From demand side management to demand side participation: Towards an environmental psychology of sustainable electricity system evolution

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2 authors:

Hannah Devine-Wright
University of Exeter

Patrick Devine-Wright
University of Exeter

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From demand side management to demand side participation: tracing an environmental psychology of sustainable electricity system evolution

H. Devine-Wright and P. Devine-Wright

Institute of Energy and Sustainable Development, De Montfort University, UK
hdwright@dmu.ac.uk

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Abstract

This paper evaluates demand side management (DSM) practices from an environmental psychological perspective, with a predominant focus upon the domestic sector. It discusses how DSM practices have begun to evolve into practices known as demand side "participation" (DSP). DSM and DSP practices are situated within four innovative contexts: the generation and supply of renewable electricity, distributed local scale "community" (or co-operative) energy initiatives, new information-technology interfaces (e.g. smart meters) and new economic structures (e.g. spot pricing). Finally, a range of potential research questions are proposed in order to generate a multi-faceted perspective (views of different stakeholders) of demand-side practices (as either DSM or DSP) that may facilitate sustainable development of the electricity system by fostering greater user involvement in energy service provision.

Introduction

Demand side management (DSM) practices have evolved within an energy supply system that is highly centralised (e.g. Guy and Marvin, 1996) and large scale, with significant spatial and psychological distances between energy generation and use. Within such a system, DSM has had two principle policy and industry objectives: to reduce demand for electricity (motivated, for example, by environmental imperatives such as limiting air pollution or carbon emissions) and to shift 'peaks' in demand (motivated, for example, by a desire for technical and economic efficiencies in the use of large scale generating plant). Demand management facilitates electricity system efficiency through better matching of demand and supply that reduces the need for back-up generation capacity during peak loads and optimises efficiency of continuously operating generating plant. DSM practices typically combine technical and economic strategies to manipulate demand (e.g. direct load control appliances that can be programmed to be switched on or off to match pricing information and/or consumer preferences; real-time price information or financial incentives for using appliances or systems during peak- or off-peak times of the day). In general, DSM practices have strong informational attributes (e.g. technologies such as electricity meters provide feedback about levels of consumption as KWh, financial savings or cost).

Behavioural studies have used empirical research methods to investigate the psychological factors affecting the efficacy of such one-way information provision. These have attempted to understand inter-individual differences in attitudinal factors affecting consumption behaviour as these have been shown to have a more significant effect than structural factors such as price or number or type of electrical appliances. For example, Heberlein and Warriner's (1983) empirical study demonstrated the effect of various price ratios on levels of on-peak electricity consumption amongst 413 US householders in 1975. They divided their sample into four groups each with different peak to off-peak price ratios: 2:1 ($n = 137$), 4:1 ($n = 139$) and 8:1 ($n = 137$). The dependent variable was amount of electricity consumed at peak periods whilst the independent variables included the actual price ratio, the number and type of appliances owned by the household, knowledge of price ratios (assessed using four survey questions e.g. "what price ratio was the household on?" or "at what time of year were peak prices charged?") and level of commitment. Commitment was assessed using a four item behavioural commitment scale that had two dimensions: two items tapping perceived moral obligation to reduce consumption and two items measuring the perceived importance of reducing electricity consumption.

Their results indicated a significant effect for both price ($p < .01$) and commitment ($p < .001$) on reducing on-peak electricity consumption; however, the relative significance of each of these factors differed markedly. Whilst price differences did significantly affect behaviour, ratio increases from 2:1 to 8:1 accounted for only 2% of the variance in behaviour. In contrast, a psychological measure, commitment to reduce consumption, accounted for 11% of the explained variance. This suggests that not only are psychological factors such as moral obligation very important in shaping electricity consumption behaviours, but also that there is no simple linear relationship between the size of the price incentive and its impact upon behaviour.

Later studies have continued this analysis of how one-way information provision within a centralised DSM perspective can be optimised by investigating the importance of interaction effects between contextual and psychological factors affecting energy use behaviour. For example, Heberlein and Baumgartner (1986) indicated how the impact of price incentives was moderated by both the quality and quantity of information provided. Complementing a utility's standard detailed information provision with advice, letters from consumer advisory organisations and frequent reminders led to a 16% greater reduction in off-peak electricity use. The impact was not just down to quantity of information provided about price incentives, a finding supported by Miller and Ford (1985) who analysed the impact of varied introductory letters on the take-up of incentives. An electricity company and its incentive programme were presented to consumers using three alternative letter formats: from the company itself; from the company but mentioning that the local authority was co-sponsoring the programme, and finally, from the local authority itself, on their notepaper, written by the chairman of the Board of Commissioners. In each case, the information provided about the incentive scheme was identical, however there was a 25% difference between the impact of the most effective (letter from local authority) and the least effective (letter from the company) intervention on consumer response.

