this is labelled as "don't know" or 'unspecified.

Table 4 – abbreviated definitions used for data collection

Publications

1. **'When the levy breaks'**

Joss Garman and Jimmy Aldridge – IPPR - 2015

- Costs of supporting nuclear, onshore and offshore wind. Capacity market and green levies.
- Lower income households are disproportionately affected.
- Makes recommendations to reform in order to reduce burden on these groups.
- Time frame: short to medium
- Materiality: impact on low income groups is relatively high.

2. **'Distributional impacts of UK Climate Change Policies'**

Final report to eaga Charitable Trust. June, 2010.
Ian Preston and Vicki White (Centre for Sustainable Energy), Pedro Guertler, (Association for the Conservation of Energy).

- Models for the costs distributed across households for supporting energy polices
- Time frame – short
- Assumptions – models for even distribution vs. income taxation
- Materiality: impact high for low income groups

3. **'The British Feed-in Tariff for small renewable energy systems: Can it be made fairer?'**

Sustainability First

Policy paper-October 2013
Centre for Climate Change Economics and Policy Grantham Research Institute on Climate Change and the Environment

- Makes argument that richer households benefit more from the FiT
- Also shows that poorer households pay more (proportionally) for the support of the FiT
- Multi-household dwellings like council estates present unique barriers to installation uptake.
- Time-frame: short

4. **Fairness in Retail Energy Markets?**

Evidence from the UK
A report by the Centre for Competition Policy
Edited by David Deller and Catherine Waddams Price with: Elizabeth Errington, Amelia Fletcher, Tom Hargreaves, Michael Harker, Noel Longhurst, David Reader and Glen Turner

- Impacts of energy markets on affordability
- Focus on fuel poverty
    - Social housing having higher rates
- Time frame: the modelling/empirical data is short term/historical, but has implications for looking ahead

5. **Performance and Impact of the Feed-in Tariff Scheme: Review of Evidence**

A Report by Dr Colin Nolden, Science Policy Research Unit, Sussex University
For the Department of Energy and Climate Change

- Report links to fuel poverty
- Suggests there is limited evidence directly linking FiT to alleviating or exacerbating fuel poverty
- However, FiT is regressive as disproportionately affects low income
- Practical ways of addressing fuel poverty using FIT include the redistribution of the benefits of the FIT by providing free electricity
- Another route to using the FIT to address fuel poverty is through local authorities.
- There is a lot more scope to diffuse fuel poverty alleviating business models supported by the FIT and greater incentives need to be provided for schemes that engage with fuel poor households through free electricity.
- Time frame: short
- Materiality: medium

6. **Tackling fuel poverty during the transition to a low-carbon economy.**

Paul Ekins, UCL Energy Institute, University College London, and Matthew Lockwood, Institute of Public Policy Research and Institute of Development Studies, University of Sussex.

- Key aspects: affordability, vulnerable groups
- Key points:
  - Energy efficiency measures needed to decrease (or prevent increase) fuel poverty as energy bills rise.
  - Incentives could be given in the form of rebates
- Assumptions: discussion of the pros and cons of energy suppliers deliver measures, also discussion of income taxation (more progressive)
- Time frame: short to medium
- Materiality: fairly significant for low income households

7. Energy prices and bills – impacts of meeting carbon budgets

CCC – March 2017

Matthew Bell, Adrian Gault, Taro Hallworth, Mike Hemsley, Eric Ling, Mike Thompson and Emma Vause.

- Key aspects:
  - Increasing bills due to decarbonisation
  - Meeting the fifth carbon budget, including sourcing 75% of UK generation from low-carbon sources by 2030, will add around a further £85-120 to the annual bill (£95 in our central estimate). Added to the impact on current bills, this implies that low-carbon policies will add £190-225 in total to the average annual bill in 2030 (£200 in our central estimate). This is consistent with the Committee's previous assessments from 2012, 2014 and 2015, which estimated a total impact in 2030 of £155-215.
  - **Fuel poverty.** If the insulation and low-carbon heat installations required to meet the carbon budgets can be successfully targeted at the fuel poor then around three-quarters can be lifted out of fuel poverty by 2030. However, meeting the Government's goal of improving fuel poor homes to efficiency band C by 2030 would require roughly doubling the funding currently provided under the Energy Company Obligation.
  - **Outlook for fuel poverty by region (England, Scotland, Wales, Northern Ireland).**
  - Shows that more devolved regions and rural areas more negatively affected.
- Assumptions:
  - Focus on the impact of low-carbon policies more than total bills; the former are less sensitive to future fossil fuel prices. However, households are most interested in their total bill and we report potential future bills across the range of fossil fuel price projections.
  - Bases assessment on the scenarios from our fifth carbon budget report under which carbon intensity of the power sector falls from around 370 gCO2/kWh in 2015 to under 100 gCO2/kWh in 2030.
  - Includes the indirect impact of electric vehicles and low-carbon heating on electricity and gas costs (e.g. through required network strengthening), but do not include their direct costs (i.e. does not include the costs of charging electric cars, or the saving on petrol/diesel costs).

  - Assumes that policies recover costs in line with their current designs under which the additional costs of low-carbon generation are met by electricity bill payers rather than general taxation.
  - We identify wider costs and benefits not currently included in energy bills, such as impacts on the Exchequer.
- Time frame: long
- Materiality: medium

8. **Policy & Regulatory Landscape Review Series - Working Paper 1: Electricity storage & electric vehicles**
   Madeleine Morris & Jeff Hardy
   EnergyREV. September 2019.
   - Some discussion of distributional impacts
   - Suggestion that current policies mean that low income groups are subsidising early adopters
   - Time frame: short to medium
   - Materiality: medium

9. **A report for the Committee on Climate Change The costs and benefits of tighter standards for new buildings Final report.**
   Mactavish, A., Brylewski, R., Hill, R., Mills, P., Pratima, W., & Stroud, B. (2019).

