
Sociopsychological perspectives on the active roles of domestic actors in transition to a lower carbon electricity economy

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Abstract. This paper explores the active roles that domestic consumers might play in different transition pathways to a lower carbon electricity economy. It begins with a review of psychological and sociological perspectives on the drivers for everyday energy-use patterns, situating these in the context of the body of research on transitions in sociotechnical systems. On the basis of the review, a social-science-based framework is proposed for analysing the active ways in which domestic actors might facilitate or support the transition to a lower carbon economy. Applying the framework to an analysis of centralised and decentralised transitions pathways suggests that domestic actors can play an active role in transition through establishing new routine and conventional uses of energy in everyday life. Domesticating lower carbon technologies such as smart meters and microgeneration equipment supports the disruption of unsustainable energy-using routines and could help to make energy consumption and energy costs more visible and relevant to the everyday lives of domestic users. The findings call attention to the need to consider the wider effects of energy-system transition within and around consumer-oriented lifestyles.

Introduction

The call for a transition to a lower carbon electricity economy for the UK is growing louder (COC, 2008). EU and UK climate legislation is putting increasing pressure on the energy industry to meet demanding carbon reduction and renewable targets (BERR, 2008; EC, 2008). Much of this legislation applies to the generation, distribution, and supply of electricity, underlining the significance of these activities to the UK's overall carbon profile (DTI, 2006). Energy security/capacity concerns are also becoming more important, as many of the coal and nuclear plants currently in use in the UK are due to close within the next ten–fifteen years due to the combined effects of the EU Large Combustion Plant Directive and old age. If end-use demand continues to grow at present rates, this would leave a 25 GW (approximately 30%) gap in capacity (DTI, 2006, page 92). The rate of growth of electricity demand is a key determinant of the scale of a potential 'generation gap', and hence the likely scale of investment needed beyond replacement levels.

Nearly a quarter of UK greenhouse gas emissions are due to electricity and gas supply linked to demands for residential lighting, heating, and power services (DECC, 2008). Efforts to reduce these emissions focus on three types of action: (1) decarbonisation of supply, eg by generating electricity from renewable sources; (2) increasing the efficiency of delivering end-use services, eg by using more efficient lighting, refrigeration, or other end-use technologies; and (3) reducing the level of end-use service demands, eg turning off devices when not in use. These require, respectively, increasingly active roles of

domestic actors to bring about changes. However, we argue in this paper, to understand and affect levels of end-use demand requires an appreciation of the social context and established psychological routines in which those roles and demands are embedded.

Much has been written about how the current electricity regime could change in response to the above pressures, focusing mainly on technological changes to achieve decarbonisation of supply and increasing end-use efficiencies for given assumptions about future levels of end-use demand [for recent overviews, see Jamasb et al (2008) or Anderson et al (2005)]. This more technically oriented work is complemented by a growing body of literature on ‘transitions in sociotechnical systems,’ which offers an interdisciplinary perspective on the relationships between energy technology/infrastructure, agents/society, and change in energy systems (eg Correlje and Verbong, 2004; Hofman et al, 2004; Verbong and Geels, 2007). Transitions theorists use insights from science studies, sociology of technology, institutional theory, and innovation studies (see in particular Bijker, 1995; Bijker and Law, 1992; Rogers, 1995) in an effort to identify common signs and triggers for the eventual dominance or closure of a particular niche technology and the formation of a new sociotechnical ‘regime’ around that technology (see Geels, 2005a). This approach argues that the coevolution of technologies and social institutions, including habits and routines, leads to the persistence of particular directions or trajectories of sociotechnical change (Dosi, 1982), and to the ‘lock-in’ of regimes, such as the current high carbon energy regime, which then favours only incremental change along these trajectories, and creates barriers to more radical change (Unruh, 2000). Central to this approach is a multilevel perspective of social and technological innovation and diffusion which consists of three hierarchical levels (eg Geels, 2005b):

- (1) *niche*—an experimental level outside of or protected from mainstream markets or sociotechnical institutions;
- (2) *regime*—the level at which social groups maintain an institutional structure of rules, norms, and conventional practices around a particular technology or cluster of technologies;
- (3) *landscape*—the broad global order of things in which sociotechnical regimes and niches both evolve.

The continual interaction of these three levels facilitates or drives changes (often incremental, but sometimes revolutionary) in sociotechnical systems. When these independent changes culminate in a fundamental shift in the technological and social character of the regime, such that technology and the ‘rules’ for using that technology change to a new stable state, a sociotechnical transition has taken place.

As outlined above, the transitions perspective has been developed and is intended for analysing *both* technical and social changes symbiotically [Geels (2005a), Geels and Schot (2007), and Rotmans et al (2001) all stress this point]. However, it has been most commonly applied to technocentric analyses of the diffusion of new niche technologies and resulting changes in the technical fabric of sociotechnical systems (Smith et al, 2005). In contrast to these relatively detailed technological histories and models, practical perspectives on the more social aspects of sociotechnical transitions remain somewhat undeveloped and perfunctory in nature. Although there are some notable exceptions to the general rule (eg van der Brugge et al, 2005), it seems that Rotmans et al’s (2001) early calls for more attention to the social and institutional aspects of transitions remain largely unanswered. In a recent trenchant social critique of the transitions approach, Shove and Walker (2007) note that “for all the talk of socio-technical-co-evolution, there is almost no reference to the ways of living or to the patterns of demand implied in what remain largely technological templates for the future” (page 768). Elsewhere, the ‘social’ aspects of the transitions perspective have been criticised

as excessively functionalistic, ignoring the agency of actors and the importance of social context at the expense of explaining what happens technologically (Smith et al, 2005). Indeed, 'culture' in transition studies is often relegated to the landscape level and considered as exogenous to the main (niche-regime) dynamics of social change (eg Haxeltine et al, 2008).

