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Demand response and energy justice: A critical overview of ethical risks and opportunities within digital, decentralised, and decarbonised futures

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Article

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Demand-side Response and Energy Justice: a critical overview of ethical risks and opportunities within digital, decentralised, and decarbonised futures

Highlights

- Energy justice is considered within DSR intervention design through to use
- Scholarship on DSR, energy justice and energy vulnerability is brought together
- This system of provision has risks and opportunities for achieving energy justice
- Coordination of interventions will maximise the GHG reduction potential of DSR
- In some instances flexibility provision can lead to a reduction of household well-being

Abstract

The transition to a digital, decarbonised, and decentralised energy system presents both risks and opportunities for the domestic consumer. Domestic 'demand-side response' (DSR), where household electrical consumption adjusts in response to external signals, has been envisioned in different ways with several trials demonstrating that DSR often has variegated and uneven consumer outcomes. This plurality of outcomes raises questions about the 'winners' and 'losers' of pursuing such policies and thus brings them into the realm of energy justice – a framing that seeks to understand the ethical implications of energy systems. This paper, based on an extensive review of current academic literature, evaluates the normative implications of DSR in relation to the eight principles of energy justice proposed by Sovacool and Dworkin (2015). Whilst there are several ways that DSR may create opportunities for furthering energy justice, there are also multiple risks of *in*justice, with much depending on how particular DSR programmes are designed and the presence or absence of sufficient policies to mitigate regressive outcomes. Further empirical research is required to better understand the conditions through which DSR can contribute to energy justice. We conclude by offering policy recommendations for those developing DSR or consumer protection policies related to DSR rollout.

Keywords

domestic demand-side response, energy justice, energy vulnerability, flexibility, smart grids, energy futures

1 Introduction

Globally, societies are facing the growing challenge of the ‘energy trilemma’, in which they are tasked with developing an energy system that is secure, low-carbon and environmentally sustainable, and socially equitable (Bridge et al., 2018). The scale and scope of addressing this trilemma is considerable, not least because its three dimensions can be in tension with one another. It is widely accepted that responding to this challenge will require significant transformations in all aspects of energy systems – especially in developed economies, who are responsible for disproportionate levels of global carbon emissions.

Technological development and falling costs have led to a vision of energy networks that include greater use of ‘smart’ technologies. Smart technologies are those than enable intelligent integration of the *“actions of all the users connected to it - generators, consumers and those that do both - in order to efficiently deliver sustainable, economic and secure electricity supplies”* (Ofgem, 2015a, p. 2). ‘Demand-side response’ (DSR) measures, described as a *“portfolio of measures to improve the energy system at the side of consumption”* (Palensky and Dietrich, 2011, p. 381) are increasingly envisioned as an integral part of this transition, and many such measures rely on smart technologies. DSR refers to measures that attempt to adjust (increase, decrease or temporally shift[1]) end-user electricity in response to external signals. Adjusting demand to balance supply at any one time has several potential benefits towards tackle the energy trilemma, and it is seen as a relatively low-cost option to secure energy system reliability in the future (Bradley et al., 2013). There is significant investment of time and money into technological developments, new network infrastructures, and business models that can

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[1] Note that unlike other demand-side energy policy measures, such as energy efficiency, DSR does not necessarily rely on overall electricity consumption reduction; indeed, in some cases it may lead to an overall *increase* in consumption (Mander et al., 2015).

enable and take advantage of DSR within national systems, particularly in high-income economies (Friis and Haunstrup Christensen, 2016; Mukai et al., 2016; Ofgem, 2017).

Whilst DSR in the commercial space is a rapidly developing market, the infant domestic DSR market and domestic DSR mechanisms are the focus of this paper. It is envisaged that household interaction with the energy system will change significantly due to DSR, with people moving away from being ‘passive’ consumers to active ‘energy engagers’. Domestic DSR can be enabled in a number of ways, with three strategies principally discussed in policy and academic discourse (Smale et al., 2017):

- *Manual consumption adjustment:* household members physically alter their actions or appliance usage in response to external signals.
- *Direct load control:* control of household electrical devices is granted to an external body such as an energy supply company, network operator, or independent company.
- *Automated appliances:* electrical devices adjust their consumption autonomously in response to external signals. This optimises consumption for the household’s benefit.

Time-of-use (TOU) tariffs, where the unit cost of electricity charged to households adjusts depending on the time of consumption, can encourage householder engagement with all three mechanisms. Financial incentives may alternatively include a payment for the amount of flexibility provided (D’hulst et al., 2015), or shifting consumption may be facilitated through non-financial reward schemes such as community-based social marketing (Anda and Temmen, 2014). Herein, drawing on work by D’hulst et al. (2015) and Powells and Fell (2019) we define ‘flexibility’ as the ability to shift energy use in time, space and/or intensity.

Given the anticipated transformative effects of domestic DSR on energy system operation and the high likelihood of its introduction in some form in many energy systems, it is surprising that little research focusses on its potential impact upon the everyday lives and well-being of individuals and households.

As Sovacool et al. (2016) note, energy policy decisions are often taken in a ‘moral vacuum’ with little consideration of their impact upon human lives and social justice. In the case of DSR, it is crucial that such issues are considered. Domestic consumers are highly varied, having different needs, vulnerabilities and capacities, and so the lived experience and impacts of DSR are very likely to be differentiated and uneven, rather than universal. Moreover, DSR could be developed and implemented in a number of ways (Goulden et al., 2018; Skjølsvold et al., 2015; Throndsen, 2017), each bringing specific sets of risks and opportunities in how they shape everyday lives. In short, DSR has the potential to produce new kinds of ‘winners’ and ‘losers’. As such, there are vitally important questions of equity and justice relating to DSR that need to be considered in a systematic manner (Smale et al., 2017), yet presently discussions around the topic are rarely framed or considered in these terms (see Darby and McKenna, 2012; Neuteleers et al., 2017; Strengers, 2010 for important but partial exceptions).

This paper addresses this research gap through the use of the ‘energy justice’ framework, and specifically the version developed by Sovacool and Dworkin (2015). Its principal objective is to bring to the fore some important questions around the ethical implications of future DSR, with the aim of inspiring further research and discussion as well as informing policy. Although the paper refers mostly to evidence from the UK and other developed economies, since most DSR research has been undertaken in these countries, its findings and the issues it raises are applicable to energy systems internationally. The paper is, to our knowledge, the first that considers the justice implications of DSR in their entirety (as opposed to focusing on one particular element of justice, or form of DSR). As such, it brings a new perspective on the justice implications of new energy futures.

The paper begins by introducing the concept of energy justice and its key components. It then evaluates, in turn, the potential ethical impacts of DSR in relation to eight principles of energy justice, stating the strength of evidence to support these principles, before concluding with reflections and implications for policy.

2 Conceptualizing energy justice

The concept of ‘energy justice’[2] encompasses an analytical approach that utilises notions and principles of justice to critically examine the structure and operation of energy systems (Sovacool et al., 2014; Sovacool and Dworkin, 2015; Walker et al., 2016). Whilst informed by the more well-established scholarship on environmental justice (Holifield et al., 2018), energy justice has a tighter focus, being concerned with justice issues closely linked to energy systems (Jenkins, 2018). As Bickerstaff et al. (2013, p. 2) identify, “*energy justice provides a way of ‘bounding’ and separating out energy concerns from the wider range of topics addressed within both environmental and climate justice campaigning*”. The ‘whole systems’ approach to energy justice highlights that concerns of equity and fairness can occur across the energy chain, from resource extraction through to energy generation, transmission, consumption and waste disposal (Jenkins et al., 2014). In this paper, we focus primarily on the consumption aspect of the chain, with particular attention on the space and scale of the household, whilst recognising that justice issues experienced at this scale will always be interconnected with features of the wider energy system (Bouzarovski and Simcock, 2017).

Literature in the energy justice field often utilises the three-dimensional justice framework originally outlined in the environmental justice literature (Schlosberg, 2004). This approach conceptualises energy justice as comprising three tenets of distributional justice, procedural justice, and justice as

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[2] Although concerns about justice have a long history in the analysis of various energy issues, the term ‘energy justice’ emerged around 2013 (Bickerstaff, 2018).

recognition. (McCauley et al., 2013). Although providing a useful analytical heuristic that helps draw attention to the different forms and experiences of energy (in)justice that can be articulated and examined, a potential limitation of the tenet approach is that it does not prescribe any normative principles of what constitutes justice or injustice in relation to each of the three dimensions.

An alternative energy justice framework has been proposed by Sovacool and Dworkin (2015). They define energy justice as *"a global energy system that fairly disseminates both the benefits and costs of energy services, and one that has representative and impartial energy decision-making"* (p.436). Fleshing out this broad idea, they develop 8 principles of what constitutes a just energy system, shown in Table 1. These principles, they argue, can be used as a decision-making tool that helps guide energy decisions so that they produce just outcomes and follow just procedures. This framework does have some overlaps with the tenet approach – note that the principles of *Availability*, *Affordability*, *Sustainability*, *Intergenerational Equity*, *Intragenerational Equity*, and *Responsibility* are all primarily distributional justice concerns. Meanwhile, the principles of *Due Process* and *Good Governance* are concerns of procedural justice.

Table 1: The eight principles of energy justice, adapted from Sovacool and Dworkin (2015)

Principle	**Explanation**
Availability	People deserve sufficient energy resources of high quality
Affordability	All people, including the poor, should pay no more than 10 percent of their income for energy services
Due Process	Countries should respect due process and human rights in their production and use of energy
Good Governance	All people should have access to high quality information about energy and the environment and fair, transparent, and accountable forms of energy decision-making
Sustainability	Energy resources should not be depleted too quickly
Intragenerational Equity	All people have a right to fairly access energy services
Intergenerational Equity	Future generations have a right to enjoy a good life undisturbed by the damage our energy systems inflict on the world today
Responsibility	All nations have a responsibility to protect the natural environment and minimize energy-related environmental threats

Although Sovacool and Dworkin’s framework has the notable limitation of not incorporating issues of justice as recognition in any obvious way, we argue that it is nonetheless useful for critically assessing the justice implications of various aspects of the energy system and how these may change in the future. In the remainder of this paper, we utilise these principles as an analytical tool. Drawing on existing literature, we assess both the *opportunities* and *risks* that domestic DSR measures pose for each principle.

