Follow the price signal: people's willingness to shift household practices in a dynamic time-of-use tariff trial in the United Kingdom

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Abstract

'Dynamic' tariffs aim to help energy users to shift their energy-related practices, and rewards them financially when they modify when and how to use electricity in response to price fluctuations. However, its irregular and unpredictable nature makes it difficult for users to change their routine practices. The ways people interact with energy systems are complex; it involves negotiating and compromising various practices. This paper draws on 37 semi-structured interviews with householders who participated in the UK's first trial of a dynamic time-of-use tariff (dTOD) for electricity. It explores trial participants' experience with variable energy pricing. Findings from the interviews show that trial participants were willing to adapt their household practices to price changes as long as the tariff did not ruin their quality of life. Moreover, the trial was a real opportunity for people to respond to price changes. Having experienced it, participants gained confidence in performing their household practices flexibly and felt more control over energy consumption. This UK-based study has relevance to the EU context because smart grids and dynamic pricing is one of the prioritised areas in its energy infrastructure policy.

Keywords:

Demand-side response, dynamic time-of-use tariffs trial, household practices, load-shifting

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1. Introduction

Meeting climate change targets requires radical changes in electricity generation (Department of Energy and Climate Change, 2014) and to increase low-carbon energy sources the European Union has a 20 per cent target for the share of energy from renewable sources such as wind and solar power by 2020. In light of this, the UK has a target of 15 per cent of energy consumption from renewables by then (European Commission, 2009), and the country now faces a hugely challenging 'energy trilemma' of 'keeping the lights on, at an affordable price, while decarbonising our power system' (Department of Energy and Climate Change, 2014, p.4). It is, however, a major challenge to match the variable and irregular supply of renewable energy to residential electricity demand. A key way to achieve a balance between demand and the limits of supply will be retail price signals through innovative tariffs aimed at making consumers more active and involved in a smarter grid (Strbac, 2008). While network constraints are predictable to some extent, the unpredictable nature of renewable energy will require time-of-use tariffs based on 'dynamic', rather than static, pricing if they are to support the integration of more of these energy sources into the grid. The universal installation of smart meters, which is part of the EU strategy to tackle high demand for energy by end-users (European Commission, 2017a)[1], has the advantage of providing detailed, instant and accurate information about energy consumption and, potentially, production. This would allow dynamic pricing and time-of-use tariffs to be part of a future renewable source based energy system (Carmichael et al., 2014).

[1] The EU aims to replace at least 80 per cent of conventional electricity meters with smart meters by 2020, and expects that this smart grids and smart meter rollout can reduce carbon emissions within the EU by up to 9 per cent and annual household energy consumption by similar amounts (European Commission, 2017a).

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This paper discusses the findings from 37 interviews with London households who participated in the UK's first trial of a dynamic time-of-use tariff (dTOU) for residential electricity. The findings are relevant to the EU-wide context, because smart grid deployment with the use of dynamic pricing is part of its priority trans-European infrastructure corridors and areas (European Commission, 2017b). There are a number of options for increasing balancing between supply and demand and for allowing greater integration of intermittent generation: for instance, interconnection, flexible generation, storage, demand side management, and demand(-side) response (Strbac et al., 2012). A number of options exist within the demand side, too, including demand reduction, direct control and a range of time-varying pricing. Beyond broad conclusions that some prosumers may be willing to change behaviour for low or no financial rewards (Parrish, Heptonstall and Gross, 2016), however, it is still too early to make predictions with much certainty about the relative potential of these respective strategies. In this light, this empirical study from the UK offers lessons about one of the demand response options to the EU countries.

The UK regulator, Ofgem (the Office of Gas and Electricity Markets), supports demand-side response (DSR) and retained scope for dynamic tariffs in their mandated simplification of tariffs:

> 'Creating a more dynamic market, in which consumers participate more actively through DSR, is a fundamental element of our vision for smarter energy markets. This will become more important with an increasingly inflexible and intermittent generation mix and the need for distribution networks to cope with the additional load imposed by electric vehicles and heat pumps as part of a move to a low-carbon energy system' (Ofgem, 2014, p.9).

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DSR services reward consumers when they modify their electricity consumption in response to external signals such as a change in price. A number of time-varying tariff designs exist with varying aims and mechanisms for incentivising more flexible electricity consumption, including fixed time-of-use rates, dynamic time-of-use rates and critical peak pricing. The current EU-wide rollout of smart meters to households potentially opens the door to such smart and time-varying tariffs including more cost-reflective dynamic tariffs. Dynamic pricing is therefore conceived as cost-reflective pricing. Yet, unlike static time-of-use tariffs, which are regular and predictable and are aimed at reducing peak load, dTOUs reflect irregular and unpredictable fluctuations in renewable generation. This potentially presents challenges to households and their domestic practices.

A body of work referred to as the 'social practice' approach discusses how energy consumption occurs through our conduct of practices (Wilhite, 2004) and how energy is consumed in people's routine practices and how such routines develop, change and evolve (e.g. McMeekin and Southerton, 2012; Ozaki and Shaw, 2015; Shove, 2003; Southerton, 2006; Spaargaren, 2011). This literature argues how practices are interrelated, sequenced, and organised within the rhythms of people's lives (e.g. Reckwitz, 2002; Higginson et al., 2014; Ozaki and Shaw, 2014). Indeed, there are a number of issues that limit people's abilities to change, and shift, their routine practices in the household (Hargreaves et al., 2010). As Bell and colleagues (2015, p.98) put it, reducing energy usage and shifting household practices is 'less a technical challenge and more a matter of understanding and responding to socio-cultural practices'. So, our research question is: how our trial participants engaged with price changes in their everyday lives.

This paper aims to reveal the richness of insights that trial participants were prepared to share. The paper takes a human-centred approach, providing understandings of cultures and lifestyles and of

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the ways residents routine household practices influence energy consumption (Sovacool, 2014, p.11). This will offer explanations to results of a quantitative analysis of electricity consumption data in response to the price signals discussed elsewhere (Schofield et al., 2014). From our empirical and qualitative analysis of households living with dTOUs, we have found that trial participants generally thought of the dTOU to be a positive thing and felt empowered with new knowledge about, and control over, energy use and the new possibility of saving money. Many tried to adapt their household practices to the tariffs, while maintaining a balance between their lifestyles and changes in routine practices. The study suggests that lessons from this trial are useful for strategies for residential energy demand management. While this paper draws on a trial in the UK, the fact that DSR is considered to be vital to European energy policy (European Commission, 2011) means that it has high relevance to other European countries and beyond.

