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Differentiating 'the user' in DSR: Developing demand side response in advanced economies

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ABSTRACT

This paper reports on the current state of Demand Side Response (DSR) in the UK – an early adoptor amongst advanced economies – and the role of the end user in determining its future. Through 21 expert interviews we establish the current state of DSR, and expectations for its development. Whilst non-domestic DSR appears healthy, if fragile, domestic DSR is considered to be currently unviable, it's future success dependant on market innovations. In following how that situation is expected to change, we highlight key assumptions about prospective end users. These assumptions are shaping the efforts of the industry actors tasked with delivering DSR. We identify two visions of the user, one passive whilst technologies automate on their behalf, the other integrated to the point of themselves being an automaton. We detail a series of concerns about the limitations of these user visions, and the ability of industry to reach beyond them towards a more differentiated view. We conclude with a call to broaden the institutional landscape tasked with delivering DSR, in order to foster a greater diversity of end user roles, and ultimately greater demand responsiveness from a broader user base.

1. Introduction

In order to mitigate the threat of climate change, states are seeking to drastically reduce carbon emissions from their energy systems. Many are transitioning towards low carbon, renewable energy sources. The growth of renewable generation with fluctuating output complicates the fundamental operating requirement of electricity grids to constantly balance supply and demand. Even without such energy sources, this balancing requirement results in ongoing inefficiencies for generation and transmission because it means coping with the 'peaky' demand profiles that societies generate through the mass organisation of activity (e.g. the '9–5 working day') (Grünewald and Torriti, 2013). These fluctuations in both supply and demand create a strong case for the kind of flexibility Demand Side Response (DSR) promises. Domestic DSR is also positioned as a powerful tool for addressing energy poverty (Koirala et al., 2016).

DSR seeks to shift or reduce energy demand, both domestic and non-domestic, in response to excess or restricted availabilities of energy on the grid. This response might be in real time (i.e. automated), near real time (for example sending a signal to users), or prospective (for example fixed Time of Use tariffs which discourage consumption during high demand periods). The potential for DSR is part of the justification for smart meters, currently being rolled out in the UK at a cost of £11bn, and in many other countries across the world (Sovacool et al., 2017). Under the EU's 2030 Climate & Energy Framework (European Commission, 2016), member states are committed to 40% cuts in greenhouse gas emissions by 2030. Notably, most key future energy scenarios in the UK that have been developed in the past decade include DSR (e.g. UKERC, 2013), though how DSR will actually mature is less clear.

Key to realising DSR's promise is the end user. Traditionally, whether domestic or non-domestic, the *end* user has been just that – an isolated, terminal node consuming energy as and when required to meet their needs, which the grid is constantly managed to provide. By contrast, DSR requires that this actor becomes an integrated, dynamic component in the balancing of supply and demand. How the end user is enrolled to play this part is the key uncertainty to which we turn this paper's attention. Whilst previous research has envisaged how end users may play a greater role in the transition to low-carbon economies, (Foxon, 2013), and examined how end users might be expected to engage and interact with DSR (Mert et al., 2008; Spence et al., 2015), there has been little attention given to perceptions of end users held by system builders, and the way that the expectations of end users shape the development of DSR (Chilvers et al., 2018). We formulate this uncertainty as a question of sociotechnical design – what are the characteristics of this new user imagined by architects of DSR, and how

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amenable to technical intervention are they?

Following Akrich's (1992) notion of technological scripting, we argue that this imagined user will ultimately be rendered concrete enough to heavily influence DSR's mature form. Our study, consisting of expert interviews, focuses on DSR within the UK but we emphasise that similar energy system developments and debates around smart energy futures are ongoing, and relevant to, many other economies.

The paper proceeds by first outlining existing critiques of predominant energy policy. We then report on the current state of DSR in the UK, before focusing on how domestic DSR is expected to proceed over the next decade, drawing out two predominant visions of the user held by our expert interviewees. We subsequently identify three underlying concerns with this picture, discuss the implications of these observations, and put forward recommendations for ensuring that domestic DSR fulfils its environmental and economic potential.

2. Theorising the user in energy policy

Current DSR policy initiatives have emphasised the importance of incentivising behaviour change through dynamic pricing tariffs (Faruqui et al., 2010) and engaging citizens with the need for reducing carbon emissions (Spence et al., 2015; Whitmarsh et al., 2011), alongside the rollout of technologies (including smart meters and in-home energy displays) to engage citizens in 'smarter' energy use (Hargreaves et al., 2010). Research suggests that public acceptance of DSM Is likely to vary a great deal depending on the device and the way it is operated, with particular concerns where comfort and health standards are perceived to be threatened (Mert et al., 2008; Butler, Parkhill and Pidgeon, 2013).

Some limited research has considered interactions around DSR. In particular, privacy protections and data sharing have been discussed as necessities for many forms of DSR. Whilst privacy concerns appear limited amongst UK publics, this has been a key issue in other countries, and in the UK, a significant proportion of the population express unwillingness to share energy data (Spence et al., 2015). There are also some, predominantly economic, investigations of interactions between DSR users indicating, for example, cooperation is possible around energy demand scheduling (Mohsenian-Rad et al., 2010). We also note that there is some evidence that oversimplistic DSR programmes may be manipulated by consumers in order to make money (Chao and DePillis, 2013; Chen and Kleit, 2016).

Critics have raised fundamental concerns about the predominance of energy policy approaches that implicitly individualise the carbon reduction problem (Shove, 2014; Strengers, 2012). These concerns feature in Strengers' critique (2014) in which she argues that the 'solution' to the problem of carbon reduction is typically envisaged in conventional policy thinking as an 'engaged consumer' whom she dubs 'Resource Man'. Strengers elaborates that Resource Man is imagined to be a responsive and rational economic agent, styled in the image of the male engineers who design for him. He both actively monitors and automates energy consumption, and is perfectly integrated with price signals and the latest smart technologies, in order to ensure that the optimally efficient level of energy consumption is achieved. However, Strengers argues that the characterisation of individualised energy use promoted by this model grossly misrepresents the aspirations and practical realities of most people's energy consumption by glossing over key social dynamics and processes, that figure in the context of everyday experiential understandings of energy use.