   - Key aspect. Lifetime cost benefits of building regulations. New build and retrofit
   - Modelling using different sources of heating. Air source heat pumps (ASHP) and low carbon heat networks (LCHN).
   - Key findings:
     - Without carbon tax domestic new build measures do not pay back.
     - However, lower fuel bills for inhabitants.
   - Time frame: medium to long (up to 2040)
   - Materiality: medium to high

10. **CLIMATE CHANGE AND SOCIAL JUSTICE: AN EVIDENCE REVIEW**
    Ian Preston, Nick Banks, Katy Hargreaves, Aleksandra Kazmierczak, Karen Lucas, Ruth Mayne, Clare Downing and Roger Street. 2018
    - Assesses current research into the social justice aspects of the impacts of climate change in the UK, and of policy and practice to mitigate and adapt to those impacts.
    - Key findings:
      - lower income and other disadvantaged groups contribute the least to causing climate change;
      - they are likely to be most negatively impacted by its effects;
      - they pay, as a proportion of income, the most towards implementation of certain policy responses and benefit least from those policies
    - Assumptions: not explicit
    - Time frame: medium

11. **Electricity Network Innovation Guide For Communities 2018**
    The Energy Networks Association

2018.

- Mentions vulnerability
- No-lose Demand Side Response propositions, such as non-punitive time of use (ToUTs), are well received by low income households who may be struggling with their energy bills.
- Tine frame: long
- Materiality: don't know

12. The Future of Carbon Pricing in the UK Report prepared for the Committee on Climate Change The Future of Carbon Pricing in the UK

Vivid economics

2019

- Consideration of three types of carbon pricing: trading scheme linked to EU ETS, a UK ETS, or carbon tax
- Main links to distributional impacts:
  - Policy should be aligned with achieving social objectives to reduce inequality and expand access to economic opportunity.
  - This can be achieved through policies that redistribute income from high- income groups to low-income groups (e.g. by replacing regressive taxes), or by reducing the costs of economic transition and addressing regional economic disadvantage.
- Time frame: medium to long
- Materiality: medium to high

13. UK Climate Change Risk Assessment 2017: Evidence Report. Chapter 8 : Cross-cutting issues Chapter 8 : Cross-cutting issues

- Report about climate impacts and adaptation
  - Mainly flooding and heat
- Considers distributional impacts explicitly
- This includes spatial distribution and social vulnerability
- Time frame: medium to long
- Materiality: high

14. A consistent set of socioeconomic dimensions for the CCRA3 Evidence Report research projects

Cambridge Econometrics - 2019

- Evidence for the 3rd Climate Change Risk Assessment (CCRA3)
- Considers the following evidence:
- Population –
  - The population projections used in our database are based on official projections published by the Office for National Statistics (ONS), StatsWales, National Records of Scotland (NRS) and the Northern Ireland Statistics and Research Agency (NISRA). The
- GDP –
  - GDP projections are based on the Office for Budget Responsibility (OBR): Fiscal Sustainability Report 2018 real GDP growth projections.
- Gross Value Added (GVA) –

    - calculated from the historical sectoral GVA data published by the ONS and from the GDP and working-age population (16-65) projections
- Employment –
    - The employment projections are based on the OBR UK employment projections (available from 2018 to 2068) and on the historical employment data at the regional and local authority area from the Business Register and Employment Survey (BRES). The sectors considered are the same as those presented for GVA.
- Labour productivity –
    - Labour productivity is presented in terms of thousands of pounds sterling per job and it is estimated by dividing the GVA projections by the employment projections produced in this study in each of the three scenarios considered. Sectoral estimates are provided according to the same sectoral classification used for GVA and employment.
- Land use –
    - scenarios used in dataset are based on the Centre for Ecology & Hydrology (CEH)
- Expenditure on R&D –
    - scenarios are based around current R&D expenditure to GDP ratios, or stated government aims (to raise R&D expenditure in the UK to 2.4% of GDP by 2027), combined with the GDP projections calculated in this study.
- Energy generation by technology –
    - national grid scenarios
- Average household numbers and size
    - based on the ONS central projection of number of households.
- Time scale: medium to long

15. Policy Pathways to Justice in Energy Efficiency

Carolyn Snell, Mark Bevan, and Ross Gillard (University of York) Joanne Wade, and Kelly Greer (Association for the Conservation of Energy)

December 2018

- Focus on energy efficiency measures
- Emphasis on low income houses/families and disabled people
- Also considers stakeholder perspectives
- Qualitative research – interviews
- Considers the following impacts to these groups:
    - Fears about mess
    - Direct or indirect cost
    - Administrative requirements
    - Physical requirements
    - Mental energy required to engage with process
    - Disruption to household and energy routines
    - Loss of space
- Time frame: short to medium

16. Paying for energy transitions: public perspectives and acceptability

Dr. Christina Demski, Prof. Nick Pidgeon, Dr. Darrick Evensen, Dr. Sarah Becker

- Main focus on the perceptions of costs of energy bills in due to energy system change
- Mixed methods – survey and 5 focus groups
- Key findings:
    - People are willing to accept some cost on their bills to fund the energy transition (between 9-13%), but this is dependent upon a number of conditions.
    - Public willingness to contribute is conditional upon energy companies and government being committed to do the same, although currently neither are particularly trusted in this regard.
    - Peoples' own financial circumstances are not necessarily the driving factor in their acceptance of costs, with procedural (having a say in the process) and distributive (how costs are distributed, not disproportionately affecting low income groups) justice concerns are also important.
- time frame – short
- materiality – uncertain

17. Funding a Low Carbon Energy System: a fairer approach?

Professor John Barrett, Dr Anne Owen and Professor Peter Taylor, University of Leeds, 2016