2. Dynamic pricing, energy consumption and practices

DSR is a priority area in the changes envisaged in the UK energy system. Ofgem aims to ensure 'simpler, clearer, fairer' billing and tariffs, greater competition in energy markets, and better protection for consumers (Ofgem, 2013, p.27) and sees DSR as a way to create value for money, promote security of supply and sustainability by using renewable energy sources, and improve consumer trust and energy literacy. DSR can also lower electricity bills for consumers who shift load to lower-rate periods. Whether or not consumers benefit from smart tariffs, however, will 'depend upon their usage patterns, whether they can respond flexibly and whether they can make sense of the information to adjust demand' (Owen and Ward, 2010, p.24). Indeed, research in the USA and Italy demonstrates that demand response measures such as time-of-use tariffs and real-time pricing

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have led mostly to energy saving in peak hours, but to little load shifting (Allcott, 2011a; Torriti, 2012).[2]

UK households' experience with time-varying pricing is limited to fixed time-of-use tariffs[3], such as Economy 7 and Economy 10, which give cheaper night-time rates predominantly, but not exclusively, to households with overnight storage heaters. Thirteen per cent of UK domestic electricity bill payers use time-of-use tariffs (Ipsos MORI, 2012). While 50 per cent of those time-of-use tariff users run appliances (other than water and space heating systems) at off-peak periods to save money, 38 per cent have no storage heating and do not load-shift appliance usage to off-peak. This means that the latter users receive no real benefit from the tariff they are on; in fact, they are likely to be paying more for their electricity annually as a result (ibid.). There are therefore concerns about the distributional impacts of dynamic pricing on households. Owen and Ward (2010) suggest that while many low income and vulnerable households in the UK could benefit from time-of-use electricity tariffs, those with on-peak electric heating may be the main group who could be disadvantaged. The number of low-income households with electric heating but without storage has recently decreased in the UK, and yet the number could rise if the use of heat pumps becomes more prevalent (ibid.).

[2] Meta-analyses of dynamic pricing (Ehrhardt-Martinez, Donnelly and Laitner, 2010; Faruqui and Sergici, 2009; Faruqui and Palmer, 2012) collating findings from several trials also indicate that the reduction in electricity consumption during peak demand periods is typically larger than that in total energy consumption, although results have been highly varied across trials.

[3] A recent UK trial of static time-of-use energy tariffs demonstrated that peak-time and overall electricity use was reduced compared to control groups (by 10 and 3 per cent respectively) and the vast majority of participants were keen to use multi-rate tariffs in the future (Powells et al, 2014).

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The opponents of dynamic pricing use this (alleged) unfairness issue to make their case (Faruqui, 2010). Yet, 'the presumption of unfairness in dynamic pricing rests on an assumption of fairness in today's [flat-rate] tariffs' (ibid., p.19). Flat rate pricing does not signal to consumers when electricity is expensive to consume and thus results in higher prices for everyone and some households effectively subsidising others. Faruqui (2011; 2012) maintains it is a myth that customers do not want dynamic pricing, or do not respond to it (because electricity is a necessity), and that dynamic pricing will harm low-income consumers.

A recent UK study of consumer perception of time-of-use tariffs based on nationwide surveys[4] shows that dTOUs were the least popular choice (Fell et al., 2015a; Fell et al., 2015b), although adding automated responses to price changes made the dynamic tariff more attractive as automation seemed to be viewed to mitigate 'the difficulty of dealing the dynamic tariff' (Fell et al., 2015a, p.22). A qualitative study with older populations in Scotland demonstrates that while some are willing to adopt dynamic pricing programmes 'if there was sufficient notice and instruction of how to use it', others showed 'reluctance and trepidation about losing control' (Barnicoat and Danson, 2015, p.114). Similarly, a study on scenarios of DSR and a sense of control, using focus groups, finds a fairly even spread of people who thought that dynamic tariffs would give them more or less control (Fell et al., 2014): more control over costs 'by carefully planning when to use certain appliances' (ibid., p.1124) and less control due to the complexity of arranging of appliance use and 'the lack of predictability' (ibid., p.1125). Respondents in the latter study also raised concerns about shifting their practices and that 'people might start out with good intentions but ultimately find themselves unable to maintain them' (ibid., p.1125).

[4] This study asked hypothetical questions about different tariffs and is not based on a trial.

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Another UK study explores the 'shiftability' of people's daily practices (Higginson et al., 2014). In their study, participating households were asked to carry out a few challenges: e.g. not to use energy for food preparation between 4pm and 8pm and to bring forward/delay laundry by 24 hours. Higginson and colleagues (2014) argues that household practices are part of sequencing and scheduling and are temporally and spatially dispersed and that shifting means other practices 'will have to give way' (ibid., p.523). People organise their household activity in tandem with what is going on in the home or with the family. For instance, laundering is 'wrapped up in trying to capitalise on excess energy generated by their boiler to dry clothing in one household; they do not want the excess heat to go to waste' (Ozaki and Shaw, 2013, p.241). Nevertheless, some practices can be slotted in and around relatively easily, though others are more rigid (Higginson et al., 2014). Similarly, people expect disruption, i.e. it is normal to have disruption in our everyday lives (ibid.). This suggests that existing practices can potentially be unlocked, while the sequence and rhythm of practices needs to be taken into account when developing DSR strategies (ibid.). We need to understand what practices people 'consider to be negotiable' (Strengers, 2011, p.330).