In some cases, to avoid repetition, we assess two principles simultaneously. Specifically, we merge *Sustainability* and *Intergenerational Equity* on the basis that both concern the impact of energy systems on the non-human environments and ecological systems. *Availability* and *Intragenerational Equity* are merged on the basis that both broadly relate to the ability of individuals to access and use sufficient energy services to meet their basic needs, and *Due Process* and *Good Governance* in that they both relate to procedural justice concerns. For clarity of narrative, we also discuss the principles in a slightly different order than they appear in Sovacool and Dworkin’s original framework. We focus first upon those principles that have a distributional justice focus, before considering the principles relating to procedural justice concerns.

3 DSR and the principles of energy justice

3.1 Sustainability, “Energy resources should not be depleted too quickly” and Intergenerational Equity, “Future generations have a right to enjoy a good life undisturbed by the damage our energy systems inflict on the world today”

Perhaps the most widely proclaimed rationale for use of DSR is that it can provide multiple beneficial functions for operation of an electricity network, facilitating a transition to a low-carbon energy system (Qadrdan et al., 2017). Domestic consumption is seen as a key target sector for DSR, for example in the UK it accounts for ~1/3 of total electrical end-use consumption (Department for Business, Energy & Industrial Strategy, 2019). Through reducing the greenhouse gas emissions resulting from energy system operation, it is hoped that DSR could help further *Intergenerational Equity* by mitigating the injustice of future generations and the most vulnerable being harmed by climate change. It can also help ensure that finite energy resources are depleted at a slower rate, thus contributing to the energy justice principle of *Sustainability*. How DSR may perform these network functions in practice is complex and multifaceted, relying on the ability of DSR mechanisms to shift electricity consumption to *'optimal times'*[3] – most often, this means away from times of peak consumption when there is the greatest pressure placed on generation, distribution and transmission systems.

DSR modelling shows a theoretical potential to safely permit an increase of low-carbon generation that has uncontrollable output in the electrical network. It may, for example, lead to a reduction in 'wind curtailment' – a situation in which wind turbines are disconnected if there is not the appropriate level of stand-in generation to take over when there is a drop in output. By synchronising demand reduction with any output reduction of low-carbon generation, DSR has been argued to be a form of 'reserve' power (Bradley et al., 2013). Hypothetically, this could substitute the current reserve provided by carbon intensive gas generators, even where current capacity exists, thus also leading to further reductions in carbon emissions.

Modelling has also found that reducing peaks in consumption and shifting this consumption to times with spare generation and network capacity should reduce the physical strain placed on existing electrical transmission and distribution systems. This would permit the connection of new electrical loads, introduced to reduce energy system GHG emissions, that would otherwise be constrained by local and national capacity; for example, the electrification of transport and heating, which are low

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[3] times of low cost generation and low carbon generation, which may be deemed as 'optimal times' are not necessarily simultaneous (Dong Energy, 2012), and therefore trade-offs between functions may be required

carbon policy priorities in the UK (National Grid, 2019; Ofgem, 2019). A reduction in future infrastructure reinforcement is therefore expected with DSR (Dupont et al., 2014; Martínez Ceseña and Mancarella, 2018), thus avoiding significant material resource use and associated embedded carbon, whilst lowering damage to the physical environment from installation.

It is expected that managing loads flexibly will increase network resilience when facing the impacts of climate change, with increasing future resilience deemed an important element of *Intergenerational Equity* (Sovacool and Dworkin, 2015). These impacts include the loss of generation or transmission capacity due to extreme weather events and rising temperatures (Electricity North West Ltd, 2015; Hu and Cotton, 2013), alongside additional strain being placed on electrical networks from a predicted rise of domestic air-conditioning units (National Grid, 2016).

Although theory and modelling suggest DSR can bring these considerable benefits, initial empirical findings from small trials indicate uncertainty over whether these can or will be achieved in practice. On the one hand, a number of DSR pilots have met their design specifications and/or led to significant drops in peak consumption – for example, the Smart Community Project in Greater Manchester (NEDO, 2017), and a trial of ‘critical peak pricing’ in California that led to a 41% drop in baseline electricity load during hot weather events (Herter et al., 2007). On the other hand, some studies have found much lower consumption change than anticipated. For example, Bartusch et al. (2011) describe a TOU scheme that led to 11.1% and 14.2% reduction in *total* energy consumption over the two years of research, but a shift in the *timing* of consumption of only 0.8% and 1.2% from peak time to off-peak time. Vanthournout et al. (2015) found a limited impact on the local distribution grid from a DSR pilot they evaluated. Torriti (2012) report a reduction in morning peak with a TOU tariff, but increased pressure on substations during the evening peak. DSR interventions increasing network pressures in this way has been highlighted as a risk both in modelling (Martínez Ceseña and Mancarella, 2018; Pudjianto and Strbac, 2017), and seen in other pilots where increased peaks of consumption were created (Khan et al., 2016; Sweetnam et al., 2018; Tindemans et al., 2014). Reasons for the difference between the theoretical and actual performance of DSR interventions are discussed in more detail in subsequent sections. These include inequalities in households' capacity to provide the level of flexibility required, with much of the modelling that projects significant benefits often treating households as homogenous and failing to capture such inequalities.

Furthermore, the 'whole systems' approach to energy justice as highlighted by Jenkins et al. (2016), draws attention to energy system supply chains. DSR management often requires new equipment, and here it is important to recognise the embedded emissions and waste from the associated ICT monitoring and control equipment. This resource use is intensified by wastage from redundant equipment due to a potential lack of compatibility of equipment across companies (Broman Toft and Thogersen, 2015; EcoGrid, 2015), and the need for physical hardware upgrades to increase functionality (Jenkins et al., 2018). Lastly, DSR, with a high reliance on data processing and storage, also demands power and physical infrastructure, which cannot be ignored when considering *Sustainability*. However, a limitation of the current research literature is that, to date, there have been no studies that seek to quantify the extent of these potential drawbacks (e.g. the level of embedded carbon associated with ICT production, and how this compares to the level of carbon savings). Therefore, it is difficult to assess with confidence the degree to which they will offset the potential benefits of DSR noted above.

In summary, there is not strong or consistent empirical evidence to suggest we can be fully confident DSR will be as beneficial for *Sustainability* and *Intergenerational Equity* as some hope. Outcomes appear to vary between different cases, and there is a need for further research to understand whether and how the potential sustainability benefits of DSR can be optimised. As Martínez Ceseña and Mancarella, (2018) note, coordination between multiple different actors (politicians, regulators, utilities, distribution operators, households) is required for the sustainability benefits of DSR to be realised.

3.2 Affordability, "All people, including the poor, should pay no more than 10 percent of their income for energy services"

DSR carries both opportunities and risks for the *Affordability* of domestic energy services. In terms of opportunities, it has been argued that reductions in the workload placed on energy transmission and distribution infrastructures would result in a relative aggregate cost saving against today's costs (Bradley et al., 2013). Future energy demand scenarios highlight further cost savings may result from a reduction in generation and network capacity investment, on the proviso of strong market coordination (Pudjianto and Strbac, 2017; Strbac, 2008). These cost savings could, theoretically, be passed on to all domestic consumers through lower energy bills – or at least limit the extent of energy cost increases in the future (Citizens Advice Bureau, 2014). Whole system modelling by Pudjianto and Strbac (2017) has estimated that DSR, predominantly acting on electric vehicles and electric heating following widespread uptake of these technologies, would reduce energy bills in 2050 by 4-6% relative to not having any form of domestic DSR.

DSR schemes that are implemented via Time of Use (TOU) tariffs have additional potential for household energy bill reductions – on the condition that households using such tariffs are able to shift a sufficient proportion of their total electricity demand from peak times to periods when the unit cost of electricity is lower. TOU tariffs can take different forms including real-time pricing, critical peak pricing or static time of use pricing. In the EFlex project, where households had DSR technology installed to optimise their heat-pump electricity consumption according to a TOU tariff and/or local renewable energy generation, all participating households saved in the range of €35 to €80 per year (Dong Energy, 2012). Similarly, a trial of TOU tariffs by Bartusch et al. (2011) found financial benefits for consumers, with *average* household energy costs dropping by ~40% in the summer, and ~17% in the winter.

Often, however, these reports of reductions in energy costs relate to *average* reductions across the sampled households. In terms of the energy justice principle of *Affordability,* it would be especially beneficial if lower energy bills resulting from DSR were experienced by low-income or otherwise disadvantaged households who are at heightened risk of experiencing energy poverty[4] – understood here as "*the inability to attain a socially- and materially-necessitated level of energy services*" (Bouzarovski and Petrova, 2015, p. 31). Energy poverty can often result from unaffordable or expensive energy costs, with one common definition arguing that energy poverty occurs when a household must spend more than 10% of their income to use an adequate level of energy services (Boardman, 2010). Indeed, if a reduction in energy bills for energy poor and vulnerable households were to result from the widespread implementation and uptake of DSR, this could theoretically contribute to in a reduction in the prevalence and depth of energy poverty at local, regional and national scales.

One challenge for this in practice is that some of those households who are most vulnerable to energy poverty can face barriers that can prevent them fully engaging with, and so benefitting financially from, DSR technologies and associated TOU tariffs. These include:

- Infrastructure constraints, such as having incompatible energy meters (for example pre-payment energy meters, which are more common among low-income households), or not being

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[4] We use the term 'energy poverty', but recognise that there are various other terms used to refer to fundamentally the same phenomenon. These include 'fuel poverty' and 'energy insecurity'. Following Bouzarovski and Petrova (2015), we believe that energy poverty is the term that best encapsulates the problem of inadequate and unaffordable domestic energy services.

able to decide to install the relevant technologies due to renting rather than owning one's home – again a situation more common among low-income households (Sovacool et al., 2019). Additionally, in many countries there remains a substantial number of households,[5] many of them vulnerable to energy poverty, who do not have access to the internet and so are unable to use the 'smart' appliances required to participate in DSR (Buchanan et al., 2016; Citizens Advice, 2011; Milchram et al., 2018).

- Psychological constraints, with those who are 'risk averse' less likely to sign up to DSR. Risk aversity is more common among low-income and vulnerable households (Lunn and Lyons, 2010; Nicolson et al., 2017; Ofgem, 2013, p. 20), and among those who already find the existing energy market too complex (Barnicoat and Danson, 2015; Marikyan et al., 2019)
- Skills based constraints, as those who are unfamiliar or uncomfortable using digital technologies or applications may be unable to take part (Citizens Advice, 2011; Snell et al., 2015).