Our reading of the transitions literature and its theoretical underpinnings suggests that the lack of serious social-science engagement within the application of the transitions framework is more reflective of the convenience of discussing and analysing transitions in terms of their more tangible, technical elements [see Geels (2005a) on this point], than it is of a lack of solid social science theory underpinning the perspective itself. The fact that mainstream social theorists have been content (until recently) to leave most of the development of transitions theory to technologically oriented researchers does not detract from the potential value of the transitions perspective for understanding reciprocal change in sociotechnical systems. Indeed, we would argue, as others have (eg Bijker, 1995; Bijker and Law, 1992; Nye, 1998), that adopting an explicitly 'social' perspective offers some unique points of entry for understanding how and why energy systems and society coevolve, and the challenges of achieving transition in this area.

In this paper we apply psychological and sociological lenses to an investigation of the active roles that domestic actors might play in transition to a lower carbon electricity economy. We first outline two different centralised and distributed pathways to a lower carbon electricity system, and then review the sociopsychological drivers of everyday energy-use patterns. We focus on ongoing energy-use behaviour, as distinct from (though not exclusive of) the acquisition of efficient technologies or deliberate energy-conservation behaviour, in an effort to capture the challenges of shifting or 'transitioning' embedded energy-using routines into more sustainable patterns of everyday living. Starting from the position that domestic energy users are 'locked into' habitual, circumstantial, or culturally prescribed patterns of unsustainable energy consumption/demand, we analyse the transition to a lower carbon electricity economy as it will unfold on the domestic level—as a process of unfreezing old, unsustainable habits and creating new psychosocial rules for sustainable energy use through the domestication of new, lower carbon technologies. Our intention is to sketch a new agenda and to raise new areas of enquiry within the transitions perspective on the role and agency of mainstream users of energy services (ie not transitions managers, government officials, entrepreneurs, or venture capitalists) in holding open and facilitating transition pathways to a more sustainable energy system. In doing so, we also reflect critically on the usefulness of a multilevel transitions perspective for addressing the demand-side elements of transition in energy systems that operate at the more mundane and oft-overlooked levels of everyday (un)sustainable actions by energy consumers.

Pathways to a lower carbon electricity economy for the UK

Envisioning the pathways by which a transition to a lower carbon energy system might be achieved within a context of different legislative targets, a potential generation gap, and competing interests and technologies is a complicated task, not least because the factors that shape the current and future carbon content of the UK electricity regime can interact in unpredictable ways. Two of the authors (Nye and Foxon) are involved in a major, multidisciplinary study funded by EPSRC and E.On UK⁽¹⁾ of transition pathways for a lower carbon electricity system in the UK. This study seeks to explore the complex processes and potential outcomes of transition to a lower carbon electricity system,

⁽¹⁾ 'Transition pathways to a low carbon economy', EPSRC Grant Ref.: EP/F022832/1.

by combining scenario-based and historical analyses of change in energy systems with whole-systems technical analyses and assessment. The project also seeks to incorporate social science perspectives on the role of institutions, cultural norms, and constraints/opportunities for both large-scale and small-scale actors to shape transition pathways. It is this latter activity to which this paper contributes.

Drawing on a variety of technical and theoretically based literature including dynamic processes, innovation in electricity systems, and long-term sociotechnical transitions, Foxon et al (2008a; 2009) have begun to explore possible transition pathways to a low-carbon electricity system based on different technological options and governance patterns relating to one of two (predominant) supply options:

(1) A system dominated by centralised electricity supply, incorporating large-scale deployment of low-carbon generation technologies such as offshore wind, biomass, wave/tidal power, or nuclear. Consumers would play a demand response role via 'smart meters' linked to variable tariffs.

(2) A mainly decentralised (distributed) system, incorporating community-level and domestic microgeneration equipment such as combined heat and power, wind turbines, or photovoltaics to generate electricity much closer to end use. Consumers (at community or 'micro' levels) would now also assume the role of electricity producers/suppliers, which, as we shall argue, could give rise to interesting interactions with their levels of end-use service demand.

Either one of these alternative sociotechnical electricity regimes represents a significant departure from the centralised, fossil-fuel-based regime currently in place. However, it is also important to note that these groupings are not mutually exclusive. Both currently do coexist at the niche level and it is likely that the future will incorporate some level of both distributed and centralised lower carbon generation (a hybrid system). It is unclear at this stage which system will become dominant, although both can be considered very real options given the right mix of incentives, legislation, social changes/drivers, and, of course, technological investment.⁽²⁾

It is not our intention to engage with the nuances of technical mixes here. Instead, we wish to focus on and further develop our understanding of the roles that social actors might play in either of these transition pathways as they interact with loosely bundled decentralised or centralised systems of electricity supply and monitoring. The discussion of psychological and sociological perspectives on energy use in the following sections lays the groundwork for an argument that everyday energy-use patterns reflect and emphasise the power of the institutions and conventions that surround them in particularly vivid ways. Even though these perspectives overlap in important areas, we argue that they offer useful complementary views on the motives for energy conservation behaviour and the broader range of sociotechnical factors that help to shape everyday energy-use patterns.