In response, critics have called for a more contextualised view to better account for the wider socio-cultural, organisational, and political milieu implicated in social practices of energy consumption (Hargreaves, 2011; Shove, 2003). Whilst variation exists in the conceptualisation of 'practices' as a unit of analysis, they are commonly theorised as dynamically integrated assemblages of skills, materials and technologies, and meanings that emerge and become stabilised through their performance until such time as the links between them are undermined, broken, or replaced, and they subsequently die out (Shove and Pantzar, 2005). Rather than focussing on the 'moments' of individual behaviour and decision making, this more holistic approach attends to wider considerations including how practices operate and change, and what goals energy consumption seeks to achieve (Shove et al., 2012; Sweeney et al., 2013).

The broader policy implications of a practice theory perspective is that demand management is complicated and qualified by the variable social contours and trajectories of peoples' energy use. This has led to proposals for decentering the current emphasis on steering individualised energy consumption from the top down and repositioning demand management in more open terms in order to effectively engage with localised and collective practices and cultures of energy consumption (Chilvers and Longhurst, 2016). For example, alternative notions of the 'Energy Citizen' assert the necessity of public participation in energy governance and policy-making processes at all levels, incorporating ideas of sustainable development such as taking responsibility for climate change, fairness, and promoting the welfare of communities and future generations (Devine-Wright, 2007). Using this frame, citizens, practitioners, and other locally-situated stakeholders are considered to have a close understanding of how current assemblages of understandings, infrastructures, and practical knowledge are reproduced through daily routines at home, in the market, and in the workplace, and might therefore hold other key insights into how organised relations of energy consumption can be reconfigured to bring about significant cultural change (Foster et al., 2012; Stephenson et al., 2010).

A growing number of policy programmes and local initiatives have accordingly begun to illustrate the potentials of Energy Citizen ideals through such means as community renewable energy projects, localised micro energy generation, and energy co-operatives (Devine-Wright, 2007). In line with this, in 2014 the UK government published its 'Community Energy Strategy' (DECC, 2014) with the goal of supporting sector development. Whilst welcoming of the Strategy's intentions, Smith et al. (2016) have questioned whether such an approach risks imposing a "micro-utility" (P.429) template on community energy which ultimately hampers its effectiveness at sourcing alternative solutions. More recently practitioners have highlighted how simultaneous cuts in funding support have been detrimental to the goals of the Strategy (Community Energy England, 2017). These developments thus raise key questions about what elements have been put in place or are missing, and what links now need to be made, in order to overcome current obstructions to more sustainable energy practices (Shove, 2014). Yet, despite notable shifts in discussions around the conceptualisation of the user within energy demand broadly, there is little empirical evidence on how system builders within industry and policymaking perceive the role of DSR users (Chilvers et al., 2018). Given how key users are to achieving the vision of DSR, addressing these gaps is imperative. This research sets out how DSR users are conceptualised among stakeholders, and how these different conceptualisations affect possibilities for enacting future DSR policies.

3. Methods

The study draws on 21 semi-structured expert interviews carried out in late 2016 and early 2017. Interviews obtained the views of a range of participants engaged in the energy sector (see Table 1). Participants were recruited through existing contacts and snowballing, in part using the authors' own expert knowledge of the field to identify suitable participants (Littig, 2009, p. 103). The intention was to capture a snapshot of current expectations and intentions for DSR across a diverse range of stakeholders, and particularly the role of 'end users'.[2] Our

[2] 'End users' is a potentially problematic term to use in describing agents who are expected to have active roles in the functioning of the electricity grid, in its

Table 1
Breakdown of participants by sector role.

Subsector [tag]	Count
Policy [P]	5
Large industry [LI]	3
SME industry [SME]	3
Academic [A]	4
Third sector [TS]	6

interest in experts' knowledge was not as a source of 'facts', but rather as indicative of their own, and their community's, efforts in shaping the future of DSR (Bogner et al., 2009). Accordingly, our experts included both those within the domains of government and industry which are most directly driving DSR developments, and those in the third sector and academia who might offer more critical perspectives (Meuser and Nagel, 2009). Interviews primarily took place by Skype or phone (two were face-to-face), lasted around one hour, and were audio recorded before being transcribed.

A social practice theory frame, as described in Section 2, was used to orientate our interview questions and subsequent analysis. Interview questions elicited participant's perspectives concerning the following issues: how participants currently conceived of energy consumption as problematic; how they defined their involvement with DSR, along with the involvement of other respective stakeholders; their understandings of strategies currently employed to promote DSR; their conceptions of how energy practices are likely to change in the future; and what key enablers to DSR practices will be required for more sustainable changes in energy use to materialise.

All of the interviews were coded thematically in Nvivo software. A first round of low-level coding was used to group data with a minimum of interpretation. Two subsequent rounds of coding drew on a practice theory frame to distill preliminary codes into broader interpretations. Five interviews were second-coded by another team member and over two iterations (rounds 1 & 2) were compared with the first researcher's codings. Where differences were identified they were reflected on by the team and implications for analysis folded back into the coding. To help ensure the internal validity of the research findings, our interpretations of the data were reported back to study participants for their feedback and comments (Yin, 2003).

4. Current DSR in the UK

Assessing the current UK development of DSR, it should be noted how young this field is. Although the notion of demand side response is not new – following capacity constraints the US began experimenting with it in the early 2000s – it was only with the passing of the Energy Act in 2013 that the UK grid regulator OFGEM was empowered to launch a capacity market to spur development of demand side measures. Amongst European states, where comparisons are perhaps most apt, the UK was a frontrunner, alongside Belgium and Switzerland (SEDC, 2014). In 2014 the Committee on Climate Change [CCC] – the UK's independent body monitoring progress towards future carbon targets – first included 'demand response' amongst their list of required measures in their annual *Report to Parliament* (2014).

Despite its relative youth, consideration of the field's development needs to be set in the context of the ambition of the UK's carbon targets, given greater impetus by record global temperatures in 2015 and 2016. Notably, the CCC's (2017) report highlights demand response amongst areas requiring stronger policy implementation. This is then a timely moment to assess DSR in an advanced economy.