Even if vulnerable households are able to overcome these challenges and participate in DSR and TOU tariff schemes, evidence from several trials are unclear about whether TOU rates will benefit less affluent households. In Cappers et al. (2018) and Herter et al. (2007), studies of 'critical peak pricing' trials, all consumer groups experienced bill *decreases*, with vulnerable groups[6] in the Cappers et al study, and specifically lower-income groups in the Herter et al. study, financially benefiting in the

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[5] For example, in the UK, 39% of properties of only one person over 65 years did not have internet access in 2016 (Office for National Statistics, 2017), and there are lower levels of internet connectivity for households with a disabled member (Department for Work and Pensions, 2014).

[6] The phrase 'vulnerable' is used by Cappers et al. (2018) in relation to customers who have low-incomes, are elderly and/or chronically ill

same proportion as their higher income or 'non-vulnerable' counterparts. Conversely, in a recent study by White and Sintov (2020) ~7.5k households in the southwestern United States took part in a randomized control pilot of TOU tariffs. They found that *all* participants piloting TOU tariffs experienced bill *increases*. Moreover, households with elderly and disabled occupants faced disproportionately greater bill increases than other groups in the study. This is an especially significant given than such households are considered among those most vulnerable to energy poverty (Snell et al., 2015). Essentially, the *opposite* of the proposed energy justice benefit occurred. This demonstrates that the hypothetical justice benefits of DSR related to the energy justice principle of *Affordability* may not necessarily play out in practice.

The type of TOU employed may well change the distributional outcome of an intervention. In addition, the outcomes may also be affected by slight alterations in the time designated as 'peak consumption', the cost ratio between 'peak' and 'off-peak' consumption[7], the type of consumption targeted (e.g. electric vehicles, heating, or all electricity consumption), and where the trial is undertaken. 'Capacity fees' have been trialled as an alternative to a TOU. Capacity fees seek to encourage households to shift their electricity demand via financial compensation that is allocated based on the length of time a household is happy to delay the starting of appliances. An external party is then able to externally turn on/off these appliances at the times they deem optimal (D'hulst et al., 2015). Whilst there has been some examination of the equitability of the same TOU tariffs applied across populations, there has been less comparative enquiry of the distributional outcomes and fairness of different forms of TOU, of alternative forms of financial incentives, or of the impact of adjusting the context in which they are applied. Further enquiry is needed to paint a clear picture of how

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[7] Which has ranged from 1.75x higher in (Vanthournout et al., 2015) to 10 to 40x higher in (Strengers, 2010)

different TOU arrangements impact the energy costs of different social groups and thus the potential for different tariffs to mitigate energy poverty.

Many of the proposed distributional justice benefits of domestic DSR are underpinned by a fundamental assumption of ‘flexibility’. This is the belief that individuals and households have both the means and the willingness to shift their energy use in time, space and/or intensity in response to external signals and network needs (Powells and Fell, 2019).[8] In reality, the capacity for such flexibility varies greatly. Powells and Fell (2019, p. 57) argue that it is useful to conceptualise flexibility as a form of ‘capital’, one that is unevenly shared across society as an *“inevitable consequence of it being embedded in heterogeneous forms of socio-technical and socio-spatial contexts”* (p.57). A wide and complex array of contingencies can impact on a household’s relative flexibility capital. Table 2 synthesises these contingencies drawing on examples from the literature.

If DSR is incentivised with a TOU tariff, limited flexibility capital can result in financial penalisation as households are unable to shift their consumption away from peak hours or to the time which is being actively promoted (Bartusch et al., 2011). And, significantly, *those groups with lower flexibility capital are often already vulnerable to energy poverty*. For example, Table 2 notes the limitations on flexibility for households on lower incomes, with chronic health conditions, older people, and those with children, all of whom can be at greater risk of energy poverty (Snell et al., 2015). Meanwhile, those with greater flexibility capital, and so able to take advantage of TOU, may also be those who are already more affluent and advantaged. Whilst tariffs that are cost neutral for those unable to adjust

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[8] ‘Flexibility’ in relation to DSR is a concept that has been defined in various ways (Althaher et al., 2015; Leijten et al., 2014), but here we follow the definition of (Powells and Fell, 2019).

their consumption have been used in a small number of TOU trials to date (Cappers et al., 2018; Stokke et al., 2010), this has not been the norm.

Table 2: Factors influencing flexibility capital

Factor	Explanation	References
Bodily capacity	Health status influences domestic energy needs and thus people's ability to respond to DSR requests. People with disabilities, or suffering from chronic health problems, can have higher and more stringent energy consumption requirements (e.g. use of medical equipment, or requirement for high indoor temperatures) and may lack flexibility to easily adjust consumption patterns.	Powells and Fell, 2019; Snell et al., 2015; Strengers, 2010
Affluence	Greater financial resources can increase flexibility by making the capital costs of investing in new technologies that enable engagement with DSR more affordable. For example, wealthier consumers can more easily invest upfront capital in battery storage, 'smart' appliances, microgeneration or electric vehicles – thus increasing their flexibility capital.	Ofgem, 2017; Powells and Fell, 2019; Smith and McDonough, 2001
Time	Occupation of the home during daytime can increase flexibility by providing greater opportunity to complete energy-consuming tasks, such as laundry and cooking, outside 'peak' evening and morning hours. Due to time constraints, households may become fatigued with, or lack the time for, manual consumption changes. Lack of time to invest in learning how to use household DSR technologies.	Friis and Haunstrup Christensen, 2016; Hampton, 2017; Mander et al., 2015; Strengers, 2010; Vanthournout et al., 2015; Wilson et al., 2017
Household composition	Households with fewer occupants can have (relatively) fewer social constraints compared to those living in multi-person households, especially those containing children where energy consumption changes can require a complex process of negotiation between household members with different needs, routines and priorities.	Bell et al., 2015; Dong Energy, 2012; Hargreaves et al., 2010; Nicholls and Strengers, 2015; Powells et al., 2014; Toth et al., 2013
Materiality of housing and infrastructure	Those who live in smaller homes or share adjoining walls with others (e.g. those living in apartment blocks or terraced housing) can be unwilling to use white goods, especially washing machines or tumble driers, overnight (when energy costs are often lower under many DSR interventions) due to noise disturbance for themselves and neighbours. Available infrastructure can also shape a household's ability to switch from one form of energy carrier for another (e.g. from gas to electricity, or electricity to wood burning). For example, those who have gas hobs or ovens can avoid cooking with electricity at peak times. A high thermal mass can reduce the impact of, and therefore extend the time in which thermal energy services can be flexible without comfort loss. Those who have gardens can dry clothes outside as an alternative to a tumble drier.	Friis and Haunstrup Christensen, 2016; Higginson et al., 2014; Mert, 2008; Nyborg and Røpke, 2013; Strengers, 2010; Vanthournout et al., 2015
Information provision, skills and understanding	Households many lack an understanding of how DSR systems and apps work, and how they can be utalised to optimise personal benefit, due to technological complexity,	Abi Ghanem and Mander, 2014; Broman Toft and Thogersen, 2015; EA Technology and Durham University, 2015; EcoGrid, 2015;

	a lack of ease and user accessibility, and poor provision of information and training.[9]	Friis and Haunstrup Christensen, 2016; Mander et al., 2015; Marikyan et al., 2019; NEDO, 2017; Nyborg and Røpke, 2013; Western Power Distribution and Wales & West Utilities, 2018

In summary, whilst TOU tariffs have the hypothetical potential for positive justice outcomes via reductions in energy bills for vulnerable households, empirical evidence thus far demonstrate that the picture is complex and that there are significant risks of injustice. There is a need for further research to understand the conditions under which those most vulnerable to energy poverty can benefit from DSR. Not acknowledging or attempting to redress inequalities in flexibility capital may mean that domestic DSR, and especially DSR incentivised via a TOU tariff, carries significant risks in terms of regressive outcomes for the energy justice principle of *Affordability*.

3.3 Availability, "People deserve sufficient energy resources of high quality" and Intragenerational Equity, "All people have a right to fairly access energy services"

The principles of *Availability* and *Intragenerational Equity* relate to an individual's ability to attain sufficient energy services to meet their basic needs, and this access being fair across the population. Enabling all individuals to attain the material resources required for a basic minimum of wellbeing is an important principle of several theories of distributional justice, such as those informed by 'basic needs' and 'capabilities' frameworks (Doyal and Gough, 1991; Nussbaum, 2011). Energy, and more precisely the service energy provides, is argued to be included in this set of material goods (Sovacool et al., 2014) since being unable to attain sufficient levels of energy services can cause significant harms to human wellbeing (Day et al., 2016; Sherriff, 2016). People are therefore entitled to a certain

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[9] A range of DSR trials have reported a lower level of engagement with apps and online platforms than expected, with some users not engaging at all with these functions. In the FREEDOM project, where DLC was enabled on electric heat-pumps, 14% did not use an app provided, with 10% who did finding it difficult or very difficult to use (Western Power Distribution and Wales & West Utilities, 2018).

level of ‘necessary’ energy services (Walker et al., 2016), an idea represented within public discussions on consumer flexibility propositions (Demski et al., 2019; Thomas et al., 2020).

Whilst the financial outcomes of DSR are an energy justice consideration in themselves (as discussed in 3.2 above), a reduction in energy costs may also contribute to the achievement of the energy justice principle of *Availability* and *Intragenerational Equity*. Several studies have shown that those living in energy poverty are often forced to ration and limit their energy consumption to ensure that their energy bills remain affordable (Middlemiss and Gillard, 2015; O’Sullivan, 2019; Snell et al., 2018). Consequently, they ‘under-consume’ key energy services, with harmful consequences for their health and wellbeing (Liddell and Morris, 2010; O’Sullivan, 2019). Thus, if DSR measures result in lower energy costs for energy poor or energy vulnerable households (as is evidenced in some pilots in section 3.2 above), then it will also become affordable for them to use more of the energy services that they require for well-being.

Yet there is also risks related to negative impacts on householder well-being, and thus for further energy injustice. In some forms of DSR, households may have little control over whether they adjust their consumption in response to an external request. Alternatively, a household may deem a financial penalty too high to avoid the DSR request (Neuteleers et al., 2017). Obliging or pressuring households to adjust their consumption away from their current routine runs the risk of leaving people unable to consume sufficient levels of energy services *at the particular time when they are required* (Hargreaves and Middlemiss, 2020; Strengers, 2010; van der Werff and Steg, 2016; Vanthournout et al., 2015). In theory, this could mean, for example, that households are not able to use space heating or cooling systems when they are most required – with potentially problematic health and well-being consequences.[10] This is especially pertinent as heating system are electrified as part of decarbonisation agendas, and given that both electrical heating and cooling services are key targets of DSR due to their likelihood of adding to exiting consumption peaks or creating new ones during extreme weather events (McLachlan et al., 2016).

