Energy efficiency or energy demand?

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Abstract

Energy efficiency has long been hailed as a central pillar in climate change mitigation through its role in reducing energy demand – not least by eceee. However, some now question whether the energy efficiency narrative is sufficient for emission reduction goals. This is a welcome development, as this narrative has often been synonymous with improving technical efficiency, while obscuring the question of reducing demand for energy services – as opposed to delivering those same services more efficiently. Further, it carries an implicit techno-centric bias, overlooking non-technological solutions. A classic example is the EU's estimates of potentially large energy savings that could be achieved by more efficient tumble dryers – a study measure which could encourage dryer purchase, significantly increasing energy use over hanging clothes to dry.

This paper draws on conclusions from three research projects at the Centre on Innovation and Energy Demand (CIED), including one finding that a shift to electric cars risks maintaining high travel demand, preventing a deeper transition to a more sustainable transport system, and another forecasting significantly lower household energy savings from the UK smart meter rollout than previously estimated. I conclude that the energy efficiency narrative might lock us in to high energy lifestyles through seeking ways to maintain, rather than disrupt, business as usual behaviours. I suggest that a complementary energy demand reduction narrative could highlight the limits to (technical) efficiency savings, and open a way for policy to engage with the deeper changes needed to our demand for energy services.

Introduction

The Centre on Innovation and Energy Demand (CIED)[1], which recently concluded its research, was one of the UK's end use energy demand (EUED) centres. CIED engaged in research on the transition to a low carbon economy, looking at how a variety of new technologies, business models and institutions have the potential to transform the way we use energy and achieve significant reductions in energy demand (and greenhouse gas emissions). CIED's research examined how new, low-energy innovations emerge and spread and how this process is shaped by market forces, government policy, social interactions and cultural norms.

Not surprisingly, questions of using energy efficiently played an important role in this research. Focusing on energy efficiency in order to reduce energy demand is of course welcome. However, during my 4 years researching at CIED, I noticed two things that lead me to write this paper: first, that the meaning of 'energy efficiency' as used in a variety of academic papers, policy-related documents, and other literature, seemed to be elastic and unfixed, sometimes to the point of using 'energy demand' and 'energy efficiency' interchangeably. The second was the focus of energy efficiency, which often foregrounded technology and technical changes, with less attention to people and behaviour, and especially to changes (or lack of change) to behaviour and practices.

This paper aims to contribute to the question *Is efficient sufficient?* by drawing on three different CIED research projects, all of which had a technological innovation as their focus, and all centred on the UK. The first (in which I participated) was on personal transport, and the roles of electric vehicles and

1. See http://www.cied.ac.uk.

car (sharing) clubs in a transition to a low-carbon transport system. The second looked at the energy implications of automated and smart freight mobility, and at governing processes of automated mobility transitions, in both freight and personal transport. The last was on the UK smart meter rollout and its potential to reduce domestic energy demand.

The paper is arranged as follows: the next section gives an overview of the research approach, giving a brief overview of expectations and visions of the future as used in our research, and looking at the energy efficiency discourse and some relevant critiques. This is followed by three sections on the specific case studies, and then a discussion section with some final conclusions.

Research approach

EXPECTATIONS AND VISIONS

While CIED research was multi-method and interdisciplinary, and different from project to project, one recurring theme was considering the roles of visions and expectations of the future, and how these affect the present in terms of policy, perceptions, investments and more. Visions can be seen as broadly imagined (usually desirable) futures, while expectations are more specific details, such as the technologies that enable such futures. There is a well-established literature in innovation studies examining visions of the future, especially around novel science and technology, for their generative potential to mobilise action in the present, often through articulating expectations of the future. Expectations can give real-time representations of future technologies (Borup et al. 2006), thereby helping to construct and manage the future through providing structure and context. These future-orientated discourses can strongly affect technological development through affecting current contexts and collectively making sense of future technological situations (Konrad et al. 2017). Expectations and visions of the future can be used to attract financial support for research and development and other innovation activities (Fujimura 2003); they can motivate product designers and engineers to initiate projects (van Lente 1993); and more broadly raise interest among a wide range of stakeholders, increasing legitimacy and uptake of novel technologies (Schot and Geels 2008; Geels and Verhees 2011). Visions and expectations are indeed a key part of the process of technological innovation, not an unintended side effect (van Lente and Rip 1998; Brown, Rappert, and Webster 2000; Borup et al. 2006; Hultman 2009).

