Abstract

Managing the electricity network through 'smart grid' systems is a key strategy to address challenges of energy security, low carbon transitions and the replacement of aging infrastructure networks in the UK. Small and Medium Enterprises (SMEs) have a significant role in shaping patterns of energy consumption. Understanding how their activities interrelate with changes in electricity systems is critical for active network management. A significant challenge for the transformation of electricity systems involves comprehending the complexity that stems from the variety of commercial activities and diversity of social and organisational practices amongst SMEs that interact with material infrastructures. We engage with SMEs to consider how smart grid interventions 'fit' into everyday operational activities. Drawing on analysis of empirical data on electricity use, smart meter data, surveys, interviews and 'energy tours' with SMEs to understand lighting, space heating and cooling, refrigeration and IT use, this paper argues for experimenting with the use of practice theory as a framework for bringing together technical and social aspects of energy use in SMEs. This approach reveals that material circumstances and temporal factors shape current energy demand amongst SMEs, with 'connectedness' an emergent factor.

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Fostering active network management through SMEs' practices

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1. Introduction

Small and Medium Enterprises (SMEs) play a significant role in shaping local and national patterns of electricity consumption. Understanding how their practices relate to changes in electricity systems is, we argue, an important part of future power system management. The principal aim of this paper is to explore the potential of practice theory, which thus far has been mostly focused on residential electricity consumption, to shed light on this area of enquiry. Drawing on smart meter data from 1,787 SMEs, survey responses from 152 and qualitative research with 50 SMEs we examine the grounds for and merits of a practice led approach to understanding the mechanisms shaping SMEs' current electricity use and how they engage with ideas and initiatives relating to electricity use. This analysis is conducted in order to inform future design and delivery of initiatives that seek to enrol businesses in smart, flexible electricity systems. In this regard we identify the flexibility of common business practices and draw conclusions about what might enable or inhibit the availability of flexibility in electricity consumption, which is increasingly being considered an asset by developers of smart grid projects.

Practice theory calls for two substantive changes in approaches to conventional research on electricity consumption. First, it requires that analysis should focus on what it is that SMEs do, rather than what they think or say about their electricity use. Secondly, a practice–led approach treats practices themselves as the units of enquiry rather than the businesses performing them. This way analysis can focus on the constitution and drivers of activities that demand electricity and the commonalities and points of difference between these activities; rather than focusing on specific SMEs, which are notoriously difficult to study as a result of their heterogeneity (Hillary 2000:561). We experiment with this approach in order to assess whether it can offer new ways to understand how existing forms of SME electricity use could change, in ways that can promote or impede flexibility. We also seek to understand opportunities that may exist for SMEs to engage with electricity network managers.

Our study of took place in the north-east of England and is set within a wider industry-regulator funded research project, undertaken by an interdisciplinary team of social scientists and engineers at Durham University and Newcastle University. The nature of the project and the research from which this paper derives can be found in Section 3.

We first establish the case for experimenting with practice theory in the context of SMEs through analysis of the results of a survey completed by 152 businesses. We then use qualitative data to identify important practices and their potential for demand side flexibility before drawing attention to material and temporal constraints that in different ways inhibit flexibility. First however we set out the academic and policy contexts for the research.

2. Smart Grids, SMEs and Energy Policy

Uncertainties abound over how the transformation of the UK's electricity system into a low carbon yet resilient one will be achieved, and particularly over the roles to be played by consumers of all kinds. Questions concerning the role of consumers in the emerging politics of UK's energy policy have come to the fore recently through the notion of a 'smarter grid'. While there are many definitions of smart grids (cf. European SmartGrids Technology Platform (ESGT) 2006; Clastres 2011; Gellings & Samotyj 2013), for the purposes of this paper we view a smart grid 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 a sustainable, efficient and secure supply of energy" (SmartGrids European Technology Platform 2013).

Smart grids are increasingly regarded as central for achieving decarbonisation and security goals (Clastres 2011) and reckoned to offer savings of between 0.9 and 2.2 Gt CO2 a year (IEA 2010:154). These reductions are related to lower grid losses, faster deployment of energy-efficiency schemes and peak-hour energy savings, as well as changes in how electricity is used (Clastres 2011). Despite disagreement over specific details of how smart grids can and ought to be realised, there is a consensus that the concept of the smart grid involves integrating innovative technologies, products and services extending from generation, transmission and distribution through to appliances and equipment. These new interfaces will be enabled by advanced sensing, communication, and control technologies (Moura et al. 2011). Importantly, smart grids will also include the participation of electricity customers, some of whom are beginning to exceed that category by exporting power to the network, and in doing so becoming producers as well as consumers; giving rise to the neologism 'pro-sumers' (Lehtonen & Nye 2009; Verbong et al. 2013).