This body of empirical research indicates how both situational factors such as price and psychological factors such as awareness, commitment and trust typically interact in often complex ways to shape energy consumption behaviours. Interactions such as these suggest that interventions targeting prices alone will not be optimally effective in changing user behaviour. They also testify to the importance for energy policy makers of designing behavioural change strategies that are informed by social science research evidence, even if this is often absent (Halpern et al., 2004).

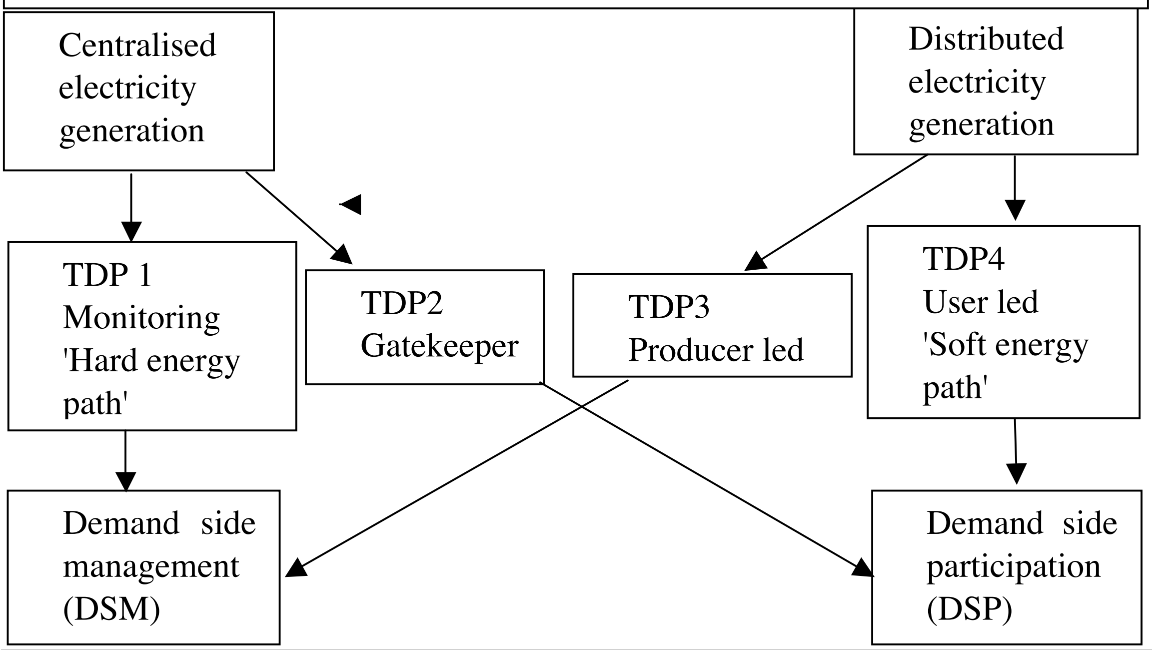
From Demand Side Management to Demand Side Participation

Increasing supply capacity from renewable or low carbon sources has become a key objective of UK government policy, with the target of 10% of electricity to be supplied by renewable sources by 2010 and an aspiration of 20% by 2020 (Department of Trade and Industry (DTI), 2003). Renewable energy generation capacity and other forms of distributed generation (e.g. combined heat and power plants) are often embedded in the distribution network (i.e. situated in localities where electricity is required) and small-scale (less than 50-100MW capacity). Both distributed generation and forms of micro-generation (e.g. building integrated solar photovoltaics or micro-CHP) can be installed by individual households or community groups and used to generate their own electricity. Increasingly, as part of the wider sustainable development agenda characterised by Local Agenda 21 activities and the goals of involving and empowering local people in environmental action, attention is being paid to the social dimension of distributed generation, where localised contexts of electricity generation suggest the potential for innovative relationships of co-provision between consumers and energy companies as well as the evolution of new roles (e.g. owner, user, and investor), responsibilities, control mechanisms and information communication technologies (ICT).