Everyday practices are a big factor in the uptake of dTOUs. People's practices, such as cooking, heating and bathing, are deeply socially and culturally embedded and their associated energy consumption behaviours can be unaffected by energy price (see Wilhite et al., 1996). Households with similar demographics and ownership of technologies have different practices, norms and values, and habits and routines (Hargreaves et al., 2010, p.6112). Energy is consumed in complex entanglements of daily practices; practices are interrelated, with one practice influencing another, such as cooking and having a shower afterwards to remove the cooking smell, and having a bath before going to church (Ozaki and Shaw, 2014). They all have socio-cultural meaning attached: the way people have a shower or a bath, for instance, may be influenced by desires for comfort or to conform to socio-cultural norms of being clean through taking a shower (Shove 2003; Wilhite et al.,

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1996). Similarly, domestic energy consumption can be about caring for others such as washing clothes for family members (Murtagh et al., 2014). So, there are 'wide-ranging subjective differences between households in what constitutes necessary use of energy and what is therefore perceived as not possible to change' (ibid., p.1132). Certain domestic appliances cannot be discarded no matter how they are energy 'greedy', and the use of those appliances or household practices are a necessity because life is for living and also because of temporal rhythms of the household (Hargreaves et al., 2010). Importantly, this practice perspective suggests that domestic resource intensive behaviour is not simply based on individual utility maximisation in response to cost incentives (Pullinger et al., 2014).

The decision to consume energy is different from that of purchasing a commodity (Murtagh et al., 2014), as electricity is not an 'end product', but is part of the inconspicuous consumption in everyday life such as boiling water in the kettle to make tea (Abi Ghanem and Mander, 2014, p.1172). This perspective contrasts with the assumptions commonly held by policy makers: that consumers are rational individuals whose daily routine practices are 'objective and neutral and thus open to intervention and governance' and that their decision-making behaviour is based on their rational choice (Ozaki and Shaw, 2014, p.591; Webb, 2012). In this rational choice model 'when consumers do not behave to maximise their utility, the problem is inadequate information: if only they had the right information they would behave as expected' (Murtagh et al., 2014, p.1132). The policy response to this information deficit model is to offer consumers appropriate data through smart meters or in-home displays (Hargreaves et al., 2010). The recent literature on social practices, instead, proposes alternative ways for policy intervention (Spurling et al., 2013; Spurling and McMeekin, 2015, pp.70-81): (a) 'recrafting' to reduce the resource intensity of an existing practice by changing the elements of a practice, such as materials; (b) 'substituting' to replace unsustainable practices with more sustainable alternatives; and (c) 'changing how practices interlock' to intervene

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in ways in which practices are sequenced and interrelated. This approach does not target particular types of behaviour, but attempts to change a system of practices that involve energy consumption. In this light, this paper explores if consumers adapt their household practices to dTOU at all, and if so, in what way they respond.

3. Methodology

In the UK dTOUs have yet to be offered, and debate and controversy over consumers' appetite for the perceived complexities, risks and fairness still remain. To shed light on how UK consumers would respond to unpredictable price signals, what would happen inside their homes, and what potential drivers there are to increase flexibility in their routine practices, a dTOU trial was conducted as part of a large smart meter installations trial in London. It was done in collaboration with EDF Energy and UK Power Networks for 12 months from January until December 2013.

There were three tariff rates – 3.39 pence as Low, 11.76 pence as Normal, and 67.2 pence as High – with day-ahead notification and monthly feedback about overall spend and units consumed.[5] These price points were developed for the tariff on the basis of being commercially viable for EDF Energy. This, however, presented a potential methodological weakness of the study. As the high rate was almost six times more expensive than the normal rate, it was possible that trial participants were more motivated to save money. Nonetheless, the trial has offered a number of insights with regard to the 'shiftability' of household practices.

Rate change notifications/alerts were sent at 8am the day before the rate change in order to allow

[5] Savings feedback was benchmarked to a flat-rate tariff or a standard variable tariff only after the end of the trial.

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the possibility of bringing practices forward in time before the rate change as well as delaying them. There was a maximum of three price events per week. Notifications were delivered to the In Home Display (IHD) and the option of having alerts sent to mobile phones as text messages was also available. Furthermore, IHDs had a traffic light indicator for current energy usage: the red signal indicated high usage, the yellow moderate and the green low consumption.

Initially, 5,111 households opted-in to having a smart meter and in-home-display (IHD) provided by EDF Energy in the London Power Networks (LPN) area[6] through a recruitment campaign via local events, mail shots and phone calls. Out of these households with the smart meter, 1,119 households were recruited for the dTOU trial through the EDF Energy call centre by phoning in; and an opt-in recruitment process involved cash incentives, a dTOU tariff design with the normal rate lower than EDF Energy's standard variable tariff (SVT), and a guarantee of reimbursement if the household was worse off on the dTOU tariff than if they had stayed on their previous flat-rate tariff. A total of 1,044 households completed the dTOU trial, with 75 households switching from EDF Energy to other suppliers. Interviewees were recruited from this dTOU trial group by email and telephone with no incentive payments. The trial participants were selected, using a stratified sampling approach to represent the 17 Acorn consumer profile groups[7] (Table 1) for EDF Energy customers in the LPN area. Thirty-seven households were chosen for interviewing to represent the EDF customer household demographics of the LPN area (Table 2). The smart meter installations and dTOU group were self-

[6] EDF Energy residential customers were recruited from the London distribution network administration area (LPN) only because of the availability of UK Power Networks network data within this area (see Carmichael et al, 2014).

[7] ACORN, A Classification Of Residential Neighbourhoods, is a geo-demographic consumer segmentation system developed by CACI ltd.

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selected and might be biased towards the early adopter of new technology. This, however, should be considered in the context of future commercially-available residential dTOU tariffs, which households will opt in.

[Table 1 and Table 2 about here.]

Interviews were conducted between June and December 2013 during the trial. They were carried out either face-to-face in their homes or by telephone with either one household member, a couple or several household members, and took between 40 and 80 minutes. Interviews were semi-structured with a discussion guide that incorporated issues from the literature on demand response and was modified based on interviews completed. They were recorded and fully transcribed, and then analysed with the help of NVivo, software that organises and manages qualitative data. To code the interviews a 'bottom-up' approach was employed; i.e. the interviews were coded openly without using pre-existing themes to code into ('top-down'). The decision to take this approach was influenced by the review of current literature on time-of-use tariffs and consumer behaviour, which discusses both difficulty in shifting and willingness to shift household practices in accordance with price changes. We therefore wanted to explore what people did when rates changed and how they engaged with fluctuant prices and energy-related practices. An open-coding approach helped us refrain from starting with any assumptions about householders' experiences; instead, emerging themes were captured by thematic analysis (Thomas, 2006). Focusing on the 'shiftability' issues, the initial lower-level codes were grouped into 13 higher-level shared themes according to topic. They were then thematically categorised into four groups and analysed to address householders' reflections on their experiences of engaging with price changes (see Table 3 for categorisation of themes and descriptions). These four categories provide the structure for the findings below.