Smart grids have attracted significant investment and effort through their promise to resolve the fundamental tensions between decarbonisation, security of supply and cost reduction. Central to their potential and limitations is the extent to which smart grids are able to yield actual and significant time-shifts and reductions in electricity demand through active forms of network management.

2.2 Active Network Management

A key feature of smart grids that connects consumption and production practices is the concept of active network management (ANM). By ANM we refer to innovative arrangements for the management of electricity systems involving a range of technologies and strategies to accommodate demand on the grid (Lehtonen & Nye 2009; Ofgem 2013; Jamasb & Pollitt 2011). In the UK, the shift towards ANM is driven partially by the Distribution Network Operators' (DNOs) desire to optimise asset utilisation, defer reinforcement and strategically plan the replacement of ageing assets (McDonald 2008:4348).

ANM assigns energy users a key role in the making of smart grids through demand-side response (DSR) (Bilton et al. 2008). Traditionally DSR programmes are driven by the supply industry, through "the planning, implementation, and monitoring of activities designed to influence and encourage customers to modify their levels and patterns of electricity usage in such a way that the load profile can be modified by the utility company i.e. changes in the time pattern and magnitude of a utility's load" (Jamasb & Pollitt 2011:133). The promise of ANM is that by manipulating consumption to enable electricity demand to react to network conditions the power system can be managed in an optimal way (Arteconi et al. 2013; Gellings & Samotyj 2013).

A subset of demand side management strategy, demand-side response (Element Energy 2012), also termed demand-side participation (Torriti, Leach & Devine-Wright 2011), relies on financial signals as incentives for altering patterns of consumption (Arteconi et al. 2013), often as 'active, short term' measures (Grünewald & Torriti 2013) responding to events on the electricity system or smoothing daily and seasonal peaks on the grid (Kim & Shcherbakova 2011). The value of demand response to actors across the power systems is that of a fast, cheap network capacity resource, shifting consumption in time on a regular basis to minimize use of electricity at times when networks are close to capacity. Rapid response DSR that reacts to changes in solar and wind output limits the need for peaking plant and cuts emissions by reducing the use of spinning reserve (Darby et al. 2013) Additionally, reliable time-shift DSR can reduces or defer requirements to upgrade distribution networks. DSR can be enabled by advanced metering technology, which is a key building block towards consumer involvement in the smart grid for its capability to a) measure, store, monitor, and transmit data to the utility company, b) convey real-time tariff changes, supply-wide conditions and peak-load information to the consumer (Darby 2010a). The existence of this technology alone is a necessary pre-condition for smart grids but is likely to be insufficient for their realization. An international review of DSR programmes found that success in reducing or shifting demand is determined not by the technology itself, but whether different consumer groups can be successfully enrolled (Stromback et al. 2011).

How SMEs might contribute towards electricity efficiency and peak management policy objectives is dependent upon several factors, central among them being how and when businesses use electricity. Previous research on energy use and flexibility tends to concentrate on the domestic sector and focuses on technological elements of smart grids and DSR (Element Energy 2012; Gellings & Samotyj 2013) such as advanced meters as the means to enable flexibility. Whilst smart metering offers possibilities for electricity management and customer–utility relations, implementation is embryonic in the context of UK SMEs.

A Carbon Trust report (2010) of a trial of advanced gas, water and electricity metering suggests there is scope for SMEs to make “significant progress on energy management given the right incentives” (2010:23), especially among intensive users of electricity. However, the report’s admits that, even as the costs of the meters and their fitting reduces, for the foreseeable future the business case for “energy suppliers appears to remain marginal overall” (2010:2). Proponents of smart meters counter this view by arguing that smart grids can enable network flexibility through feedback and dynamic pricing and the automation of certain ‘smart’ appliances (Stromback et al. 2011), which the Carbon Trust report agrees could be beneficial for SMEs. Of most salience to our approach is how such technical measures intervene directly in the daily routines and practices of consumers. The implication is that understandings of business users’ daily practices are pivotal to the realization of smart grids (Darby 2010b; Hall 2013; Steg 2008).

2.3 Small and Medium-sized Enterprises and Energy Use

According to the European Commission “The category of SMEs of micro, small and medium-sized enterprises is made up of enterprises that employ fewer than 250 persons and which have an annual turnover not exceeding 50 million euro, and/or an annual balance sheet total not exceeding 43 million euro.” (Schmiemann 2006) In the UK SMEs account for 99.9% of private sector businesses with an estimated 4.8 million private sector SMEs creating a significant contribution to the economy and to employment (Hillary 2000; BIS 2012). Around 55% of delivered energy use in the public and commercial sector is in SMEs (Sykes 2009). For these reasons, SME energy use is critical to any holistic energy policy. Nevertheless, with the exception of specifically intensive users engaged in high energy manufacturing activities, energy bills do not form a large proportion of business overheads being eclipsed by “salary bills, rental for business premises, and petrol/diesel where vehicles are used for business purposes” (Lawrence & Reiman 2011:17). UK SMEs, rank environmental issues such as carbon reduction “relatively low on their list of business priorities” (Bradford & Fraser 2007, citing Bichard 2000).