Overall, empirical evidence is limited regarding the extent to which DSR interventions will impact upon households' use of 'necessary' energy services and their well-being, and mostly relates to air-conditioning and space cooling. Referring to the impact of households in Australia turning off their air-conditioning during peak electricity pricing, Strengers (2010, pp.7317) states that "*While some householders talked about how they had to 'survive' or 'bide out' these periods most did not consider them to be a significant burden or source of discomfort*". Similarly, Newsham and Boker (2010, p. 3294) found that when air conditioning units are turned off during DSR events, "*there is little evidence of substantial discomfort penalties*" even if indoor temperature and humidity are higher than the householder's default preference. They suggest that this may be because the temperature rise is slow, and so not noticed during the few hours of the event. At the same time, the authors also recognise that rates of householder override (i.e. manually turning the AC unit back on) increase as the length of the DSR event increases – presumably because of comfort reasons, which indicates that there is a limit on the extent to which occupants can or will tolerate of temperature diversions. In contrast, a review paper by Khan et al (2016, p. 1317) suggests that "*curtailment of [an air conditioning] facility at the exact moment when it is required the most (ACs in a sunny day), causes great discomfort to the consumers*", although the evidence for this statement is not made clear. In relation to externally controlled electric

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[10] The negative health implications of being unable to meet domestic thermal comfort needs is well documented for both space heating (Marmot Review Team, 2011; O'Sullivan, 2019) and cooling (Klinenberg, 1999; Thomson et al., 2019). This is especially the case for older people and those with pre-existing health conditions (Klinenberg, 1999; Song et al., 2017).

heat pump technologies, Sweenam et al (2018) report households experiencing overheating, particularly overnight, resulting in fairly significant discomfort and some participants in the trial having the technology removed (see also Western Power Distribution and Wales & West Utilities, 2018 for a similar example). This misalignment between the energy services required by users and that provided by DSR technology can also occur due to the complexity of using new technology and lack of training for householders (Abi Ghanem and Mander, 2014; Marikyan et al., 2019).

A notable gap in research on the impact of DSR on households is the lack of investigation into whether and how the well-being effects of energy-use curtailment vary between different types of households depending on their social and physiological characteristics (age, health status, etc.). Work on energy and recognition justice highlights that the amount and types of energy services that are 'necessary' for well-being varies across the population and over time. It is well documented, for example, that older people and those with certain chronic health conditions are more sensitive to low or high indoor temperatures (Marmot Review Team, 2011; Song et al., 2017), and it may be that the curtailment of space heating or cooling due to DSR has a more harmful effect for such groups relative to the wider population. Similarly, those with certain medical conditions may have higher energy-use requirements and face severe consequences should their ability to consume electricity during a DSR event be restricted (Barnicoat and Danson, 2015; de Chavez, 2018). Further research is necessary to investigate such contingencies.

In summary, by improving energy affordability DSR may also provide opportunities for the achievement of the energy justice principles of *Availability* and *Intragenerational Equity.* At the same time, it also carries potential risks regarding the possibility of households 'under-consuming' energy services when they are most required. Without feedback on the impact of consumption change and flexibility provision, reductions or changes in consumption could superficially be seen as a positive outcome even if the effect on household health or wellbeing is negative.

3.4 Responsibility, "All nations have a responsibility to protect the natural environment and minimize energy-related environmental threats"

In relation to the energy justice principle of *Responsibility*, Sovacool and Dworkin argue that industrialized countries bear the greatest obligations to address energy-related environmental threats – particularly climate change – because they have emitted the greatest amount of greenhouse gas into the atmosphere and have therefore contributed most to climate breakdown (see also Sovacool et al., 2016). It is, in effect, a version of the 'polluter pays principle', in which those responsible for causing environmental harm should bear the responsibility for correcting it (Caney, 2015). Although Sovacool and Dworkin's original framework focuses upon obligations at the nation state level, we argue that there are also critical questions of responsibility *within* nation states, and that, if appropriately designed, DSR offers opportunities for distributing responsibility for reducing energy-related externalities in a more just manner.

In several countries, it has been observed that electricity consumption varies widely between households. In the UK, Bell et al. (2015) report *"higher consumers using between two to four times the amount of energy lower consuming households use, even for demographically similar families living in similar homes"* (p.99). Chatterton et al (2016) found wide geographical disparities in household energy consumption,[11] and suggest that such disparities raise clear questions of distributional justice because *"a minority of areas appear to be placing much greater strain on energy networks and environmental systems than they need"* (p.71). There is also strong evidence that households with higher levels of energy consumption are also more likely to have *higher incomes*, for whom affordability of energy is most secure (Chatterton et al., 2016; Gough et al., 2011; Sayer, 2014).

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[11] Specifically, they found that areas of the highest household energy consumption used between 68% and 124% more energy than the lowest consuming areas, and between 26% and 67% more energy than the average (Chatterton et al., 2016)

From the perspective of the polluter pays principle, it can be argued that there is both an ethical and practical case for asking those households with high levels of energy consumption to bear a greater responsibility for reducing their energy demand. DSR mechanisms could be especially targeted at or encouraged among higher income groups to facilitate reductions or shifts in their energy consumption to off-peak times. Not only do higher income groups contribute relatively more to energy-related environmental threats, but as noted in Section 3.2 they also often have greater flexibility that enables them to more easily alter their energy consumption (e.g. through installing new technologies or energy efficiency measures) and/or to afford higher costs that may be associated with a TOU tariff. This echoes an additional principle of justice in responsibility proposed by Caney (2014): that those who have the greatest ability to enact change should bear the responsibility for that change.

Alternatively, DSR mechanisms could be targeted at those with the largest peak-to-off-peak consumption. With flat rate energy tariffs, customers with low peak to off-peak consumption subsidise those with high peak consumption (Herter, 2007). A TOU tariff has, therefore, been referred to as a 'reward and penalty mechanism', where costs related to peak consumption in the energy system are recovered from those who do not react to peak signals, with the reward going to those who can (Torriti and Leach, 2012, p. 584). Although aligned with principles of energy justice in terms of *Responsibility*, targeting DSR in such ways also carries some ethical risks (an overview of some of these can be seen in Herter, 2007). If implemented via a form of TOU tariff, it could effectively mean that the most affluent households (with the greatest flexibility capital and thus most able to respond to DSR signals) would have the opportunity to profit from lower energy bills, whilst less affluent households (who arguably have a greater need for cheaper energy costs) would be excluded from such benefits. These risks increase the imperative of ensuring that any reductions in overall network costs are passed on to less affluent consumers, as well as adopting policies that can increase the 'flexibility capital' of low-income households – such as subsidised access to smart appliances, home batteries and micro-generation technologies.

A further energy justice risk relates to the sharing of responsibility *within* households. A recent paper by Johnson (2020) has argued that many of the everyday changes that households' undertake to 'flex' their energy demand in response to DSR signals are typically undertaken by women. This echoes previous research, which has demonstrated that behavioural adjustments that aim to alter household energy demand are often culturally-coded as 'feminine' activities and usually undertaken by women (Petrova and Simcock, 2019; Tjørring, 2016). As such, without deep societal changes in gendered divisions labour, there is hypothetically a potential risk that DSR may lead to new or increased domestic workloads that fall disproportionately on women. Johnson (2020) argues that such disparities require further attention in the design of DSR policies, and raises questions about who participates in emerging electricity markets and under what conditions. This is an area that requires further research.

In summary, DSR has the potential for positive justice outcomes via targeting and placing the responsibility of shifting energy practices on those who have the highest income, flexibility capital and energy consumption - particularly at peak times. However, reiterating section 3.2, policy measures to redress inequalities in flexibility capital could enable more households to engage in, and benefit from, energy shifting interventions. Further research would be beneficial in this area, as would more enquiry into the impact of DSR interventions on household roles and responsibilities.

3.5 Due Process, "Countries should respect due process and human rights in their production and use of energy" & Good Governance, "All people should have access to high quality information about energy and the environment and fair, transparent, and accountable forms of energy decision-making"

We now turn to concerns of procedural justice – that is, justice in relation to decision-making processes. The principle of *Due Process* suggests that all those affected by energy projects must be involved in all stages of decision-making about those projects, from agenda setting and design through to implementation and use, and give fair and informed consent for involvement throughout (Sovacool and Dworkin, 2015). It also argues that affected stakeholders must have access to neutral arbitration procedures to handle grievances and administer effective recourse (ibid.). Meanwhile, *Good Governance* proposes that to improve accountability and transparency, high-quality information about energy policies is required.

DSR has been proposed as a method to 'democratise' the energy system, enabling 'empowered' everyday citizens to take a more active role in balancing supply and demand and moving power away solely from big companies and government. However, claims about DSR being a panacea for democratising energy systems have also come under some criticism (Throndsen, 2017). In this section, we suggest that there are real risks that DSR has the potential to both amplify existing procedural injustices and create new ones. We structure our analysis into two distinct phases of decision-making: the process of research and design of DSR technology and policy, and the implementation and usage of DSR in the home.

3.5.1 Research and design stage

Concerning agenda-setting and policy design, it is worth noting that DSR policy development is taking place against a backdrop of broader energy system decision-making processes that are highly technocratic with very limited public participation (Walker and Day, 2012). In relation to the USA, for example, Jones et al., (2015, p. 150) argue that energy policy making "*runs afoul of most theories of procedural justice, which emphasize 'public participation' and 'due process'*". Clear signs of injustice include a lack of gender and ethnic minority representation on the governing bodies of a range of institutions that influence energy policies (Jenkins et al., 2016), with barriers to participation faced by vulnerable actors such as those in energy poverty and/or with disability (Gillard et al., 2017; Sovacool, 2015).

Much of the technological and business-model development for DSR is taking place within the private sector. Although some projects are taking place a degree of public transparency,[12] in many cases it is unseen R&D within companies which involves little direct consumer engagement. Additionally, the omission of public voices is evident in academic research utilised as evidence for DSR policymaking. Despite some notable outliers, there is an evidential bias towards gaining opinions from highly educated and above-average-income participants (van der Werff and Steg, 2016), or intentionally focusing on the non-technophobic public who are deemed most likely to adopt DSR (Parag and Butbul, 2018). The reliance on online market research for understanding expected DSR acceptance (Broberg and Persson, 2016; Fell et al., 2015; Nicolson et al., 2017) omits those who may have very different perspectives on technology introduction. Strikingly, Strengers (2010) commented that some projects have *purposely* avoided working with certain demographic groups due to their perceived vulnerability, as occurred in the UK Low Carbon London Project (UK Power Networks, 2015, p. 17), whilst in some studies, there has been an omission of users entirely (Skjølsvold and Lindkvist, 2015). Instead, without user engagement, DSR systems have been designed for 'ideal users', who are capable of, and interested in, using the associated technologies. Expectations of having access to the internet (Skjølsvold and Lindkvist, 2015) or having simple structured routines meaning households can plan their energy management (Abi Ghanem and Mander, 2014) designs-in exclusions for those who do not. For example, a lead technology designer in the EU DSR EcoGrid project stated "*we all have a smart phone and are using apps because it makes life easier and more fun"* (EcoGrid, 2015, p. 39) – a statement that ignores clear inequalities around internet access and the 'digital divide' more broadly (Office for National Statistics, 2017).