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[Table 3 about here.]

4. Findings and discussions

As seen above, the existing literature shows mixed views on dTOU, discussing both challenges in people adapting to price changes and possibilities that everyday household can be changed. Furthermore, the literature suggests that much of the positive outcomes found in changing energy-related behaviours and practices may be made by a small number of highly motivated households (Murtagh et al., 2014). This emphasises the need to investigate in greater depth on how trial participants lived with and adapted to rate change alerts, and hence our 37 detailed interviews. The thematic analysis of householders' actions below demonstrates the ways in which they responded to dynamic price signals in their everyday lives. It shows the willingness of trial participants to follow price changes, with some expressing caution, and discusses how they managed (or did not manage) to shift their everyday practices, positive consequences of participating in the trials, and observed difficulties.

4.1. Adapting to price signals

Many trial participants tried to adapt to their household practices to price changes during the trial. Typically, they avoided the high tariff period by shifting practices and planning ahead:

> "My washing tends to pile up until it [the tariff] goes low. If I run out of things, then I have to do a bit, but otherwise it just sits in the bowl and waits for a low. … I'll say I'd have to wash up in-between on a normal as long as I avoided a high." (Mrs ST)

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> "On my phone I have a list of what I should and shouldn't do in a high tariff. … I know that if I'm going to have a high, I don't want to have the television on, I don't want to do x, y, z during that time." (Ms PO)

Some took advantage of the low tariff period by shifting and doing as many household tasks as they could:

> "I think there's a 12-hour low tariff tomorrow, so… we'll wash the bedclothes and do this. We do as much as possible when we can." (Mr MA)

> "What makes it easier for us is to have done what we needed to have done when it's a low period and got all our vacuuming done and all the stuff done, and then probably the next week we didn't have to do so much, so we just relax and it doesn't matter what tariff comes on." (Mrs WH)

When they could not avoid the high tariff, they 'balanced out' later by shifting practices:

> "I've been very disappointed recently because we had a high period for 24 hours the other day. There's no way you can avoid it. I've got five adults in the house. They all wear a huge amount of clothes, I have to do washing… So, I try to balance it… like this morning we had a low period [from] 2am to 5am, and for the next day, so I can see if I can [do] washing and ironing." (Mrs WO)

Some household practices such as laundering and vacuuming are easier to shift than other ones such as cooking. What people did was shifting these practices to match the prices through planning in advance and moving household practices around. Unlike previous studies show (e.g. Allcott, 2011,

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Torriti, 2012), participants were willing to make changes to their routines, whether their motivations were economic or environmental. This suggests that load shifting does happen.

4.2. How to change routine practices

How, then, did trial participants change their routine practices to match dynamic tariffs? Two kinds of action are identified: changing the material element of a particular practice; and adding a new meaning to a particular practice. First, regarding changing the material element of a practice, many trial participants changed the appliances they used to perform the practice of cooking in accordance with the tariffs:

> "When it's high, we use the gas cooker for boiling water to make tea, on the hob." (Mrs MA)

> "Because I knew when the high rate was coming in I may [might] have just slightly altered what we were going to be having for dinner, so I would do something that I could do on the gas hob." (Mrs THT)

> "If I cook in the oven [when low], I'll cook a lot of stuff, and then what I'll do is I'll put it in the freezer, and so I'll use the microwave to defrost and heat it [when high]… I do that for two reasons. I do it to make life easier some days as well… but that would make me use the oven less." (Ms WR)

Cooking is typically seen as one of the most difficult practices to shift: no matter what tariff they are on, they have to cook, especially an evening meal, at certain times of the day (see for example Powell et al., 2014). Yet, here these respondents do not change the timing of cooking, but change the cooking appliance while still preparing a meal at their usual hour.

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We further found examples of permanently changing a material element of the home to make a particular practice more energy efficient:

> "I have got rid of carpets. I never liked carpets anyway, except for this big rug, because it's easier to clean a floor, you can dust it, you can wipe it, you don't have to use a vacuum cleaner. … It saves energy. So, you can work it out." (Mrs WH)

Others added a new material element – a timer – to their appliances and saw it as a way to go forward:

> "For completely unrelated reasons, I've had to replace most of my white goods over the year. … Now washing machine, tumble dryer, and dishwasher all have easy-to-use timers. … It seemed to me that even if this one [the trial] was only on for a comparatively short time, this was the sort of thing that was likely to be happening in the future. Whereas I sort of thought at the time it was purely convenience, now it's also been a, potential anyway, cost advantage." (Mr SH)

These actions illustrate what Spurling, McMeekin, Shove, Southerton and Welch (2013) propose as potential alternative policy interventions. Actions such as changing cooking appliances and adding a timer to a washing appliance can be characterised as 'recrafting practices' to reduce the resource intensity of an existing practice through changing some of its elements. Changing from vacuuming to mopping or sweeping the floor by discarding carpets and having wooden floors is what Spurling and colleagues (2013) call 'substituting' or replacing an unsustainable practice with a more sustainable alternative. In the long-term (and because this was a 12-month trial), this points to the importance

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of changing the system of everyday practices if the objective is to be more effective and sustainable in energy use.

Some respondents referred to automation as an important added feature to electrical appliances. Automation could reduce the complexity associated with behavioural flexibility on dynamic tariffs (Fell et al., 2015a; Fell et al., 2015b) and could make user engagement easy with minimal effort (Throndsen and Ryghaug, 2015). It could also potentially change how practices are sequenced and interrelated (Spurling et al., 2013) and have a positive impact on domestic energy consumption:

> "Automated smart appliances would make life a lot easier, wouldn't it? They will appear eventually, I guess. … If it were put of the trial as well you were given sort of smart plugs that you could put in the wall, I mean, I have not tried this with my own devices. But… if all of my devices start just because the power is on, that's the problem. A lot of them you have to press a button. But if you could start them at, you know, with an electric plug thing that could talk to the smart meter or talk to the phone or whatever, and be initiated, and then the device would start. That would already be a big step." (Mr WE)

Second, some participants added a new meaning to their energy-related practices by attaching a 'fun' element:

> "It's [a] kind of project with a certain amount of fun element in it. It would just be interesting to know… how much has it been worth it both in green terms of being a less heavy electricity consumer and also has it saved us money. You know, in doing the washing a day later or not baking bread or, you know, cooking pasta rather than having something roast in the oven, you

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know, all those little changes we made and the effort we've put into it. Has it born fruit, you know?" (Mr GR)

"Well… you have got a lot of ironing and washing. It was on a Saturday and we were on a low rate, and I got the ironing board out and was racing through my shirts. And it was five to eleven… it wasn't going to go to high. It was only going to go to normal, And it got to five past eleven, and I had one more shirt and I was like, oh my God, I am going over my budget, I am going over my time." (Mr SK)

Again, by attaching a new meaning to a particular practice, that is, by changing an element of a practice, this action 'recrafts' an existing practice (Spurling et al., 2013). Also, the fun element makes the act of matching to the changing tariffs easier and more enjoyable.