The cultural shift required of energy network actors by the adoption of DSR is far from trivial. The contrast with traditional energy generation and the risks involved is here highlighted by one of the policy makers spoken to:

> *people are quite risk averse in this area […] clear generation solutions are more dependable than demand side solutions, because they are physical assets, people understand those assets and how to pay for them and how to turn them on. [P1]*

Nevertheless, the belief that change – in the form of greater grid flexibility – is required was universally held amongst experts spoken to. Where experts were more equivocal is on what this shift will entail.

Discussing progress on DSR developments to date, experts reported a sharp distinction between domestic and non-domestic DSR. Whilst there is seen to be considerable scope for further growth, non-domestic DSR was seen to be in good health, with expansion across both industry and larger commercial operators. For such operators, using equipment with large but potentially flexible demand (e.g. industry using heating processes, commercial operators using refrigeration), they not only have a clear financial case for DSR due to the scale of their energy consumption, but crucially through well established 'audit cultures' have the practical means to achieving it (Brown, 2010; Kragh-Furbo and Walker, 2018):

> *they have the scale of demand available, it's concentrated, it's more readily metered, it's settled on a half-hourly basis, they can have sub-metering in order to analyse that demand on potentially a second by second basis. [LI1]*

This progress is seen as fragile however. A concern, articulated by aggregators providing DSR services to commercial and industrial operators, was the degree to which non-domestic DSR was reliant on both ongoing political support, and regulatory mechanisms which currently produce unstable market conditions. In light of the political uncertainties around austerity and Brexit, and the recent history of UK energy policy, which has seen the collapse of the domestic PV installation market following abrupt changes to the Feed-In Tariff scheme, the possibility of similar developments in the capacity market was a concern. A larger threat however was perceived to be uncertainties in how the capacity market is structured. One aggregator suggested that volatility in prices was hampering the development of the non-domestic DSR sector by putting off potential customers:

> *What happened with a lot of customers actually in Britain that we met is they […] lost confidence in the whole area of the demand side, they said "actually I did that before and I got six months out of it and then it wasn't worth my while after that." It was very hard for us to talk to the customer and say well we can guarantee you this grid price forever, when for example we've already seen a drop off in price in our particular service and frequency response, and that was purely down to the market putting in things like diesel and stuff into the service that we were delivering. [SME1]*

This tension was recognised by policy makers, who in ceding control to market forces have experienced their own thwarted intentions for the capacity market – previous iterations of the capacity market auctions inadvertently encouraged the growth of highly polluting diesel generation as the cheapest solution for load balancing. That means of curtailing the incentives for diesel are now being sought reminds us that the market is ultimately a political artefact (Davies, 2014), but under the neoliberal model of governance practiced in the UK, such direct political intervention is largely reactive, and not able nor intended to prevent short-term instability. Nevertheless, our interviews indicated

(*footnote continued*)
implication that they come at the 'end' of the process. The use of the term here is a deliberate choice to reflect the imaginaries of the designers of this process, as described in this paper. As we shall see, there is a clear tension between proposed active and passive roles.

that the perceived benefits of a market-led approach (which we return to below) were such that it remains the preferred approach amongst Westminster [3] policy makers:

> *[T]here has been a view from some quarters of the industry that the system requires system architects in charge of it. That's not where we are – the players involved are all pretty committed to the market. The thing with the market is that it could overshoot, it could go off in unpredictable directions – we've seen that with DSR and the unintended growth of new diesel generation, that the market came up with. So there is an interesting aspect to this about how you do public policy in a space where there are unknowns from a consumer side, but also commercial actors are constructing their strategies and investing in things and we don't necessarily know what they are thinking of. [P1]*

4.1. Domestic DSR

The domestic DSR [dDSR] sector in the UK is similarly characterised by a market-led approach, but is far less advanced. Amongst experts from all fields spoken to, domestic DSR in the UK is widely seen as being unviable for the time being. As with the non-domestic sector, government is active in seeking to foster a dDSR market, but here its current efforts are of a more fundamental nature, in establishing – through the smart meter rollout – an infrastructure to enable the systems of measurement which are a prerequisite for a market to function. The more granular billing enabled by smart metering is seen to open up possibilities for tracking and, ultimately, incentivising demand response in the home. Whilst there was agreement amongst experts that smart metering was a necessary first step to making dDSR possible, there was far less clarity over what subsequent steps will be. What was clear amongst those spoken to is that the existing approach for non-domestic DSR does not work at the domestic scale:

> *it can't just be this conventional utility aggregator programmes where an aggregator is going out knocking door-to-door and making a £200 capital investment in that customer in order to then get demand reduction from that customer over time. [TS1]*

The size of any domestic demand response was considered simply too small to justify the necessary investment by third parties. Similarly, there were doubts about installing the necessary hardware in the form of white goods to allow for automated demand response – one policy maker who conducted preliminary modelling of this found the economics to be currently unpersuasive. Indeed, the challenges of modelling dDSR appear to be an important factor in policy makers' limited engagement. The uncertainty contributes to a situation in which policy makers report that dDSR is problematic for them organisationally. UK energy policy is heavily influenced by modelling, specifically in the form of the Dynamic Dispatch Model[4] used by BEIS.[5] Policy makers spoken to reported that currently, their capacity for modelling dDSR is very limited, due to a shortage of data, regarding both the cost of technology, and – of particular interest here – "*the behavioural side*" [P2]. Within BEIS, the uncertainty around dDSR impacts on internal decision making as to the best means of distributing resources between different energy sector programmes. This challenge is particularly acute when dDSR is evaluated alongside more "*obvious and proven*" [P2] technologies. Grid-scale storage was named as an example of such a technology, which evidences the first quote in this section on the preference for *physical assets*. Storage effectively works much like traditional generation, without complicating end users to factor into the modelling. As a consequence, whilst those we spoke to are optimistic about dDSR, it was clear that there is no consensus amongst policy makers that dDSR is worth investing resources in beyond the smart meter rollout. For policy makers, the necessary next step is for market actors to fill in the perceived evidence gap:

> *There are no inherent barriers to modelling DSR, it's just you need a certain amount of actual commercial activity to have empirical evidence about how things will work, and then you need models of factoring that in. So I think it's just a work in progress. [P1]*

It should be noted that devolved administrations in Wales and Scotland offer an alternative stance to the UK Government's. Both have taken a more involved approach regarding evidence generation, through supporting community-led, non-profit energy schemes. We return to such schemes below.