New relationships implied by localised contexts of renewable electricity generation can be understood through comparison with relationships described within different technical metering systems (e.g. Marvin, Chappells and Guy, 1999). Marvin et al., (1999) identified and compared four metering 'technical development pathways' (TDPs) that differed according to the type of producer-user relationships they implied: monitored (TDP1) (with a traditional meter that maintains independence and distance between the electricity supplier and the user), gatekeeper (TDP2) (that is principally defined by the use of pre-payment metering technologies), producer-led (TDP3) (which extends 'beyond the meter' and enables the utility company to control the communication of up-to-the-minute tariff information as well as energy efficiency advice and to remotely control demand through manipulating the operation of appliances) and user-led (TDP4) (characterised by the provision of environmental/energy information to the user that increases the visibility of resource use).

The identification of such TDPs is useful since it brings attention to the reciprocal relationship between the design and use of metering technologies and their social and/or environmental contexts. Whilst Marvin et al., (1999) focused specifically upon metering technologies, their technical development pathways mirror pre-existing distinctions in other ‘pathways’, specifically the ‘hard’ versus ‘soft’ energy pathways used by Lovins (1977) to describe energy system evolution more widely. From Marvin et al’s., (1999) socio-technical perspective, TDPs or 'soft' energy paths are not characterised by the presence or absence of technology per se since all energy paths require technologies for energy generation, supply or use; instead alternative pathways reflect different socio-technical relations and configurations between producers/utilities and energy users. The relationship between TDPs and soft and hard energy paths with different styles of management and user participation on both the supply and demand-side are illustrated in figure 1.

Figure 1: Contextualisation of metering TDPs (Marvin et al., 1999) and 'soft' and 'hard' energy paths (Lovins, 1977) within demand and supply side electricity practices



TDP1: Monitoring - conventional type meters with simple functions and limited relationship between producer/user
TDP2: Gatekeeper - smart card meters maintain distant relationship between producer/user
TDP3: Producer led - functions configured by producer resulting in authoritative relationships
TDP4: User led - functions configured by user in devolved relationship

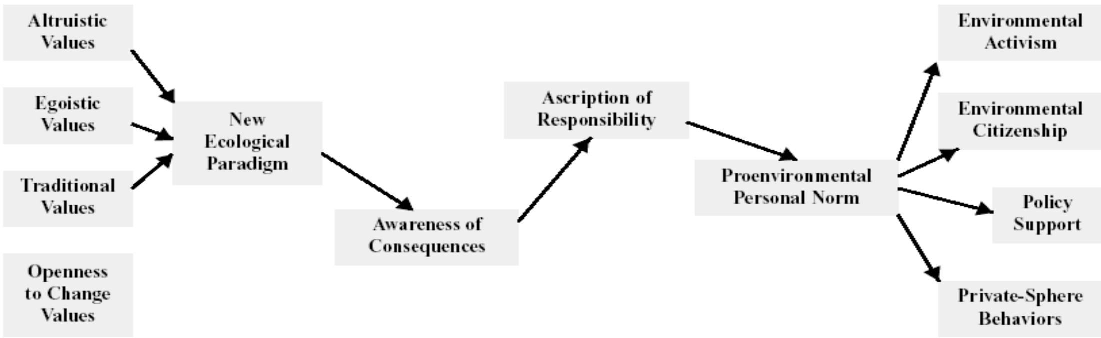
Although figure 1 suggests discrete categories, it is envisaged that there is a continuum between forms of generation and demand-side practices. This continuum reflects degrees of centralisation/localisation and control as well as transitions from management to participation with intermediate states of co-production and co-provision envisaged.

The technical development pathways identified by Marvin et al., (1999) suggested different degrees of control, responsibility, power and activity between suppliers and users. However, their TDP typology was principally developed around quantitative and qualitative distinctions in the frequency, type, amount and direction of information flowing between suppliers and users. For example, the traditional monitored metering (TDP 1) implied simple, infrequent, remote and limited unidirectional information (in the form of electricity units i.e. KWh) flowing between supplier and the user that has characterised DSM research on the effectiveness of information provision that was outlined earlier (e.g. Heberlein and Baumgartner, 1986; Miller and Ford, 1985). By contrast, user-led metering (TDP 4) suggests 'feedback' information that was multi-format (e.g. graphical or electronic), frequent, accurate, diverse (e.g. KWh, renewable or non-renewable source data, carbon emissions etc.) and bi-directional.