It is worth noting that visioning is not neutral, but an inherently political technique. It can be used by powerful actors to affect common perceptions of the future, influencing expectations and strategies. Such techniques have their downsides, though. Actors associated with a particular innovation might strategically inflate expectations or technological promise to attract resources and attention, causing hype through over-optimism, often followed by downscaling of expectations and disappointment (Ruef and Markard 2010). In all three of the CIED case studies used here, consideration was given to how expectations of the future shaped the unfolding of an innovation, but also how expectations were used as a means to advance an innovation or a broader agenda.

LIMITS TO THE ENERGY EFFICIENCY NARRATIVE

From a technical perspective, energy efficiency can be defined as delivering the same (or equivalent) energy services using less energy, or delivering more services using the same amount of energy. It is also used more broadly to refer to more efficient use of energy resources. Moreover, in the author's experience, energy efficiency is sometimes used indiscriminately in some policy and even academic literature to refer to any means of reducing energy demand, from wearing warmer clothes to reduce heating demand, to making cities more compact. In some cases, demand reduction is assumed to come from energy efficiency measures alone, often referring to technical efficiency. For example, the UK's Committee on Climate Change (CCC) states that "Emissions can be lowered by taking steps to become more energy efficient and by switching to low-carbon fuels" (Committee on Climate Change 2019). The energy efficiency measures listed by the CCC are mostly technical – from switching lightbulbs to insulating homes and office buildings, although reducing car journeys is listed alongside purchasing more efficient vehicles. In other words, transport energy efficiency has technological components (efficient vehicles) and behavioural and lifestyle components (mobility patterns, shifting transport modes) (Grubler et al. 2012).

There is no doubt, as in the above example and many others, that energy efficiency and demand for energy services are overlapping concepts (e.g., is car sharing a behaviour change or improved efficiency?). However, in this paper I argue that beyond overlapping, there is a conflation of energy efficiency and demand for energy services, which can act to obscure the non-technical side of energy demand, and thus allows us to avoid discussing behaviour, practices and context of energy use. A classic example of the technological focus of the energy efficiency narrative is the EU's estimates of potentially large energy savings that could be achieved by more efficient tumble dryers (European Commission 2014) – a study measure which could encourage dryer purchase, significantly increasing energy use over hanging clothes to dry. There is no corresponding calculation from the commission of the energy potentially saved by not using dryers at all.

The concept, discourse and framing of energy efficiency have been critiqued before. If energy efficiency is about delivering services using less energy, then energy 'services' have to be captured and standardised (Shove 2018a, 781). This implies an assumption of keeping energy services similar to those we have today, of stabilising contemporary standards of comfort, lighting and cleanliness, for example (Shove 2018a). In other words, "To focus on energy efficiency is to make present ways of life non-negotiable. However, transforming present ways of life is key to mitigating climate change and decreasing our dependence on fossil fuels" (De Decker 2018). This is evident in the UK government's commitment to drastic emission reductions without compromising 'current standards of living' – making 'efficiency' the only way forward (Shove 2018a, 785). However, this 'efficiency paradigm' hides the fact that societal needs and demands are not constant, they are evolving and dynamic, they are negotiable and cannot be fully predicted (Shove 2018a; Shove 2018b). Energy demand of the future can therefore be said to be affected by visions and expectations of the future, and therefore are at least in part shaped by political and interested action of different actors.

One of the ways energy efficiency has been critiqued, with the need to reduce energy demand beyond technical efficiency, is the 'sufficiency' narrative, including eceee's own energy sufficiency project[2]. One of the project papers defines energy sufficiency as *a state in which people's basic needs for energy services are met equitably and ecological limits are respected* (Darby and Fawcett 2018, 8). Energy sufficiency starts from basic human needs, translated into more concrete demands and desires, and ultimately into products and services that fulfil them. Sufficiency could require radical new policy approaches, beyond energy efficiency policy instruments, as it excludes options which do not meet environmental and social sustainability requirements (Thomas et al. 2014). Sufficiency research argues that behaviour change towards 'energy-sufficient' lifestyles can contribute to greenhouse emission reductions, and that lifestyle changes can and should be included in global scenarios (Samadi et al. 2017). It is a more challenging concept than energy sustainability, as it questions the 'sustainable growth' narrative and highlights difficult issues such as separating needs from wants (Darby and Fawcett 2018).