A brief overview of psychological perspectives on energy-use behaviour

Although environmental problems have never rivalled social or health problems as a focus for psychological investigation, since the 1970s an impressive body of environmental psychology literature has developed on energy consumption and conservation behaviour (eg Brandon and Lewis, 1999; Stern and Kirkpatrick, 1977). In theoretical terms, four broad approaches to understanding or accounting for energy-use behaviour

⁽²⁾ It is also difficult at this stage to gauge the relative likelihood of either one of these pathways developing instead of the other. Many of the technologies included within either of these groups are at the R&D, demonstration, or precommercial stages (Jamash et al, 2008). However, this issue will be explored later in the project.

have emerged, each of which offers a unique perspective on the role(s) of actors in a transition to a lower carbon economy. The two most dominant of these are 'expectancy-value' approaches, which rest on the premise that how one evaluates the outcomes of behaviour in terms of rewards and costs will determine one's intention to act (eg Ajzen, 1991); and norm-based approaches, which challenge the assumption that action is motivated in anticipation of tangible or social outcomes and focuses instead on 'internal' rewards associated with adhering to personal values (Axelrod and Lehman, 1993). A somewhat less dominant, but still well-established, strand of research highlights the role of unconscious processes, such as habit, on behaviour, including energy use (eg Verplanken et al, 1998). Finally, more recent qualitative approaches within the sociocultural, discursive, and critical psychology literatures have provided an alternative to the traditional positivist paradigm, and these have much in common with the sociological perspectives on consumption discussed later in this paper. These new trends—although often not explicitly linked to an environmental or energy agenda—have begun to expose the social construction of identity and consumption (eg Billig, 1999). Recent efforts have also focused on providing integrative theoretical frameworks that encompass these diverse determinants of behaviour, including attitudes, values, beliefs, contextual forces, personal capabilities and resources, and habit (Stern, 2000).

Energy-conservation behaviour versus everyday energy use

Empirical studies of psychological drivers of energy use appear to provide more support for the expectancy-value, habit, and identity-based models of behaviour, than for the (ecological) norm-based approach. Consistent with the expectancy-value paradigm, financial motivations have been shown to be an important, if not primary, factor in deliberate energy-conservation behaviour (Brandon and Lewis, 1999; DEFRA, 2002). Recent research by Whitmarsh (2009), for example, found that turning off unused lights and buying energy-efficient bulbs are most often motivated by a desire to save money. Unsurprisingly, at least in light of the so-called 'value-action gap' [see Barr (2006) for an overview in the domestic context] environmental concerns were somewhat less significant predictors of energy conservation behaviour. Similarly, Kurz et al's (2005) qualitative study of barriers to energy conservation found that consumers were unlikely to characterise energy use as a moral/environmental issue (see also Black et al, 1985; Poortinga et al, 2004).

The invisible and somewhat abstract nature of energy use in everyday life (as well as its environmental/social impacts) would seem to play an important role in the dominance of financial heuristics or frames for considered energy-use behaviours. Some research shows that consumers exert considerable effort to understand their energy-use levels from the information that is available to them on energy bills or meters (Kempton and Layne, 1994). However, it may be difficult for average consumers to connect their daily activities to energy-use levels or daily expenditure on energy (Burgess and Nye, 2008).

Deliberate energy-conservation behaviour, and its apparently rationalistic set of drivers, form a convenient starting point for exploring psychological aspects of energy use. However, it would be misleading to assume that all, or indeed the bulk of, everyday energy-use behaviour is financially or environmentally driven, or even necessarily rational. Here we invoke the distinction between deliberate energy-conservation behaviour and everyday energy-use patterns, the latter being driven largely by habits and conventional routines. Research within the habits and unconscious processes field shows very strongly that energy-use behaviours can, and often do, move quickly from considered deliberations over perceived personal costs and benefits to the more habitual sphere (Bamberg and Schmidt, 2003). This has implications both for behaviour-change

strategies and for our understanding of how transitions to a lower carbon economy might occur, since habits are not driven by conscious intent (Ouellette and Wood, 1998). Preexisting habits or deeply embedded routines can inhibit deliberate intentions for behaviour change (Verplanken et al, 1997; 1998).

Apart from habits, some research in the psychological tradition also points to the importance of identity, lifestyles, and 'subjective norms' in driving everyday, 'unthinking' energy use. For instance, comfort has been shown to be a key consideration for domestic heating (Gatersleben and Vlek, 1998); while decisions about lighting and home appliance use are bound up with social identities and lifestyles and related to assumptions about quality of life and prosperity (Layton et al, 1993; Poortinga et al, 2004). Concerns underpinning energy choices may also include the resale value of one's property, aesthetic qualities of energy equipment, self-image, status, or personal comfort. Such diverse concerns can result in energy-consumption behaviour that is seemingly inconsistent or 'irrational'—that is, someone might save electricity by cooking two meals at once, but keep the heating on 'for the cat' or open windows to 'air the house' (Layton et al, 1993). As discussed in the review of sociological perspectives on energy-use behaviour that follows, there are important overlaps between these ideas about identity and subjective norms, and sociologically oriented findings about the relationships between energy use and conventional understandings of the proper use of energy in everyday life.

A brief overview of sociological perspectives on energy-use behaviour

In contrast to psychology, sociology has found 'energy' and its relationship to the natural environment and society a more difficult problem to tackle, often displaying a reluctance or 'ambivalence' (Buttel, 1986) about engaging with the natural world. This is partly due to a lingering emphasis on Durkheimian 'social facts' as the primary determinants of social phenomena (eg Dunlap et al, 2002). The abstract nature of 'energy' itself further complicates matters. Shove and Warde (2002) point out that consumption of goods like energy and water are "by any standards ... peculiar forms of consumption, so peculiar that they cannot be captured in the sociological language of mechanisms propelling consumer culture" (page 240). This is not to argue that a sociological perspective on energy does not exist, but rather that it still exists in a somewhat dispersed form across several loosely linked fields. In terms of increasing our understanding of the roles of social actors in a transition to a lower carbon energy system, the most relevant of these seem to be sociological studies on consumption and related discourse on the coevolution of sociotechnical systems and conventions of normality. These are discussed in more detail below.