Information provided as 'feedback' is usually conveyed rather than communicated, where communication is understood as a more complex process in which the energy user is an active participant rather than passive receiver of information (Stern and Aronson, 1984). Smart metering technology has the potential to blur the distinction between information receiver and provider and thereby contribute to a more interactive, participative and sustainable framework for energy demand and supply. However, technology alone cannot 'fix' an absence amongst electricity consumers in the UK of a “tradition of involvement in metering” (DTI Smart Metering Working Group Report, 2001, p. 4) that may reflect a more general absence of public 'enthusiasm' for greater influence over the development of future technologies (e.g., associated with genetically modified crops and food as described by Grove-White, Macnaghten and Wynne, 2000).

Our understanding of the impact of demand and supply side management or participation strategies upon behaviour requires the use of sophisticated, multi-level conceptual frameworks. One psychological framework at the individual level that might be effective for such a task is value-belief-norm theory proposed by Stern, Dietz, Abel, Guagnano and Kalof (1999). This theory is useful in addressing three of the key psychological concepts implicated in the research literature: awareness (related to quantity and quality of information provided), sense of responsibility and moral obligation. Value-Belief-Norm theory aims to explain the psychological processes giving rise to diverse forms of pro-environmental behaviour such as environmental citizenship (e.g. signing petitions to support environmental organisations or voting in support of pro-environmental policies) and private sphere behaviours such as recycling of waste, energy conservation or the purchase of eco-products. In this theory, a combination of values, beliefs and norms motivate individuals to engage in behaviours that may not lead to any immediate personal benefit, but instead may benefit other people (e.g. future generations or the wider community today) or the environment. The specific constructs within the framework are illustrated in figure 2.

Figure 2: Value-belief-norm theory (Stern et al., 1999) for predicting environmental citizenship



VALUE BELIEF NORM THEORY APPLIED TO PRO-ENVIRONMENTAL BEHAVIOURS SHOWING DIRECT CAUSAL RELATIONSHIPS BETWEEN PAIRS OF VARIABLES

The framework describes a series of causal stages from the left to right hand side. According to the theory, environmental behaviours are rooted in stable, deeply held personal values and the adoption of a worldview that recognises limits to growth, potential disadvantages of science and technology and attributes rights to the natural environment (described as the "new ecological paradigm"). Flowing from this is a layer of beliefs concerning the person's awareness of negative consequences to valued people or environments about which action could or should be taken - in this case, this is likely to be awareness of climate change, air pollution etc. If awareness is present, the individual may ascribe responsibility to themselves to act to remedy the situation and if the person feels a sense of moral obligation to act, then acts of pro-environmental behaviour are likely to occur.

VBN framework has been empirically validated by recent research in the Netherlands (De Groot and Steg, 2004) about the psychological predictors of public support for a range of energy policies, including increases in fuel prices. However, it may be less useful in predicting behaviour where self-interest is also a key motivator for behaviour or when issues of behavioural control or interpersonal social norms are important. For such contexts, an alternative theoretical framework to explain individual actions could be Azjen's Theory of Planned Behaviour (1991), which has been widely validated across a range of behavioural domains, and is based upon intentions being predicted by specific attitudes to behaviour (whether the outcomes are expected to be positive or negative for the individual), social norms (what social pressures are perceived to relate to specific actions) and the concept of perceived behavioural control (perception of the ease or difficulty of performing an action).

Both theories suggest a range of directions for research and practice into issues of user participation in the supply and demand of electricity. However, they are not sufficient for addressing how beliefs held by individuals are socially constructed nor do they address how conventions such as the 'lack of tradition of involvement' in metering (DTI Smart Metering Working Group, 2002) evolve or change over time. Adopting a more social constructivist perspective upon electricity demand and supply leads to consideration of the type of roles and relationships that exist between individuals, groups and institutions, and how such relations are characterised by social influence processes that in turn shape thought and action. In this way it is useful when modelling electricity use behaviour to combine elements of both VBN and TPB at the individual level (e.g. the inclusion of an explicit role for values and perceived behavioural control) with socially constructed normative beliefs such as conventions of involvement, convenience and comfort associated with energy use (Shove, 2003). In this manner, it may be possible to understand more fully the processes by which the social context informs environmental behaviours at both an individual and a collective level of analysis.

Table 1 illustrates discrete facets of the two demand-side perspectives conceived in this paper (DSM and DSP) by contextualising behavioural and techno-economic aspects of energy use identified within this review within social-psychological distinctions identified in market communication about other forms of environmental technologies i.e. GM crops and foods (Grove-White et al., 2000) and the co-production and behaviour change associated with health and education policy delivery (Halpern et al., 2004). Having identified potential facets, future research is required to empirically investigate their existence and distinctiveness as well as their relationship to different technical development pathways.