Case study 1 – Electric vehicles

CIED work on electric vehicles (henceforth EVs) looked at visions of future personal transport. This work analysed UK policy-relevant documents from government and other actors in the transport sector, which looked at possible futures, and included EVs. Over 40 relevant documents were identified, with 20 chosen for in-depth analysis, written by or for government, industry, consultancies and transport coalitions. Visions of car (sharing) clubs were also considered as a counterpoint to the technological innovation. The documents were explored in terms of how they portrayed the future of personal transport, in terms of visions and expectations, and the dominant narratives and framings (Bergman, Schwanen, and Sovacool 2017; Bergman 2017; Bergman 2019).

This work draws largely on the transitions to sustainability literature. The UK personal transport can be said to be locked into a regime of *automobility*: a system dominated by privately owned cars, reinforced by infrastructure, institutions, vested interest, norms and practices (e.g., Schwanen 2015; Urry 2004). A significant shift towards sustainable personal mobility therefore requires systemic change – a *sociotechnical transition*. The dynamic suggested in the documents is of UK regime actors, including incumbent manufacturers, seeing change as inevitable due to sustainability agendas, specifically emission reduction targets, and gradually introducing lower emission vehicles (probably EVs), while attempting to preserve other aspects of the automobility system. In transition terms, the regime is reorienting its trajectory, attempting to make the EV niche more symbiotic in order to limit change (Bergman 2019).

VISIONS OF THE FUTURE

The work concluded that incumbent actors portray a near consensus future: this 'central vision' is of a slow move towards lower emission vehicles (probably EVs), with little disruption, and crucially, hardly any change to the transport system beyond changing vehicles' powertrains. Visions produced by regime actors craft possible futures in a way that makes the continuity of the sociotechnical regime more plausible, and this vision is strengthened by a convergence towards a single future, implying a dominant sociotechnical imaginary (Jasanoff 2015). In other words, these visions contain an element of determinism, reminiscent of *la pensée unique* – there is no alternative future. Deeper changes to the automobility system, such as reduced use of personal vehicles enabled by practice change, such as modal shift to public transport or a rise of car clubs, are either absent or portrayed as unrealistic or negligible in their effect.

This is problematic for several reasons. First, it is unrealistic. The radical nature of EVs, the largescale uptake of which would cause disruption to the system, is not taken into account. A study of EVs in Germany (Augenstein 2015) suggests there are discrepancies between visions of the future based on sustainable electric mobility, and strategies for change rooted in the current regime; this innovation cannot simply replace conventional cars one for one without significant change to the role of the car in society. The unrealistic lack of disruption in the central vision could leave us poorly prepared for the future.

Second, portraying EVs as a techno-fix locks out alternative futures, including potentially deeper transitions towards sustainability with lower car dependency. It relies on technological progress to meet a narrowly defined sustainability agenda. Electric mobility offers a variety of possible futures with ICT connectivity that do not rely on current transport patterns or car ownership – nor even on what we currently think of as a car. This vision is designed around conventional vehicles, and so does not play to the strengths of electric mobility. It can therefore reduce the efficiency of the system, or even constrain, rather than drive, diffusion of EVs and transition dynamics more broadly.

The lack of disruption in envisioned futures is also evident in the paucity of scenarios in which emission targets are missed or technology fails to deliver on its promises; failure is hardly considered, even as a heuristic tool. In other words, the futures portrayed are only a subset of plausible futures, constrained by a vision matching vested interests of incumbent actors. Overall, this central vision is limited and limiting in scope, hindering genuine transformation, as the unsavoury parts of the transition are downplayed, problematised or ignored. It potentially prevents a deeper transition towards sustainability by locking out alternative futures and limiting EVs to the role of a techno-fix, rather than explore vast possibilities of electrical mobility.

PEOPLE, USERS, BEHAVIOUR

Another feature of the visions is the simplistic portrayal of people, almost exclusively as consumers, users, or (potential) adopters of technology. Other roles for the public, from demonstrators of sustainable lifestyles to political activists, to producers of knowledge, to experimenters with new technologies who could create new and unforeseen functionalities, are absent. This simple imagining of the public as passive and undifferentiated actors whose single role is technology adoption is an inherent part of constructing these futures, as other roles complicate and potentially undermine the business as usual framing (cf. Walker et al. 2010).