Perhaps surprisingly, given the uncertainty around how dDSR will be achieved, only two experts questioned whether it would happen at all, though given the non-random interview sample we cannot extrapolate from this. From the dissenting voices, there was a suggestion that whilst dDSR is theoretically useful in the current transitionary stage of the grid, as renewables mature, and importantly interconnections with other grids increase, the need for demand response may lessen – certainly where used as an irregular option to address particularly extreme peaks, for which it might be uneconomical. One of these experts did see value in dDSR as an ongoing technique for dissuading peak demand through such measures as simplified time of use (TOU) tariffs but questioned – echoing those above – how this might best be achieved in practice.

One factor in dDSR's favour is industry support. Despite the uncertainties about how it can be realised, or perhaps because of them, there was a conviction amongst industry members spoken to that domestic DSR offers them considerable commercial opportunities. There is an element of dDSR being 'everything to everyone' – for new entrants to the energy supply and consumer device markets, dDSR promises to disrupt the dominance of incumbents, allowing newcomers to target emerging niches or differentiate themselves with novel technologies and services. The incumbents, facing threats of energy price caps from politicians, talk of pivoting from supply to services. Decentralisation poses a clear threat to existing business models; in dDSR they see the opportunity to create a virtuous circle between selling ancillary services and extracting ever-more customer data upon which further services might be built. Finally, for those offering technology and engineering services to customer-facing businesses large and small, dDSR promises demand for new infrastructures, equipment, and techniques.

To conclude on the current state of DSR, across our interviewees there was a widely held view that dDSR will become established *in some form* over the next decade, and a clear interest amongst industry in the new commercial opportunities that are expected to emerge with it. It remains, however, little more than a vision at this moment. By contrast, whilst still vulnerable, non-domestic DSR has an established foothold, underpinned by a clear economic case and a pre-existing set of readily-adaptable accounting practices. There is a debate to be had as to whether the current market is excessively unstable, and whether a more pronounced 'system architect' role might be beneficial, but for this paper's focus on end users, we turn our attention in the remainder of this paper to dDSR. Here far more question marks remain.

5. Where is the user?

The key uncertainty around dDSR is end users: it is, currently, a wholly technological programme driven by policy and commercial interests. Technology was seen by our interviewees as enabling dDSR in two forms. Firstly, as already noted, the smart meter rollout will,

[3] "Westminister" here refers to the UK Government – being the location of the main institutions of state – and distinguishes from the devolved administrations – in Cardiff and Edinburgh – which have partial control over Wales and Scotland respectively.

[4] Though the Dynamic Dispatch Model now covers both supply and demand, that its name only refers to the former is another reminder of the shift entailed by demand response.

[5] The Department for Business, Energy & Industrial Strategy (BEIS) is the UK Government Department responsible for energy.

through the standardised creation and transmission of measurement data, provide the necessary infrastructure required for a market in dDSR. Secondly, building on notions of the Internet of Things, and particularly the 'smart home' vision, networked technologies will present the means for automating or reshaping various demand response practices within the home. These twin developments are interlinked – smart meter data will provide much of the 'ground truth' upon which automation and information feedback systems will rely, which will in turn realise the economic potential created by the metering infrastructure. During discussions of dDSR there was a tendency to render the end user invisible, as can be seen in the following assessment of a policy expert, in whose account people are sublimated to different forms of adopted technology:

there will be lots of innovation, and people will segment different types of consumer. So there will be adjustments for storage heaters, a cohort for electric vehicle consumers or electric heat pumps, who have large loads who need to be managed not to exacerbate critical peaks. [P1]

Present amongst this innovation discourse is the expectation that in melding demand response with the 'smart' programmes of the Silicon Valley tech sector, the successes those companies have achieved in 'disrupting' media, advertising, transport etcetera, will be replicated within the energy grid:

if Apple get involved more […] it creates a platform for more things to happen. So if things carry on as they are I don't know how much that smart meter data will be used, but I think I see enough interest and talk that would suggest that more will be done. If the likes of Apple get involved and they have home hubs that are able to control as well as monitor then that will be a really interesting one. [TS2]

Further cementing the blurring of energy and smart home markets, several experts commented that with no clear economic case currently existing for dDSR, progress will rely on consumers adopting smart technologies for other intentions (e.g. convenience or comfort) which can be repurposed for energy demand response. Google's Nest thermostat provides such an example. The Nest is marketed as a product that will save consumers both money and effort through automation, but relies heavily on a premium design aesthetic which renders it at least as much as lifestyle product as a functional utility controller. Once adopted it creates the possibility of demand response heating and cooling, a service it is now offering in the US. A second potential route for dDSR into the home, raised by interviewees, is as an add-on service which could lower the high upfront capital costs of a purchase, such as solar panels, an electric vehicle, or a heat pump.

In effectively smuggling demand response into the home, in the form of networked technologies foregrounding other services, there is no requirement for a shift in the role of the end user. The domestic end user has historically been a highly passive role – as we argued in previous work (Goulden et al., 2014) – and this has been by design. The continuation of this role is seen in one industry expert's summation of how dDSR might operate once in the home:

There's two ends to [dDSR] really, that either it needs to be completely hidden and the end user doesn't see it, doesn't interact with it, doesn't know or care anything about it. It just gets the benefit and they can ignore it. Those kind of things customers like. The other option then is that you almost turn it into a game. You provide loads of people competing against each other, or you provide those kind of very clear, very heavily interactive end of things instead. [LI2]

The quote contains two strategies for enrolling the user's home as a functioning unit in the electricity grid: automation, in which the user remains passive, and gamification, in which the user is motivated to alter their practices through the application of game mechanics. Whilst presented in this account as opposing approaches, they in fact share a common root. As used here, gamification consists of "*impos[ing] game elements into the lives of other people, purporting to improve their experiences without genuine engagement or dialogue*" (Woodcock and Johnson, 2017, p. 6). As a consequence, gamification typically does "*not aim to change the way people think, but how they behave*" (Schrape, 2014, p. 22). Effectively, such forms of gameful design seek to render the user themselves an automaton, mechanistically responding to the grid's demands just as their automated technologies do.

