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Peak electricity demand and the flexibility of everyday life

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ABSTRACT

Reducing greenhouse gas emissions from energy consumption in the UK is increasingly linked to the introduction of uncontrollable sources of power, such as solar PV and wind, and the electrification of energy services (Darby, 2012; Department of Energy and Climate Change, 2013, 2011). Electrifying heating and personal mobility requires moving them off the gas grid and petrol pump and onto the electricity system, which in turn may have implications for the profound peak in electricity use that takes place in the early evening. While the conventional response would be to reinforce electricity networks, under conditions where there are an increasing range and diversity of sources of electricity generation that are less predictable and controllable, there is increased political and commercial interest in managing demand in these periods. Demand Side Management (DSM) enabled by smart grids promises to bring consumers of electricity into the management of the grid by asking them to provide the flexibility and responsiveness that the industry may lose in the future. In this paper we draw on 186 qualitative home tours in the UK to examine how such forms of flexibility are constituted. Rather than seeing flexibility as related to the characteristics of individuals and their behaviour, as is common in the industry and policy, we argue that it is the social practices which shape electricity demand curves that need to be at the centre of analysis. To illustrate this argument, we consider how, in what ways and for what purposes consumption of electricity may be or become flexible in response to a time of use tariff designed to reduce consumption in the early evening. We argue that the rhythmic qualities of practices and the degree to which there are socially conventional times and ways to perform particular practices can constrain or open up their ability to adapt to interventions.

Introduction

As greenhouse gas emissions associated with energy use have become central to climate and energy policy, so too has the demand for energy become a principle area of interest for social scientists across (sub-)disciplines including Human Geography, Anthropology, Sociology and STS. The growing interest in energy demand has been accompanied by a distinct shift in focus away from the attitudes, behaviours and choices of individuals (Shove, 2010), towards an engagement with how energy use is constituted socially and materially (Guy, 2006; Maassen, 2009) (Spaargaren, 2011; Spaargaren et al., 2006; Stephenson et al., 2010; Strengers, 2011, 2009; Wilson and Chatterton, 2011; Gram-Hanssen, 2011). While this research has significantly advanced our understanding of how and why energy is used and the possibilities and limits of 'behaviour change' as a means for reducing demand, its predominant focus on the domestic sphere as the site through which energy use is constituted has limited its engagement with the dynamics of wider energy systems and a rather abstract engagement with the nature and properties of energy itself (Strengers and Maller, 2012). This has led to a disconnect between *energy* use research and the related but distinctively different issue of demand for *power*, the different material forms of energy used to meet such demands, and the ways in which demands for power are socially and temporally arranged (for important exceptions, see (Strengers, 2011, 2008; Southerton et al., 2004; Chappells and Shove, 2004; Higginson et al., 2013). In this paper we seek to contribute to the ongoing debate within the social sciences about energy consumption through engaging with a key dynamic that links the everyday contexts of energy use and broader power system transitions in response to climate change, energy security and peak demand. Drawing on work conducted as part of a regulator-sponsored and industry-led project, the Customer

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Led Network Revolution (CLNR[1]), we examine how peak demand and its flexibility is constituted through everyday life and draw out the implications for the future of smart grids.

The paper proceeds in the Section 'Constituting peak demand: Load, flexibility and household practices' by deconstructing load curves and exploring practice entities and performances as constituents of peaks in demand. The next part of the paper sets out the research process and context from which the paper comes before an analysis of the flexibilities of different practice entities in Section 'Contrasting flexibilities: Cooking, dining, laundry and washing dishes'. We then draw conclusions which highlight the diversity of ways in which practices are reproduced, the suitability of laundry and dishwashing for practice-aligned interventions and the opportunities to produce flexibility by working with or around the rhythms, conventions, economies and capacities of practices.

Constituting peak demand: Load, flexibility and household practices

From a socio-technical perspective, network 'load' is not only a physical phenomenon measured in voltage but is also a social one, representing the aggregation, at different scales, of the multiple ways in which electricity is used across the distribution network, in households and businesses. This is particularly important in thinking about the socially shared and loosely orchestrated practices – such as cooking, laundry, dining and home-comings – that animate the early evening and in doing so create peaks in demand for power which are registered at every scale on the network, from individual street-scale feeders to the national demand curve (Gridwatch, 2014). Understanding how load is constituted and the ways in which electricity use may be flexible entails examining the ways in which electricity is used in the everyday contexts and workings of households and businesses. In what follows we first examine the means by which load has become problematised, and in particular how "peak demand" has come to be understood before drawing on theories of practice and rhythm to suggest that while much research has emphasised the socially shared quality of social practices, practice entities have different degrees of variability in how and when they are performed in different contexts with some exhibiting little variation and others being highly differentiated. This has consequences for their contribution to evening peak demand for electricity and, we argue, these differences in the heterogeneity of their reproduction mechanisms makes practices differently able to adapt or respond to changing contexts.