Further, consumer behaviour is often portrayed simply as consumer choice, primarily in terms of modal choice or even

2. See https://www.energysufficiency.org/.

vehicle purchase choice, with rational actor models and financial considerations often dominating. Some of the documents have future projections which consider only change in type of vehicle (e.g., conventional, hybrid, electric), with no change in overall car ownership or even travel patterns (distance, number of trips, etc.). Behaviour change is seen primarily as choice of vehicle powertrain, with other changes portrayed as marginal or unlikely. This limits discourse of the role of policy to support of development of low emission vehicles and their markets, and maximisation of their uptake. The frustration found in some documents at the low uptake of EVs, when the 'rational economic actor' model suggests they are a good deal for consumers, matches Lakoff's (2010) description of how framing an issue can limit our understanding.

ENERGY AND EMISSION IMPLICATIONS

The central vision relies on markets and technological innovation in an attempt to limit future disruption. It is therefore a good match for the idea of a post-political future, similar to the automated vehicles research (see below). This can also be seen in the call for 'technology neutrality' (Bergman 2017; Bergman 2019), i.e., the assumption that with the right supporting policies, markets will choose the best options among fuel and engine technologies through competition and deliver required greenhouse gas emissions reductions with no major changes to mobility trajectories. For government, this could be a hesitation by the state to back any specific winner in a market economy; this has been observed elsewhere in relation to EVs and is particularly likely when the free market paradigm prevails (Nykvist and Nilsson 2015). For the industry, this could be a delay tactic that preserves the regime's stability as conventional vehicles can meet emission targets in the short term.

This energy efficiency-compatible narrative poses two risks: First, it limits energy and emission savings to those that can be achieved through the improved efficiency of vehicles, both in terms of improved energy efficiency of electric vehicles, and in terms of reduced emissions assumed by low carbon electricity generation. This ignores, and even prevents, deeper transitions to futures with more significant change in terms of reduced personal car use, reduced demand and need for travel, and even reduced access to mobility, which offer energy and emission savings above and beyond electrification of transport. Second, this seamless transition to the future appears to be unrealistic due to the disruptive nature of electric vehicles; it is a transition which does not play to the strengths of electric transport, as it mimics a system designed around the internal combustion engine. The lack of engagement with individual behaviour change and deeper societal transformation, and desire for a techno-fix, both demonstrate the post-political and techno-centric view, for which energy efficiency is a good fit, but unpacking the drivers of energy demand are not.

Case study 2 – Automated vehicles

CIED work on automated vehicles (henceforth AVs) looked at the energy implications of automated and smart freight mobility, and at governing processes of automated mobility transitions, in both freight and personal transport (Hopkins and Schwanen 2018; Schwanen, Hopkins, and Sovacool 2016). The work draws on insights from forty-one qualitative interviews with diverse stakeholders from government and industry, entrepreneurs and start-up businesses, NGOs and charities, as well as a workshop with stakeholders focused on automation in freight. It also includes analysis of government policy from documents including the UK's Industrial Strategy green paper (HMG 2017), documents from the Department for Transport, and more.

GOVERNANCE OF TRANSITION TOWARDS AUTOMATED MOBILITY

The work on mobility transitions analyses the governance of the transition towards automation in mobility in the UK, drawing on concepts from transition management, and using a post-political analytical lens (Hopkins and Schwanen 2018). The post-political approach used builds on work such as Swyngedouw (2010) and Mouffe (2011), in which governance is reduced to practices and institutions organising human existence, executed through consensus formation among stakeholders, technocratic management and problem-focused action, with strong ties to neoliberalism. This governance is dominated by efficiency, economic rationality and economic administration of markets. It makes private sector participation and buy-in essential, while limiting engagement with citizens in what could be seen as a democratic deficiency.

Hopkins and Schwanen see the transition management discourse of AVs showing signs of such post-political thinking. This discourse can obscure conflicts by highlighting consensus and by seeing disagreement as temporary and conflict as economic, not political (Kenis, Bono, and Mathijs 2016). It often envisions people as consumers, rather than citizens or agents of change. The framing is of a global race towards automation, which can be won by technological innovation. It privileges cutting red tape over public participation. So while a diverse range of partners has been involved, the imagination of automation as a series of technical problems leaves publics marginalised. People are portrayed primarily as 'future technology adopters' (Chilvers and Kearnes 2016), although more recently 'users' have been seen as part of the innovation pathway (Hopkins and Schwanen 2018). Similarly to findings on EVs (Bergman, Schwanen, and Sovacool 2017), a wider range of public roles, including citizens, is not envisaged in AV governance and experimentation. In sum, "the UK has adopted a reasonably comprehensive approach to the governing of automated vehicle innovation, but this approach cannot be characterized as sufficiently inclusive, democratic, diverse and open" (Hopkins and Schwanen 2018, 1).