- Key findings:
    - Money from households subsidises renewable energy sources of electricity and heat, and funds programmes that improve energy efficiency in low income households. These help deliver a cost effective low carbon pathway and address important issues such as fuel poverty. Without these improved energy efficiency measures, the average annual household energy bills would be £490 larger than they are today.
    - Energy policy costs are applied to household electricity and gas bills, equating to £132, or 13% of the average energy bill in 2016. However only 17% of these costs fund energy efficiency programmes supporting low income households, with concerns raised by the Energy Saving Trust that the current system is "unfair".
    - The poorest households contribute £271 million per year towards energy policy costs. The 2016/17 cost of the Carbon Savings Communities and Affordable Warmth schemes, which are designed to help the poorest homes, was £220 million. Therefore, the poorest homes are self-funding these schemes.
    - Low-income households are hit hardest by the current arrangements. The poorest households spend 10% of their income on heat and power in their homes, whereas the richest households only spend 3%, so any increase in prices hits the poor disproportionately.
    - Placing policy costs on businesses or funding the costs from general taxation would lower the burden on the poorest households. The general taxation approach would better align energy demand with policy costs, and would reduce costs for 70% of UK households. The poorest households would pay nothing, saving them £102 a year, while

the richest households would pay an additional £410 a year (under £8 a week).
    - None of the funding approaches offer a "perfect solution" in terms of distributional impacts, however, raising the funds through general taxation offers a fairer and practical.
- Assumptions of cost data:
    - Breakdown of policy costs (National Audit Office (2016). 'Controlling the consumer-funded costs of energy policies: The Levy Control Framework')
- Time frame: medium to long

18. "Vulnerability and resistance in the United Kingdom's smart meter transition,"

Sovacool, BK, P Kivimaa, S Hielscher, and K Jenkins.
Energy Policy 109 (October, 2017), pp. 767-781.

- Key points related to distributive impacts and smart meters
- Consumer misunderstanding
    - Confusion over proper use of smart meters among the elderly, poor, or non-English speaking population
- Financial burden
    - Expense of installing smart meters placed on consumers
- Rural peripheralization
    - Social marginalization of rural groups and a preference for channelling smart energy systems to urban areas

19. The whole systems energy injustice of four European low-carbon transitions.

Sovacool, B. K., Hook, A., Martiskainen, M., & Baker, L. (2019).
Global Environmental Change. https://doi.org/10.1016/j.gloenvcha.2019.101958

- Introduces systemic framings of energy justice
    - Spatial scales of injustices
        - Micro
            - Exclusion of rural areas,
            - exclusion of those living in social housing blocks,
            - rising household energy prices,
            - negative impacts on vulnerable groups,
            - added stress for families
        - Meso
            - Loss of jobs
            - higher national energy prices,
            - the environmental impacts of the smart meter roll out
        - Macro
            - reliance on raw materials from unstable regions,
            - hazardous waste streams
        - Life-cycle stage of impacts
            - Production
            - Reliance on raw materials from unstable regions.
        - Consumption
            - Exclusion of rural areas

        - Exclusion of those living in social housing blocks
        - Rising household energy prices
        - Negative impacts on vulnerable groups
        - Added stress for families
        - Loss of jobs
        - Higher national energy prices
    - Waste
        - Environmental impacts of the smart meter roll out
        - Hazardous waste streams

20. Capturing the distributional impacts of long-term low-carbon transitions. Fell, M. J., Pye, S., & Hamilton, I. (2019). Environmental Innovation and Societal Transitions. https://doi.org/10.1016/j.eist.2019.01.007

- Stakeholder interviews explore the range of distributional impacts that may accompany low-carbon transitions.
- Twelve individuals participated across six individual and group interviews drawn from government, regulators, an independent policy advice body, a consumer organization, a university department and a non-academic research organization
- Assumptions/scenarios:
    - 0%: A scenario that meets UK climate policy, including carbon budgets 1–5 and the 2050 target.
    - 80% NoCCS: as for 80%, but with no CCS technology deployment assumed.
    - Reference: A scenario that assumes no climate policy.
- Used the interview results and the background research to construct a diagram of possible long-term mechanisms of distributional impacts and groups most likely to be impacted, which provides testable hypotheses for future evidence reviews and empirical research
- Time frame: medium to long
- Materiality: Don't know

21. A critical analysis of the new politics of fuel poverty in England. Middlemiss, L. (2017). Critical Social Policy, 37(3), 425–443. https://doi.org/10.1177/0261018316674851

- Uses a subjectivity framework to analyse the government documentation around LIHC ('Low income, high costs')
- Finds that:
    - a distinction between poverty and fuel poverty is reinforced by the new politics, resulting in energy efficiency measures being prioritised as the appropriate solution
    - The austerity maxim of 'helping those most in need' is threaded through this new politics, belying an acceptance that not all fuel poverty can be alleviated.
    - LIHC underplays the role of changing energy costs, which now have no impact on the headline indicator
- Argues that this new politics is symbolic, and unlikely to have positive impacts for most fuel poor households.

- Time frame: short
- Materiality: low

22. Shifting the focus: energy demand in a net-zero carbon UK.

Fell, M., Higginson, S., Jenkinson, K., Lowe, B., Marsden, G., Shove, E., … Livermore, S. (2019). https://www.creds.ac.uk/wp-content/pdfs/CREDS-Shifting-the-focus-July2019.pdf

- CREDS' first major publication.
- It builds on research undertaken by members of the CREDS consortium over many years to address the question "What can changes in energy demand contribute to the transition to a secure and affordable UK energy system that is compatible with net-zero carbon emissions?"
- Key recommendations:
  - Prioritise energy demand solutions
  - Consider and promote all the benefits of demand-side solutions
  - Scale up policies that work
  - Develop long term plans for demand-side innovation
  - Build effective institutions for delivery of demand-side solutions
  - Involve a wider range of stakeholders to build capacity across society
- Time frame: long

23. Energy justice at the end of the wire: Enacting community energy and equity in Wales.

Forman, A. (2017). Energy Policy. https://doi.org/10.1016/j.enpol.2017.05.006

- Expands analysis of energy justice to address bottom-up perspectives.
- Discusses the energy justice implications of community energy in Wales.
- Data – qualitative – interviews
- politics and contestation of energy justice, emphasising issues such as energy justice for whom, on whose terms, and under which circumstances.
- By focussing on bottom-up perspectives, this paper addresses an empirical gap in the audience and actors to which energy justice has mainly been directed.
- Time frame - short
- Materiality: Don't know

24. Report to the Committee on Climate Change of the Advisory Group on Costs and Benefits of Net-Zero

Ekins, P. (2019)., 59.