Janda et. al. confirm in their 2014 study that the energy use by SMEs is largely under-researched (Janda et. al., 2014). Understanding energy use in SMEs, including electricity, is made especially difficult because of their heterogeneous nature, and individually specific characteristics: what Hillary describes as a “vast array of different businesses” (2000:561). A lack of accurate data and reliable information on UK SMEs is further complicated by the multiple ways of setting the boundaries for defining or segmenting SMEs (Hillary 2000). Variation across businesses indicates some important differences in consumption of energy, including electricity (DECC 2012; Sykes 2009). Energy use among SMEs and their capacity to change use patterns are influenced by the size, composition and interests of the organization, as well as the equipment and appliances in use, (Hitchens et al. 2005; del Brío & Junquera 2003; Trianni et al. 2012) strategic management, decision-making motivations and understandings (Lawrence et al. 2006), and networks (Gadenne et al. 2009).

Within this context of heterogeneity research on energy and environmental management has considered external influences on environmental awareness and practices of SMEs including wider stakeholder groups beyond the business: suppliers, customers and legislators (Gadenne et al. 2009). Gadenne and colleagues identify 'confounding factors' that may limit the environmental-friendly practices of business owners which include: access to information, time and financial resources, and owner/managers' personal characteristics. To develop this discussion further we now turn to consider the ways in which energy use in SMEs has been conceptualized.

2.4 Understanding Energy Use in SMEs

Contending theoretical perspectives assert that psychological, sociological or economic based accounts are best placed to offer explanations of the ways in which different forms of energy are used (Darby 2010b:4; Higginson et al. 2014; Shove 2010). This debate has however largely taken place in relation to domestic use. Approaches for engaging with the use of energy within the SMEs have similarly been dominated by a narrow set of disciplinary perspectives that seek to interpret demand as a matter of attitudes, incentives and behaviour change (Sorrell et al., 2000; Trianni and Cagno 2012). In an attempt to overcome limited explanations of SME engagement in energy and environmental management offered by approaches focused on organisational behaviour there is a move towards integrated frameworks that incorporate social and cultural factors. Cox et al., (2012) adopt a model that seeks to integrate individual, social, and material contexts, identifying common themes among case studies about what promotes low carbon behaviours In their work on industrial energy efficiency. Palm and Thollander (2010) stress the importance of focusing on social context in seeking opportunities for energy reduction.

We suggest that developing a framework for understanding effects due to social contexts and processes shaping demand can be aided by considering how demand is influenced by practices that cut across businesses. Most practices are performed by many businesses.

Whilst social practice theorists differ in emphasis, (Gram-Hanssen 2010; Reckwitz 2002; Røpke 2009; Schatzki 2002), for the purposes of this paper there is loose agreement that practices are comprised of routinized forms of action which consist of interacting elements. Examples are commuting practices, cleaning practices, production practices and lighting practices. From a practice perspective, activities in the workplace and those connected to the workplace (such as goods delivery, for example) are conceptualized as specific performances of wider, socially shared 'practice entities' (Shove et al. 2012).

Practices have been theorized as being comprised of bodily activities, mental activities, 'things' and their use; as well as background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge (Reckwitz 2002). Shove distils these down to three 'elements': materials, meanings and forms of knowledge (Shove et al. 2012). Work places can also be viewed as being spaces in which 'communities of practice' (Brown and Duguid 1991, cited in Hargreaves 2011) unfold that include or intersect with customers, suppliers and infrastructures of provision. And, moreover, that at work: "The processes of environmental socialization that practices bring about (or fail to), in which new social identities, interactions and relations are forged, would seem to deserve further empirical attention" (Hargreaves 2011:96).

Our data shows how many of the tasks and routines conducted in SMEs can be treated as social practices, though some, like those of a manicurist or a professional cook, are conducted differently to how they would be performed at home; partly because a commercial relationship with a customer creates different meanings and requires different competencies. Other activities such as milking cows in a commercial milking parlour, or laboratory work, have no domestic equivalents, but nevertheless follow regular routines and are comprised of social and material elements. In what follows we present an analysis of data about the day to day work of SMEs in order to determine whether such a conceptualization is useful in helping understand the fabric of everyday activity in SMEs. This is of particular relevance to energy network providers who, as they move into an era of active network management, are seeking new ways to engage with business energy use.