The context of the research is the UK government's Industrial Strategy (HMG 2017), post-Brexit referendum. The strategy seeks ways to drive up productivity across the UK, highlighting artificial intelligence, robotics and automation as areas of strategic importance. The narratives from government see the UK as a leader in the unfolding technological revolution. They are dominated by market driven, expert focused visions, which limit the range of futures imagined – with automation seen as a highly desirable and inevitable future, leaving no room for failure or scepticism, although these are slowly appearing in the media and the broader discourse.

One of the most important consequences of the narrow futures and post-political pathways is that environmental benefits, and specifically, emission reductions, of automated vehicles is not assured (Schwanen, Hopkins, and Sovacool 2016; Wadud, MacKenzie, and Leiby 2016). This is because the benefits are less the consequence of automation itself, and more to do with change to operation and design of vehicles themselves and the entire transport system. Highly automated vehicles could actually result in an increase in demand for travel, and therefore energy. "Far better transport options – from both an emissions standpoint, and an energy efficiency standpoint – are to rely on a mix of walking, cycling, and public buses and trains... From emissions, energy efficiency, and health standpoints, a mix of active and public modes is optimal." (Schwanen, Hopkins, and Sovacool 2016.)

ENERGY SAVINGS FROM CONNECTED AND AUTOMATED VEHICLES

Various research highlights how energy savings are possible through automation of vehicles. Technical energy savings could come through more precise adjustment of motion, connected or cooperative driving allowing a group of vehicles to move in a coordinated matter, by vehicles reducing energy consumption of neighbouring vehicles (Vahidi and Sciarretta 2018), as well as by enabling advanced technologies (Brown, Gonder, and Repac 2014). Further energy savings could be achieved through better routing that can reduce traffic congestion (Brown, Gonder, and Repac 2014).

However, much of the research acknowledges that AVs could also increase travel distances and speeds, and increase transportation use by currently underserved groups (Brown, Gonder, and Repac 2014). It follows that reaping the potential benefits of AVs requires the technological development to "be accompanied by a social change [whereby] public and sharing will be seen as superior to private and individual transport" (Thomopoulos and Givoni 2015, 1).

In conclusion, automation, seen as a source of efficiency, does not guarantee energy or emissions savings, nor other perceived benefits, when users and their behaviour are not taken into account. Infrastructure, routines and practices from which the demand for travel arise must also be considered. The simplistic portrayal in some AV narratives of people as potential adopters of AV technology echoes the narratives of electric mobility.

Case study 3 – Smart meter rollout

Smart meters have taken a prominent role in UK government discourse around energy demand over the past decade, with a complex rollout programme different from other countries. The Smart Metering Implementation Programme (SMIP) aims to rollout 53 million residential and non-domestic gas and electricity meters by 2020, including every household in Great Britain[3] (GB), with the goal of improving the efficiency and cost-effectiveness of energy use and changing consumer behaviour. The long planned roll-out is unique in its policy design and implementation arrangements (Darby et al. 2015), with different consumer engagement approaches planned (and to a lesser extent carried out) as the roll-out progresses. The rollout is linked to broader visions of a future electricity system based on a smart grid.

CIED work on smart meters (Sovacool et al. 2017; Hielscher and Kivimaa 2018) focused on the expectations and visions of SMIP by various actors, including policymakers, businesses, third sector and community groups, including how expectations differ between actors, and how they change over time in response to developments. The research used mixed methods, including document analysis, interviews and participant observations. Specifically, smart meter relevant policy documents were analysed for the period 2000–2016.

POLICY AND EXPECTATIONS

Smart meters' place on the policy agenda affects expectations of the future – and the future energy system being pursued (Hielscher and Kivimaa 2018). Hielscher and Kivimaa show how the policy relevance of smart meters in the UK was maintained over the period from 2000–2016 through governing associated expectations and connecting them to shifting energy policy goals. Policy documents successfully developed persistent narratives of smart meters, such as empowering consumers, whilst paying less attention to scrutinising how the expected benefits for consumers would be met. SMIP is one of the UK government's "largest attempts to date to change consumer behaviour" (Hill 2015), implying that achieving the government's aims, and realising the potential for energy savings and reduced energy bills, depends on the impact smart meters have on behaviour.