4.3. Positive consequences

Participation in the trial led to a number of positive outcomes. Becoming aware of 'what they do', for instance, was what many interviewees talked about:

"I haven't even thought about it [energy] before really. … I think probably the biggest plus point for me that's come out of doing the 'high-low' thing is that you just become more aware of what electricity you're using, and that makes you turn things off more and cut back. Do I really need to do this? I've definitely become better at turning the telly off and not leaving it on standby, and little things like that." (Mrs TO)

"You are going to know that things like kettle, things like electric elements use more electricity … it was a sort of training thing … to know that the things that make it [IHD] go red and the things

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that make it go yellow and the things that don't have any effect on it. It's quite interesting because it's not completely obvious, you know. If you boil a kettle it goes red, toaster will send it yellow, electric blankets can make it go yellow and not red, the oven makes it go red until it reaches temperature then it goes back to green until it kicks back in again, and the washing machine. So, we know the things that make it go red." (Mr GR)

These quotes have implications for consumer engagement. As the Early Learning Project research (Department of Energy and Climate Change, 2015) finds, a well-designed IHD helps raise energy awareness and understanding and promote reduced consumption. The 'traffic light' real-time feedback, especially the rate is high, would make residents consider what practices they might be able to delay.

There were also educational effects. Participants said they had learned about energy consumption and how to save energy and its cost. Some took the trial to the next level and analysed their own energy usage:

"I've learned from it [the trial], which is a good thing, … what things to use and when to use it and things like that. So, when I go back on a normal tariff in January, I will still carry on this learned way of doing things. … [I am] recording what it used, and then turning that off and going and turning something else on, everything. I got my granddaughter to do me some Excel graphs and things." (Ms PO)

"We do keep our own chart daily of when we've had a low and a medium and a high, and how much its' been at the end of the day, and what we've used, so we know month by month what we've done." (Mr WH)

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The literature on smart meters discusses the ability of energy consumption feedback to raise awareness and its limited effect on reconfiguring household practices (e.g. Buchanan et al., 2014; Hargreaves et al., 2010; 2013; Strengers, 2011). This particular 12-month trial, however, seemed to have given confidence to the participants in terms of shifting and changing their household practices. This may be because the dTOU trial made participants 'actively' work to follow fluctuant prices in their daily contexts, rather than just look at the smart meter about their energy consumption. Providing people with actual experiences of 'doing' usual things differently may keep them engaged. Indeed, having experienced dynamic tariffs, respondents were more confident that they can be more flexible than they expected in performing their daily routines and can shift some of their practices and change behaviours:

> "When you think you are using electricity and how flexible you think you can be. Having had the advantage of the pilot [trial], I think I know that I can be really quite flexible. So, I can therefore, I think, roughly work out… how much I could push things around." (Mr SH)

> "I think you just try. If you are aware, then, you do change your habits. But it is not difficult to do so, not at all." (Mrs SK)

Lastly, getting control over their own energy consumption is another positive consequence of the trial. Many reported that they had a 'greater sense of control' over energy bills and felt they were "taking charge" (Mr CA):

> "The main positive is that it is possible to monitor it [energy usage] and control your consumption, and that's good. It's progress in that sense, and trying to be proactive in relation to

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that. … I think that if it does give you a sense of being a bit more in control, with the frustration that you forget what you are doing because you lost the message of today." (Mr HO)

"Just feeling as though I'm a bit more in control of it. Then, you know, it's quite nice to know that I can actually have an effect on how much I get charged." (Mrs TO)

As discussed in the literature, loss of control is a concern for some consumers (see Barnicoat and Danson, 2015; Fell et al., 2014). By being able to adapt to changing prices and make the most of them, some of our trial participants gained a greater sense of control over their household energy consumption or bills.

4.4. Observed limitations and difficulties

Trial participants identified a few negative aspects, too. First, some participants talked of the difficulty in shifting certain practices, such as cooking. This was evident in households with children. It is hard for those households to change the timing of their household practices even if the high rate period coincides with their 'family peak', i.e. times when multiple tasks such as cooking, clearing up, laundering and bathing are performed (Nicholls and Strengers, 2015). The same goes for household with older people, for whom days are structured in a certain way, such as around favourite television programmes or activities and the time when their carer comes (Barnicoat and Danson, 2015):

"It's not always easy to do because, you know, if the girls come back from the gym or something… [and] if it's saying it's high then… I can't leave these hanging around. So, from a mechanical point of view, it doesn't work." (Mrs MAR)

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> "You have always got to cook at certain times, aren't [haven't] you? You are not going to wait… [you] aren't going to wait until ten, eleven o'clock at night to eat, and especially on the weekend when they have lunch times and that sort of things." (Mr CA)

Second, people do not want the tariff to 'rule their lives'. It has to be the tariffs that fit in with their lifestyles, not the other way around:

> "You see, the house is also… it's got to be a pleasant place you live in… There's a limit to what you do." (Mr CL)

> "It's interesting when you have the sort of time to think about it. But you can't really have it ruling your life… Everything's relative, isn't it? But I think you have to take a view on it and think, well, it's got to fit in with our lifestyle, you know, and if things have got to be washed for tomorrow for games at school, then we do them." (Mr DO)

The nature of dynamic tariffs, its unpredictability and irregularity, made it difficult to work around the tariff for some trial participants. Having control and being able to plan ahead is a key concern for the participants, and this presents a major challenge in the implementation of dTOUs.