3. Research Context: The Customer Led Network Revolution

This research was conducted as part of the Customer Led Network Revolution (CLNR) project, one of several trials funded by Ofgem under the Low Carbon Network Fund (LCNF). The core objectives of the project include understanding current and likely future electricity demand and to examine the potential for fostering customer flexibility within both domestic and SME users. In line with the socio-technical approach adopted, the CLNR project is designed around twenty 'test cells' each of which entails a different combination of households, SMEs, low carbon technologies, tariffs, smart meters and monitoring equipment. Overall, the project involves the participation of 12,607 domestic and SME customers, with the majority forming the 'control group' in Test Cell 1. The 1,787 SMEs that took part in the trial all had smart meters which were used to gather half-hourly electricity consumption data.

3.1 Researching SMEs Electricity Practices

The social science research methods adopt two main approaches – a survey and a qualitative research interview. An online survey was distributed to all SME participants with email contact details in October 2012, of which 152 completed a questionnaire. The survey was designed to produce data on the characteristics of SME respondents, energy use behaviours, attitudes towards energy initiatives and the extent of low carbon technology installations.

The survey sample was structured to ensure the inclusion of respondents from all UK Standard Industrial Classification categories, except Mining and Quarrying, Financial Intermediation, and Social and Public Administration (UK Standard Industrial Classification [ONS] 2007). Most SMEs completing the survey were from sectors entitled Other Service Activities (S)(35); Wholesale, Retail Trade and Vehicle Repairs (G)(23); Manufacturing (C)(27); and Accommodation and Food Services (I) (21). See Figure 1 below.

FIGURE 1: SMEs THAT PARTICIPATED IN THE SURVEY BY ACTIVITY

<FIGURE 1 HERE>

The second method was qualitative, entailing face-to-face interviews with owner-managers of fifty businesses during 2012 and 2013. The research visits also included a tour of the premises. The tours of business premises were participant-led and acted as a catalyst for conversations about all aspects of electricity use, and enabled links between business practices and materialities to be included in the conversation in ways that would be less likely to emerge in conventional, static interviewing as Hitchings and Pink have argued (Hitchings 2012; Pink 2005). The qualitative semi-structured interviews focused on: participants' overall energy use; information about occupancy; major electrical loads; heating regimes; thoughts and feelings about electricity use; seasonality and working hours; and experiences of and attitudes to new and existing tariffs and technologies. Participants were asked to draw a graph of their perceived daily electricity use over twenty four hours. Participants were also able to discuss their own specific concerns, as well as the topics of flexibility, peak consumption and potential for demand side participation (DSP). Interviews were recorded then coded and analysed within NVivo software using a coding framework developed in iterative analysis workshops in which the research team shared experiences and observations about emerging themes. Fifty SMEs participated in the initial qualitative research, and seven businesses from outside these samples were recruited via local business associations into a focus group discussion.

The focus groups included discussion of all forms of energy consumed within the business premises and encouraged participants to reflect on their electricity use in particular. Participants were prompted to discuss whether and how they managed consumption; if and from where they sought advice; what they considered to be the main problems they faced in managing energy in their businesses and what capacity they had for flexibility in their use of electricity. Video recordings of the focus group and notes taken by researchers were analysed using the coding framework and software used for the interview data.

British Gas Business, one of the project partners, recruited all SMEs except those involved in the focus group, which were recruited by Durham University researchers via local business associations. No significant differences were found between the qualitative data generated in the two differently recruited qualitative research groups so we do not distinguish between these groups in the analysis.

4. SMEs and Electricity Demand

In order to quantify the heterogeneity of SME demand somewhat and to present a useful record of SME electricity demand in the UK, we present here electricity demand profiles taken from businesses participating in the CLNR study.

These load profiles add to the relatively small (compared to domestic energy use) pool of business electricity use data and reveal some clear patterns in the timing of electricity use. But they also offer powerful confirmation that more attention and new modes of enquiry are needed to understand SME energy use.

Load profiles recorded between 01/09/2011 and 30/04/2012 are based on half hourly monitored electricity data from 1,787 SMEs. Derived from initial analysis of metering data, from meters either installed as a part of the trial or pre-installed, electricity profiles are presented for four main Standard Industrial Classifications (SIC) of trial participants: Agriculture, Industrial, Commercial/Office, and Public Sector/Other. A breakdown of the classification and proportion represented in each tariff is shown in Table 1. Significant differences are apparent between the SIC classifications on aggregate (Figure 2).

TABLE 1: NUMBER OF TRIAL PARTICIPANTS

<TABLE 1 HERE>

Industrial customers show the most pronounced variation in electrical consumption, with roughly constant peak demand during the daytime period and minimal consumption outside of these hours. Participants in the Agricultural classification show little variation between weekday and weekend profiles with a distinct twin-peaked profile for multi-rate customers. The Agricultural classification also shows the highest peak demand across the sample of all sectors. Profiles for the Public Sector/ Other category show little change in their shape between weekday and weekend, however, consumption is slightly reduced in the weekend period.