- Report considers multiple aspects of deep-decarbonisation, including: co-benefits, macroeconomic costs, financing
- Contains multiple annexes on specific aspects relating to these topics
  - **Direct Resource Costs and GDP** - Philip Summerton, Cambridge Econometrics
  - **Achieving Net Zero Emissions** - Mallika Ishwaran, Shell International
  - **The Power of Innovation** - Dimitri Zenghelis, London School of Economics
  - **Macroeconomic Impact of Deep Decarbonisation** -Philip Summerton, Cambridge Econometrics

    - **The Need for Sustainable Finance** - Rain Newton-Smith, Confederation of British Industry
    - **A Just Transition?** - Karen Turner, Centre for Energy Policy, University of Strathclyde
    - **A Societal Lens on Accelerating the Pace of Energy Transition** - Mallika Ishwaran, Shell International
    - **What Makes Good Policy?** - Rain Newton-Smith, Confederation of British Industry
  - Main conclusions:
    - The costs and benefits of deep decarbonisation are unknowable with any precision.
    - They depend too fundamentally on deeply uncertain outcomes, such as the damages from climate change in the long term, and the evolution of the costs of low-carbon technology over several decades.
    - the cost of decarbonisation in decades to come will be a function of the action and investment taken today.
- Time frame: long
- Materiality: 'uncertain with any precision'

25. **Heat Decarbonisation Potential impacts on social equity and fuel poverty** National Energy Action, Frerk, M., & MacLean, K. (2017). Final Report, (September).
    - Considered implications of current policies
    - Focusses primarily costs and on impacts on fuel poverty
    - Also considers geographical locations, having options and access
    - Time frame: medium
    - Materiality: medium

26. **A JUST TRANSITION REALISING THE OPPORTUNITIES OF DECARBONISATION IN THE NORTH OF ENGLAND FINAL REPORT** Emden, J., & Murphy, L. (2019). The progressive policy think tank, (March). Retrieved from www.ippr.org
    - Regional strategies to promote just transition
    - Recommendations:
      - Step 1: Long-term certainty and devolved powers
      - Step 2: A Just Transition Commission and Just Transition Funds for the North
      - Step 3: Skills audits, skills standards and devolved skills funding
    - Time frame: medium to long
    - Materiality: don't know

27. **The importance of social relations in shaping energy demand.**
Hargreaves, T., & Middlemiss, L. (2020). Nature Energy. https://doi.org/10.1038/s41560-020-0553-5
- Argues more attention should be paid to how people's social relations influence energy demand.
- Reviews recent qualitative research to show how social relations shape how much energy people use, when and where they use it, as well as how they respond to interventions.
- Propose a typology that identifies three types of social relation as especially significant: those with family and friends, with agencies and communities, and those associated with social identities.
- Show how a focus on social relations can generate new forms of policy and intervention in efforts to build more just and sustainable energy futures.
- Time frame: short to medium

28. **Fuel poverty in the UK: Is there a difference between rural and urban areas?**
Roberts, D., Vera-Toscano, E., & Phimister, E. (2015). Energy Policy. https://doi.org/10.1016/j.enpol.2015.08.034
- Urban fuel poverty is more persistent on average than rural fuel poverty.
- Rural fuel poor are on average more vulnerable to energy price shocks
- Fuel poverty policy measures may have different effects in rural and urban areas.
- Both spatial and household targeting required for policy effectiveness.
- Policy makers should to consider additional monitoring of dynamics of fuel poverty.
- Time frame: short
- Materiality: medium

29. **Justice, fuel poverty and disabled people in England.**
Snell, C., Bevan, M., & Thomson, H. (2015). Energy Research and Social Science. https://doi.org/10.1016/j.erss.2015.07.012
- Paper considers the relationship between fuel poverty, disabled people, and policy changes in England.
- Drawing on statistical analyses of the English Housing Survey, the paper presents three key findings.
    - Fuel poverty rates in England are typically higher amongst households containing disabled people.
    - High levels of fuel poverty are found amongst single disabled people of working age.
    - A greater proportion of households containing disabled people are on prepayment meters compared to other households.
- Paper concludes that the distributive inequalities evident in the findings may have been driven by a lack of recognition by energy policy makers in terms of their understanding of the highly varied needs of disabled people, the impact of current measures of fuel poverty, and the way in which disability benefits are understood within calculations of fuel poverty.

- Argues that current political rhetoric that typically marginalises disabled people of working age on low incomes has further driven distributional inequalities.
- Time frame: short
- Materiality: unspecified

30. **Flexibility capital and flexibility justice in smart energy systems.**
Powells, G., & Fell, M. J. (2019). Energy Research and Social Science. https://doi.org/10.1016/j.erss.2019.03.015
- Paper explores inequalities related to flexibilities in energy markets.
- The level of service enjoyed by the more affluent may not simply be higher than those who are less affluent, but may be directly enabled by reductions in the latter's comfort and/or convenience which may not feel fully voluntary.
- There is a real risk that such injustices could be locked into energy infrastructure and market design and governance for the long term as has already happened in labour markets.
- Time frame: not specified
- Materiality: Don't know

31. **Energy poverty and indoor cooling: An overlooked issue in Europe**
Thomson, H., Simcock, N., Bouzarovski, S., & Petrova, S. (2019).. Energy and Buildings. https://doi.org/10.1016/j.enbuild.2019.05.014
- Conceptualises links between energy poverty and urban heat
- Compiles factors that contribute to vulnerability to excessive indoor heat.
- Considers three main factors:
    - Risk of exposure
    - Sensitivity
    - Adaptive capacity
- Time frame: unspecified
- Materiality: N/A