Third, novelty does wear off for some even with price changes, as pointed out in the literature (e.g. Abrahamse et al, 2005), and thus shifting and changing household practices was difficult to facilitate:

> "I don't relentlessly study it and I have lost a little bit of interest in it. [It started to wane] a few months back really…. It was in January, wasn't it, so I reckon probably three months in." (Mr SK)

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Fourth, remembering price changes can be an issue. Even if people wanted to follow the tariffs, it was often difficult to know which rate was current:

> "People lead such busy lifestyles, you forget what your energy tariff [rates] is, unless you have some magic app, which seems to be the buzz word these days, oh you've got to have an app for this or an app for that." (Mr MT)

> "I sometimes forget and I think, oh, sod it, I am not going to bother, because I can't remember what it said yesterday and it's too late because the message has changed, I just go and spend the money and put the dishwasher on. So, that's one reason why I am a little bit careless about it at times…" (MR HO)

These observations illustrate the challenges of keeping the user engaged in dTOU programmes and also of helping them to remember price changes, and imply they are essential to the success in the implementation of a dynamic tariffs programme.

5. Conclusions

This paper has examined householders' experience of living with a dynamic electricity tariff and discussed how they adapted to unpredictable price changes during the trial. Findings from their accounts show, unlike some views in the existing literature, that load shifting does happen. Our trial participants were willing to adapt their practices to the rate fluctuations as long as the tariff did not rule their lives and ruin their quality of life. They mostly tried to avoid the high rate and perform their household practices when the price was low, as the high rate was set almost as six times more

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expensive than the normal one by the electricity company. They also managed to balance out their energy usage by taking advantage in the low rate when they could not avoid the high rate.

The trial provided them with a real opportunity to respond to price changes in their daily lives. This differentiates this trial from previous studies of energy consumption feedback, which showed the limitation to making sustainable effects on users' daily behaviour. In the present study, the experience of using a dynamic tariff has generally made the majority of participating households confident that they could be flexible in performing their daily practices and that they could have a greater sense of control over their domestic energy consumption. In this sense, having an 'option' to go for the low rate was highly appreciated.

This was a one-year trial and came with a guarantee, however. Participants willingly chose to take part in this trial; with the duration and end date defined, they might have been expected to be eager to try what they could and shift their routine household practices to adapt to price changes. The issue, therefore, is how to encourage the broader population in the UK, in the EU, and beyond, to take up a dynamic tariff and to make changes in their real-life contexts.

A few general lessons can be drawn from the findings. First, price signals do have effects on householders shifting their practices. Avoiding the very high-rate period is a big incentive and people like having control over electricity bills. However, there should be mechanisms to help people remember tariff changes. In our trial the IHD displayed one message at a time and any messages on price changes could not be saved in the device. Unless participants take a note or check messages on mobile phones (if they had subscribed for SMS message notification), they could not recollect price change information. This feature needs improving. People live busy lives and need to be reminded of tariff changes, and an alarm system that reminds people of forthcoming tariff changes may be

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helpful. Second, a real-time information of high energy usage in the IHD goes in tandem with dTOUs. A visual warning to let people know that what they are doing is consuming large amounts of electricity when the price is high, for instance, might help people shift their practices. In this regard, the real-time notification of itemised electricity usage would greatly help people. Third, as Spurling and colleagues (2013) propose, governments should encourage people to reconfigure the systems of existing practices. In their attempt to avoid the high rate and make the most of the low rate, some trial participants changed elements of particular practices such as cooking, and others, on some occasions, replaced existing practices, such as cleaning rooms, with more environmentally friendly ones. These reconfigurations illustrate the ways in which sustainable ways of living could be facilitated. As Higginson and colleagues (2014, p.534) state, existing practices can be 'transformed when new elements are introduced or existing elements are arranged in different ways', and the trial participants' reorganisation of their practices can be used as examples.

This paper set out to investigate the ways in which the dTOU was applied in people's daily lives. Findings from interviews with householders present a more complex picture of the relationships between householders and electricity price changes than is portrayed in the literature and adds a new understanding to existing studies of consumer interaction with smart meters and time-of-use tariffs. The dynamic tariffs are generally thought to be an unpopular option due to their unpredictable nature. However, this study has demonstrated otherwise and shown its potential. In order for smart grids to be successful and effective in managing household peak demand and reducing energy consumption in the EU-wide context and beyond, how to encourage the general public to sign up for the renewable-source-based dTOU and how to help them make changes in their routine practices is an important issue. Use of renewable energy will have to increase to meet the energy trilemma challenge societies are facing. For that reason, energy has to be supplied in various,

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different forms, and the renewable-based dTOU could play an important part in mixed method energy provision in the future.

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References

Abi Ghanem, D. and Mander, S., 2014, 'Designing consumer engagement with the smart grids of the future: bringing active demand technology to everyday life', *Technology Analysis and Strategic Management*, 26, 1163-1175.

Abrahamse, W., Steg, L., Vlek, C. and Rothengatter, T., 2007, 'The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviors, and behavioural antecedents', *Journal of Environmental Psychology*, 27(4), 265-276.

Allcott, H., 2011, 'Rethinking real-time electricity pricing', *Resource and Energy Economics*, 33, 820-842.

Barnicoat, G. and Danson, M., 2015, 'The ageing population and smart metering: a field study of householders' attitudes and behaviours towards energy use in Scotland', *Energy Research and Social Science*, 9, 107-115.

Bell, S., Judson, E., Bulkeley, H., Powells, G., Capova, K. A. and Lynch, D., 2015, 'Sociality and electricity in the United Kingdom: the influence of household dynamics on everyday consumption', *Energy Research and Social Science*, 9, 98-106.

Buchanan, K., Russo, R. and Anderson, B. (2014) 'Feeding back about eco-feedback: how do consumers use and respond to energy monitors?', *Energy Policy*, 73, 138-146.

CACI (2004) *The ACORN User Guide: The Smarter Consumer Classification*, London, CACI Ltd.

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It is not the copy of record. Copyright © 2018, Elsevier.

Carmichael, R., Schofield, M., Woolf, M., Bilton, M., Ozaki, R. and Strabac, G., 2014, *Residential consumer attitudes to time-varying pricing*, Report A2 for the Low Carbon London LCNF Project, Imperial College London, London.