FIGURE 2: AVERAGE ELECTRICITY USE FOR SIC, DECEMBER 2011

<FIGURE 2 HERE>

These large and inclusive categories contain so much variation that further categorical analysis was not found to be useful. Instead we turn to consider what the social science research methods reveal about energy use in SMEs.

5. A Practice-led Analysis of SME Electricity Use

To begin our analysis we first turn to the survey data to begin to examine the case for using practice theory to understand SME engagement with energy initiatives. Although there are differences in how SMEs and domestic energy use have been studied and in many ways the SME literature has taken more account of contextual and cultural matters (see DeCanio 1993 and Cebon 1992), research in both literatures usually take the energy user rather than practices as the objects of enquiry. Such theories of energy use start from the assumption that there is an ‘AIDA’ logic that drives action through which energy is used (Barr and Gilg 2007). In such a conceptualization, awareness (A) and information (I) determine decisions (D) about energy use that in turn, lead to action (A). This approach has come under criticism because of a consistent disconnection between what people report their attitudes and levels of awareness to be and the actions they take. This so-called value-action gap prompts questions about the usefulness of the AIDA logic.

Fundamentally, if this logic was sound then one would have to conclude there to be a persistent problem with the empirical research conducted and the effectiveness of well funded behavior change initiatives based on the premise of the AIDA logic. The counter argument we find convincing suggests that rather than pointing to problems with the implementation of interventions the value-action gap is better interpreted as a window through which to observe problems with the AIDA logic. Indeed, it is around this kind of thinking that practice theory defines itself and has come to be regarded as useful in the context of domestic energy use – as argued most vociferously and convincingly by Elizabeth Shove (Shove 2010).

We find in the SME survey data, as is the case in studies of domestic energy use (Barr and Gilg 2007), that awareness and information about energy use and efficiency are largely in place but are not leading to actions as predicted by the AIDA model of behaviour. We therefore suggest our data provides evidence in support of arguments for the need to adopt new ways of conceptualizing energy use in SMEs that do not rely on the AIDA logic.

The evidence to support this particular argument is that 78% of businesses completing the survey knew what kind of tariff they were on and a majority (72%) of the SMEs agreed that they needed to reduce the amount of electricity and other forms of energy use at their premises. These two statistics imply that levels of energy awareness were relatively high. Participants also reported having suitable motivations to engage with their energy use and energy companies, with many reporting they were concerned to achieve electricity reduction for financial and environmental reasons.

However, appropriate actions and decisions were not being taken by the majority within the 152 businesses who completed the survey. Few businesses had designated environmentally-orientated roles (e.g. energy manager) and the majority (82%) had never sought support for improving environmental sustainability. Furthermore, 76% of companies had never undertaken an energy audit and just over half did not operate any site-wide environmental policies or organisational practices. These numbers suggest that despite reasonably high levels of awareness and motivation, businesses were not 'engaged' by energy initiatives and had not taken the kinds of 'action' that would make them ready for further steps toward engagement with energy companies.

This pattern cannot be discounted as being associated only with a narrow or skewed sample as there was considerable variation in size, organisation and activities among the SME survey respondents (n=152). Approximately two thirds (69%) operated from a single site, 89 were family owned, and 46 were part of multi-site organisations. The majority of companies (68%) owned their own premises but most (64%) were not built for purposes and the date of construction was unknown by 87% of the SMEs. Most of the premises (67%) had central heating and almost half had programmable thermostats. Twenty five had air conditioning but four respondents stated the air conditioning was unused. Around half of the SMEs in the survey used plug in electric heaters, with an average of three per premises. The majority of SMEs participating in the survey (59%) were not on a time of use (multi-rate) tariff.

We suggest that these survey results lend weight to the argument that conventional conceptualizations of SME engagement with energy improvements and initiatives based on attitudes, information and motivations come up against the same conceptual problem, the value-action gap, found in studies of domestic energy use. Because of this, we argue that those developments in the domestic energy use literature that have responded to the persistence of the value-action gap should be experimentally applied to SME contexts. In the remaining part of the paper we conduct a practice-led analysis to examine the business practices with potential for flexibility before identifying factors affecting the potential for flexibility in business practices.