Energy use as embedded within unsustainable systems of consumption

Studies of the cultural and social aspects of consumption are an obvious entry point for approaching transitions in energy systems from a social perspective. Recent work on sustainable consumption has begun to move away from a largely 'reactive' (Georg, 1999) emphasis on attitudes and responsibilities of consumers, towards a focus on less conspicuous patterns and drivers of consumption behaviour enacted by social actors in different contexts. In general, this line of enquiry characterises consumption as driven by: wider cultural trends towards consumerism, insatiable wants transformed into 'needs', shifting conventions of normality, increasing individualisation and the use of consumption to define the self, and (un)sustainable sociotechnical systems of provision or supply (eg Jackson and Marks, 1999; Røpke, 1999; Spaargaren and van Vliet, 2000). A number of studies highlight the difficulties of changing consumption patterns in the face of sociotechnical systems that structure or 'lock in' consumers to various consumption

practices (Reisch, 2001; Sanne, 2002; Schor, 1995). Complementary strands of research focus on the roles that consumption practices play in helping to maintain social conventions or cohesion, the use of consumption in the construction and maintenance of a lifestyle, and the use of material objects in expressions of identity (Douglas and Isherwood, 1979; Hobson, 2002; Shove, 2003).

A more focused sociological literature on energy consumption has begun to emerge in recent years, particularly with regard to the relationships between ‘inconspicuous’ energy consumption and sociotechnical systems. Energy-use patterns are portrayed as a byproduct of the nonlinear coevolution of technological infrastructures, their conventional applications, and the skills, expectations, and standards of the social actors who use them (Gronow and Warde, 2001; Shove and Warde, 2002). Proponents of this ‘social revealing’ (Goldblatt, 2005) approach tend to focus more on the ‘obligatory’ (Hackett and Lutzenhiser, 1991) elements of energy consumption and to engage less with the possibility for social actors to reflexively change the systems of freely available credit, rising expectations, cheap energy, and technological momentum in which they have ‘ensnared’ themselves (Nye, 1998).

Conventional uses and symbolic meaning

Understanding energy-use patterns as a byproduct of the contingent construction of social systems and technological artefacts also encourages us to consider the social conventions and symbolic meanings that coevolve with different technological artefacts, and the reciprocal ways in which artefacts ‘objectify’ social structures (eg Miller, 1987). The ‘proper’ or socially appropriate use of energy-consuming technology (artefacts) is a social construction that varies from one culture to another (eg Scheele, 2006). Strictly speaking, the ‘proper use’ of an artefact refers to using it in the specific capacity or purpose for which it was designed (see Preston, 2000). However, the term is also used here in a normative sense as the range of socially accepted or ‘approved’ uses for a particular technological artefact. These conventional functions are not given by specific technologies themselves, but are instead contingently constructed alongside social norms and expectations as technologies diffuse through the layers of social and cultural systems and take on a ‘life of their own’ (eg Bijker, 1995). So, for instance, a family might use an air-conditioning unit both to cool the home (its intended use) and to generate ‘white noise’ during a baby’s nap (Hackett and Lutzenhiser, 1991). Whilst such an alternative use for air conditioning could be considered almost universally acceptable (except perhaps in green cultures where sustainable energy consumption is the norm), one can easily envisage significant, perhaps even controversial, variations between accepted and acceptable uses of similar artefacts in different cultural contexts.

Just as the proper uses of things are coconstructed, so are their meanings, and so is the meaning of consuming them in different places and spaces (Appadurai; 1986; Jackson, 2004). There are important overlaps here with the aforementioned sociological discourse on the symbolic aspects of consumption, lifestyles, and the construction and maintenance of a social identity. As Røpke (1999, page 410) puts it, “people use goods as one of the means to define themselves, as goods transmit messages to others.” Whilst electricity itself arguably has little symbolic value, its use is implicit in many of the material goods that add meaning and continuity to modern life. For instance, Wilhite et al’s (1997) examination of the takeup of air conditioning in Japan found many Japanese families installing and using air conditioning, despite a preference for natural ventilation, because air conditioning was seen as an important symbol of modern living. Similarly, some families may wish to project the image of an inviting and cosy home through maintaining a warm and well-lit house (Shove, 2003).

Unfortunately, little is currently known about the magnitude or effect (in terms of comparative energy consumption) of the sorts of different ‘approved’ or symbolic uses of energy-consuming technology in different contexts that have been discussed to this point. However, the discussion to this point does open up some important new areas for inquiry into how downstream actors might lead, act, or react in transition to a lower carbon economy. We now turn our attention to a deeper analysis of how these factors might affect and be evidenced in transition pathways to a lower carbon electricity economy for the UK.

Towards a framework for understanding the active roles of domestic actors in transition to a lower carbon economy

The preceding review of psychological and sociological perspectives on domestic energy demand offers several promising angles for analysing the active or passive roles that mainstream demand-side actors might play in transition to a lower carbon electricity economy. This distinction between active and passive roles in transition for different actors enrolled at different levels of the sociotechnical regime is an important one, and should be addressed before we move forward.