In Strenger's (2014) discussion of Resource Man, she identifies a number of mechanisms through which the figure is enrolled in the grid. Alongside gamification and automation, this includes energy feedback, TOU tariffs, and micro-generation (p.27). Whilst automation might at first glance appear extraneous given the active role Resource Man is imagined to adopt, recall that this figure is fundamentally concerned with optimisation, through the rational application of technology and associated skills. In the sense that Resource Man acts as a utility "*Mini-Me*" (p.26), the notion of him as automated – no more than a transparent shim between grid and domestic device – is thematically consistent. This blurring of *engaged-user* and *automated-user* is clearly present in some of our experts' talk:

Provision of information [is key], empowering people with understanding when they might be able to use energy more efficiently or cheaply and ways of delivering that information in a way that's engaging and encourages that behaviour to change […] and then I think gradually over time you can bring in the technology to automate that and take some of that load off. [LI3]

In places, this model of user leads to some fairly heroic assumptions about the degree to which the home can be repurposed as a balancing node subservient to the demands of the grid operator. At these extremes Resource Man offers almost limitless potential for technologically reconstituting domestic life, as dynamically switchable as a substation circuit breaker, and no less amenable:

A person likes to run their home in a specific way but in theory they have some flexibility, they don't need to heat their water at the exact same time every day, they don't need to charge their car at the same exact same time of the day, they don't need to cook their dinner, they don't need to wash their dishes, they don't need to wash their clothes, the customer will buy into the flexibility. [SME1]

There was also a second figure present in experts' talk, particularly the accounts of industry members, who offers very different characteristics. The Indifferent Consumer, to apply our own label, is effectively everything Resource Man is not – disengaged, lazy, irrational, ignorant. These are the figures that industry cannot touch, and that temper any expectations of what dDSR might achieve – indeed it is barely hyperbolic to suggest this figure haunts the accounts of many experts.

I think experience to date has shown that customers aren't as interested in energy as perhaps government might hope them to be in order to drive this change really. [LI1]

The Indifferent Consumer is the ghost of energy grids past. The energy industry has, save for the very earliest days of electricity (Morus, 1998), designed for, and so encountered, a user who is insulated from both the grid and the current it delivers, through an infrastructure which renders electricity opaque behind walls in which wires are buried, illegible meter bills, and power stations built in the urban hinterlands. Their absence in Strengers' (2014) account of smart technology design reflects, we suggest, the different experiences of the tech and energy industries, and specifically of the idealised role of the user within it. For the tech industry and its platform capitalism (Srnicek, 2017), extracting wealth from the peer-to-peer flows of 'Web 2.0', the user is sovereign, both generator and consumer of the data which washes through the industry's networks, and from which they derive value. This is an industry used to the sight of customers motivated to the point of queuing outside stores overnight to get their hands on new devices. The energy industry has no comparable touchstone, instead existing in a market which is often treated as disfunctional by policy makers for the refusal of customers to engage with it. This is reflected in the Indifferent Consumer.

Recognition of the very obvious tensions between this figure and Resource Man can be seen in the idea of *customer differentiation*. Several of the experts spoken to saw the disintegration of the once monolithic domestic end-user, which for decades in the UK has existed in one of only two forms: Profile Class 1 (standard users) and Profile Class 2 (Economy 7 [6] users). In its place, a fragmentation into multiple niches, defined by how willing and how able users are to respond to dDSR – indeed this affordance is the fundamental purpose of granular smart meter data (see Fig. 1 for example of this). At the furthest extents of the Resource Man ideal there are visions of real-time pricing signals guiding the moment-to-moment decision-making of homeowners and/or the technologies they have installed, as well as informing their ongoing adoption of additional technologies and services. This group are spoken of in our interviews as 'early adopters' and 'ecos' or 'greens'. At the opposite pole, the extreme end of the Indifferent Consumer, whose disengagement from the grid is so profound that in some cases they may become classed as 'energy vulnerable', their sovereign consumer role partially usurped by the state in order to protect their interests. Between them, different forms of technology adoption and different levels of engagement. Some experts saw effective dDSR as requiring means of catering to various constituencies along this distribution:

> *you can't push flexibility on to people […] you might just find those options within niches, you're not going to find it blanket across all.* [A2]

It is consumer differentiation which allows for the otherwise incommensurate visions of Indifferent Consumer and Resource Man to exist side by side in the imaginaries of dDSR advocates.

6. Conclusion and policy implications

The development of dDSR in the UK is, with the exception of the devolved administrations in Wales and Scotland, largely being left to the market to determine. Our study highlights that the market in question is a melding of the traditional energy sector with the tech sector. Sociotechnical perspectives have long emphasised the importance of the *design of the user* in the creation of new sociotechnical systems, and yet to date, the characterisation of the DSR consumer has often been implicit, and discussed without reference to empirical evidence. One exception to this – Strenger's Resource Man (2014) – draws from the tech sector's design community. We have complemented it with the Indifferent Consumer, which our research finds to be a more common figure in the imaginaries of the energy sector incumbents. dDSR is then being envisaged around two sharply contrasting visions of user and their role, with opposing levels of ability and willingness to engage with energy. In this section, we highlight three limitations of this bifurcated view of dDSR users and the market which will serve them, (see Table 2 for a summary), before putting forth our own recommendations for a more diverse institutional landscape which might better serve a more differentiated understanding of users.

6.1. Appealing beyond Resource Man

Introducing Resource Man, Strengers (2014) makes the point that he is not simply a delusion of technology designers – he exists in the aspirations of many users and policy makers, for whom ideas of novel technology adoption and rational self-optimisation hold great appeal. Whilst dDSR offers only limited economic sense currently, with the hoped for electrification of heating and transport the associated operating costs will create greater leverage for cost saving legitimations, in the form of demand response measures such as TOU tariffs. Such developments will further the appeal to Resource Man.