5.1 Potentially Flexible Practices

In this section of the paper we identify opportunities for flexibility that are most commonly talked about in the qualitative data in order to draw attention to the areas of potential electricity use flexibility. Our analysis makes clear that some practices entailing electricity use are common to all businesses that participated in the study. These are:

- Heating practices
- Lighting
- Use of ICT

Beyond these three, food preparation emerged as a notably common practice and as such is given attention below. Outside of these practices there was great variety in types of business activity, organization size, structure and organisational cultures. This diversity, described by Parker et al. as creating problems in studying orientation to environmental issues (Parker et al. 2009), meant that beyond the core common practices there are various business-specific practices which were not shared between participants and may only be shared across businesses in specific fields. These are attended to at the end of this section of the paper.

5.1.1 Flexible heating practices

Informants identify heating, cooling and ventilation amongst their most electricity-intensive practices. Where there is a reliable alternative heating supply interviewees indicated their preparedness to view electric heating loads as interruptible in exceptional circumstances by using alternatives like gas or biomass. Some SMEs agree that heating practices could be altered to reduce loads or interrupt supply without detrimental effects:

'As long as we were notified about it, we wouldn't have a problem. I'd gladly turn the thermostat down and put the big fire on.' [Public house]

[We only heat a room when] *"there is a course on"*. [Catering business]

"We have one oven that probably comes on once a month" (oven for surface mounting)" [Public house]

Heating practices are in some respects inflexible, in that they are clearly structured by long lasting material conditions (building envelope, current appliances/systems, gas connectivity, etc.), and in other respects flexible, because electric heating is perceived as capable of being compromised without undue impact. This interplay between structured heating practices and day to day trade-offs in control is an area for future attention, as heating is best suited of the major load types to on-site storage of energy, as in thermal tanks.

5.1.2 Inflexible lighting practices

Reduction in lighting is less acceptable among SME interviewees because they believe its effects are exceptionally noticeable, particularly by customers, and thus impact on business turnover. Lighting is associated with the correct environment for working, or for customers. In some SME settings such as retail or where employees need 'the right light', as in lab work, there is very little perceived flexibility in reducing lighting. Some businesses extended their lighting beyond opening hours to illuminate window displays, or operate lighting and other devices for security. However in terms of flexibility, as well as changing to more efficient lighting technology, informants demonstrated their use of timers and sensors for switching off lights when spaces are not being used meaning that for many SMEs, where there is scope for efficiency or reduced lighting it has already been acted on.

5.1.3 Use of ICT

Computing practices are important to almost all businesses as part of everyday work routines. The use of ICT is affected most by the design and age of the equipment, and the desire for connectivity and reliability. Although the computing load is often relatively small, it is frequently regarded by the owner-managers in our sample as uninterruptible, especially because of their need for connectivity. To enable flexibility from a network point of view involves finding other ways to ensure connectivity.

Computing practices are largely tied to opening hours, but there is a significant 24hr load associated with servers which were found on site at many medium sized businesses, routers, and back-up devices. Increasing use of mobile devices – whether battery operated laptops that can work offline but still on battery power, or tablets or smartphones as temporary alternatives to desktop machines – offers scope for mobility and flexibility in working practices but also greater tolerance of power interruption where core activities like email, diary, and data access can be sustained for several hours by a combination of laptop and smartphone/tablet working without a fixed power connection. A few interviewees suggest they are alert to these possibilities. Although load reductions at work might transfer to increases at home:

'We could switch to laptops, or mobile devices, so that they run off battery … we could do that when we switch them but we couldn't afford to do that all at once.' [Real estate agency]

'The people who move between here and head office, they use laptops ... They would be using a battery. In fact we should get them to charge them at home!' [Contract management services]

The potential here is that by ensuring a service (connectivity) that requires very little power business customers may be prepared to be flexible in their arrangements with suppliers on other less important but more energy intensive practices.

5.1.4 Food preparation in exceptional circumstances

For those SMEs involved in food production such as pubs, hotels, B&Bs and nurseries/family centres, practices were most heavily influenced by temporal structures, with flexibility limited by advertised times of food service or children's' meal times. Initial indications suggest however there is some flexibility around how food services are delivered, through modifying operations:

'We could very easily say hot food is no longer available and just serve sandwiches … that's an option for us … but if I've got a hot food party then I'm contracted to provide hot food in that period.' [Children's' activity centre]

'I always ask if they need both [deep fat fryers] on. Realistically, we could get away with just one on. There are certain foods you can't fry together … but I always question them. … Oil takes a while to heat up so once they're on they stay on all day.' [Public house]

5.1.5 Business-specific practices

Load reduction is particularly problematic for interviewees whose business requires electricity for machinery and equipment that may be called upon at any time during working hours. Some business specific processes, are perceived to be beyond the control of people in the SMEs, and are driven by the requirements emanating from materials or equipment that has to be supervised on a 24hr basis.