32. **Future Energy Scenarios**
National Grid ESO. 2019
- Overall, very little discussion of impacts
- Features several hydrogen network trial schemes
    - Some mention of impact on customers through H21 project
- Time frame: medium to long
- Materiality: don't know (unspecified)

33. **British Public Perceptions of Climate Risk**
Steentjes, K., Demski, C., Seabrook, A., Corner, A., & Pidgeon, N. (2020). Adaptation Options and Resilience (RESiL RISK), (March).
- Used a survey design to collate data on perceived risks of climate adaptation

- Includes extreme weather, flooding
- Includes inclusion issues related to trust
- Time frame: medium
- Materiality: don't know

34. **Better Energy Futures : Developing a framework for addressing fuel poverty.** Groves, C., Henwood, K., Pidgeon, N., Shirani, F., & Cherry, C. (2019)., (February 2018), 1–20.
    - Paper looks at:
        - Different ways in which people's efforts to control energy use are affected by financial and social instability
        - Ways in which housing and attempts to improve it can exacerbate these problems
        - The need to ensure that landlords are both properly regulated and incentivised to improve housing conditions
        - Ways in which the complexities of needs and people's real capabilities to adapt (dependent on social networks and the character of place as well as the characteristics of households) can affect the extent to which they might experience energy vulnerability.
    - Proposes a set of criteria for energy vulnerability which takes a larger range of factors into account
    - Includes:
        - Spatial distribution
        - Access issues such as type of property, user needs
    - Makes recommendations:
        - Reducing financial burdens – reduce upfront costs
        - Incentivising landlords
    - Time frame: medium to long

35. **Just Transition Commission - Interim Report**
    Scottish Government. (2019)., 1–40. Retrieved from https://www.gov.scot/groups/just-transition-commission/
    - Outlines approach of the just transition commission
    - Focus on 'fairness' as a core principle
    - Produces current recommendations
    - Currently quite aspirational
    - This is due to timing, report being presented to government to wanted to outline key issues, even it not fully developed (in terms of implementation strategy)
    - Time frame: long
    - Materiality: high

36. **Distributional impacts of a carbon tax in the UK**
    Burke, J., Fankhauser, S., Kazaglis, A., Kessler, L., Khandelwal, N., O'Boyle, P., & Owen, A. (2020). http://www.lse.ac.uk/GranthamInstitute/publication/distributional-impacts-of-a-carbon-tax-in-the-uk/

- Main messages:
  - Carbon pricing is essential for effective climate action. It is a powerful fiscal and environmental tool that encourages emissions abatement where it is cheapest and sends a clear price signal that the polluter must pay.
  - The UK's transition to net-zero greenhouse gas emissions must be distributionally fair, and policies must be designed to mitigate undesirable distributional impacts.
  - The current economic framework for decarbonisation in the UK is inefficient and uneven. A broader-based carbon tax consistent with net-zero greenhouse gas emissions would be desirable.
  - Without mitigation measures, a carbon tax on energy fuels is regressive, hitting low-income households disproportionately. In the transport sector a carbon tax is largely progressive as the share of income spent on transport increases with income.
  - Understanding the geographic spread of carbon tax impacts is vitally important to prevent adverse impacts. For example, the impact of a carbon tax in Scotland will be particularly high because Scotland is colder and more rural than other parts of the UK, and therefore more heating and transport are used.
  - Judicious use of carbon tax revenues – where economic 'losers' are compensated – can help ensure distributional fairness and protection for fuel-poor households.
  - It is therefore possible to design a recycling scheme that leaves fuel-poor and low-income households better off while driving the transition to net-zero emissions in the UK by 2050.
  - Revenue recycling schemes that each use a similar amount of revenue can have vastly different impacts depending on how they are designed. With a similar amount of revenue the redistribution policy can either be somewhat or extremely progressive.
  - A pricing scheme that augments carbon prices with border carbon adjustment has a large impact on household bills across all income groups. However, of all the policy options it also generates the largest amount of revenue, which could be further used to mitigate the impact.
  - A pricing scheme that uses carbon prices differentiated by sector has the least impact on bills across all income groups.
- Time frame: medium to long
- Materiality: high (potentially)

37. **Distributional impacts of carbon taxation in Scotland**
CSE (2014). https://www.cse.org.uk/projects/view/1252

- Uses the DIMPSA model and IFS's TAXBEN model
- On household energy use and private transport
- The richest 10% of households would pay on average more than twice the carbon tax on household fuels and road transport than that of the poorest 10%

of households; however this represents a smaller proportion of their household income compared to lower income households.
- Households in the more rural areas pay on average more tax on energy consumed in the home; this is likely to reflect the nature of dwellings (a higher proportion of older, less energy efficient properties and reliance on more carbon intensive heating fuels due to lack of mains gas network).
- Time frame: medium to long

38. **Funding UK Residential Energy Efficiency: The economy-wide impacts of ECO and its alternatives.**
Katris, A., & Turner, K. (2019).
- Briefing paper
- Models spill-over effects (co-benefits) of energy efficiency policies
- If costs are fully socialised through income tax, lower income households will initially gain at the expense of mid-to-high income groups
- The precise nature of distributional impacts also depends on access to funding.
- The main outcomes reported assume an equal distribution of/access to funds.
- Also reconsiders the case where costs are fully socialised, but focus on a scenario where the 20% of households on the lowest incomes receive most (54%) of the grant support and the 20% of households with the highest incomes the least (2%).
- The outcome is that real income gains to the average household in the lowest income group grow by over £30per year, but this is at the cost of more constrained macroeconomic gains, and this is associated with around 5,300 fewer FTE jobs sustained into the long term.
- Time frame: medium to long