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[12] The UK has an Electricity Network Innovation Competition (NIC) for large R+D demonstration projects. These are led by Distribution Network Operators and funded from Price Controls managed by OfGem, the UK energy regulator

The requirements of *Due Process* and *Good Governance* have not always been evident during the design stage of DSR. Not only is this a form of injustice in itself, but also has a direct influence on distributional justice. Incorporation of lay knowledge into energy policy decision-making can have substantive benefits (i.e. lead to better decision outcomes) (Hoff, 2015) as well as instrumental benefits (by increasing public acceptance and trust in the policy-making process) (Knudsen et al., 2015).

3.5.2 The implementation and use stage

Access to information is a key aspect of procedural justice (Walker and Day, 2012) and has particular importance when considering the installation of new energy technologies (Gillard et al., 2017). For DSR, information provision must include clarity on technologies due to be installed and/or new tariffs, and possible or expected outcomes in relation to cost, comfort and convenience. Additional implications of being involved in a DSR scheme need to be clear, for example, how data is captured, stored and used (Milchram et al., 2018). This information provision needs to be accessible to enable individuals to make informed decisions about their energy services and provide consent.

Importantly, Fell et al., (2014) make a distinction between the acceptance of DSR technology being installed and the acceptance of long term adjustment of energy service provision. In terms of *Due Process*, this suggests that consent is not just required when signing up to DSR but also for individual DSR events. To some extent, consent is clear when households have to actively participate in DSR through manual consumption adjustment. Consent becomes more complicated where no active participation is required from the household for a DSR event to take place – as in the case of direct control or with automated appliances. There is some evidence of DSR trial participants being unhappy at not being able to opt-out or override automated appliances, suggesting a continued desire by some for ultimate control to be with householders (Broberg and Persson, 2016; Mander et al., 2015).

Additionally increased market complexity from DSR presents a risk of procedural injustice if households are unable to navigate the market. Existing tariff complexity, and confusing and unclear billing and contract information are already seen to reduce the ability of some customers from engaging fully (Stearn, 2012). With new consumer-facing intermediary companies (Ofgem, 2019), and DSR being able to act on different electrical loads within the property, this complexity will increase, and this risks amplifying existing injustices. Although somewhat speculative, a scenario could be envisioned where a household may have a TOU tariff which incentivises off-peak electric vehicle charging (e.g. EDF Energy, n.d.)[13], alongside direct load control of electric heating aggregated by the heat pump manufacturer (NEDO, 2017).

Finally, recourse is also an integral part of procedural justice. As Sovacool and Dworkin (2015) state, *"[Due process] necessitates effective recourse through judicial and administrative remedies and forms of redress"*. Whilst general consumer protection for the buying and selling of goods is well developed, and therefore some structures of redress exist for the mis-selling of DSR technologies, redress due to inconvenience caused by faults in hardware or software, or communication errors between technologies, are less well developed. There are several examples of such issues occurring in DSR pilots (Friis and Haunstrup Christensen, 2016; Nyborg and Røpke, 2013). Although such interruptions may seem a mere inconvenience, for some a significant impact may be felt; for example, being dismissed from a job after being late if an electric vehicle didn't charge in time for use. Being able to apportion blame when DSR technology does not perform as intended or required has been problematic (Sweetnam et al., 2018), with compensation for non-financial damages yet to be fully explored. This is of particular concern for the most vulnerable households who suffer the greatest detriment when things go wrong (Ofgem, 2015b).

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[13] A tariff specifically marketed to electric car owners, where electricity is half price at evenings and weekends

Overall, whilst enforcement of strong regulation and bespoke consumer protection may reduce procedural injustice within the installation and use of DSR, pre-empting what is needed is challenging due to market infancy, with pilots often taking place in niches, isolated from the full market (e.g. NEDO, 2017; Sweetnam et al., 2018). The UK regulator acknowledges a need for evolving regulation in line with the developing energy landscape to reduce possible gaps of protection that could lead to a detriment for consumers (Ofgem, 2019, 2017, p. 13). However, without particular forethought in this area, alongside evidence-led policy, there is a risk of procedural injustices taking place before regulation and consumer protection catch up.

4 Conclusion and policy implications

In this paper, we have used the framework of Sovacool and Dworkin (2015) to examine DSR developments through the lens of energy justice. This has brought to the fore aspects of DSR development that require consideration from policymakers, regulators, and those designing DSR schemes if we are to develop a future energy system that is decarbonised but is also just and equitable. Table 3 provides a comprehensive summary of DSR in relation to each of the energy justice principles, with a note to state the strength of the current empirical evidence for each of these. Issues where the evidence is noted as ‘uncertain’ will unlikely be known until full role out of DSR in the market.

Our analysis shows that DSR has the potential for multiple energy justice impacts that span across the whole range of principles proposed by Sovacool and Dworkin, evidencing DSR’s significance in terms of fundamentally altering energy systems. It is crucial to remember that the changes brought about by DSR would not merely be technological, but also inherently social and ethical. Whilst there are several ways that DSR may create opportunities for furthering energy justice, there are also multiple risks of *in*justice that result either by enhancing pre-existing inequities or creating new ones. This problematises the dominant policy narrative which tends to view DSR as inherently positive and beneficial. However, we emphasise that whether these various justice opportunities and risks occur is not inevitable, but rather is contingent on the particular ways that DSR is designed and implemented. Thus, although there are substantial risks of energy injustice arising from DSR, there is still the opportunity to steer it in a more just direction with sufficient and well-designed policies that can mitigate against regressive outcomes (we list some policy recommendations below).

Our review has also highlighted that there are several gaps and limitations in the evidence base around the justice implications of DSR. As Table 3 shows, there are multiple areas where the empirical evidence is currently uncertain or could be further strengthened, and so it is clear that further research is necessary. This includes:

- A greater understanding of the barriers faced by low-income and other households in accessing and using DSR and smart technologies, and how these could be overcome
- Whether and how the potential environmental sustainability benefits of DSR can be optimised, and under what conditions. This should include quantifying the levels of embedded carbon associated with DSR and how this compares to actual carbon savings it achieves
- The financial implications of different forms of TOU tariffs, especially on low-income households and those most vulnerable to energy poverty. This needs to be undertaken in a manner that keeps other variables the same (or as similar as possible) to be able to understand the comparative distributional impacts
- The implications in relation to carbon, and costs born to users, of different DSR design, including the time targeted for consumption reduction and the electrical loads targeted
- The impact of different DSR schemes on household well-being and ability to use necessary energy services when required, particularly focusing on comparing impacts across different householder types with varying energy needs
- The impact of DSR on the division of responsibility within households (e.g. gender relations)

Table 3: Summary of findings in relation to Sovacool and Dworkin's (2015) eight principles of energy justice

Principle	**Opportunities for justice**	**Risks of injustice**
Sustainability & Intergenerational equity	Allows for greater penetration of renewable energy and other low-carbon measures in the electricity network, enabling mitigation of climate change ***(moderate evidence)*** Increased energy system resilience against expected climatic events ***(moderate evidence)*** Reduction of resources required to provide necessary energy services to households ***(uncertain)***	A lack of coordination between different actors may lead to an increased strain placed on the energy network, thereby counteracting energy system gains ***(moderate evidence)*** Resource intensive infrastructure and technology supply chains lead to hidden environmental damage ***(moderate evidence)***
Affordability	Lower aggregate costs for network operation and maintenance can be passed on to consumers via lower bills including/targeted at those most at risk of energy poverty ***(moderate evidence)*** Low-income households are able to adjust their consumption to gain financial benefits of TOU tariffs ***(uncertain)***	Low-income and vulnerable households can face barriers to their ability to engage with DSR and TOU tariff schemes, leaving them unable to access the potential benefits ***(strong evidence)*** Capacity for flexibility of consumption is not universal. Financial penalisation for lack of flexibility can lead to vulnerable households, who are often less able to be flexible, paying more for their energy ***(moderate to strong evidence)***
Availability & Intragenerational equity	Lower energy costs can enable those who currently 'under-consume' to gain greater energy services ***(moderate evidence)***	Obligating or compelling households to reduce their consumption at a time of need risks a loss of comfort or harm to wellbeing ***(uncertain)***
Responsibility	Households pay more per unit of energy when the associated externalities of consumption are higher ***(strong evidence)***	Targeting DSR at all households does not factor in that higher consuming households place a greater strain on the energy system ***(moderate evidence)***
Due process & Good governance	Households can take part in energy system decision making at the micro-scale ***(moderate evidence)***	A lack of diverse voices being heard within the development of policy and technology means exclusions are designed-in for households that do not fit designers concept of the 'ideal user' ***(strong evidence)*** Inaccessible or incomplete information provision may lead to mis-selling or a lack of informed consent ***(uncertain/ moderate evidence)*** Increased market complexity interplays with existing vulnerabilities, reducing households' ability to engage in the market, and makes attributing blame for redress problematic ***(uncertain)***

4.1 Policy recommendations: Developing DSR with justice principles in mind

In conducting this analysis, we have made visible the energy justice implications of DSR. This is the first step in promoting justice and mitigating injustice, because once implications are more visible then decision-making about DSR design and implementation can be made from a position of greater knowledge. Specifically, we believe the following policy measures should be considered to increase the justice of a future DSR roll-out.

Sustainability & Intergenerational equity: Whilst new market actors develop business cases for domestic DSR, any intervention must show how it is contributing to wider system network functions to tackle the injustice of climate change. This requires coordination across different market actors to ensure that shifting of energy consumption does not create new peaks in consumption adding to existing network constraints. These market actors should also be required to assess and minimise life-cycle emissions related to infrastructure and technologies introduced as part of interventions. This must be coordinated between actors to ensure compatibility of technology to reduce equipment redundancy when households change suppliers or services.