Aside from the 24hr loads and common office loads, certain business specific loads can be 'spikier' than others. High power but intermittent loads such as printing, air cleaners, heaters and specialist salon equipment were referred to as 'necessary', although these activities are not immovably fixed in time. Participants talked about such 'spiky' loads as potentially offering flexibility to the power system as they can be moved to times outside of the evening peak period (16:00-20:00 hrs weekdays).

Some businesses with strict deadline constraints were the most open to change if the SME owner-manager was to receive the right kind of advice and support and if a different course of action was taken to 'make sense' to them, as illustrated in this example:

'we manufacture to stock not to order … some of the planning could be brought forward from the next working period … there's always ways to re-schedule what you do if it is advantageous from a cost point of view … so we could look to do things like that.' [Printer cartridge re-manufacture and supply]

Even among owner-managers who declare inflexibility in most other respects there are indications of potential for load reduction:

'I can't turn my cellar off .... it would ruin my beer.... we do have timers on the fridges and the ice machine so we do turn them off at midnight and it comes on again in the morning. So we are looking at things like that but we can't turn the kitchen off between 4 and 8 because we do services.' [Public house, accommodation and restaurant]

To conclude this section, by identifying the common practices and analyzing them across businesses we have reduced some of the barriers to analysis and insight caused by SME heterogeneity, while accepting that there is a degree of heterogeneity in businesses that is not eradicated by a practice-led approach. In this sense, we make the argument that the approach is a useful complement to other research and that its inability to overcome every aspect of business heterogeneity should not blind researchers to the valuable if measured contribution that it can make in this regard.

5.2 Barriers to Business Practice Flexibility

We now consider the factors that arose from the analysis as those that constrain flexibility in business practices. The two themes we identify have emerged from the qualitative data and suggest that material and timing related challenges need to be addressed and overcome by actors seeking to enable businesses to engage with future forms of demand side response.

5.2.1 Material and socio-technical constraints

Material constraints emerged in our analysis as a consistent theme in discussions with interviewees. We use this term to refer to the location of the business and its access to power supply, as well as the constellation of services (such as lighting, heating, cooling and ventilation) and the various types of electrically powered equipment required for the business to operate. These material constraints resonate with one of the three 'elements' of domestic social practices that lead to the use of energy, as theorized by Shove et al. (2012) and Røpke (2009) who argue that material things should be treated as discrete elements of practice .

For some participants businesses specific loads were rendered un-interruptible or non-negotiable because of the characteristics of technologies, materials and bodies. The most common examples of these were lighting, heating and/or cooling. Examples of non-negotiable loads include using floodlights for all night security, extra heating required for clients undergoing health treatments or refrigerating food in accordance with externally imposed safety protocols to meet hygiene regulations.

Certain types of equipment are also common across the sample. All SMEs in the study used at least one computer. However, many businesses feature specialized, electric intensive machinery essential to their product or service. These range from hot wax heaters to ventilation systems, and industrial production equipment. Cooling practices such as refrigerating food and drink, processing foodstuffs in production contexts, animal welfare concerns and machinery requirements are affected by material conditions, and the characteristics of 'non-humans' rather than by business owners' choices, for example:

'When you're working in a lab, working with gases and such like, you've got to make sure they're extracted ...' [Bio-technology/R&D]

'The milk cooling system has a timer that runs on for 2 or 3 minutes every hour - like a thermostat. It has to keep it (milk) below 4 degrees. And that's the water heater, that's for going through the milk units to sanitize them.' [Dairy farm]

'When I'm working I need the right lights, so couldn't turn them off, or down. No.' [Beauty salon]

These examples provide a sense of the diversity of socio-technical situations that are perceived to 'need' cooling, ventilation or light as a result of the interplay between natural conditions (biological/chemical/physical properties) and socio-technical conditions (regulation, technology design, building design, building maintenance). This interplay contributes to the case for the use of practice theory in understanding SME energy use and the barriers to engagement with smart grids.

ICT technologies are those most associated with changing work practices, but their various uses appear obdurate to change. ICT practices are important to all businesses in our study and play a part in a range of practices including production, procurement, management, sales and communication. The use of ICT is affected by material considerations pertaining to the design and age of the equipment. Our interviewees want fast and reliable connectivity from their ICT equipment; while the desire to maintain availability to customers and stay 'open for business' leads to overnight loads that are often unnecessary and result from a lack of understanding of how email services work and can be connected to (Gram-Hanssen 2010):

'We have a computer that gets left on overnight, because we do get customers placing orders through the night.' [Printing/Membrane keypad design and production]

'There are constantly two PCs running upstairs. There's a laptop I try to turn off. But the main PC is always picking up emails any time of night.' [Public house]

5.2.2 Temporal constraints

Temporal constraints refer to the diurnal, weekly, monthly or seasonal patterns of activities in pursuit of business goals. These patterns might cohere around regular routines such as opening hours, meal times, weekend clients, food production and harvests, holiday periods and the like, when electricity consumption is unavoidably high in relation to other lighter periods:

'We couldn't change [milking time] really, cows need as long an interval between them as possible, its animal welfare.' [Dairy farm]

Some electricity use in SMEs in the UK is determined by connections with businesses in different time zones: *'We start early in the morning ... at 6 or 6.30am because the factories are all in the East and at 3pm we're done for the day'* [Textile manufacture]. But not all business activities have temporal predictability, for example, when manufacturers have to work overtime to meet unusually large orders. In other cases the materiality of equipment and the purpose to which it is put coincide with temporal factors:

'They have to heat up, digital printers have to be at operating temperature so they need to be more or less left on …' [Digital printing]

'The wax pot needs to be on all day - it keeps the wax warm and soft for doing legs or eyebrows. It takes 20 minutes to warm up so if we need it on we can't wait for it, so it stays on all day' [Beauty salon]

'For all the optics, the pumps, there's a big unit with a coil in it, that's on 24/7. If you turn it off the ice block inside will melt and you've got to start again and it takes 24 hours to cool down.' [Public house]

These arrangements, especially those relating to timing, are implicit to the functioning of businesses, sometimes as a consistent centre of action or otherwise intermittent practices that are equally essential to production, as illustrated by the following example relating to printing equipment:

'That's quite high power, taking about 6.5kW, and it's in use, in a good day about 20 minutes a day.' [Printing/Membrane keypad design and production].

6. Conclusions and Policy Implications

In this paper we have argued, on the basis of our analysis of survey results (n=152) that conventional behavioral models of energy use are as flawed in theory explanation of SME energy use and engagement with energy initiatives as they are in the context of domestic energy use. We then presented an analysis of a qualitative dataset (n=50) which identified the business practices most likely to offer flexibility in their use of energy.

Previous work has highlighted the heterogeneous nature of SMEs and the associated challenges to understanding electricity use. We argue that analysis that works with business practices as the unit of analysis, rather than businesses types alone, helps avoid confusion bred by overwhelming variation in types and styles of businesses, enabling us to concentrate on the commonalities and themes in SME owner-managers' "doings and sayings" (Schatzki 1996:89). Their preoccupations with material circumstance and temporal constraints are thus brought to the fore and can be relayed to policy makers and actors in the power system as general, high level constraints likely to affect many of the business they seek to enrol in smart grid schemes. In terms of material circumstances, analysis shows types of equipment and types of service provision heavily influence electricity practices and seriously – if not fatally – constrain flexibility in practices. Public health and safety regulations and those applying to animal welfare often overrule flexibility. A further limitation on flexibility is temporal factors attached to production and service regimes closely connected to customer and supplier's expectations. SMEs may want to maintain connectivity with customers and suppliers on a 24 hour basis.

Despite the difficulties being encountered in enrolling SMEs into smart grid projects such as the Customer Led Network Revolution, there are clear signs of potential. Most state that they would like to use less electricity or are willing to be financially rewarded for using less at certain times of the day or week, but it is in packaging up a mutually advantageous proposition where uncertainty remains.

Three areas of potential engagement and flexibility are returned to here by way to re-emphasize the possibilities they hold. Firstly, for many businesses being available to customers and to colleagues is a high ranking priority that will not be compromised on but which actually requires little power. This may be a valuable part of a SME flexibility proposition that could give both parties a mutual benefits; connectivity for businesses and scope to be flexible on less valued but more power-hungry practices. Connected to this is an emerging theme in the data that boundaries between work and home often intersect and that this is becoming more pronounced as flexible working arrangements and the arrival of myriad portable internet enabled devices. This is a fluid phenomenon across all businesses and may contribute to changes in SMEs' ITC practices in ways that create new possibilities for flexibility.

Secondly, heating practices are among those most power hungry of practices and we found to some respects flexible, because electric heating is perceived as capable of being compromised without undue impact for short periods of time. This interplay between highly energy intensive practice with the scope for day to day trade-offs is a near perfect mix of already existing loads with flexibility (a low energy practice that is flexible still offers little network flexibility to the power system). This ought to be the focus of future research into SME energy flexibility.

Thirdly, in addressing the scope for flexibility amongst SMEs in smart grids a practice-led approach reveals some practices contain more scope for flexibility than others. In the cluster of practices that represent a business's electricity-related activities, heating practices come out as most likely to offer demand side flexibility.

Future active network management via smart grids is likely to involve a combination of 'things' such as material infrastructure, the introduction of new knowledge and competencies, and new ways of collaborating between different groupings of SMEs and those seeking to implement smart grids. New research areas signalled by the work discussed in this paper include the need to formulate research and policy together with commercial products that target specific business practices rather than specific businesses types.

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