Department of Energy and Climate Change, 2014, *Delivering UK Energy Investment*, Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/331071/DECC_Energy_Investment_Report.pdf (accessed on 21.11.16)

Department of Energy and Climate Change, 2015, Smart Metering Early Learning Project: Synthesis Report, Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/407568/8_Synthesis_FINAL_25feb15.pdf (accessed on 24.5.2018).

Ehrhardt-Martinez, K., Donnelly, K, A. and Laitner, J. A. S., 2010, *Advanced Metering Initiatives and Residential Feedback Programes: A Meta-Review for Household Electricity-Saving Opportunities*, Report Number E105, American Council for an Energy-Efficient Economy, Washington D. C.

European Commission, 2009, Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=EN (accessed 21.11.16)

European Commission, 2011, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Smart

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Grids: From Innovation to Deployment, COM/2011/202, EU, Brussels, available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0202&from=EN (accessed 20.02.17)

European Commission, 2017a, Smart Grids and Meters, available at: https://ec.europa.eu/energy/en/topics/markets-and-consumers/smart-grids-and-meters (accessed 20.02.17)

European Commission, 2017b, Smart grid Projects of Common Interest, available at: https://ec.europa.eu/energy/en/smart-grid-projects-common-interest (accessed 20.2.17)

Faruqui, A., 2010, 'Ethics of dynamic pricing', *The Electricity Journal*, 23(6), 13–27.

Faruqui, A., 2011, 'Dynamic pricing the Top 10 Myths', presented at the University of Texas Austin, Texas, 7 April 2011.

Faruqui, A., 2012, 'Shaping our energy future through dynamic pricing', paper presented at the Smart Grid Educational Series, IBM Innovation Center, Foster City, CA, 21 August 2012.

Fell, M., Shipworth, D., Huebner, G. M. and Elwell, C. A., 2015, 'Exploring perceived control in domestic electricity demand-side response', *Technology Analysis and Strategic Management*, 26, 1118-1130.

Fell, M., Nicolson, M., Huebner, G. M. and Shipworth, D., 2015, Is It Time: Consumers and Time of Use Tariffs, Report for Smart Energy GB, UCL Energy Institute, London.

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It is not the copy of record. Copyright © 2018, Elsevier.

Fell, M., Shipworth, D., Huebner, G. M. and Elwell, C. A. 2015b, 'Public acceptability of domestic demand-side response in Great Britain: the role of automation and direct load control, *Energy Research & Social Science*, 9, 72-84.

Hargreaves, T., Nye, M. and Burgess, J., 2010, 'Making energy visible: a qualitative field study of how householders interact with feedback from smart energy monitors', *Energy Policy*, 38, 6111-6119.

Hargreaves, T., Nye, M. and Burgess, J., 2013, 'Keeping energy visible: exploring how householders interact with feedback from smart energy monitors in the long term', *Energy Policy*, 52, 126-134.

Higgison, S., Thomsom, M. and Bhamra, T., 2014, '"For the times they are a-changin": the impact of shifting energy-use practices in time and space', *Local Environment*, 19(5), 520-538.

Ipsos MORI 2012, Consumer Experiences of Time of Use Tariffs Report, available at: https://www.ipsos-mori.com/DownloadPublication/1506_Ipsos-MORI-report-on-Consumer-Experiences-Of-Time-Of-Use-Tariffs.pdf (accessed 09.11.16)

McMeekin, A. and Southerton, D., 2012, 'Sustainability transitions and final consumption: practices and sociotechnical systems', *Technology Analysis and Strategic Management*, 24, 345–361.

Murtagh, N., Gatersleben, B. and Uzzell, D., 2014a, 'A qualitative study of perspectives on household and societal impacts of demand response', *Technology Analysis and Strategic Management*, 26, 1131-1143.

Nicholls, L. and Strengers, Y., 2015, 'Peak demand and the "family peak" in Australia: understanding practice (in)flexiblity in households with children', *Energy Research and Social Science*, 9, 116-124.

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It is not the copy of record. Copyright © 2018, Elsevier.

Ofgem, 2013, Creating the Right Environment for Demand Side Response: Next Steps, available at: https://www.ofgem.gov.uk/ofgem-publications/85129/creatingtherightenvironmentfordemandsideresponsenextsteps.pdf (accessed 02.11.16)

Ofgem, 2014, Electricity Settlement Reform – Moving to Half-hourly Settlement, Launch Statement, 4 April 2014, available at: https://www.ofgem.gov.uk/ofgem-publications/87053/electricitysettlementlaunchstatement.pdf (accessed 02.11.16)

Ozaki, R. and Shaw, I., 2013, 'Close encounters of the third kind: social housing residents and new technologies for sustainability', *Environment and Planning A*, 45, 238-245.

Ozaki, R. and Shaw, I., 2014, 'Entangled practices: governance, sustainable technologies, and energy Consumption', *Sociology*, 48(3), 590–605.

Owen, J. and Ward, J., 2010, *Smart Tariffs and Household Demand Response for Great Britain*, Report, Sustainability First, London.

Parrish, B., Heptonstall, P.J. and Gross, R., 2016, *The Potential for UK Residential Demand Side Participation*, HubNet, accessed at http://www.hubnet.org.uk/filebyid/1014/file.pdf, May 2016.

Powells, G., Lyon, S., Bulkeley, H. and Bell, S., 2014,' Understanding evening peak electricity use in the UK: a socio-technical analysis', presented at the Smart Grids and the Social Sciences workshop, Norwegian University of Science and Technology, Trondheim, Norway, 10–11 April 2014.

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It is not the copy of record. Copyright © 2018, Elsevier.

Pullinger, M., Lovell, H. and Webb, J., 2014, 'Influencing household energy practices: a critical review of UK smart metering standards and commercial feedback devices', *Technology Analysis and Strategic Management*, 26, 1144-1162.

Reckwitz, A., 2002, 'Toward a theory of social practices: a development in culturalist theorizing', *European Journal of Social Theory*, 5(2), 243-263.

Schofield, M., Carmichael, R., Tindemans, S. Bilton, M., and Strbac, G., 2014, *Residential consumer responsiveness to time-varying pricing*, Report A1 for the Low Carbon London LCNF Project, Imperial College London, London.

Shove, E., 2003, 'Converging conventions of comfort, cleanliness and convenience', *Journal of Consumer Policy*, 26, 395–418.