Changing the curve? Electricity use and flexibility in the smart grid

Load curves represent the daily, monthly, and seasonal variation in how and where energy is used and produced across the low voltage, or distribution, network. In different national contexts, load curves bear the distinct features of the systems of provision and demand they represent. In the UK, annual load curves exhibit seasonal peaks and troughs while weekly or monthly load curves are saw-toothed in nature, reflecting daily demands for energy services and nightly periods of reduced demand[2] (Gridwatch, 2014). The 24 h load curve for electricity magnifies this pattern – with a clear late afternoon/evening peak (Fig. 1). Currently, power systems are governed in such a way as to ensure that there is sufficient capacity to meet these peaks in demand – both in terms of available energy resources to produce the electricity required, but

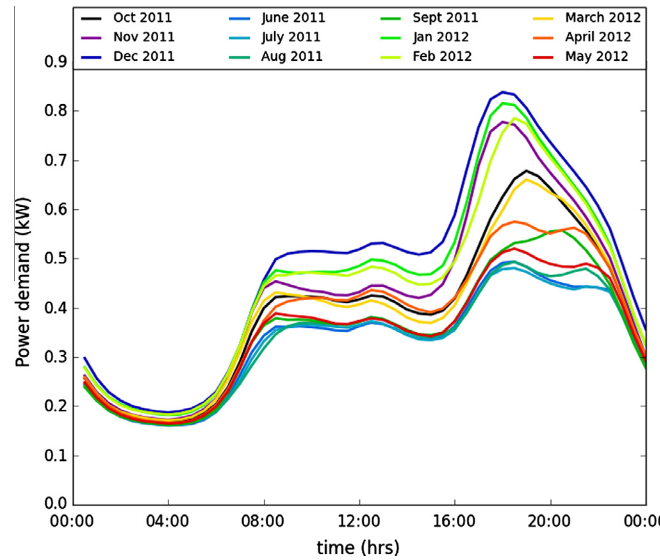

Fig. 1. Daily mean demand for Electricity from smart meters customers for 12 months (June 2011 to May 2012 inclusive) (Wardle et al., 2013) (Graph shows monthly mean electrical energy demand from a structured sample population of 7043 domestic customers in the North East and Yorkshire in the UK using 30 min interval data. Reproduced with permission of the authors.)

also, and most importantly for our discussion here, ensuring that networks have the capacity or 'headroom' to distribute electricity reliably in any given demand scenario (Roberts et al., 1991, p. 51).

However, in the light of the twin challenges of decarbonisation and energy security, the extent to which networks will continue to be able to serve peak demand under this logic, in which consumers are able to consume without constraint, is coming under question (Darby, 2012; Department of Energy and Climate Change, 2013, 2011). While energy consumption (kW h) has been widely associated with greenhouse gas emissions, managing power (kW) and its peak demand will become an important part of both ensuring affordable energy provision by delaying or deferring network reinforcement costs and, crucially, in realising the potential offered by renewable sources such as sun and wind energy. Both are relatively uncontrollable, so that that managing output requires either crude methods (e.g. turning wind turbines off) or storage solutions which are still in their infancy (e.g. large scale batteries, thermal storage), each of which has significant implications for the economies of investment in renewable technologies. Further, the typical 24 h generation profile from both wind and solar is not ideally aligned to the dominant 24 h demand profile for power in the UK. As a result, any realistic argument for climate change mitigation that relies on renewables must also address the issue of matching power generation to demand through new interventions in the electricity grid itself. Framed as a technology problem alone, the infrastructure renewal required would be both technically and financially challenging. Instead, policy-makers and market actors are seeking to examine ways to defer the costs of reinforcement while at the same time meeting low carbon and energy security challenges through Demand Side Management (DSM) of the system as part of socio-technical imaginaries often collectively referred to as smart grids (Jasanoff and Kim, 2009).

While different interpretations of what constitutes a smart grid exist, it is defined by the EU Smart Grid Forum as, "an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies. A smart grid employs innovative products and services together with intelligent monitoring, control,

[1] www.networkrevolution.co.uk.

[2] An exception to this is on networks where there are high numbers of night storage heaters that exhibit peak loads after midnight when storage heaters begin to draw power.