The market then appears well provisioned to recruit Resource Man's niche for demand response. The niche is just that however. Our concern is for the majority of users who do not share in this vision. It is telling that the TOU trials which have shown promising results have been small scale and – crucially – opt in (see (Faruqui and Sergici, 2010)) for a meta-analysis. As we argued in previous work (Goulden et al., 2014), there is a niche amongst end users who will respond to such measures, and who will self-select for such trials. By contrast, in the few large-scale trials of TOU tariffs in which participation has *not* required opt-in, results have been poor (Miller et al., 2017; Torriti, 2012). Engaging a broader demographic in demand response has yet to be demonstrated.

6.2. The limitations of making dDSR effortless

One alternative response to the niche appeal of dDSR offerings is also present in several experts' talk – to render dDSR sufficiently effortless that little or no engagement is required by the user, imagined here as the Indifferent Consumer. Automation is offered as one means of negating user apathy, another is local storage of heat or electricity. There is potential here, for example, heat storage offers seemingly easy opportunities for shifting demand – there is little reason to try and move showering away from peak morning demand if fed from an off-peak heated water tank.

To imagine however, that such technology can be incorporated into the home without disruption is to render invisible the home as a defined socio-spatial structure for which some process of accommodation is required. By way of example, one academic expert spoke of a study using a pilot deployment of Tesla Powerwall batteries, which were too large to be installed in a row of British homes, save for on the roof terraces. This required installing heavy cabling through the middle of the house, which many householders refused to allow. Another expert highlighted that many water tanks have been removed from homes, and the space repurposed for general storage. Such mundane practical troubles are precisely the kind that dissuade the adoption of new technologies. Studies of trials where such technologies *are* deployed show that occupants are liable to resist service operators attempts to control practices in unexpected ways (Hansen and Hauge, 2017). "Calm" technology design (Weiser and Brown, 1996) which seeks to be invisible in everyday life may well be an effective approach for reaching many potential dDSR users, but the home presents very real constraints on what can be achieved with such an approach. Some level of disruption is seemingly inevitable, and the need to think about the user, and how they can be engaged, remains.

6.3. Market-fostered rebound effects

Above we report experts' suggestions that end user engagement will be driven by consumerism – the adoption of smart home technologies for which dDSR is an afterthought. We also saw how market 'innovations' to the challenge of low-cost demand response took the form of dirty diesel generation, a development which wrong-footed policy makers. This highlights the potential for unintended consequences, where in aiming to promote energy engagement and conservation, users are directed towards the adoption of new services and technologies which foster practices with greater energy consumption profiles. This aligns with Nyborg and Ropke's (2011) concerns about the potential for smart home technologies to normalise *'new expectations to comfort, convenience, entertainment, security, health care and so on'* (p.1858).

Targeting technologies at comfort and convenience is an obvious route for industry seeking to expand the adoption of dDSR beyond Resource Man. We fear current arrangements are a recipe for creating a 'diesel moment' in dDSR, but one far more obdurate to shifting once it's established, due to the raised expectations it will generate amongst

[6] Economy 7 is a differential tariff introduced into the UK in 1978, which charges a lower rate for overnight consumption.

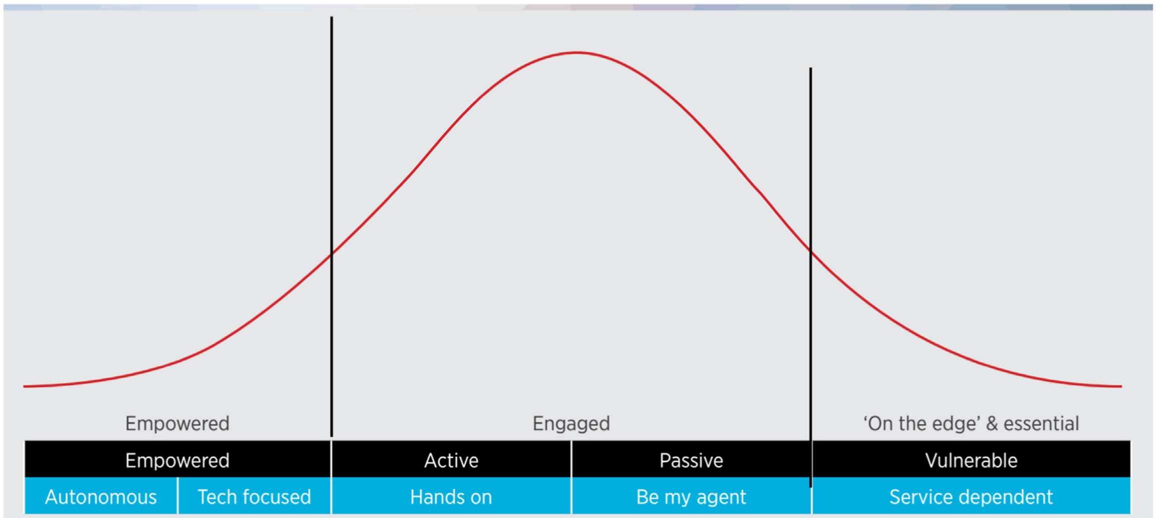

Fig. 1. Example of a market differentiation vision (CSIRO and Energy Networks Association, 2015, p. 33).

Table 2
Weaknesses identified in current dDSR adoption process.

