Customer-Led Network Revolution

Key Social Science Findings:

Domestic and SME Customers

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1 Introduction

We have adopted a socio-technical approach to where we seek to take account of the ways in which electricity use and its flexibility are shaped by social and material factors. The approach developed through analysis we have conducted across the various test cells suggests that energy use is shaped by the interaction of five core elements:

- **Conventions**: A shared sense of what is considered to be normal energy use. Conventions are shaped through, for example, standards, cultural expectations, design of appliances.
- **Capacities**: the ability and potential for objects, artefacts, and techniques to use energy and provide energy services, constituted through their design, physicality, knowledge and know-how.
- **Rhythms**: the multiple rhythms operating at daily, weekly, monthly, annual scales through which activities are organised and patterned
- **Economies**: dispositions towards and management of social, natural and financial resources and investments
- **Structures**: enduring features of the socio-material world, e.g. structures of employment, school hours, building structures, layouts and materials, systems of energy provision, family structures, household life-stages, social class

The recurrent interaction of these elements leads to the reproduction and patterning of social practices, and shapes the ways in which people are able to adapt to the tariff.

1.1 Methodology

This report draws on qualitative and quantitative and quantitative social research conducted across the 5 test cells within the CLNR project summarised in Table 1.

Table 1 – Qualitative research summary

Total Number of Domestic Participants	**131**
Total Number of SME Participants	**57**
Total Number of Unique Participants	**186**
Total Number of Qualitative Research Interviews including follow ups	**250**
Total Number of Unique Domestic Survey Respondents included in analysis	**913**[1]
Total number of Unique SME Survey Respondents included in analysis	**152**

[1] There were 1,119 unique responses in total but only 913 of these were from respondents for whom electricity use data was also available. Our analysis focuses only on these respondents to make it comparable with future research involving the electricity use data.

2 Emerging trends in domestic electricity use

We used qualitative research methods in Test Cells 1, 3, 5, 9, 20 to identify emerging trends in how electricity is being used at home in relation to different practices.

Household structures: Our analysis reveals evidence of the impact of wider social trends relating to economic downturn, housing shortage, unemployment, changes in household composition and patterns of energy use. Social trends reported by the Office for National Statistics support the notion that family structures are becoming more complex; the fastest growing household type in the UK is the household containing two or more families while more than one in three marriages are now remarriages. Stepfamilies are the fastest growing family form in Britain accounting for one in ten of all families. Our evidence suggests that the extent of mobility within and between households shapes energy practices in ways that are difficult to capture because of their variety and sometimes temporary nature. This emerging situation indicates that **there are opportunities and challenges for the management of electricity systems and suppliers, particularly in overcoming notions of customers as households as internally uniform and unchanging.**

Economy: Increased sensitivity to the cost of energy has led 49% of participant households (n = 131) to change their use of energy. While there is no single new approach, domestic customers reported that **managing energy is now commonly understood to be part of managing the home economy**.

The emergence of new ways of working result in impacts on domestic energy use. For 59% of all households visited (n = 131) we found evidence that boundaries between home and work (both education and employment related) are becoming blurred, enabled by the widespread adoption of smartphones and flexible working arrangements. These changes have the effect of creating a need for electrical equipment at home including printers, monitors and desktop PCs as well as mobile devices. These changes also point to **opportunities for new routines to replace those conventionally associated with returning home from more structured working arrangements opening up potential to create a longer, shallower peak by reducing the synchronicity of home-comings.**.

Socio-technical capacities: For some 55% of participant households interviewed from all test cells (n = 131) the use of new entertainment and internet enabled devices is perceived to be of great importance. For many homes the **capacity** to establish and maintain connectivity is becoming a new essential feature of domestic life though to be at least as highly valued as other longer established and electricity enabled practices. **This suggests opportunities for demand flexibility, as mobile devices such as laptops, smartphones and tablets can continue to provide valued connectivity without a power connection for extended periods of time**.

We can identify patterns in technology ownership, visualised in Figure 1, which shows many homes own more than one of several appliance types, with the average home in our study having 1.84 televisions, 1.62 mobile chargers and 2.24 cold appliances (including refrigerators and freezers).