39. **Zero Sum.**
Citizen's Advice. – 2020.
https://www.citizensadvice.org.uk/Global/CitizensAdvice/Energy/Energy%20Consultation%20responses/Zero%20sum%20(2).pdf
- Not everyone has access to energy markets
    - 4.5m in private rented homes
    - 1 in 4 don't have savings
    - 5.3m are non-internet users
    - 51% not comfortable sharing data
- Today's protections not ready for net-zero
- Majority of people willing to make changes needed but large majority need help in doing so
- Time frame: medium to long

40. **Towards a just and equitable low-carbon energy transition. Briefing paper No 26** Ajay Gambhir, Fergus Green, Peter Pearson – Grantham Institute – 2018
    - Recommendations:

    - Imperative that governments work closely with businesses, local communities and labour representatives to produce long-term visions of successful, just and equitable transitions around which all stakeholders' voices are considered.
    - A range of measures such as near-term employment and wage protections, medium-term retraining and investment in alternative industries, and long-term education and innovation investment are central to ensuring protection and prosperity for people and communities.
- Focus on oil and gas and goal industries mainly
- Time frame: medium to long
- Materiality: high

41. Who ultimately pays for and who gains from the electricity who gains from the electricity network upgrade for EVs ?

Turner, K., Alabi, O., Calvillo, C., Katris, A., Turner, K., & Alabi, O. (n.d.).

- The predicted rapid expansion in EV ownership over the next decade will shift demand away from vehicles fuelled with petrol and diesel and will require upgrades to the electricity network itself.
- This will carry significant costs that are ultimately paid by consumers both through their energy bills and the costs of other goods and services where electricity prices impact production costs. Large-scale investment can also be disruptive to the wider economy.
- Time frame: medium to long

42. Investing in a just transition in the UK: How investors can integrate social impact and place-based financing into climate strategies.

Robins, N., Gouldson, A., Irwin, W., & Sudmant, A. (2019). LSE
Retrieved from http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2019/01/Investing-in-a-just-transition-in-the-UK.pdf

- Principles of just transition
- Covers all aspects of decarbonisation (energy and transport)
- Covers impacts and protecting vulnerable groups
- Focus on jobs and re-skilling
- Estimates people in sectors affected using by transition using ONS data
- Proposes guidelines for policy and market
- Includes regional case studies
- Time frame: medium to long

43. **An independent assessment of the UK's Clean Growth Strategy.**
UK Committee on Climate Change. (2018). Technical Report: Committe on Climate Change, (January), 84. Retrieved from https://www.theccc.org.uk/wp-content/uploads/2018/01/CCC-Independent-Assessment-of-UKs-Clean-Growth-Strategy-2018.pdf
    - Relatively little on distributional or social impacts of clean growth strategy in report
    - This may reflect a lack of consideration in the actual report itself
    - Some discussion of targeting fuel-poverty with regards to extension of the ECO and increasing ERC ratings to C
    - Also inclusion of heat recovery programs – not explicitly linked to distributional impacts
    - Time frame: short to medium
    - Materiality: low to medium

44. **Energy Systems Catapult Response to the BEIS Call for Evidence : Clean Growth – Transforming Heating.**
Energy Systems Catapult. (n.d.).
    - ESC has a modelling capability at every level of the energy system, including:
        - National Energy System Modelling and Analysis-internationally peer-reviewed Energy System Modelling Environment (ESME) tool, based on deep sector expertise. Developing additional tools such as the Storage and Flexibility Model and national datasets such as the Infrastructure Cost Calculator.
        - Local Energy System Modelling and Analysis-drawing on the EnergyPath Networks local area energy planning tool, to inform and support local authorities and Local Enterprise Partnerships with a cost-effective low carbon energy transition.
        - Building Energy System Modelling and Analysis-drawing on the Integrated Electric Heat tool to understand the interactions within a home, between different domestic heating systems, controls, building fabric, weather and consumer needs.
        - Time frame: medium to long

45. **Citizens Advice Response to BEIS's Clean Growth - transforming heat overview of current evidence.**
    - Recommends the government consider how it can further develop this thinking in three key areas:

        1. Consumer protection
        2. Distributional impacts and fairness issues

3. Building the evidence base for decarbonising on-gas properties

- Engagement with consumers and insight into consumer attitudes and behaviour are vital to the success of the policy roadmap.

- Consumers will pay for the implementation of these new policies. It is essential that the financial impact on all consumers is considered at all stages of planning for the decarbonisation of heat.

- Time frame: medium to long

46. Deliberating the social acceptability of energy storage in the UK.
Thomas, G., Demski, C., & Pidgeon, N. (2019). Energy Policy. https://doi.org/10.1016/j.enpol.2019.110908

- Considers acceptability of energy storage
- Pays attention to vulnerabilities arising from:
  - Cost (affordability)
  - Access
  - Distributional impacts
- Findings:
  - Energy system flexibility was an unfamiliar problem amongst our participants.
  - Considering the lack of trust expressed towards large energy providers and the unfamiliar nature of flexibility issues, we would suggest energy storage may run risks of public backlash.
  - Concerns that vulnerable groups should not be penalised by changes were articulated in every workshop and were voiced in great strength.
- Time frame: medium to long
- Materiality: unspecified

47. Living with fuel poverty in older age: Coping strategies and their problematic implications.
Chard, R., & Walker, G. (2016). Energy Research and Social Science. https://doi.org/10.1016/j.erss.2016.03.004

- Findings:
  - Telephone and face-to-face interviews with 17 households during the winter period in England.
  - Achieving warmth is seen as important due to concerns about health consequences.
  - Households used different coping strategies to keep warm.
  - Many residents saw coping strategies as unproblematic.
  - These results have implications for organisations tackling fuel poverty.
- Time frame: short
- Materiality: unspecified

