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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.

1. Introduction

Meeting climate change targets requires radical changes in electricity generation [1] and to increase low-carbon energy sources the European Union has a 20% 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% of energy consumption from renewables by then [2], and the country now faces a hugely challenging 'energy trilemma' of 'keeping the lights on, at an affordable price, while decarbonising our power system' ([1], 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 [3]. 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 [4],[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 [5].

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 [6]. 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 [7]. 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 [8], 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:

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[1] The EU aims to replace at least 80% 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% and annual household energy consumption by similar amounts [4].

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> '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' ([9], p. 9).

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 [10] and how energy is consumed in people's routine practices and how such routines develop, change and evolve (e.g. [11–14,17]). This literature argues how practices are interrelated, sequenced, and organised within the rhythms of people's lives (e.g. [15–17]). Indeed, there are a number of issues that limit people's abilities to change, and shift, their routine practices in the household [18]. As Bell et al. ([19], 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 the ways residents routine household practices influence energy consumption ([20], p. 11). This will offer explanations to results of a quantitative analysis of electricity consumption data in response to the price signals discussed elsewhere [21]. 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 [22] 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 ([23], 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' ([24], p. 24). Indeed, research in the USA and Italy demonstrates that demand response measures such as time-of-use tariffs and real-time pricing have led mostly to energy saving in peak hours, but to little load shifting [25,26].[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 [27]. While 50% of those time-of-use tariff users run appliances (other than water and space heating systems) at off-peak periods to save money, 38% 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 [27]. There are therefore concerns about the distributional impacts of dynamic pricing on households. Owen and Ward [24] 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 [24].

The opponents of dynamic pricing use this (alleged) unfairness issue to make their case [28]. Yet, 'the presumption of unfairness in dynamic pricing rests on an assumption of fairness in today's [flat-rate] tariffs' ([28], 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 [29,30] 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 [31,32], 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' ([31], 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' ([33], 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 [34]: more control over costs 'by carefully planning when to use certain appliances' ([34], p. 1124) and less control due to the complexity of arranging of appliance use and 'the lack of predictability' ([34], 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' ([34], p. 1125).

Another UK study explores the 'shiftability' of people's daily practices [16]. In their study, participating households were asked to carry out a few challenges: e.g. not to use energy for food preparation between 4 pm and 8 pm and to bring forward/delay laundry by 24 h. Higginson et al. [16] 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' ([16], p. 523). People organise their household activity in tandem with what is

[2] Meta-analyses of dynamic pricing [53,54] 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% respectively) and the vast majority of participants were keen to use multi-rate tariffs in the future [45].

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