In the 00s (2000–2009), smart meters were linked to UK policy ambitions to be seen as a leader on addressing climate change, as they were expected to enable energy savings and therefore emissions reductions. They were tied to ideas of informing consumers with real-time information about energy costs, potentially linked to variable time-of-day tariffs. In the present decade (2010–2018) smart meters have been linked to changing policy goals, for example, tied to a broader expectation of smart grids. Expectations shifted to be associated with developments of new markets and innovations, emphasising cost savings over energy savings. Yet details are lacking on how consumers will achieve savings beyond being more informed, rather "this vision is based on a simple and implausible equation: if people know about energy, they will use less of it" (Shove 2014).

Part of the lengthy approach was the Smart Meter Early Learning Project, which highlighted the complexity of behaviour, including stages of household engagement with smart meters and the advantage of voluntary approaches to installation. The project ultimately suggested a 3 % ongoing saving of energy was realistic based on literature and worldwide trials. Still, the early stages of the rollout showed "no general shift in routine energy-related behaviours and practices due to the installation of smart meters" (Darby et al. 2015, 9).

At first glance, this in-depth public study offers a contrast to the post-political framing of AVs, which suggested cutting red tape over public participation. However, a more careful look suggests that here too the 'race to automation' is central to policy. Despite the Early Learning Project trials, the UK government has offered limited explanation as to how and why expected energy savings will happen, with little attention paid in policy documents as to how the smart meter and in-home displays (IHDs) will (or will not) be used (Hielscher and Kivimaa 2018). In fact, the policy documents examined "seem to assume

3. The rollout covers Great Britain, i.e., England, Scotland and Wales, but not the whole of the UK, as Northern Ireland is not included.

a predictable outcome of energy savings" (Hielscher and Kivimaa 2018). The efficacy of IHDs has also been questioned (Hill 2015), as other – less technological – behaviour interventions have been shown to be more effective.

UNCERTAIN BENEFITS

The UK's energy suppliers (private sector companies) are expected to benefit from smart meters through reducing costly meter-reading visits and increased information about energy use. The benefits of smart meters to consumers, on the other hand, have been disputed throughout. Hielscher and Kivimaa (2018) review how earlier (2000–2005) policy documents saw benefits of smart meters as uncertain, later documents showed expectations of real-time communication and information, linked to an expectation of energy and emission savings. Expected energy savings (and other benefits) were set against costs of the rollout. Meanwhile, the rollout suffered repeated delays and the costs were highly disputed (Sovacool et al. 2017).

Recent reviews of SMIP question expected benefits to consumers, and suggest household reduction in energy consumption and energy bills could be considerably less than anticipated by government, with energy savings averaging 1–3 %, yielding bill reductions as low as £11 a year, as opposed to earlier projections of 5–15 % (Sovacool et al. 2017; British Infrastructure Group 2018). While the numbers have been disputed, there is no doubt that the potential for energy (and cost) savings have been central to the smart meter narrative.

PORTRAYAL OF PEOPLE AND ITS CONSEQUENCES

Behaviour was deemed an important part of the smart meter rollout, but people were still considered only as consumers or users. While earlier engagement aimed to 'provide and advise' about smart meters, the advice fell by the wayside more recently as deadlines grew closer; centring consumers was not accompanied by an appreciation of what such engagement entailed. Narratives of empowering consumers are at odds with the lack of scrutiny of technological promise and do not consider achieving consumer benefits through other means; specific technological configurations lead to disregarding alternative futures, a feature of the governance of expectations (Hielscher and Kivimaa 2018). Sovacool et al. (2017) go further in their critique, accusing SMIP of portraying consumers as rational actors, "rather than an emotional actor who may progressively influence what the future energy system will look like through a complex and interconnected socio-technical system" (p. 779).

The pre-assigned role for consumers does not allow for people to play other roles. In this the SMIP acts as a major obstacle to visions of a decentralised energy system, where people act as 'prosumers' (Sovacool et al. 2017). Further, the technological focus, with private sector requirements fitting the idea of a post-political context, mean that "complexity in a liberalized market, with retailer/supplier responsibility for a rollout, with control delegated to DCCs [Data and Communications Companies], with complicated meter specifications and IHD requirements, and extensive consumer engagement requirements – has so far negatively shaped the UK smart meter rollout" (Sovacool et al. 2017, 779).

Discussion

This section aims to tie together the three case studies with lessons for the energy efficiency discourse. The first part looks at the limited portrayal of people and the practical lack of engagement with the public. The second part considers how these technologies are tied to visions of the future, linking to the post-political paradigm.