Key Theme	Illustrative Quote	Policy Implication(s)
Most energy consumers are not 'Resource Man'	*'I think experience to date has shown that customers aren't as interested in energy as perhaps government might hope them to be in order to drive this change really.' [LI NJ]* *'you can't push flexibility on to people […] you might just find those options within niches, you're not going to find it blanket across all.' [A1]*	Services and Products relying on extensive user engagement are only likely to work within a subsection of the population. A greater understanding and differentiation of energy users is needed.
Automation has potential for promoting dDSR to the Indifferent Consumer, but it inevitably entails some degree of disruption	*'[dDSR] needs to be completely hidden and the end user doesn't see it, doesn't interact with it, doesn't know or care anything about it. It just gets the benefit and they can ignore it. Those kind of things customers like.' [LI2]* *'ideally speaking you would be installing dedicated heat storage to make your job easier in moving the heating demand around in time. The size of people's homes, or the fact that they've had storage tanks removed and replaced with clothes storage, might make it difficult to put that storage back in.' [A2]*	Automation can bypass the need for some engagement but will still require users willing to accept some degree of physical and social disruption to the home – meaning the user still needs to be considered. Characterising consumers as 'Indifferent' could lock out potential flexibility.
Potential for unintended consequences from market-driven DSR products	*'[T]here has been a view from some quarters of the industry that the system requires system architects in charge of it. That's not where we are – the players involved are all pretty committed to the market. The thing with the market is that it could overshoot, it could go off in unpredictable directions – we've seen that with DSR and the unintended growth of new built diesel generation, that the market came up with.' [P1]*	There is potential for market solutions to promote new energy practices which consume more energy.
DSR determined by the market alone will not maximise DSR potential	*'we fell out big time with [major energy supplier] […]we kept saying to them, look, you just want stuff out of us, we can actually really help you because nobody trusts you, interface you with people over the Green Deal for instance, and we want you to trial new technology in this area because that's one of the things we're about. We want to be at the forefront of getting the community involved in that. And we had so many meetings with them which were a complete waste of time in the end. Nothing was forthcoming. They only wanted to do anything in a way which worked with their kind of commercial model.' [TS3]*	Trusted organisations and community driven initiatives provide an alternative route to dDSR uptake, enrolling those poorly served by market offerings.

users. In the case of Nest, perhaps the most high profile smart home dDSR service to date, there is indirect evidence of this already happening. Pisharoty et al. (2015) study found that users who manually programmed their thermostats saved 8% more energy than those relying on Nest's 'smart', automated service. It should not come as a surprise that the algorithms governing an expensive lifestyle product favour the risk of wasting energy over the risk of leaving users uncomfortable. Conflicts between the sustainability goals of dDSR, and the unsustainability of many values fed by consumerism, are significant.

6.4. Sourcing alternative user visions

In Section 2 we discuss the UK's current Community Energy Strategy (DECC, 2014), which seeks to embed community energy in future policy making (p.16), and yet with the exception of the devolved Governments of Wales and Scotland, we found little sense amongst those we interviewed that this was being applied to DSR. On the contrary, there was an explicit expectation that the market would push DSR forwards. This leaves a gap in policy support for mechanisms that can generate locally-responsive solutions and build relationships that draw on sources of trust not available to large industry players (Mumford and

Gray, 2010), and which can invoke moral arguments unavailable to commercial entities.

Mechanisms include energy advisors who can support such schemes and share best practice (Hargreaves et al., 2013); energy charities supporting necessary skills for users with impartial advice (Fischer et al., 2014); participatory system design (Foster et al., 2012) and co-management models (Strengers, 2011); social housing schemes, which have deployed large microgeneration and community heat schemes (Judson et al., 2015); and community energy schemes. In previous work (Goulden et al., 2014) we argued for the value of community energy, using some form of shared local renewable generation. The current Ynni Ogwen pilot in Bethesda, North Wales, financed in part by the Welsh Assembly, is an example of how such a scheme might work with dDSR. It links variable local hydro-power generation with local consumption, using a bespoke billing system, information feedback, and community activities to encourage demand response.

Such approaches are not only useful in surfacing notions of energy as a finite *resource*, rather than a utility simply taken for granted when flicking a light switch, but also in making possible the harnessing of a set of morally-rooted meanings – ownership, community, self-reliance, solidarity, even potentially notions of self-sacrifice for a greater good – which are difficult for private industry to credibly evoke. Used alongside new technologies, such meanings offer hope for reformulating energy-using practices where the meaning – e.g. better stewardship of community resources – aligns with sustainability goals, rather than cuts against them, as many consumer-targeting meanings do.

6.5. Research synthesis: better serving user differentiation

How might we better support the development of dDSR? Above we note the common expectation amongst those interviewed that end user differentiation will be a central component of dDSR. We concur, and suggest that recruiting a broader constituency for dDSR necessarily calls for a wider range of policy options giving greater support to bottom-up approaches *alongside* the efforts of industry, that recognise the numerous alternative ways in which users could be engaged with demand response. However, this requires moving beyond the bifurcated visions of industry, via policies which support a more diverse institutional landscape to serve a more differentiated understanding of users (see Fig. 1).

Akrich (1992) describes how designers inscribe their technologies with particular "scripts": "*like a film script, technical objects define a framework of action together with the actors and the space in which they are supposed to act*" (p.115). We do not see this process as determinisitic, instead users and technologies reciprocally *co-produce* one another (Oudshoorn and Pinch, 2005). In this process of co-production, the user imagined by the technology designer nevertheless remains influential. For example, in assigning particular roles to technology users, scripting has a moral dimension, a set of values which are realised in the doing of the practices the technology is a part of Marres (2012). We have already discussed some of the values contained in pitching dDSR at Resource Man – rationality, self-optimisation, technology mastery. Alternative scripts would be conducive to enrolling others. Markets are promoted as a catalyst of innovation for meeting the diverse 'needs' of consumers, and yet dDSR is problematic in this sense because the need being responded to is that of policy makers and grid operators, not householders. This complicates efforts to engage with niches beyond the 'utility Mini-me' figure of Resource Man. A lower carbon grid may ultimately be in householders' interest but this is a 'social good' argument which industries are not well placed to deliver, and our interviews give little impression that industry or policy makers themselves dissent from this view.

As we discuss in 6.2 and 6.3, the interviews conducted during this study suggest that a two-pronged strategy of automation and consumerism will be employed. Our interest here is in what this reveals of customer differentiation, that bifurcates between *engaged* users to be targeted with one set of scripts, and *disengaged* users to be targeted with another. The forms of user in the talk of industry and policy makers, which we have labelled Resource Man and Indifferent Consumer, risks mistaking a current diversity of *reconfigurable* energy-using practices as the fixed characteristics of immutable population archetypes. Our interviews suggest there is a danger that any rejection of Resource Man will lead to users being identified as Indifferent Consumers and targeted as such, with scripts which reinforce disengagement from energy provision, effectively locking them into a continuation of the passive historical role the consumer has played in the electricity grid. If demand response is subsequently sourced from such users, it is liable to be modest, and will represent a missed opportunity. That technologically-mediated self-optimisation does not dovetail with the majority of electricity users' existing practices need not preclude other means of involving these users in demand response, however. Rather, we propose a more dynamic, integrative view recognising the ways in which users, energy practices, and energy discourse are co-constituted through various forms of interaction and tailored for specific ends and purposes according to different imperatives for environmental policy intervention (Fiorino, 1990; Wardman, 2008). Adopting this more holistic perspective would allow for the greater flexibility required to meet the differentiated needs of a distributed user base and help to facilitate the 'opening up' of user engagement in different forms, at different times, and in different places (Stirling, 2005).