Affordability: It is crucial that policymakers recognise that the capacity to be ‘flexible’ and shift energy consumption in response to a DSR signal is highly unequal, and that those with least flexibility capital are also often those who are vulnerable to energy poverty. Additionally, such households can face infrastructural, psychological and skills-based barriers that prevent them accessing DSR schemes. Targeting support to increase the flexibility capital of the least advantaged and enable them to access DSR – for example, through subsidised access to smart appliances, insulation, energy storage technologies or microgeneration – would help ensure the potential opportunities of improving the affordability of energy for the most vulnerable can be maximised. Providing training and information for households in the optimal use of smart home technology is also important. Finally, governments could also regulate to ensure any reductions in aggregate network costs that result from DSR are passed on to those consumers at the greatest risk of energy poverty.

Availability & Intragenerational equity: The celebration in DSR discourse of any consumption change as inherently positive without enquiry into whether there has been a loss of householder well-being risks perpetuates inequalities that exist around access to energy services within the home. DSR interventions must not obligate or compel households to reduce their consumption at times when needed. Energy consumption that can be adjusted without reducing *necessary energy* should be the target of interventions, whilst being cognisant of the different energy needs between households. This infers that a basic level of energy access is a right and should not be jeopardised by market pressures.

Responsibility: For those vulnerable to energy poverty, forms of DSR and TOU tariff that are cost neutral could be prioritised, whilst more penalising forms could be targeted at more affluent consumers (as also suggested by Stokke et al., 2010). This would involve the development of a plurality of DSR schemes, with different forms of incentive available in the marketplace to accommodate the needs of different types of households.

Due process & Good governance: Although domestic DSR provides an opportunity for households to become greater players within the energy system, this role is limited by the DSR offerings designed. Policy decisions cannot be based solely on the views and experiences of self-selecting interested individuals. System development from design to use requires greater input from end-users to ensure the roles developed mirror the needs and desires of a range of households. Furthermore, strong consumer protection measures are required, particularly around the introduction of unregulated businesses to the market, which increases complexity for the consumer both in understanding the options available and gaining redress. Provision of informed consent is integral for the introduction of new technology and/or tariffs, and, once technology is installed, for any automation or direct load control. Enabling households to opt-out of DSR events through accessible design is a first step to ensuring households retain the ability to manage their domestic energy-use practices.

References

Abi Ghanem, D., Mander, S., 2014. Designing consumer engagement with the smart grids of the future: bringing active demand technology to everyday life. Technology Analysis & Strategic Management 26, 1163–1175. https://doi.org/10.1080/09537325.2014.974531

Althaher, S., Mancarella, P., Mutale, J., 2015. Automated Demand Response From Home Energy Management System Under Dynamic Pricing and Power and Comfort Constraints. IEEE Transactions on Smart Grid 6, 1874–1883. https://doi.org/10.1109/TSG.2014.2388357

Anda, M., Temmen, J., 2014. Smart metering for residential energy efficiency: The use of community based social marketing for behavioural change and smart grid introduction. Renewable Energy, Renewable Energy for Sustainable Development and Decarbonisation 67, 119–127. https://doi.org/10.1016/j.renene.2013.11.020

Barnicoat, G., Danson, M., 2015. The ageing population and smart metering: A field study of householders' attitudes and behaviours towards energy use in Scotland. Energy Research & Social Science, Special Issue on Smart Grids and the Social Sciences 9, 107–115. https://doi.org/10.1016/j.erss.2015.08.020

Bartusch, C., Wallin, F., Odlare, M., Vassileva, I., Wester, L., 2011. Introducing a demand-based electricity distribution tariff in the residential sector: Demand response and customer perception. Energy Policy 39, 5008–5025. https://doi.org/10.1016/j.enpol.2011.06.013

Bell, S., Judson, E., Bulkeley, H., Powells, G., Capova, K.A., Lynch, D., 2015. Sociality and electricity in the United Kingdom: The influence of household dynamics on everyday consumption. Energy Research & Social Science, Special Issue on Smart Grids and the Social Sciences 9, 98–106. https://doi.org/10.1016/j.erss.2015.08.027

Bickerstaff, K., 2018. Geographies of energy justice: concepts, challenges and an emerging agenda, in: Handbook on the Geographies of Energy. Edward Elgar Publishing.

Bickerstaff, K., Walker, G., Bulkeley, H., 2013. Energy Justice in a Changing Climate: Social equity and low-carbon energy. Zed Books Ltd.

Boardman, B., 2010. Fixing Fuel Poverty: Challenges and Solutions. Routledge, London.

Bouzarovski, S., Petrova, S., 2015. A global perspective on domestic energy deprivation: Overcoming the energy poverty–fuel poverty binary. Energy Research & Social Science 10, 31–40. https://doi.org/10.1016/j.erss.2015.06.007

Bouzarovski, S., Simcock, N., 2017. Spatializing energy justice. Energy Policy 107, 640–648. https://doi.org/10.1016/j.enpol.2017.03.064

Bradley, P., Leach, M., Torriti, J., 2013. A review of the costs and benefits of demand response for electricity in the UK. Energy Policy, Special Section: Transition Pathways to a Low Carbon Economy 52, 312–327. https://doi.org/10.1016/j.enpol.2012.09.039

Bridge, G., Barr, S., Bouzarovski, S., Bradshaw, M., Brown, E., Bulkeley, H., Walker, G., 2018. Energy and Society: A Critical Perspective. Routledge, Georgetown, CANADA.

Broberg, T., Persson, L., 2016. Is our everyday comfort for sale? Preferences for demand management on the electricity market. Energy Economics 54, 24–32. https://doi.org/10.1016/j.eneco.2015.11.005

Broman Toft, M., Thogersen, J., 2015. Exploring private consumers' willingness to adopt Smart Grid technology. Int. J. Consum. Stud. 39, 648–660. https://doi.org/10.1111/ijcs.12201

Buchanan, K., Banks, N., Preston, I., Russo, R., 2016. The British public's perception of the UK smart metering initiative: Threats and opportunities. Energy Policy 91, 87–97. https://doi.org/10.1016/j.enpol.2016.01.003

Caney, S., 2015. Two Kinds of Climate Justice, in: Goodin, R.E., Fishkin, J.S. (Eds.), Political Theory Without Borders. John Wiley & Sons, Inc, pp. 18–45.

Cappers, P., Spurlock, C.A., Todd, A., Jin, L., 2018. Are vulnerable customers any different than their peers when exposed to critical peak pricing: Evidence from the U.S. Energy Policy 123, 421–432. https://doi.org/10.1016/j.enpol.2018.09.013

Chatterton, T.J., Anable, J., Barnes, J., Yeboah, G., 2016. Mapping household direct energy consumption in the United Kingdom to provide a new perspective on energy justice. Energy Research & Social Science, Energy demand for mobility and domestic life: new insights from energy justice 18, 71–87. https://doi.org/10.1016/j.erss.2016.04.013

Citizens Advice, 2011. Access for all: The importance of inclusive services. London.

Citizens Advice Bureau, 2014. Take a walk on the demand-side: Making electricity demand side response work for domestic and small business consumers. Citizens Advice Bureau, London UK.

Darby, S.J., McKenna, E., 2012. Social implications of residential demand response in cool temperate climates. Energy Policy, Special Section: Fuel Poverty Comes of Age: Commemorating 21 Years of Research and Policy 49, 759–769. https://doi.org/10.1016/j.enpol.2012.07.026

Day, R., Walker, G., Simcock, N., 2016. Conceptualising energy use and energy poverty using a capabilities framework. Energy Policy 93, 255–264. https://doi.org/10.1016/j.enpol.2016.03.019

de Chavez, A.C., 2018. The triple-hit effect of disability and energy poverty: a qualitative case study of painful sickle cell disease and cold homes, in: Simcock, N., Thomson, H., Petrova, S., Bouzarovski, S. (Eds.), Energy Poverty and Vulnerability: A Global Perspective. Routledge, Abingdon, Oxon, pp. 169–187.

Demski, C., Thomas, G., Becker, S., Evensen, D., Pidgeon, N., 2019. Acceptance of energy transitions and policies: Public conceptualisations of energy as a need and basic right in the United Kingdom. Energy Research & Social Science 48, 33–45. https://doi.org/10.1016/j.erss.2018.09.018

Department for Business, Energy & Industrial Strategy, 2019. Digest of United Kingdom Energy Statistics 2019. UK Government, London.

Department for Work and Pensions, 2014. Disability facts and figures [WWW Document]. GOV.UK. URL https://www.gov.uk/government/publications/disability-facts-and-figures/disability-facts-and-figures (accessed 11.29.18).

D’hulst, R., Labeeuw, W., Beusen, B., Claessens, S., Deconinck, G., Vanthournout, K., 2015. Demand response flexibility and flexibility potential of residential smart appliances: Experiences from large pilot test in Belgium. Applied Energy 155, 79–90. https://doi.org/10.1016/j.apenergy.2015.05.101

Dong Energy, 2012. The eFlex Project. Dong Energy, Virum, Denmark.

Doyal, L., Gough, I., 1991. A Theory of Human Needs. MacMillan.

Dupont, B., De Jonghe, C., Olmos, L., Belmans, R., 2014. Demand response with locational dynamic pricing to support the integration of renewables. Energy Policy 67, 344–354. https://doi.org/10.1016/j.enpol.2013.12.058

EA Technology, Durham University, 2015. Developing the smarter grid: The role of domestic and small and medium enterprise customers.

EcoGrid, 2015. EcoGrid EU: From Implementation to Demonstration (No. 150917). Bornholm, Denmark.

EDF Energy, n.d. Home energy tariff for electric car drivers [WWW Document]. EDF Energy. URL https://www.edfenergy.com/electric-cars/tariffs (accessed 2.3.20).

Electricity North West Ltd, 2015. Second Round of Climate change Adaptation Reporting. Electricity North West Ltd, Stockport UK.

Fell, M.J., Shipworth, D., Huebner, G.M., Elwell, C.A., 2015. Public acceptability of domestic demand-side response in Great Britain: The role of automation and direct load control. Energy

Research & Social Science, Special Issue on Smart Grids and the Social Sciences 9, 72–84. https://doi.org/10.1016/j.erss.2015.08.023

Fell, M.J., Shipworth, D., Huebner, G.M., Elwell, C.A., 2014. Exploring perceived control in domestic electricity demand-side response. Technology Analysis & Strategic Management 26, 1118–1130. https://doi.org/10.1080/09537325.2014.974530

Friis, F., Haunstrup Christensen, T., 2016. The challenge of time shifting energy demand practices: Insights from Denmark. Energy Research & Social Science 19, 124–133. https://doi.org/10.1016/j.erss.2016.05.017

Gillard, R., Snell, C., Bevan, M., 2017. Advancing an energy justice perspective of fuel poverty: Household vulnerability and domestic retrofit policy in the United Kingdom. Energy Research & Social Science 29, 53–61. https://doi.org/10.1016/j.erss.2017.05.012

Gough, I., Abdallah, S., Johnson, V., Ryan-Collins, J., Smith, C., 2011. The distribution of total greenhouse gas emissions by households in the UK, and some implications for social policy. Centre for Analysis of Social Exclusion, London School of Economics, London.

