Energy Policy 98 (2016) 108–120

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Financial incentive approaches for reducing peak electricity demand, experience from pilot trials with a UK energy provider

Peter Bradley [a,*], Alexia Coke [b], Matthew Leach [c]

[a] Department for Accounting, Economics and Finance, University of the West of England, Frenchay Campus, Coldharbour Lane, Bristol BS16 1QY, UK
[b] Department of Geography and Geology, School of Natural and Built Environments, Kingston University, Penrhyn Rd, Kingston upon Thames KT1 2EE, UK
[c] Centre for Environmental Strategy, Faculty of Engineering and Physical Sciences (D3), University of Surrey, Guildford, Surrey GU2 7XH, UK

HIGHLIGHTS

- Novel study of financial incentive approaches for shifting residential energy.
- First academic paper comprehensively identifying barriers to time of use tariffs.
- First study reporting barriers to financial incentive approaches for demand response.
- Incentive study design can be applied by government and energy companies.

ARTICLE INFO

Article history:
Received 22 September 2015
Received in revised form
12 July 2016
Accepted 13 July 2016

Keywords:
Energy policy, smart metering
Demand side response
Financial incentives
Barriers
Energy

ABSTRACT

Whilst tariff-based approaches to load-shifting are common in the residential sector, incentive-based approaches are rare. This is so, even though providing customers incentives to shape their power consumption patterns has substantial potential. This paper presents findings from an exploratory UK pilot study that trials financial payments and detailed energy feedback to incentivise load-shifting of residential electricity consumption.

An intervention study was implemented measuring actual energy use by individual households as well as conducting surveys and interviews.

From the trials it was found that the approaches resulted in reductions in peak time energy use. Evidence from the study found that the incentives-based approaches were able to overcome some of the barriers to response experienced in Time-of-Use studies, though less good on others. Interestingly, the height of the barriers varied by the electricity-using practice and the incentivising approach applied. The height of the barriers also varied by participant.

The study concludes by identifying that broad participation in demand response is likely to require a suite of incentivising approaches that appeal to different people, a key policy finding of interest to international agencies, government, public and private sector entities.

1. Introduction

Reducing peak electricity usage to avoid the necessity of building and running expensive marginal capacity has long been a goal of the power sector (Faruqui et al. 2010a, 2010b), but is also potentially important for reducing carbon dioxide emissions (Bradley et al., 2013; Darby and McKenna, 2012; Ofgem, 2010) and increasing the reliability of renewable energy systems (DECC, 2012; Walawalkar et al., 2010). There are now increasing efforts to try to encourage demand side response as seen for example by Liu et al. (2015). Tariff-based economic instruments tend to be the dominant approach to demand response in the residential sector (Ofgem, 2013), although incentive-based approaches are used in the commercial sector, particularly in the US (Albadi and El-Saadany, 2008). However, evidence from a number of different countries, especially in North America, suggest that: (a) where involvement is voluntary, participation rates in Time-of-Use tariffs tend to be low; and (b) the degree of response to such tariffs in terms of percentage reduction in peak usage of those who do participate, whilst variable, averaged only 5% in 15 trials from across the States (Faruqui and Sergici, 2010; Newsham and Bowker, 2010).

In terms of participation rates, Midwest Power's voluntary Time-of-Use (ToU) experiment attracted a 4% uptake (Baladi et al.,

* Corresponding author.
E-mail addresses: Peter.Bradley@uwe.ac.uk (P. Bradley), a.coke@kingston.ac.uk (A. Coke), m.leach@surrey.ac.uk (M. Leach).

http://dx.doi.org/10.1016/j.enpol.2016.07.022
0301-4215/

1998) and California's many voluntary time-of-use programmes just 1% in contexts where air-conditioning is a major feature (Braithwait and Faruqui, 2001). Whilst 8% has been reported in one recent UK voluntary Time-of-Use trial, this involved direct marketing (Darby and McKenna, 2012), reflecting experience from energy conservation that effective marketing and communication can be a significant factor affecting participation rates (Stern et al., 1986). Participation in the UK "Economy 7" tariff has been reported at 15% (cited in Faruqui et al., 2001), but this form of semi-dynamic pricing is tightly connected with those homes which have night storage heaters (often because they are not connected to the natural gas infrastructure) and therefore high usage because of electricity-based heating. Indeed little data exists for contexts where electricity use for heating and cooling is not a feature; perhaps partly because it has been assumed there is less scope for load-shifting in such settings (AECOM, 2011).

Economics, psychology and sociology-based research on energy consumption has identified a number of what one can call 'consumer barriers' (Kim and Shcherbakova, 2011) that appear to influence the degree of participation and response in residential tariff-based approaches. These consumer barriers go beyond issues of design, communication and marketing of an energy-related measure and are summarised in Fig. 1 below as six interlinking categories. The current authors assimilated this barriers framework to helped guide the design of the pilot study.

The first category of barriers relates to concern over potential disruption to existing habits and patterns of living (Ofgem, 2010). This includes issues related to the seeming temporal rigidity of certain forms of home-based electricity using practices (such as cooking an evening meal or watching TV), and the temporal constraints imposed by work (Torriti, 2012). The shifting of particular energy-using practices to off-peak periods can be perceived or experienced as causing disruption and inconvenience, as well as possible reductions in comfort (Shove, 2003).