A successful transition to a lower carbon electricity economy will create symbiotic changes in mutually dependent sets of social ‘rules’ and technical arrays governing the generation, distribution, and use of electricity. Nevertheless, the impact of those changes will not be felt equally by all actors, nor is the achievement of those changes dependent on the active enrolment of all actors in new roles, rule sets, or working relationships with new technologies. For instance, consumers could be pulled passively into a lower carbon electricity economy if the supply and generation infrastructure were sufficiently decarbonised through large-scale investment in renewable or nuclear technologies (to an extent, this represents the approach being pursued in the short term through the promotion of hybrid/electric cars, efficient appliances, and a decarbonised grid). Setting aside questions about the feasibility of such a supply-driven technofix for delivering on demanding carbon reduction and renewables targets, it could be argued that this pathway would still entail significant changes in both technical arrays and the rules for the generation and supply of electricity. However, it could also be argued that these changes would most likely occur in elite and distant social and technical systems that are not necessarily open to the direct or indirect influence of the average consumer. In these circumstances the social and psychological drivers of demand for electricity in everyday life might change very little, if at all, even though the wider regime changes around the user. Entrenched ‘rules’ of consumer–supplier relationships would continue to dominate interactions between users, generators, and suppliers (see Devine-Wright, 2006) and the bulk of everyday electricity use could continue to be driven largely by well-established routines and convention—albeit with lower carbon consequences.

In keeping with the more ‘active’ focus of this paper, the decentralised and centralised pathways that were sketched earlier offer a more balanced and egalitarian picture of the transition to a lower carbon electricity economy that includes a series of more active roles for domestic electricity users. Our brief review of literature relating to psychological and sociological perspectives on energy use not only provides a distinctly ‘social’ platform for analysing these active roles, but also provides us with some important nontechnical labels or markers for gauging transitions in energy systems where they operate at a domestic level. We summarise each of these below with reference to the discussion in preceding sections, and then pull them together into a framework for analysing the active roles of domestic actors in transition to a lower carbon electricity economy.

Firstly, the psychological approach to understanding energy-consumption encourages us to approach an understanding of transitions in terms of the ways in which the social and material aspects of sociotechnical systems are reproduced in thinking about energy, and how these affect behavioural intentions and the justifications that actors give for changing energy-consumption patterns. This would suggest that domestic actors could play an active role in transition if the ‘visibility’ of energy use were increased in everyday life, such that consumers could make more considered (perhaps still predominantly financial) decisions about energy conservation or responsible energy use.

Secondly, both perspectives remind us that deliberate conservation behaviour is merely a *minor subset* of wider patterns of everyday energy-use behaviour. For most individuals, ongoing energy-consumption behaviour is an integral and ‘unthinking’ part of the enactment of everyday life. The bulk of domestic energy consumption stems from unconscious, habitual behaviour that is wrapped up in everyday habits or routines and the maintenance of a lifestyle. Thus, to the extent that domestic actors can play an active role in the transition to a lower carbon economy, a sizeable portion of that role will likely involve overcoming and replacing unsustainable energy-using habits and routines, and redefining the conventional and normative rules/expectations for energy use in everyday life.

Thirdly, although we have focused to this point on the sociopsychological drivers of energy use, we should not ignore the more technical/physical aspects of the sociotechnical electricity system. Domestic actors could play important diffusive and reshaping roles in the transition to a lower carbon economy through activities such as installing home microgeneration kits, selecting energy-efficient appliances, or switching to a renewable energy tariff. Such purchasing activities represent an important lever for domestic influence on the technical character of the broader sociotechnical regime, as well as an opportunity to reshape everyday energy-use patterns around new technologies. Niche technologies in particular offer a convenient, and easily traceable, focal point for rewriting rules, establishing new routines, and rethinking conventions and symbols. What is needed is a focus on the ways in which new lower carbon technologies and infrastructures could be ‘domesticated’ (see Geels, 2005a; 2005b) through the sorts of psychological and sociological processes described above, such that unsustainable routines and conventional uses of energy can be replaced with more sustainable patterns of everyday living.

Finally, following on from the last point, it is important to bear in mind that actions at the niche (or domestic) level can and do affect the pace, scale, and politics of transition at the regime level. The development of new artefacts and new rules will necessarily involve political struggles for these to be seen as legitimate alternatives. Actors at the regime level will most likely seek to maintain the dominance of the existing regime, because they are well adapted to the technologies and practices within it. Accordingly, the success of niche-level innovations will depend partly on the distribution of power between different actors.

A framework for analysing the active roles of domestic actors in transition to a lower carbon electricity economy

On the basis of the discussion and analysis to this point, we propose a five-part framework for categorising and analysing the active roles of domestic actors in energy-system transition:

(1) *Facilitating deliberate energy conservation through changes in the visibility of energy:* How might changes in the sociotechnical regime affect the ‘visibility’ of everyday energy-use patterns or systems of energy provision? Are consumers more aware of

their energy-use habits and routines, or able to make more informed choices in this area?

(2) *Changes in habits/routines or shift to more sustainable lifestyles:* How might changes in the sociotechnical regime affect the more habitual or routine aspects of everyday energy-use patterns? Have unsustainable routines been disrupted and replaced with more sustainable patterns of action?

(3) *Changes in normative/conventional understandings of proper energy use:* How might changes in the sociotechnical regime, or the actions of niche-level social innovators or influential pioneers, affect conventional or normative understandings about the proper use of energy? Have individuals made positive changes in the symbolic or conventional uses of energy in their everyday lives?

(4) *Increased demand for, and new uses for, low-carbon/more-efficient technologies:* How might normative and symbolic changes associated with energy use lead to changes in consumer choices for low-carbon technologies? To what extent could 'new functionalities' (see Geels, 2005b) for low-carbon technologies, as developed by (innovative) domestic users, assist in the acceptability and diffusion of these artefacts? How might day-to-day habits/routines, in turn, be disrupted by adopting and 'domesticating' (again, see Geels, 2005b) these new technologies?