BEHAVIOUR, PRACTICES AND IMAGINING PEOPLE

One of the main themes coming out of the case studies is the insufficient and inconsistent approach in dominant policy and business narratives to the roles of people, behaviour and practices in reducing energy demand, and specifically to potential changes to energy use and how they might be achieved. This applies to consulting and learning from the public and to considering roles beyond consumer/user.

Portraying people

The case studies demonstrate the inconsistent and overly simplistic portrayal of people in energy narratives, usually seen as users or consumers, rather than citizens or agents of change. For EVs, the dominant narrative assumes no change to users' travel behaviour, other than buying the 'right' vehicle. There is therefore a focus on making EVs as similar as possible to conventional vehicles, including familiar brands and models. By contrast, in the dominant smart meters narrative, energy savings rely on significant consumer behaviour change. The envisioned reduction in energy demand is based primarily on the assumption that provision of information and feedback will trigger sustained behaviour change, with little accounting for how this will happen.

This dichotomous representation, as unchanged behaviour addressed through technological fixes, or significant behaviour change through information provision, has been criticised in the context of smart homes (Goulden et al. 2018). The latter approach portrays an informed consumer as rational actor, or even unrealistic automaton, perhaps expanding the technical efficiency approach to behaviour, i.e., standardising behavioural performance in the same way appliance performance has been standardised by energy efficiency regulations. This is unrealistic, for example, trials suggest users limit themselves to the more basic functions of smart home technologies (Tirado Herrero, Nicholls, and Strengers 2018; Hargreaves, Wilson, and Hauxwell-Baldwin 2018). The former approach implies an indifferent consumer that can be bypassed through smart technology. For example, Foulds and Christensen (2016) found that some of the EU's Horizon 2020 funding framework calls for technological provision to bypass individuals entirely, despite EU policy putting the consumer at the centre of the energy system. This bypassing matches Shove's (2018a) suggestion of 'purification' of energy from everyday practices into a parallel universe of engineering and policy. In this imaginary world, people don't have to change because technology will change the world for us; technology is the story's hero, saving the day (Janda and Topouzi 2015; Bergman 2017). Neither of these approaches leaves room for an engaged citizen, missing opportunities for energy savings through broader changes to practices and demand for energy services.

Engagement

The case studies show limited, and often unsatisfactory, engagement with the public. Given the limited portrayal of people discussed above, this is perhaps not surprising. Yet decarbonising our energy systems, while ensuring sustainable, affordable energy supply, has major implications for the public, who will be asked to accept new infrastructures, technologies and institutions. No energy policy or technology receives unequivocal public support, and understanding public attitudes is vital. For example, 'undesirable' energy related attitudes are unlikely to change without wider changes to the socio-economic environment (Whitmarsh et al. 2011).

Practices

The importance of looking at practices of everyday life was highlighted by Shove (2015) in the context of smart meters: "if we see energy as being embedded in a huge variety of different practices – that is, if we think of energy as something that is in a sense part of writing emails, watching TV, or making dinner – then demand reduction is not about energy as such, it is about changing the details of daily life". Framed in terms of practices, the EV 'central vision' sees an (arguably unrealistic) lack of change to practices through a future technological shift in car powertrains, despite the shift requiring infrastructural and institutional changes, and even changes to driving practices. The smart meter visions imply potential changes to practices, although these are unspecified and unproven. The AV research highlights how changes to the transport system, including practices beyond car use and extending to cycling, walking and public transport use, are the key to energy savings and other benefits. This disparate approach to practices is better understood in the context of visions competing to shape the future, as discussed below.

TECHNOLOGY, POLITICS AND IMAGINING THE FUTURE

Fight for the future

Different visions and narratives can be seen as a fight to shape the future. Shove (2018a; 2018b) reminds us that the energy efficiency narrative presumes certain practices and energy services, usually similar to current lifestyles, and that future demand is not predetermined and cannot be fully predicted. I would add that the use of visions, and the expectations they generate, presumes to do exactly that – assume future energy-related behaviours and practices, despite these being unknowable, and act to shape the future to suit these visions.