Table 1: Potential facets of social constructions of demand-side management and demand-side participation perspectives

Facet	**DSM practices**	**DSP practices**
Perspective of operation	To manage	To involve
Implicit characterisation of people	Highly individualised, passive 'consumers'	Socially aware active participants (citizens)
Implicit model of public's understanding	Deficient, limited and with little interest beyond minimising inconvenience	Discriminating, grounded in own or trusted others' experiences
Mode of communication	Information provision	Knowledge transfer
Direction of communication	One-way	Two-way
Content of communication	'Factual'	'Social meanings' of technology
Purpose of communication	Inform choice and individual decision making	Build trust and respect, to enable co-provision of services
Locus of control	Producer-led	User-led
Direction of influence	Top down: expert to lay	Reciprocal
Motivation	Self-interest	Both self-interest and self-transcendent
Attribution of responsibility	Specific stakeholder e.g. utility company	Shared between stakeholders e.g. utility and users
Normative influence	Predominately individual (personal)	Predominately social
Type of 'energy path'	Hard	Soft

This review provides a conceptual foundation for a new electricity research agenda focusing upon the design and implementation of empirical approaches to demand-side renewable energy use behaviour. It identifies possible facets of demand-side and demand-participation practices that could be articulated as discrete research issues. It should be noted that although the UK electricity industry regulator (OFGEM) already advocates 'demand side participation', in practice this has involved an economic mechanism by which demand for electricity by small scale consumers (i.e. those who consume less than 100KW per annum and whose consumption is not metered half-hourly) can be aggregated and then traded on wholesale markets, rather than a process with an explicit social-psychological, sustainability dimension. Therefore research issues that could arise from this distinction between DSM and DSP could include:

- Identification of the role that stakeholders envisage demand side practices might play in the evolution of a more sustainable electricity system, and how such practices relate to emerging definitions of sustainable energy
- The way in which stakeholders represent different actors in the system, and how such representations evolve over time
- The relationship between stakeholders' definitions of user commitment, responsibility, moral obligation and awareness of consequences (after Stern et al., 1999) as well as intention and perceived behavioural control (after Azjen, 1991), for themselves and others
- Attribution of importance to different facets of demand-side practices and how this influences technological development pathways (after Marvin et al., 1999)

From this it is recommended that research be conducted that address these issues using appropriate social research methodology, such as semi-structured personal interviews with a sample of representatives from different electricity stakeholder groups. In the UK, key stakeholders would include:

- generators (e.g. multinational utility companies such as Powergen or small-scale energy co-operatives such as Baywind Energy Co-operative in Cumbria or Sherwood Energy Village in Nottingham)
- regulatory bodies (e.g. OFGEM)
- network operators (e.g. distribution network operators such as East Midlands Electricity or transmission network operators such as National Grid/Transco)
- electricity supply companies (e.g. EDF, Ecotricity)
- electricity users
- consumer groups (e.g. Energywatch)
- lobbying organisations (e.g. Greenpeace; Electricity Intensive Users' Group)

At an international level, future research is required to compare the similarities and differences between representations of demand side practices, as held by similar stakeholders in different socio-cultural contexts.

Conclusion

Demand side actions within the electricity sector have typically been geared toward managed (DSM) rather than participatory (DSP) practices. With this in mind there would seem to be potential within the UK to move not only 'beyond the meter' (e.g. Marvin, Chappells and Guy, 1999) but beyond DSM towards DSP with its attendant emphasis upon user participation and involvement which is a key attribute of sustainable practices. DSP could therefore be understood in relation to the way in which demand side actions are socially constructed and embedded within existing and future industry practices such as smart metering technologies since these practices provide part of the context in which environmentally significant behaviours such as foregoing or modifying electricity consumption occur.

Electricity meters make an invisible commodity (i.e. electricity) visible. In fulfilling this function they can be seen to structure the relationship between the electricity user and the electricity supplier both in terms of technical development pathways and in terms of delineating the sense of perceived behavioural control that the user experiences. If co-providers such as electricity utility companies like Baywind are to become normative and everyday, rather than unfamiliar and exceptions to the rule, then the 'rules of engagement' in the energy sector need to change to enable distributed generation and civic engagement with energy supply and demand in ways that are different to those conceived within a centralised electricity system. Furthermore, the evolution of domestic and community-scale electricity generation technologies suggests new roles and responsibilities in a future electricity system. Identification of these roles and other facets can inform our understanding of energy use behaviour and contribute towards the wider agenda of sustainable development.

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