(5) *Influencing the shape of the sociotechnical regime:* How do the actions in parts (1)–(4) influence the politics and technological character of the sociotechnical electricity regime? To what extent do changes in electricity demand, or the domestication of new niche technologies at the domestic level shape the trajectory of transition at regime level?

In the remainder of this paper we apply this framework to an exploration and discussion of how pathways to a lower carbon economy might evolve, paying special attention to the scope for domestic users to play an active role in transition to either system. This discussion is not intended to provide a detailed technical and behavioural summary of either system, but instead to highlight the value of a socially and behaviourally led approach for understanding the more generalised role-based aspects of mainstream actors in energy-system transition. Referring to the two different types of pathway outlined earlier, we explore the active roles of domestic actors; firstly, in a transition to a centralised low-carbon electricity system and, secondly, in a transition to a decentralised system.

Domestic actors in transition to a centralised low-carbon electricity economy

Much of the initial activity facilitating transition to a centrally supplied lower carbon electricity system will likely occur in large-scale, centralised generation and supply networks incorporating a combination of renewable or lower carbon generation technologies [see Foxon et al (2008a) for a discussion of how reorientation of the existing regime might occur]. As discussed previously, these sorts of changes in elite and distant supply/generation infrastructures would seem to offer little material (at least on their own) upon which to reframe sociopsychological drivers of everyday energy patterns and well-established consumer–producer relationships. However, there are a number of complementary demand-side technologies that could offer domestic users the chance to play more active roles in the transition to a centralised system—both in terms of conservation behaviour, and in terms of the sociopolitical character of the supply-side regime. 'Smart meters' (with two-way communication facilities) linked to variable rate tariffs are the obvious entry point here, offering both increased visibility of everyday energy use in everyday life, and the opportunity to play important load-balancing roles through the demand response to variable rate pricing. These new load-balancing functionalities could significantly increase the levels of renewable generation technologies

that could be included in the generation mix, thereby offering consumers an opportunity to play an active role in shaping both the politics and the technological character of a centralised regime dominated by renewables (as opposed to some other centralised low-carbon technology such as nuclear power). Assuming that consumers responded ‘properly’ to variable price signals, such an arrangement would also be beneficial to energy suppliers seeking to meet increasingly difficult renewable targets, whilst balancing the variability of renewable output in a more predictable manner

Important questions remain, however, as to the scale of demand reduction that could be attained through domestication of smart meters, and the means by which it might be achieved. Regarding the latter concern, it appears most likely that the domestication of real-time displays and variable rate tariffs would reinforce or facilitate increased conservation behaviour and investment in efficiency. As noted in our review of psychological drivers of energy use, deliberate conservation behaviour plays a fairly insignificant role in shaping aggregate patterns of domestic electricity demand. Therefore, it could also be assumed that the relative demand reduction that could be achieved by manipulating this driver would be similarly modest. Early evidence from trials of real-time displays supports these conclusions, showing only 5–10% decrease in demand (DTI, 2001). Findings like these must also be weighed against evidence of the relative price inelasticity of household electricity demand (eg Reiss and White, 2005) and the fact that householders tend to consider the bulk of household energy use (70–80%) as nondiscretionary (Owen and Ward, 2007). Whether or not these conceptions of the obligatory elements of electricity consumption stem from socio-cultural drivers or genuine material needs, they pose a serious challenge to the efficacy of shifting demand patterns through price incentives or real-time displays.

The evidence and discussion around smart meters to this point are admittedly more psychological than sociological in nature, reflecting the relative newness of these technologies and the dearth of research on the more behavioural aspects of how they are domesticated. Further study is needed in order to determine the extent to which domestication of real-time displays or variable pricing instruments could be used as tools for disrupting unsustainable energy-use habits, reframing conceptions of ‘obligatory’ electricity consumption, or formulating new normative guidelines for more sustainable energy use. Some research shows that immediate feedback devices can empower users to take control of their energy use and to make changes in specific energy-use habits, provided that the feedback is tailored to the consumer’s needs and easy to understand and apply (eg Burgess and Nye, 2008; van Houwelingen and van Raaij, 1989). However, we would again point to the relatively modest reductions in demand achieved by such devices in early trials as evidence that there may be little impact from increased ‘real-time visibility’ across the *totality of an energy-consuming lifestyle*. A more promising thread of enquiry concerns the ways in which the domestication of variable rate tariffs linked to smart meters offer the potential to change the times when energy-intensive activities *happen*, and so to disrupt everyday energy-use routines with a temporal lever, whilst offering opportunities for reevaluating and reformulating them.

Finally, we note that provision of smart metering technology alongside other energy goods and services in a transition to an ‘energy services companies’ (ESCOs) supply arrangement might provide some further domestic-level leverage for changing everyday energy-use patterns and increasing conservation behaviour. An ESCO would sell the lighting, heating, and powering services, as well as demand-reduction technologies, usually in a single package. This has the advantage of aligning the incentives for increasing efficiency and reducing demand for both the customer and the ESCO.

Information-based energy services such as professional energy analysis and audits or monitoring and feedback on energy savings could represent a means of increasing the visibility of energy in both conservation behaviours and in everyday activities. Consumer demand for ESCOs and associated increases in the demand for energy-saving technologies could drive similar technological and demand-side changes to those discussed above. However, it is also important to note that the ESCO model might prove most viable at community level in the UK, revolving around the design, provision, and maintenance of microgeneration (distributed) technologies for specific groups of consumers. Significant barriers remain for the transition from traditional suppliers to ESCOs at the household level, not least because UK consumers are sceptical about the benefits of ESCOs and there is currently little incentive for large suppliers to change their business models (Bertoldi et al, 2006; UKERC, 2005).