For example, EVs are pushed by the UK government's agenda to reduce emissions. The expectations and future narratives have been tempered by powerful incumbent actors in the transport sector, in order to minimise disruption and focus on substitution of EVs for conventional vehicles, leading to a focus on energy efficiency of the vehicle. This matches the idea that "discourses of energy efficiency are politically convenient precisely because they play a political role in sustaining current interpretations of energy services and 'needs'" (Shove 2018b). However, more efficient cars and continued automobility offer limited energy savings. Further, this focus on continuity could ultimately be self-defeating: the focus on equilibrium and adoption of technology is in contrast to the history of *disequilibrium* in energy transitions and technological revolutions, as "the transformation is so far-reaching that the ultimate future state of the system could have never been reached by incremental improvements in efficiency and costs of existing technologies and energy services" (Grubler et al. 2012, 111).

Technology and the smart agenda

The case studies show evidence of policy level reluctance to actively engage in social change and behaviour change, preferring to focus on efficiency, primarily through technology. Even when behaviour change is addressed, it is often through information supplied via technology, 'enabling' emission reductions. Foulds and Christensen (2016) similarly demonstrate how techno-economic thinking dominates energy efficiency-related funding in the Horizon 2020 funding framework, which focuses on developing technologies and overcoming barriers to technological provision. This approach matches the ideas of 'purification' of energy use and technology as hero discussed above. However, it is hard to see how this technological focus can address some of the larger energy and emission demand challenges, from long-distance flights to buying numerous consumer goods.

All three case studies are tied to the 'smart' agenda, a vision of the future in which interconnected vehicles, appliances and gadgets automate life efficiently, providing for all our needs while reducing our energy use. This is in line with the government's emphasis on the UK's central role in the unfolding technological revolution, and its economic promise. However, the energy savings (and other predicted benefits) of the smart energy future have been contested. For example, a review of indirect energy effects of ICT (Horner, Shehabi, and Azevedo 2016) suggests that while the technical potential of net energy savings from ICT is 'likely positive', the magnitude and even sign of real savings is unclear and difficult to assess, depending on user interaction and broader societal impacts. Similarly, recent literature on smart homes highlights the need to better understand how households use smart technologies in practice (Hargreaves, Wilson, and Hauxwell-Baldwin 2018; Gram-Hanssen and Darby 2018).

Post-politics

I suggest the focus on technology is strongly tied not only to a neoliberal agenda, but more broadly to a post-political paradigm. This can be seen first, in the framing of sustainability narrowly as the need for energy and emissions reductions, i.e., a series of technological problems which can be solved through innovation and spread by markets. Second, the idea of highlighting consensus and seeing conflict as economic, not political, applies clearly in the EV study, where the focus of future visions was on how fast new vehicle technologies would come into play, and which low-carbon technology might 'win', side-lining discussions of broader changes to the transport system, mobility needs, behaviour change, and questioning the right to high-demand travel. This applies to smart meters too – the insistence on the rollout, with the idea of gains in efficiency and fuzzily defined benefits to consumers erases other possible futures by creating the expectation that smart meters are inevitable. Third, the privileging of private sector involvement, and the focus on economic rationality and markets over deeper engagement with people, has been demonstrated in all three case studies. Energy efficiency fits well into the post-political paradigm, especially when focused on technology, while social change to reduce energy demand does not.

Conclusions

This paper has reviewed the limits to the energy efficiency narrative. While more efficient use of energy, through improved technology or other more efficient provision of energy services, clearly contributes to energy and greenhouse gas emission reduction, I conclude that the energy efficiency narrative on its own is limited and limiting. As demonstrated through three CIED case studies, the focus on energy efficiency, primarily through technology, limits discourse to energy practices similar to the ones we currently experience, potentially locking us in to high energy lifestyles through seeking ways to maintain, rather than disrupt, current practices and business as usual behaviours.

It is no coincidence that the energy efficiency discourse conflates efficiency with demand reduction. The techno-economic focus, especially under post-political thinking, portrays efficiency as the only way forward as both market-driven economic growth and current lifestyles are sacrosanct. Furthermore, as the transitions approach highlights, maintaining current practices is in the interest of incumbent actors, who use visions, among other tools, to portray a single possible future. Other changes to energy demand, through altering practices and questioning social norms on how and why energy is used, are politically marginalised.

I suggest that achieving the significant energy and emissions savings needed for fighting climate change requires a renewed emphasis on the non-technical drivers of energy demand. Complementing the energy efficiency narrative with an energy demand reduction narrative, which questions current energy use patterns and considers long-term practice changes, could highlight the limits to (technical) efficiency savings, and open a way for policy to engage with the deeper changes needed to our demand for energy services. The energy sufficiency work can already contribute to this narrative. *Is efficient sufficient?* My answer is no.

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