48. **Fuel poverty from the bottom-up: Characterising household energy vulnerability through the lived experience of the fuel poor.**
Middlemiss, L., & Gillard, R. (2015). Energy Research and Social Science. https://doi.org/10.1016/j.erss.2015.02.001
    - Recent quantitative and qualitative evidence documents a dramatic reduction in average direct UK household energy consumption in the last decade.
    - The 'fuel poverty gap' in the UK (average shortfall that fuel poor households experience in affording their energy bills) has also grown substantially in that period.
    - identify six challenges to energy vulnerability for the fuel poor:
        - quality of dwelling fabric
        - energy costs and supply issues
        - stability of household income
        - tenancy relations
        - social relations within the household and outside
        - ill health.
    - Finds that:
        - Energy vulnerable have limited agency to reduce their own vulnerability.
        - Current UK policy relating to fuel poverty does not take full account of these challenges.
    - Time frame: short
    - Materiality: medium (unspecified)

49. **Energy poverty and social relations: A capabilities approach.**
Middlemiss, L., Ambrosio-Albalá, P., Emmel, N., Gillard, R., Gilbertson, J., Hargreaves, T., … Tod, A. (2019).. Energy Research and Social Science. https://doi.org/10.1016/j.erss.2019.05.002
    - Scope:
        - Focuses particularly on how relationships with family, friends, agencies and distant others impact on people's ability to cope with energy poverty
        - Finds that the connection between social relations and energy poverty is recursive: good social relations can both enable access to energy services, and be a product of such access.
        - This connection is also shaped by structural factors, such as access to a range of resources, membership of particular collectives, the need to perform social roles, and the common reasons used to explain poverty and energy use.
    - Time frame: short
    - Materiality: medium

50. **Politics, problematisation, and policy: A comparative analysis of energy poverty in England, Ireland and France.**
Kerr, N., Gillard, R., & Middlemiss, L. (2019). Energy and Buildings. https://doi.org/10.1016/j.enbuild.2019.04.002
    - Considers the political context of each nation and show how energy poverty overlaps with other agendas such as: welfare reform, energy market liberalisation and climate change.
        - Access to energy services can be hindered by low incomes, high energy prices and inefficiency (e.g. in domestic heating or other technologies).
        - Policy solutions are often inextricably linked to other problems and political issues.
        - This makes interpretation of a particular policy area, such as energy poverty, impractical without due attention to its proximate issues.
        - Policy solutions favoured affordability over efficiency
        - Political rhetoric favoured efficiency over affordability
        - Important to pay attention to definitions and framing of policy solutions
    - Time frame: short (assumed as unspecified)
    - Materiality: Don't know (unspecified)

51. **Consumer Vulnerability Strategy 25 Final decision**
Ofgem. (2019)., (October), 1–32.
    - Focus on three key areas
        - Fair outcomes
        - Market transparency
        - Compliance and enforcement
    - Main aspects of vulnerability strategy
        - Improving identification of vulnerability and smart use of data.
        - Supporting those struggling with their bills.
        - Driving significant improvements in customer service for vulnerable groups.
        - Encouraging positive and inclusive innovation
    - Time frame: medium
    - Materiality: don't know

52. **Energy Systems Catapult consultation response Ofgem ' s Draft Consumer Vulnerability Strategy 2025**
Chard, C. R., & Manager, C. I. (n.d.)., 1–3.
    - Broadly speaking the Energy system catapult agreed with the strategy laid out
    - Makes proposals to help improve inclusion by removing barriers and providing better information
    - Time frame: medium
    - Materiality: unspecified

53. **Multiple transformations: Theorizing energy vulnerability as a socio-spatial phenomenon.**
Bouzarovski, S., Herrero, S. T., Petrova, S., Frankowski, J., Matoušek, R., & Maltby, T. (2017). Geografiska Annaler, Series B: Human Geography, 99(1), 20–41. https://doi.org/10.1080/04353684.2016.1276733
    - Paper is based on an analysis of documentary evidence and 170 expert interviews
    - Findings point to the need for understanding energy vulnerability as an evolving socio-spatial phenomenon embedded in multiple layers of institutional change and organizational practice.
    - Authors identify urban landscapes as the primary site for the geographic expression and articulation of domestic energy deprivation.
    - Time frame: medium
    - Materiality unspecified

54. **Leaked report says UK net zero climate goal may increase air pollution**
New scientist. Adam Vaughn. March 2020.
https://www.newscientist.com/article/2236385-leaked-report-says-uk-net-zero-climate-goal-may-increase-air-pollution/
    - Leaked report from Defra 'Air Quality Expert Group' suggests that increase of hydrogen heating could lead to an increase in NOx and decreased air quality

55. **Analysis of Alternative UK Heat Decarbonisation Pathways**
For the Committee on Climate Change – Imperial – August 2018
https://www.theccc.org.uk/wp-content/uploads/2018/06/Imperial-College-2018-Analysis-of-Alternative-UK-Heat-Decarbonisation-Pathways.pdf
    - Doesn't explicitly talk about social impacts
    - Annex contains costs to households of different heating pathways
    - Suggests hydrogen networks lower overall cost to households
    - Time frame: medium to long

56. **The Future of Carbon Pricing in the UK**
Report prepared for the Committee on Climate Change. Vivid economics.
    - Market based mechanisms such as carbon pricing should continue to play a central role in an effective climate policy mix in the UK
    - achieving net zero emissions while supporting broader competitiveness and domestic policy objectives is possible under all carbon pricing policy scenarios.
    - The net zero objective, however, places a greater emphasis on the role of carbon pricing to achieve a deeper decarbonisation of the economy and further supplementary policies to overcome non-price barriers.
    - Time frame: medium to long
    - Materiality: medium

Appendix C – Current workstreams/on-going projects
(predominantly based on interviews)

I. Energy Rev
University of Strathclyde – EnergyREV
Dr Rebecca Ford, Lecturer
Current project on future energy solutions impact.
- Part of this research centre focus on distributional and social impacts
- Creating an evidence base
- Spatial/location based impacts
- Interested in unintended consequences
- Project based in Orkney on rural communities
- Time frame: short to medium
- Materiality: unknown