Domestic actors in transition to a distributed low-carbon electricity economy

Our outline of different transition pathways to a lower carbon electricity economy suggests that the transition to a decentralised or distributed electricity system may offer domestic users the chance to play an active role in transition at both the supply and demand levels. Here we explore the potential for domestic users to engage with domestic generation and monitoring technologies within a system that includes significant amounts of microgeneration technology at the household level (and to a lesser extent the community level), so that mainstream domestic users are actively engaged in the production and distribution of electricity. Such a system would essentially turn the old producer–consumer relationship (which still dominates in the centralised pathway) on its head, offering domestic actors the chance to play new ‘energy citizenship or ‘coprovider’ (Devine-Wright, 2006; van Vliet and Chappells, 1999) roles in the transition to a lower carbon electricity economy.

Considering the revolutionary outcomes of this pathway, it is perhaps unsurprising that its realisation presents serious technological and social obstacles at both niche and regime level. In contrast to the more established, predominantly upstream, generation and distribution arrays in a centralised lower carbon electricity system, most of the generation technologies likely to be implicated in a distributed system remain at the demonstration stage⁽³⁾ [see Jamasb et al (2008) for recent analysis of technical trajectories, and Foxon et al (2008b) for analysis of drivers and barriers to innovation for a range of technologies in this area].

High costs, long payback times, and low-value export tariffs (Jager, 2006), combined with complicated planning and installation hurdles, create strong disincentives for installation of distributed microgeneration technology by the mainstream user. Thus, *current* diffusion/use of microgeneration equipment would seem to be driven more by landscape-level concerns for the state of the global environment and the collective good than by economic utility (Brook-Lyndhurst, 2007; Dobbyn and Thomas, 2005). Consumers are unlikely to play an active role in diffusing these technologies without strong governmental (policy) support, particularly in terms of making the system economically viable and attractive (Brook-Lyndhurst, 2007; Foxon et al, 2008a; Shackley and Green, 2005). ESCOs might play an important role in helping to diffuse microgeneration equipment by subsidising the heavy start-up costs for microgeneration equipment (Bertoldi et al, 2006), provided that the aforementioned public scepticism about such arrangements could be overcome.

⁽³⁾ Although we assume that the smart metering systems discussed in the preceding section would necessarily be part of this system with/without variable-rate tariffs depending on the need for backup centralised capacity.

It is difficult to foresee how such a dramatic change in roles might affect the ‘political’ shape of the regime—particularly in terms of overcoming the vested and powerful interests of the incumbent energy generation and distribution companies in keeping things the way they are in terms of consumer–producer relationships. As mentioned above, widespread diffusion of microgeneration at domestic level is likely to require strong governmental support, or at least the opening up of space by government to enable more locally led action to flourish. As awareness grows of the challenges posed by climate change and ‘peak oil’, this type of grassroots action around more local forms of generation linked to a ‘lower impact’ lifestyles is now beginning to emerge at the niche level: for example, through the ‘Transition Towns’ movement (Hopkins, 2008). This could threaten the interests of the dominant players within the existing regime and the current institutional framings, whereby, for example, the duty on the economic regulator, Ofgem, to protect consumers’ interests is taken to mean ensuring lowest cost supply options. Hence, a path towards a more distributed low-carbon energy system is likely to involve local actors demanding more control over the way electricity is generated, together with the opening up of space for social innovations to occur: for example, by rewarding distribution network operators for supporting social as well as technological innovation under Ofgem’s Innovation Funding Incentive.

In terms of shaping patterns of habitual and/or conventional uses of electricity, it seems reasonable to assume that large-scale installation and use of microgeneration equipment in the home could have a dramatic effect on aggregate domestic electricity demand, provided that users could be persuaded to adopt a new system of reciprocal planning of energy consumption and production activities. Assuming that energy-intensive activities are more likely to occur when the householder is acting as a net exporter of energy, then installing and using home microgeneration equipment, and in particular variable equipment such as micro-wind turbines or photovoltaics, could offer an effective cost-based means for disrupting energy-intensive routines. Whilst the active basis of this relationship was also highlighted in our discussion of variable-rate tariffs, the microgeneration example implies a more complicated and involved calculus of the interface between personal generation activity, the availability of energy for export, and the performance of everyday routines. For instance, thrifty citizens relying heavily on photovoltaics to meet household electricity demand would need to consider the weather and the availability of sunlight before deciding to turn on the washing machine.⁽⁴⁾

With regard to energy visibility and its effect on energy-use patterns, more widespread installation and use of microgeneration equipment could promote a generalised increase in public awareness of energy production and supply similar to that observed in communities located close to large-scale (highly visible) generation infrastructures (eg Thayer and Freeman, 1987). The increased salience of energy infrastructure and consumption in everyday life might in turn increase awareness of the consequences of energy use and foster a sense of personal accountability for consuming electricity more responsibly (see Devine-Wright, 2006, page 69).⁽⁵⁾ Such a change would not only amplify

⁽⁴⁾ Examples like this one also raise a more cautionary note about the range of skills and competencies that might be required of the public in order to make a distributed electricity system work. To our knowledge there has been little research in this area (though see Whitmarsh et al, 2009). However, research by the Carbon Trust (2007) and Energy Savings Trust (EST, 2005) suggests that widespread adoption of microgeneration would seriously test the skill base of tradesmen involved in their installation, maintenance, and repair (see also DTI, 2007).