Southerton, D., 2006, 'Analysing the temporal organization of daily life: social constraints, practices and their allocation', *Sociology*, 40(3), 435–54.

Spaargaren, G., 2011, 'Theories of practices: Agencies, technology, and culture: Exploring the relevance of practice theories for the governance of sustainable consumption practices in the new world-order', *Global Environmental Change: Human and Policy Dimensions*, 21(3), 813–22.

Spurling, N., McMeekin, A., Shove, E., Southerton, D., and Welch, D., 2013, *Interventions in Practice: Re-framing Policy Approaches to Consumer Behaviour*, Sustainable Practices Research Group Report, University of Manchester, Manchester.

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It is not the copy of record. Copyright © 2018, Elsevier.

Spurling, N. and McMeekin, A., 2015, 'Interventions in practices: Sustainable mobility policies in England', in Y. Strengers and C Maller, *Social Practices, Intervention and Sustainability: Beyond Behaviour Change*, Routledge, Abington, pp.78-94.

Strbac, G., 2008, 'Demand side management: benefits and challenges', *Energy Policy*, 36, 4419–4426.

Strbac, G., Aunedi, M., Pudjianto, D., Djapic, P., Gammons S. and Druce R., 2012, *Understanding the Balancing Challenge*, Imperial College London and NERA Economic Consulting, London, August 2012.

Strengers, Y., 2011, 'Negotiating everyday life: the role of energy and water consumption feedback', *Journal of Consumer Culture*, 11(3), 319-338.

Svacool, B. K., 2014, 'What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda', *Energy Research and Social Science*, 1, 1-29.

Thomas, D., 2006, 'A general inductive approach for analyzing qualitative evaluation data', *American Journal of Evaluation*, 27(2), 237-46.

Throndsen, W. and Ryghaug, M., 2015, 'Material participation and the smart grid: exploring different modes of articulation', *Energy Research and Social Science*, 9. 157-165.

Torriti, J., 2012, 'Price-based demand side management: assessing the impacts of time-of-use tariffs on residential electricity demand and peak shifting in Northern Italy', *Energy*, 44(1), 820-842.

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It is not the copy of record. Copyright © 2018, Elsevier.

Webb, J., 2012, 'Climate change and society: the chimera of behaviour change technologies', *Sociology*, 46, 109-125.

Wilhite, H., Nakagami, H., Masuda, T., Haneda, H., 1996, 'A cross-cultural analysis of household energy use behaviour in Japan and Norway', *Energy Policy*, 24, 795-803.

Wilhite, H., 2004, 'Equating efficiency with reduction: a self-deception in energy policy', *Energy and Environment*, 15(6), 991–1009.

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Table 1. ACORN Groups (Source: CACI, 2004)

Category	Group	Household Types	No. of interviewed households
Wealthy Achievers	A – Wealthy Executives	Wealthy mature professionals, large houses Wealthy working families with mortgages Villages with wealthy commuters Well-off managers, larger houses	1
	B – Affluent Greys	Older affluent professionals Farming communities Old people, detached homes Mature couples, smaller detached homes	1
	C – Flourishing Families	Older families, prosperous suburbs Well-off working families with mortgages Large families and houses rural areas	5
Urban Prosperity	D – Prosperous Professionals	Well-off professionals, larger houses and converted flats Older professionals in suburban houses and apartments	3
	E – Educated Urbanites	Affluent urban professionals, flats Prosperous young professionals, flats Young educated workers, flats Multi-ethnic young, converted flats Suburban privately renting professionals	11
	F – Aspiring Singles	Student flats and cosmopolitan sharers; singles and sharers, small rented flats; student terraces	1
Comfortably Off	G – Starting Out	Young couples, flats and terraces White-collar singles/sharers, terraces	0
	H – Secure Families	Younger white-collar couples with mortgages Middle income, home owning areas Working families with mortgages Mature families in suburban semis Established home owning workers	2

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		Home owning Asian family areas	
	I – Settled Suburbia	Retired home owners Middle income, older couples Lower incomes, older people, semis	0
	J – Prudent Pensioners	Elderly singles, purpose built flats Older people, flats	2
Moderate Means	K – Asian Communities	Crowded Asian terraces; low income Asian families	2
	L – Post-Industrial Families	Skilled older families, terraces Young working families	6
	M – Blue-collar Roots	Skilled workers, semis and terraces Home owning families, terraces Older people rented terraces	0
Hard-Pressed	N – Struggling Families	Low income larger families, semis Low income, older people, smaller semis Low income, routine jobs, terraces and flats Low income families, terraced estates Families and single parents, semis and terraces Large families and single parents, many children	0
	O – Burdened Singles	Single elderly people, council flats Single parents and pensioners, council terraces Families and single parents, council flats	0
	P – High-rise Hardship	Old people, many high-rise flats Singles and single parents, high-rise estates	0
	Q – Inner City Adversity	Multi-ethnic purpose built estates Multi-ethnic, crowded flats	3
Total			37

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Table 2. Household Composition

		Number	Percentage (%)
Household composition	Economically active couple or single with dependent children	21	56.8
	Economically active couple or single without dependent children	12	32.4
	Couple or single pensioner	4	10.8
Household members	1	8	21.6
	2	9	24.3
	3	4	10.8
	4 and more	16	43.2
Total		37	100.0

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Table 3. Coding

Grouped Theme	Theme	Description
Shifting activities	Avoid 'High'	Avoid high; avoid using tumble dryer, hoover, iron and oven; turn things off when high
	Take advantage of 'Low'	Cook and freeze when low; do things while low (e.g. cleaning, laundering)
	Balance out	Balance out by doing a lot at next low after using electricity at high
	Practices that cannot be shifted	Certain things have to be done even if high
	Shift if convenient/possible	Shift only if convenient, when possible
How to change practices	Alternate appliances	Switch between electricity and gas
	Change material elements	Change what to eat when high (thus change cooking methods); change material
Positive consequences	Energy awareness/materialised energy	Aware of how and when using electricity; focus on what I do; changing prices make us think of electricity
	Confident of being flexible	Become confident that I can be flexible
	Sense of control	Control over usage; having options/opportunities to save or to be in charge
	Energy education/analysis	Education; own analysis and planning; keeping records
Observed limitations	Lifestyles/routines	Lifestyles; timetables (e.g. when to eat)
	Getting on with life	House as a comfortable place; quality of life; busy life

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