This belief is underpinned by notions of the Energy Citizen discussed in Section 2, a figure offering greater prospect of engagement than the Indifferent Consumer, and amenable to a set of scripts that are not provided by designing for Resource Man. However, a dDSR sector in which policy makers rely on the top-down approaches of the market to determine what 'works' is one which will find answers to only the questions that it asks. No robust evidence base for alternative, bottom-up approaches will be established because they will not be trialled, at least not at sufficient scales and resource-levels. Without such an evidence base our data suggests policy makers will continue their neglect of them. Instead, we are liable to see the establishment of solutions which generate the desired demand-responsiveness amongst only a subset of users, relying on hopeful asocial technological solutions to bring effortless dDSR to others, which in the process may also simultaneously encourage new or intensified energy consuming practices.

6.6. Conclusion

An electricity grid in which technologies are decentralised calls for reciprocal decentralisation of the social arrangements they are a part of. At the heart of our appraisal of Demand Side Response lies this concern. We argue that current institutional arrangements for the provision of DSR in the UK are insufficiently diverse to harness the full potential of it. From our data we cannot comment on how applicable these findings are to other states, but we note that many of the same pressures (e.g. carbon reduction) and stakeholders (most noteably, the tech sector promoting the smart home) are cross-national features of DSR development. This, combined with the UK's status as an early mover in this area, means that the UK provides a valuable point of comparison.

Whilst non-domestic DSR appears in good health, domestic DSR's status is of greater concern. Current policy at Westminster is to oversee the rollout of smart meters, but to leave development of dDSR to industry. This approach concurs with the pro-market stance of the current Government, though we also heard from experts interviewed that dDSR support is made more difficult by a current shortage of data that would allow policy makers to model its effectiveness. The market – which marks the entrance of the Silicon Valley tech giants into the energy sector – is being tasked with filling this evidence gap. Our data provides some of the first empirical evidence of how different stakeholders view DSR users and expect them to engage with technology. We demonstrate how the market is focusing on two notions of end user: as Indifferent

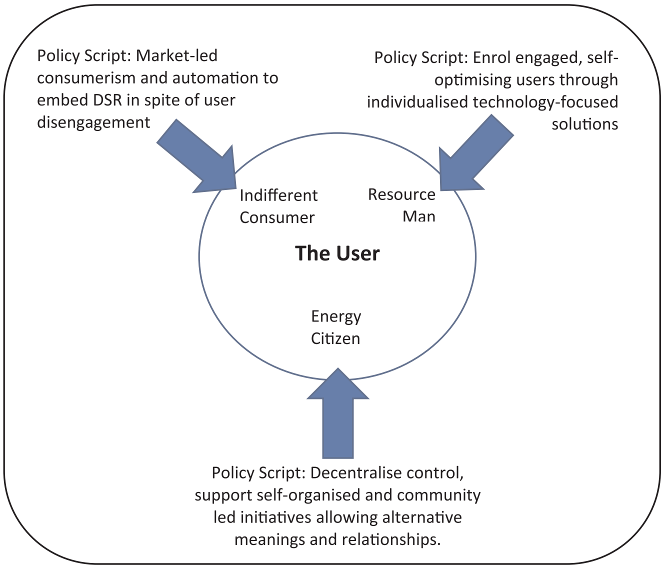

Fig. 2. A Differentiated view of 'the User' and corresponding policy scripts.

Consumer enrolled through the automation of their home, or as Resource Man acting as an automaton, and call for a more differentiated view of 'the user' (see Fig. 2). Our contention is that leaving dDSR to the market alone will result in a skewed evidence base that fails to maximise the chances of dDSR being successful, beyond those niches the industry is equipped to recruit. We highlight the danger that the scripting of these technologies will ultimately bifurcate domestic users into active ('Resource Man') and passive ('Indifferent Consumer') roles, the latter of which is likely to become a self-fulfilling prophecy – one which holds only limited opportunities for improving the sustainability of the grid.

We conclude the current approach to dDSR in the UK will have some success, but many missed opportunities. Against such an outcome we must set the scale of the task. Climate change is currently proceeding at the upper levels of predictions, global carbon emissions continue to grow, and there are fears that the UK will miss its 2030 emissions targets (e.g. (Energy Institute, 2017)). In light of this, we find it hard not to sympathise with the words of one expert, critical of current emissions reduction efforts:

> *in terms of policy making with respect to climate change – on the one hand we're saying we need to be making dramatic changes in our energy consumption, which implies dramatic changes in how we live our lives. Yet the other rhetoric about this is not a sledge hammer to crack a nut, it's the exact reverse, it's taking a very mini hammer to a giant boulder to see if you can make any impact. [I]t's almost a way of kidding yourself that you're going to be able to do something. [A1]*

We end with a call to rediscover the ambitions of the Energy Citizen role, which could compliment Resource Man as a user amenable to a different set of scripts. The industry is able to foster the latter because Resource Man already performs a set of practices involving adopting, monitoring and responding to data-driven technologies. Industry lacks the necessarily mechanisms to engage neophytes with dDSR however. We need instead mechanisms to support bottom-up, flexible arrangements, which can complement the top-down approach of industry. The Government's commitment to such approaches in the Community Energy Strategy (2014) is welcome, but our interviews gave no reason to believe that this is being applied to dDSR, despite the opportunities for synthesis. If greater involvement in dDSR is to be achieved, then a mixed strategy, which includes locally-appropriate solutions, offers a broader set of engagements for enrolling participation.

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Data statement

The authors have permission to share anonymised interview data with other researchers, and can do so on request.

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