II. Just transition commission
- Producing recommendations for Scottish government
- Still relatively new
- Multiple actors: trade unions, academics, industry
- High visibility/influence with ministers
- Core focus on fairness
- Minister recently asked for updated plan, hence broad goals in the interim report
- Mostly qualitative research
- Industries, jobs, reskilling
- Transport – including rural regions

III. FAIR – CREDS
- Started in January 2020
- Focus on transport poverty is novel
- Multiple workstreams
  - Modelling
  - Mapping
  - Urban and rural
- Not focusing on deep rural
- Working alongside Green Alliance

IV. SMART and FAIR – CSE
- Capabilities from buildings
- Capabilities lens
- 5 different clusters
  - Dwelling

    - Financial circumstances
    - Tech readiness
    - Energy usage
    - Personal and social situation
- Uses MOSAIC data
- Trial in Oxford – project Leo
- Prospering from energy revolution
- England only at the moment

V. OSF - Project 6.3.3 of the Centre for Research into Energy Demand Solutions
- Will be a systematic study of the relationship between distributed ledger technology (e.g. blockchain)-enabled energy retail market structure and potential energy policy outcomes.
- Sharing economy
- Realist approach
- Includes health impacts
- Uses Airbnb model

VI. Net Zero Review – Treasury

VII. CCC – 6th budget review
- Considering distributional benefits
- All scenarios assume 100% EV uptake
- 3 scenarios – high innovation, behaviour change, and baseline
- Considers intergenerational impacts: Defra research
- Currently still at an early analysis stage
- Time frame: long

VIII. Ofgem – distributional impacts
- Update from 2014 archetypes
- Distributional impacts framework
- Short term time frame
- Gaps in the behavioural aspects
- Using archetypes from work commissioned to CSE
    - Profiling different types of consumers
    - 13 different ones
- Ability to move this forwards and to update over time
- Living cost and food survey – ONS
- Energy expenditure
- Pensioners, rural, disabled
- Additional groups
    - Lone parents
    - Unemployed
    - No internet access
- Covers cost of expenditure
- For each group
    - expenditure linked to consumption

    - equivalised
    - range of different policy types
- 3 key metrics
- Quantitative element
    - Comparing winners and losers
    - Qualitative element – providing commentary

IX. Net Zero – Citizen's advice
- Upcoming project on distributional impacts of net zero
- Focus on consumer interest

X. Deep Red – user response and behaviour
- Dist impact of time of use
- **Assumes no behaviour changes**
- **Time of use survey**
    - 8000 people
    - Oxford
    - What they do in 10 min intervals
    - Peak time
    - Bottom up element

Demographics

- Household income
- Family composition
- Regions
- 14 regions
- NOD groups
- Not really broken down further
- Employment
- Age

Activities

- Energy consumption
- Occupancy (active)
- Cooking, laundry, ironing etc.

Uses data from 2015, 2014

Projects where it was not possible to speak to anyone in time constraints of research

XI. Energy Systems catapult
- Various workstreams:
- Fair futures
- Living lab trial

XII. Defra – Net Zero Air Quality analysis
- It was not possible to speak to anyone about this and published data is limited

XIII. H21

- Trial hydrogen network that considers the impacts on consumers with a focus on vulnerability

Appendix D - Additional papers (non UK based)

Bouzarovski, S., & Petrova, S. (2015). A global perspective on domestic energy deprivation: Overcoming the energy poverty-fuel poverty binary. *Energy Research and Social Science*. https://doi.org/10.1016/j.erss.2015.06.007

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Dubois, U. (2012). From targeting to implementation: The role of identification of fuel poor households. *Energy Policy*. https://doi.org/10.1016/j.enpol.2011.11.087

ILO. (2015). Guidelines for a just transition towards environmentally sustainable economies and societies for all, (October), 5–9.

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Monyei, CG, BK Sovacool, MA Brown, KEH Jenkins, S Viriri, and Y Li. "Justice, poverty and electricity decarbonisation," *Electricity Journal* 32(1) (January/February, 2019), pp. 47-51.

Ohlendorf, N., Jakob, M., Minx, J. C., Schröder, C., & Steckel, J. (2018). Distributional Impacts of Climate Mitigation Policies - A Meta-Analysis. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3299337

Payne, J., Downy, F., & Weatherall, D. (2014). Capturing the Multiple Benefits of Energy Efficiency. *Capturing the Multiple Benefits of Energy Efficiency*, 229–238. https://doi.org/10.1787/9789264220720-en

Popp, R., & Pous, P. D. E. (2020). THE JUST TRANSITION FUND 4 BENCHMARKS FOR SUCCESS Executive summary, (January), 1–10.

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Sovacool, BK, A Hook, M Martiskainen, and LH Baker, "Decarbonisation and its discontents: A critical energy justice perspective on four low-carbon transitions," *Climatic Change* 155(4) (August, 2019), pp. 581–619

Sovacool, BK, M Lipson, and R Chard. “Temporality, vulnerability, and energy justice in household low carbon innovations,” *Energy Policy* 128 (May, 2019), pp. 495-504.

Sovacool, BK, Noel, LD, G Zarazua de Rubens, and J Kester. “Energy injustice and Nordic electric mobility: Inequality, elitism, and externalities in the electrification of vehicle-to-grid (V2G) transport,” *Ecological Economics* 157 (March, 2019), pp. 205-217.

Sovacool, BK, SH Ali, M Bazilian, B Radley, B Nemery, J Okatz, and D Mulvaney. “Sustainable minerals and metals for a low-carbon future,” *Science* 367 (6473) (January 3, 2020), pp. 30-33.

UKERC. (2019). Disrupting the UK energy system: causes, impacts and policy implications, (June), 40.

Wood, N., & Roelich, K. (2019). Tensions, capabilities, and justice in climate change mitigation of fossil fuels. *Energy Research and Social Science*. https://doi.org/10.1016/j.erss.2019.02.014