Goulden, M., Spence, A., Wardman, J., Leygue, C., 2018. Differentiating ‘the user’ in DSR: Developing demand side response in advanced economies. Energy Policy 122, 176–185. https://doi.org/10.1016/j.enpol.2018.07.013

Hampton, S., 2017. An ethnography of energy demand and working from home: Exploring the affective dimensions of social practice in the United Kingdom. Energy Research & Social Science 28, 1–10. https://doi.org/10.1016/j.erss.2017.03.012

Hargreaves, T., Middlemiss, L., 2020. The importance of social relations in shaping energy demand. Nat Energy 5, 195–201. https://doi.org/10.1038/s41560-020-0553-5

Hargreaves, T., Nye, M., Burgess, J., 2010. Making energy visible: A qualitative field study of how householders interact with feedback from smart energy monitors. Energy Policy, The socio-economic transition towards a hydrogen economy - findings from European research, with regular papers 38, 6111–6119. https://doi.org/10.1016/j.enpol.2010.05.068

Herter, K., 2007. Residential implementation of critical-peak pricing of electricity. Energy Policy 35, 2121–2130. https://doi.org/10.1016/j.enpol.2006.06.019

Herter, K., McAuliffe, P., Rosenfeld, A., 2007. An exploratory analysis of California residential customer response to critical peak pricing of electricity. Energy 32, 25–34. https://doi.org/10.1016/j.energy.2006.01.014

Higginson, S., Thomson, M., Bhamra, T., 2014. “For the times they are a-changin”: the impact of shifting energy-use practices in time and space. Local Environment 19, 520–538. https://doi.org/10.1080/13549839.2013.802459

Hoff, J., 2015. 'Think globally, act locally" Climate change mitigation and citizen participation, in: Hoff, J., Gausset, Q. (Eds.), Community Governance and Citizen-Driven Initiatives in Climate Change Mitigation. Routledge.

Holifield, R., Chakraborty, J., Walker, G. (Eds.), 2018. The Routledge Handbook of Environmental Justice. Routledge, London.

Hu, X., Cotton, I., 2013. Impact of climate change on static ratings of overhead line in Edinburgh, in: Power Engineering Conference (UPEC), 2013 48th International Universities’. pp. 1–6. https://doi.org/10.1109/UPEC.2013.6714985

Jenkins, K., 2018. Setting energy justice apart from the crowd: Lessons from environmental and climate justice. Energy Research & Social Science 39, 117–121. https://doi.org/10.1016/j.erss.2017.11.015

Jenkins, K., McCauley, D., Heffron, R., Stephan, H., Rehner, R., 2016. Energy justice: A conceptual review. Energy Research & Social Science 11, 174–182. https://doi.org/10.1016/j.erss.2015.10.004

Jenkins, K., McCauley, D.A., Heffron, R.J., Stephan, H., 2014. Energy Justice, a Whole Systems Approach. Queen’s Political Review II, 74–87.

Jenkins, K., Sovacool, B.K., Hielscher, S., 2018. The United Kingdom smart meter rollout through an energy justice lens, in: Transitions in Energy Efficiency and Demand: The Emergence, Diffusion and Impact of Low-Carbon Innovation, Studies in Energy Transitions. Routledge, London, pp. 94–110.

Johnson, C., 2020. Is demand side response a woman’s work? Domestic labour and electricity shifting in low income homes in the United Kingdom. Energy Research & Social Science 68. https://doi.org/10.1016/j.erss.2020.101558

Jones, B.R., Sovacool, B.K., Sidortsov, R.V., 2015. Making the Ethical and Philosophical Case for “Energy Justice.” Environmental Ethics 37, 145–168. https://doi.org/10.5840/enviroethics201537215

Khan, A.R., Mahmood, A., Safdar, A., Khan, Z.A., Khan, N.A., 2016. Load forecasting, dynamic pricing and DSM in smart grid: A review. Renewable and Sustainable Energy Reviews 54, 1311–1322. https://doi.org/10.1016/j.rser.2015.10.117

Klinenberg, E., 1999. Denaturalizing disaster: A social autopsy of the 1995 Chicago heat wave. Theory and Society 28, 239–295. https://doi.org/10.1023/A:1006995507723

Knudsen, J.K., Wold, L.C., Aas, Ø., Kielland Haug, J.J., Batel, S., Devine-Wright, P., Qvenild, M., Jacobsen, G.B., 2015. Local perceptions of opportunities for engagement and procedural justice in electricity transmission grid projects in Norway and the UK. Land Use Policy 48, 299–308. https://doi.org/10.1016/j.landusepol.2015.04.031

Leijten, F.R.M., Bolderdijk, J.W., Keizer, K., Gorsira, M., Werff, E. van der, Steg, L., 2014. Factors that influence consumers’ acceptance of future energy systems: the effects of adjustment type, production level, and price. Energy Efficiency 7, 973–985. https://doi.org/10.1007/s12053-014-9271-9

Liddell, C., Morris, C., 2010. Fuel poverty and human health: A review of recent evidence. Energy Policy, The Role of Trust in Managing Uncertainties in the Transition to a Sustainable Energy Economy, Special Section with Regular Papers 38, 2987–2997. https://doi.org/10.1016/j.enpol.2010.01.037

Lunn, P., Lyons, S., 2010. Behavioural Economics and “Vulnerable Consumers”: A Summary of Evidence [WWW Document]. Communications Consumer Panel. URL http://www.communicationsconsumerpanel.org.uk/downloads/what-we-do/previous-projects/access-and-inclusion/Behavioural%20Economics%20and%20Vulnerable%20Consumers%20final%20report%20correct%20date.pdf (accessed 6.10.16).

Mander, S., Abi Ghanem, Dana, Belhomme, Regine, Ignacio, D.E., Gonzalez Sainz-Maza, R., Kessels, K., Lombardi, M., 2015. Socio economic aspects of demand response, in: Integration of Demand Response into the Electricity Chain: Challenges, Opportunities, and Smart Grid Solutions. John Wilet & Sons Inc, London, pp. 215–237.

Marikyan, D., Papagiannidis, S., Alamanos, E., 2019. A systematic review of the smart home literature: A user perspective. Technological Forecasting and Social Change 138, 139–154. https://doi.org/10.1016/j.techfore.2018.08.015

Marmot Review Team, 2011. The Health Impacts of Cold Homes and Fuel Poverty. Friends of the Earth and the Marmot Review Team, London.

Martínez Ceseña, E.A., Mancarella, P., 2018. Smart distribution networks, demand side response, and community energy systems: Field trial experiences and smart grid modeling advances in the United Kingdom, in: Application of Smart Grid Technologies. Elsevier, pp. 275–311. https://doi.org/10.1016/B978-0-12-803128-5.00008-8

McCauley, D.A., Heffron, R.J., Stephan, H., Jenkins, K., 2013. Advancing Energy Justice: The Triumvirate of Tenets. International Energy Law Review 32, 107–110.

McLachlan, C., Glynn, S., Hill, F., Edwards, R., Kuriakose, J., Wood, F.R., 2016. Air conditioning demand assessment. Prepared for Electricity North West, Manchester, UK.

Mert, W., 2008. Consumer acceptance of smart appliances, EIE project "Smart Domestic Appliances in Sustainable Energy Systems" "Smart-A." Intelligent Energy Europe for the European Comission.

Middlemiss, L., Gillard, R., 2015. Fuel poverty from the bottom-up: Characterising household energy vulnerability through the lived experience of the fuel poor. Energy Research & Social Science 6, 146–154. https://doi.org/10.1016/j.erss.2015.02.001

Milchram, C., Hillerbrand, R., van de Kaa, G., Doorn, N., Künneke, R., 2018. Energy Justice and Smart Grid Systems: Evidence from the Netherlands and the United Kingdom. Applied Energy 229, 1244–1259. https://doi.org/10.1016/j.apenergy.2018.08.053

Mukai, T., Nishio, K., Komatsu, H., Uchida, T., Ishida, K., 2016. Evaluating a behavioral demand response trial in Japan: evidence from the summer of 2013. Energy Effic. 9, 911–924. https://doi.org/10.1007/s12053-016-9440-0

National Grid, 2019. Future Energy Scenario July 2019. National Grid, London.

National Grid, 2016. Climate Change Adaptation Reporting, Second Round Response. National Grid, London.

NEDO, 2017. NEDO Implementation Report for Smart Community Demonstration project in Greater Manchester [WWW Document]. URL https://www.greatermanchester-ca.gov.uk/media/1316/implementation-report-for-smart-community-demonstration-project.pdf (accessed 10.22.18).

Neuteleers, S., Mulder, M., Hindriks, F., 2017. Assessing fairness of dynamic grid tariffs. Energy Policy 108, 111–120. https://doi.org/10.1016/j.enpol.2017.05.028

Newsham, G.R., Bowker, B.G., 2010. The effect of utility time-varying pricing and load control strategies on residential summer peak electricity use: A review. Energy Policy, Large-scale wind power in electricity markets with Regular Papers 38, 3289–3296. https://doi.org/10.1016/j.enpol.2010.01.027

Nicholls, L., Strengers, Y., 2015. Peak demand and the 'family peak' period in Australia: Understanding practice (in)flexibility in households with children. Energy Research & Social Science, Special Issue on Smart Grids and the Social Sciences 9, 116–124. https://doi.org/10.1016/j.erss.2015.08.018

Nicolson, M., Huebner, G., Shipworth, D., 2017. Are consumers willing to switch to smart time of use electricity tariffs? The importance of loss-aversion and electric vehicle ownership. Energy Research & Social Science 23, 82–96. https://doi.org/10.1016/j.erss.2016.12.001

Nussbaum, M.C., 2011. Creating Capabilities: The Human Development Approach. Harvard University Press, Cambridge, MA.

Nyborg, S., Røpke, I., 2013. Constructing users in the smart grid—insights from the Danish eFlex project. Energy Efficiency 6, 655–670. https://doi.org/10.1007/s12053-013-9210-1

Office for National Statistics, 2017. Internet access – households and individuals [WWW Document]. People, Population and Community. URL https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/bulletins/internetaccesshouseholdsandindividuals/2017#household-internet-access-continues-to-rise (accessed 6.4.18).