⁽⁵⁾ Increased awareness does not, in and of itself, always lead to positive changes in behaviour where the environment is concerned [see Whitmarsh (2009); also Barr (2006) in reference to value–action gap]. We address it here as an additional catalyst for change working alongside disruption of routines and changing roles from consumers to coproviders.

the importance of conservation behaviour as a driver of electricity demand, but could also be used as a basis for a reorientation of everyday routines around more altruistic concerns for responsible coproduction/consumption. Whilst it is unclear exactly how much increased responsibility might affect overall electricity demand amongst the UK public, the well-established positive relationship between personal responsibility for the environment and proenvironmental behaviour (eg Eden, 1993) could be considered grounds for at least cautious optimism in this respect.

Finally, increasing the visibility of generation and supply infrastructure as connected to a particular household or a specific community could also reshape conventional relationships with energy in positive ways. A distributed electricity system offers the potential to connect highly visible systems of generation and supply to everyday life in specific places and spaces. Using microgeneration equipment to turn the lights on or to create a cosy living room implicates a connection to a more personal and proximate lighting and heating system than that implicated in connections to a big, distant power station. In addition to serving as a reminder to use electricity more responsibly, constructing and maintaining these more intimate and frequent connections to energy infrastructures and technologies could also foster a parallel reevaluation of the more conventional or social attachments to energy within everyday habits and consumer-oriented lifestyles. Given that we still know very little about the ways in which energy-use patterns are driven by symbolic or conventional factors (Shove and Warde, 2002), it is again difficult to estimate how this sort of symbolic/conventional domestication and reframing activity might affect electricity demand. However, as mentioned with reference to the effect of real-time energy tariffs, any disruption in traditional, 'unthinking' energy-use patterns could represent an important departure point for forming new, more sustainable energy-use patterns. Combining a reevaluation of symbolic attachments to energy within everyday routines with increased awareness of energy infrastructure and an increased sense of responsibility for using/producing electricity responsibly could facilitate a significant consumer-led shift in demand for electricity.

Conclusions

The preceding socially oriented analysis of centralised and distributed transition pathways to lower carbon electricity systems raises several key points for understanding the role of domestic actors in transition to a lower carbon electricity economy. Engaging with electricity system transition from this perspective has also provided an opportunity to reflect on the value of social science analysis for investigating the more complicated sets of sociotechnical relationships that form around abstract or distant technical systems and the deeply embedded routines that they support.

The social science framework that we have described identifies five processes for enabling active participation of consumers in an electrical system transition: facilitating deliberate energy conservation through changes in the visibility of energy; changing habits/routines to more sustainable lifestyles; changing normative/conventional understandings of proper energy use; increasing demand for, and creating new uses for, low-carbon/more-efficient technologies; and influencing the shape of the sociotechnical regime. Although the opportunities appear limited for mainstream users to influence large-scale, centralised supply and generation networks, our analysis reveals several opportunities for domestic actors to redefine conventional understandings and uses of energy, and to break out of old energy-using habits through domesticating new technologies. Most lower carbon technologies explored in this paper operate by changing the order and pace of routines and/or making costs more apparent. The analysis suggests that these new functionalities offer potential for bringing habitual and conventional drivers of everyday energy use into a more considered and potentially malleable frame.

This would seem to be particularly relevant in the case of pricing mechanisms like variable rate-tariffs linked to smart meters, which offer the potential to link conservation behaviour to a stronger (financial) driver of behaviour than more altruistic conservation activities undertaken for the sake of the planet. The decentralised pathway offers further potential in these areas (whilst incorporating many of the benefits of the centralised pathway, assuming that smart meters are present) in that energy generation and supply infrastructure could become more intimately tied to the planning and practice of everyday activities. However, the relative gains that could be achieved in this pathway need to be balanced against the sociopolitical and technical hurdles that must be overcome before it could be realised.

More socially informed research is necessary in order to clarify the dynamics of these relationships and to exploit these findings in transition-management approaches or energy-system analysis. In particular, the discussion and analysis in this paper suggest three areas in which a deliberately social analysis of energy-system transition could offer further conceptual and empirical value:

- (1) Exploring the symbolic dimensions of domestic energy use and energy conservation, and—drawing on empirical examples of cultural/value shifts (eg Gardner and Stern, 2002)—how these may change in order to help drive or support an energy transition.
- (2) Further exploration of the unintended consequences and rebound effects on energy practices of energy-policy interventions.
- (3) Considering the necessary understanding and capabilities for domestic actors to have a more active role in a transition to a lower carbon energy system. One promising area of work, for example, has described this requisite ‘carbon capability’ in terms of the situated meanings of carbon and energy in everyday life and individuals’ abilities and motivations to reduce emissions (Whitmarsh et al, 2009).

Our review of the sociopsychological drivers of energy-use patterns shows that ‘social’ factors are central to explaining patterns of aggregate electricity demand. In turn, our analysis confirms what is becoming an increasingly common position within policy and practical circles: that shifting to more sustainable patterns of consumer electricity demand is as much about a shift to more sustainable lifestyles as it is about the adoption and diffusion of new, lower carbon technologies. Whilst this relationship is theoretically implicit within the transitions approach, it is not always explicit or applied in the practice of analysing *sociotechnical* transitions. Adopting a deliberately social lens for analysing the transition to a lower carbon electricity economy has helped us to recover some important social ground in the transitions field by revealing important relationships between the social drivers of everyday electricity use, technological arrays implicated in the (un)sustainable production and use of electricity, and changing patterns of electricity consumption.

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