The second category is uncertainty over the scale of financial benefit (if any) that would be attained by moving to a semi-dynamic pricing tariff (Faruqui and Sergici, 2010; Faruqui et al., 2010a, 2010b). The third category is access to and understanding of technology that can facilitate shifts through reducing 'asymmetries in information' (Torriti et al., 2010), that is, differences in information that the customers currently have and could have if technology (for instance, electricity monitoring equipment) were to be successfully implemented, or if timers on electricity-using devices and appliances were implemented and understood (Kim and Shcherbakova, 2011).

The fourth category is the issue of consumer knowledge and rationality (or apparent lack of it). Bounded rationality and relevant other factors linked to rationality can all be seen in the field of behavioural economics, which questions the overall assumption of consumer rationality.[1] Bounded rationality (Simon, 1957) is where time-poor consumers may make 'sufficing' decisions (Kim and Shcherbakova, 2011) based on a combination of inertia, incomplete or inaccurate knowledge about their electricity usage and the tariffs available (Kim and Shcherbakova, 2011; FERC, 2009) as well as their cognitive capabilities. In such situations 'rules of thumb' and other heuristics can replace rational choice. The invisibility of electricity use within energy-related routinised practices of consumption (Shove, 2003; Shove and Warde, 2002; Burgess and Nye, 2008; Hargreaves et al., 2010), and common behavioural biases such as 'limited user capacity' in assessing options (e.g. issues with menu choice), 'loss aversion'[2] as opposed to valuing material gains (Kahneman and Tversky, 1979), discounting of the future[3] (as seen in Ofgem, 2011), and preferences for the 'status quo'[4] (Tversky and Kahneman, 1981), are possible associated factors.

The fifth category covers other psychological and social variables that have been shown sometimes to play a role in an individual's energy consumption decisions: the values, attitudes and beliefs they hold that relate to energy use (Gatersleben et al 2002; Abrahamse and Steg, 2011), the social norms they recognise and apply (Alcott, 2011; Bradley et al., forthcoming), their commitment to shifting (Heberlein and Warriner, 1983), and/or their social interactions and social orientation (Rasanen et al., 1995).[5]

The last category focuses on circumstantial factors which can make it difficult to participate or respond. Examples include the particular nature of household living arrangements (for instance, whether someone lives in a flat or a house, and with others or on their own) or whether a home uses electricity for space heating/cooling, as where residents do use electricity for at least some of their space heating or cooling (e.g. use of a fan when it is experienced as hot or a fan heater when cold), changes in ambient temperature may be important in understanding electricity consumption patterns (Rasanen et al., 1995; AECOM, 2011).

Drawing on this conceptual framework, a small-scale exploratory UK-based pilot study was designed to test two novel financial incentive approaches to encouraging the shifting of residential electricity consumption from peak to off-peak periods

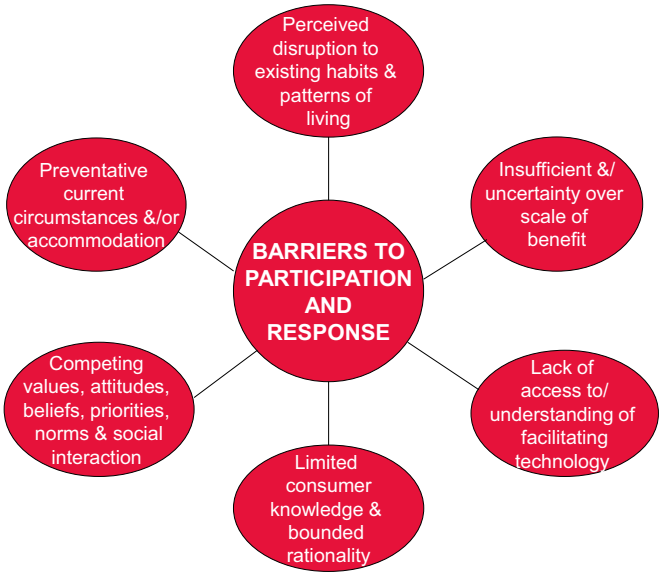

Fig. 1. Consumer barriers to participation and response in tariff-based approaches to shifting residential peak electricity use.

[1] Bounded rationality is also associated with a number of other economics disciplines.

[2] Loss aversion, is the situation where losses are weighted substantially more than objectively commensurate gains, when consumers are assessing trade-offs. With regards to demand response this is discussed in (Ofgem, 2011) and originally seen in (Kahneman and Tversky, 1979). This has to do with susceptibility of preferences to variations of how the decision is framed, i.e. framing the outcome for the decision as a loss or a gain, an excellent analysis and full discussion of framing is provided in (Thaler, 1981).

[3] With regards to time inconsistency it is stated that: "*In standard economic theory, consumers prefer to receive goods and services today than tomorrow. This preference for receiving things now more than in the future is constant over time. In practice, however, the amount that consumers discount the future by varies depending on how far in the future points are.*" (27, p. 8, identified first in Thaler, R., 1981) . Examples of this phenomenon in practice can be seen in (Ainslie and Varda, 1983) as well as evidence that shows that people can overweigh certain outcomes compared with risky outcomes (McKenna, 2013).

[4] Status quo bias comes from (Samuelson and Zeckhauser, 1988, p7): "*that is, doing nothing or maintaining one's current or previous decision*". Literature review of behavioural economics and demand response can be seen in (McKenna, 2013; Letzler, 2010).

[5] It should also be noted that behavioural economics sometimes also looks at social influences on decision making, so in this instance there can be some overlap.