Ofgem, 2019. Our Strategic Narrative for 2019-23. Ofgem, London.

Ofgem, 2017. Future Insight's Series: The Future of Domestic Energy Consumption, Future Insights Series. OfGem, London.

Ofgem, 2015a. The customer-focused smart grid: Next steps for regulator policy and commercial issues in GB, Report of Workstream Six of the Smart Grid Forum, 2015.

Ofgem, 2015b. Consumer Vulnerability Strategy Progress Report. Ofgem, London UK.

Ofgem, 2013. Consumer Vulnerability Strategy. Ofgem, London uK.

O'Sullivan, K.C., 2019. Health impacts of energy poverty and cold indoor temperature, in: Nriagu, J. (Ed.), Encyclopedia of Environmental Health. Elsevier, pp. 436–443.

Palensky, P., Dietrich, D., 2011. Demand Side Management: Demand Response, Intelligent Energy Systems, and Smart Loads. IEEE Transactions on Industrial Informatics 7, 381–388. https://doi.org/10.1109/TII.2011.2158841

Parag, Y., Butbul, G., 2018. Flexiwatts and seamless technology: Public perceptions of demand flexibility through smart home technology. Energy Research & Social Science 39, 177–191. https://doi.org/10.1016/j.erss.2017.10.012

Petrova, S., Simcock, N., 2019. Gender and energy: domestic inequities reconsidered. Social & Cultural Geography 0, 1–19. https://doi.org/10.1080/14649365.2019.1645200

Powells, G., Bulkeley, H., Bell, S., Judson, E., 2014. Peak electricity demand and the flexibility of everyday life. Geoforum 55, 43–52. https://doi.org/10.1016/j.geoforum.2014.04.014

Powells, G., Fell, M.J., 2019. Flexibility capital and flexibility justice in smart energy systems. Energy Research & Social Science 54, 56–59. https://doi.org/10.1016/j.erss.2019.03.015

Pudjianto, D., Strbac, G., 2017. Assessing the value and impact of demand side response using whole-system approach. Proceedings of the Institution of Mechanical Engineers, Part A: Journal of Power and Energy 231, 498–507. https://doi.org/10.1177/0957650917722381

Qadrdan, M., Cheng, M., Wu, J., Jenkins, N., 2017. Benefits of demand-side response in combined gas and electricity networks. Applied Energy 192, 360–369. https://doi.org/10.1016/j.apenergy.2016.10.047

Sayer, A., 2014. Why We Can't Afford the Rich. Policy Press, Bristol.

Schlosberg, D., 2004. Reconceiving Environmental Justice: Global Movements And Political Theories. Environmental Politics 13, 517–540. https://doi.org/10.1080/0964401042000229025

Sherriff, G., 2016. 'I was frightened to put the heating on.`, Evaluating the Changes4Warmth approach to cold homes and mental health. Sustainable Housing & Urban Studies Unit Salford University.

Skjølsvold, T.M., Lindkvist, C., 2015. Ambivalence, designing users and user imaginaries in the European smart grid: Insights from an interdisciplinary demonstration project. Energy Research & Social Science, Special Issue on Smart Grids and the Social Sciences 9, 43–50. https://doi.org/10.1016/j.erss.2015.08.026

Skjølsvold, T.M., Ryghaug, M., Berker, T., 2015. A traveler's guide to smart grids and the social sciences. Energy Research & Social Science, Special Issue on Smart Grids and the Social Sciences 9, 1–8. https://doi.org/10.1016/j.erss.2015.08.017

Smale, R., van Vliet, B., Spaargaren, G., 2017. When social practices meet smart grids: Flexibility, grid management, and domestic consumption in The Netherlands. Energy Research & Social Science 34, 132–140. https://doi.org/10.1016/j.erss.2017.06.037

Smith, P., McDonough, M., 2001. Beyond Public Participation: Fairness in Natural Resource Decision Making. Society & Natural Resources 14, 239–249.

Snell, C., Bevan, M., Thomson, H., 2015. Justice, fuel poverty and disabled people in England. Energy Research & Social Science 10, 123–132. https://doi.org/10.1016/j.erss.2015.07.012

Snell, C., Lambie-Mumford, H., Thomson, H., 2018. Is there evidence of households making a heat or eat trade off in the UK? Journal of Poverty and Social Justice 26, 225–243. https://doi.org/10.1332/175982718X15200701225205

Song, X., Wang, S., Hu, Y., Yue, M., Zhang, T., Liu, Y., Tian, J., Shang, K., 2017. Impact of ambient temperature on morbidity and mortality: An overview of reviews. Science of The Total Environment 586, 241–254. https://doi.org/10.1016/j.scitotenv.2017.01.212

Sovacool, B.K., 2015. Fuel poverty, affordability, and energy justice in England: Policy insights from the Warm Front Program. Energy 93, Part 1, 361–371. https://doi.org/10.1016/j.energy.2015.09.016

Sovacool, B.K., Dworkin, M.H., 2015. Energy justice: Conceptual insights and practical applications. Applied Energy 142, 435–444. https://doi.org/10.1016/j.apenergy.2015.01.002

Sovacool, B.K., Heffron, R.J., McCauley, D., Goldthau, A., 2016. Energy decisions reframed as justice and ethical concerns. Nature Energy 1, 16024. https://doi.org/10.1038/nenergy.2016.24

Sovacool, B.K., Lipson, M.M., Chard, R., 2019. Temporality, vulnerability, and energy justice in household low carbon innovations. Energy Policy 128, 495–504. https://doi.org/10.1016/j.enpol.2019.01.010

Sovacool, B.K., Sidortsov, R.V., Jones, B.R., 2014. Energy Security, Equality and Justice. Routledge, London.

Stearn, J., 2012. Tackling consumer vulnerability: An action plan for empowerment. Consumer Focus, Citizens Advice and Citizens Advice Scotland, London, UK.

Stokke, A.V., Doorman, G.L., Ericson, T., 2010. An analysis of a demand charge electricity grid tariff in the residential sector. Energy Efficiency 3, 267–282. https://doi.org/10.1007/s12053-009-9071-9

Strbac, G., 2008. Demand side management: Benefits and challenges. Energy Policy, Foresight Sustainable Energy Management and the Built Environment Project 36, 4419–4426. https://doi.org/10.1016/j.enpol.2008.09.030

Strengers, Y., 2010. Air-conditioning Australian households: The impact of dynamic peak pricing. Energy Policy, Energy Efficiency Policies and Strategies with regular papers. 38, 7312–7322. https://doi.org/10.1016/j.enpol.2010.08.006

Sweetnam, T., Fell, M., Oikonomou, E., Oreszczyn, T., 2018. Domestic demand-side response with heat pumps: controls and tariffs. Building Research & Information 0, 1–18. https://doi.org/10.1080/09613218.2018.1442775

Thomas, G., Demski, C., Pidgeon, N., 2020. Energy justice discourses in citizen deliberations on systems flexibility in the United Kingdom: Vulnerability, compensation and empowerment. Energy Research & Social Science 66, 101494. https://doi.org/10.1016/j.erss.2020.101494

Thomson, H., Simcock, N., Bouzarovski, S., Petrova, S., 2019. Energy poverty and indoor cooling: An overlooked issue in Europe. Energy and Buildings 196, 21–29. https://doi.org/10.1016/j.enbuild.2019.05.014

Throndsen, W., 2017. What do experts talk about when they talk about users? Expectations and imagined users in the smart grid. Energy Efficiency 10, 283–297. https://doi.org/10.1007/s12053-016-9456-5

Tindemans, S., Djapic, P., Schofield, J., Ustinova, T., Strbac, G., 2014. Resilience performance of smart distribution networks, Report D4 for the “Low Carbon London” LCNF project: Imperial College, London.

Tjørring, L., 2016. We forgot half of the population! The significance of gender in Danish energy renovation projects. Energy Research & Social Science 22, 115–124. https://doi.org/10.1016/j.erss.2016.08.008

Torriti, J., 2012. Price-based demand side management: Assessing the impacts of time-of-use tariffs on residential electricity demand and peak shifting in Northern Italy. Energy, Integration and Energy System Engineering, European Symposium on Computer-Aided Process Engineering 2011 44, 576–583. https://doi.org/10.1016/j.energy.2012.05.043

Torriti, J., Leach, M., 2012. Making The Least Active Pay: A Simulation of Rewards and Penalties Under Demand Side Participation Programs. International Journal of Green Energy 9, 584–596. https://doi.org/10.1080/15435075.2011.625582

Toth, N., Little, L., Read, J.C., Fitton, D., Horton, M., 2013. Understanding teen attitudes towards energy consumption. Journal of Environmental Psychology 34, 36–44. https://doi.org/10.1016/j.jenvp.2012.12.001

UK Power Networks, 2015. Low Carbon London Project Close Down Report V.10. UK Power Networks, London UK.

van der Werff, E., Steg, L., 2016. The psychology of participation and interest in smart energy systems: Comparing the value-belief-norm theory and the value-identity-personal norm model. Energy Research & Social Science 22, 107–114. https://doi.org/10.1016/j.erss.2016.08.022

Vanthournout, K., Dupont, B., Foubert, W., Stuckens, C., Claessens, S., 2015. An automated residential demand response pilot experiment, based on day-ahead dynamic pricing. Applied Energy 155, 195–203. https://doi.org/10.1016/j.apenergy.2015.05.100

Walker, G., Day, R., 2012. Fuel poverty as injustice: Integrating distribution, recognition and procedure in the struggle for affordable warmth. Energy Policy, Special Section: Fuel Poverty Comes of Age: Commemorating 21 Years of Research and Policy 49, 69–75. https://doi.org/10.1016/j.enpol.2012.01.044

Walker, G., Simcock, N., Day, R., 2016. Necessary energy uses and a minimum standard of living in the United Kingdom: Energy justice or escalating expectations? Energy Research & Social Science, Energy demand for mobility and domestic life: new insights from energy justice 18, 129–138. https://doi.org/10.1016/j.erss.2016.02.007

Western Power Distribution and Wales & West Utilities, 2018. Freedom project final report. Western Power Distribution, South Wales.

White, L.V., Sintov, N.D., 2020. Health and financial impacts of demand-side response measures differ across sociodemographic groups. Nat Energy 5, 50–60. https://doi.org/10.1038/s41560-019-0507-y

Wilson, C., Hargreaves, T., Hauxwell-Baldwin, R., 2017. Benefits and risks of smart home technologies. Energy Policy 103, 72–83. https://doi.org/10.1016/j.enpol.2016.12.047