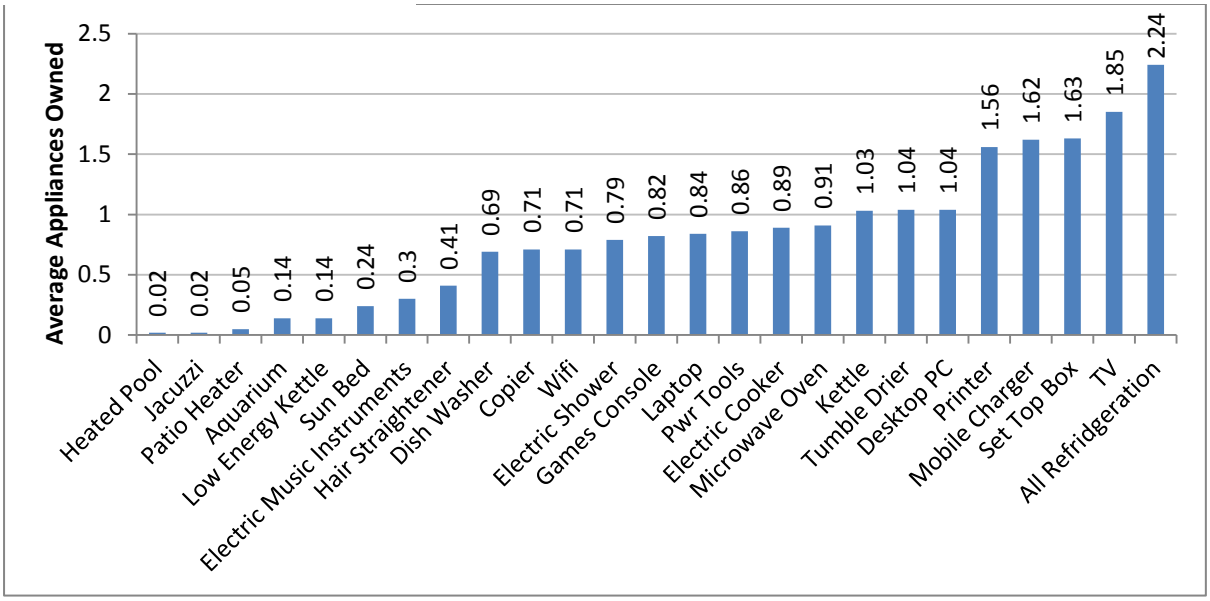

Figure 1 - Average appliance ownership per household

The pattern of ownership displayed here paints a picture of homes in which digital, internet connected devices are extremely commonly owned and where smart meters and in-home display devices (IHDs) are not out of place. Indeed, **smart meters and IHDs have been widely welcomed by the households included in the qualitative research (n = 131) and the survey (n =469[2])**. We found that no concerns about security or privacy were expressed by the participants. IHDs are a valued part of interventions for managing energy within the home. IHDs were positively received, easily understood and their **capacities** actively enrolled into managing the home, household **economy** and household life. Evidence of this can be found in the survey responses, where the vast majority of respondents found the IHD quite easy (249) or very easy (174) to understand, accounting for 90% of responses. In terms of their impacts on energy use, the evidence suggests that IHDs are felt to have led to either a small decrease in energy use, which clearly was the most common response (n=193) or no change in energy use which was the second most common response (n = 138). These two responses account for 70% of responses.

Making visible and some of the links between home energy use and the workings of energy systems is an area of considerable potential for positive interventions. Analysis of qualitative data from owners of new low carbon technologies such as solar panels, heat pumps, traffic-light in home displays and electric vehicles found that **the presence of low carbon technologies has significant potential to change how households think about energy provision and use and how they relate to power infrastructures.** Colour coding the IHDs to make the connection between the home and the wider grid was seen as particularly powerful.

[2] 469 survey respondents completed the section about IHDs

3 Evening domestic electricity demand

3.1 Variability and flexibility

Variability is the degree to which current demand for electricity in the peak evening period is fixed or varies over time for households. Our analysis shows that evening demand varies considerably for each household on a daily basis due to the **rhythms** of already existing **structures** such as work, school and TV schedules, meaning **that availability of flexible loads may differ from day to day even for the same households**.

Within the early evening peak period, dish washing, laundry and household chores were the least fixed of the practices studied amongst participants in the qualitative research (n=131). Depending on the task, these could be completed either within 24 hours or within the week. In particular, we found that laundry is an activity that some groups of respondents (most typically working families) felt could be shifted within a 24 hour time-frame, or even between days, in relation to **convenience**, weather and the weekly **rhythm** of working patterns. Dining was reported to be less flexible by participants in the qualitative study even though cooking was not as firmly fixed, as can be seen both in the responses to the survey of IHD users (Figure 1), and in the qualitative data:

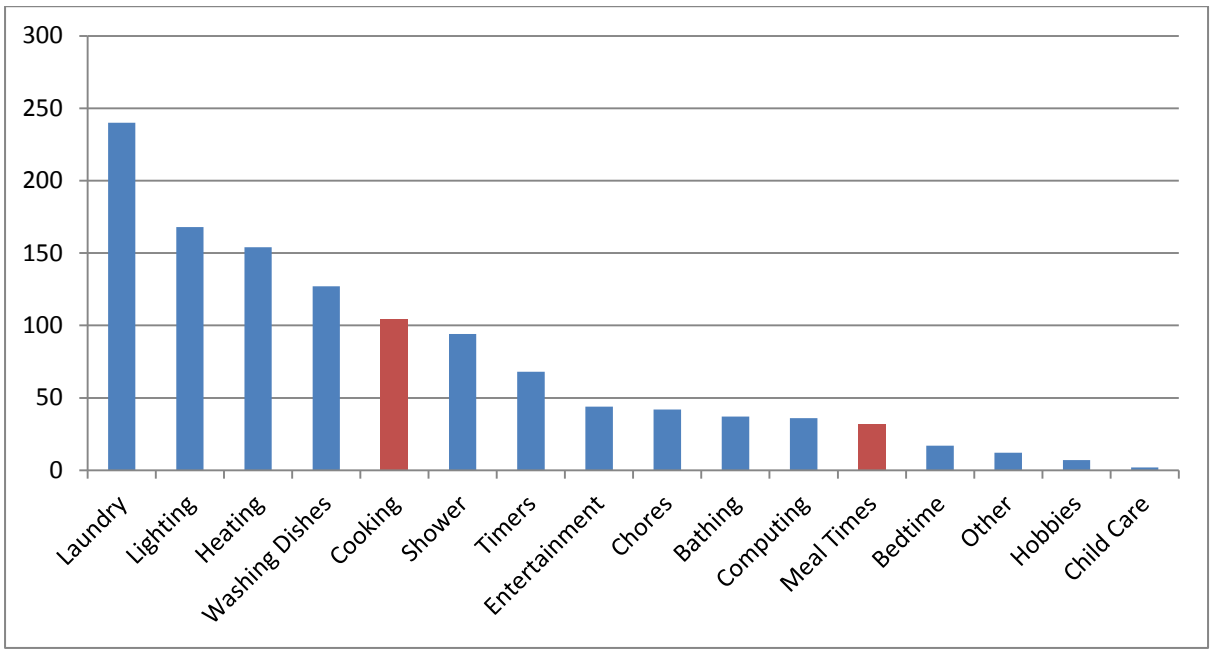

Figure 2 - Number of people who changed the time at which they do each activity as a result of interaction with the in-home display (people could choose more than one activity)

Quotations about fixed dining but flexible cooking:

> **"I'm very strict, I have breakfast at nine, dinner at twelve and tea at five o'clock."**

> *"As a family, we've always had our meals early evening, and if you go past 8 o'clock at night you're getting late."*
>
> *"I'm not using the oven near as much as before, I'm using the slow cooker more often – It's amazing really, little things like that. I didn't realise the micro took as much power, but there again it's better than the oven because it's a shorter period of time"*

Our analysis of social and technical data reveals that flexibility is a property of the CCRES factors outlined above (conventions, capacities, structures, economies and rhythms) which operate through social practices. **From this we suggest that targeting demand side interventions most optimally would benefit from targeting groups of shared social practices as an alternative to targeting groups of people. This is because groups of practices are more directly associated with flexibility and inflexibility than is the case for identifiable groups of people.** This would mean intervening to modify laundry, dishwashing and cooking practices across relevant networks as an alternative to identifying flexible groups of customers. We stress that such interventions should reward contributors of flexibility through a wide range of possible schemes.

The everyday household practices most directly relevant to demand side management are those which meet the following criteria:

- Practices with a likelihood of being performed during the 4pm – 8pm period
- Practices which include appliances owned by many households
- Practices which have a high electrical load.

On this basis, we find that **the household practices most relevant to domestic demand side interventions are household chores, cooking and dining, laundry and dish washing**. The rationale for this is presented in Table 2 which uses qualitative research to augment the CREST domestic energy use model[3] to identify practices and uses of energy which are most appropriate for demand side intervention.

[3] https://dspace.lboro.ac.uk/2134/5786

Energy Uses	Employed Electrical Appliances	4-8 Peak Likelihood[4]	Typical Electrical Load[5]	Electrical Load Band[6] Mean Duration (mins)	Proportion of Dwellings with Appliance	Ownership Band[7]	Summary	Rational for possible Demand Side Engagement
Use of Consumer Electricals	PC / Console	High	0.14 kW	Low 300 min	70.8%	High	H/L/H	Mass participation in peak
	TV	Very High	0.12 kW	Low 73 min	97.7%	Very High	VH/L/VH	
	TV Receiver box	Very High	0.03 kW	Very Low 73 min	93.4%	Very High	VH/VL/VH	
Cooking and Washing Up	Hob	Very High	2.40 kW	High16 min	46.3%	Middle	VH/H/M	Load intensity, mass participation in peak
	Oven	Very High	2.13 kW	High 27 min	61.6%	Middle	VH/H/M	
	Microwave	Very High	1.25 kW	High 30 min	85.9%	High	VH/H/H	
	Kettle	Very High	2.00 kW	High 3 min	97.5%	Very High	VH/H/VH	
	Dish washer	Middle	1.13 kW	High 60 min	33.5%	Low	M/H/L	
Laundry	Tumble dryer	Middle	2.50 kW	Very High 60 min	41.6%	Middle	M/VH/M	Load intensity, possibly in peak
	Washing machine	Middle	0.41 kW	Middle138 min	78.1%	High	M/M/H	
	Washer dryer	Middle	0.79 kW	Middle198 min	15.3%	Low	M/M	
Bathing	Electric shower	Low	9.00 kW	Very High 5 min	67%	Middle	L/VH/M	Split: Load intensity for electric showering and mass participation of child bathing
	Central Heating Pump	Middle	0.6kW	Middle	90%	Very High	M/M/VH	
Refrigeration	Chest freezer	High	0.19kW	Low	16%	Low	H/L/L	Mass ownership, reliable peak load
	Fridge freezer	High	0.19kW	Low	65%	Middle	H/L/M	
Ironing	Iron	Middle	1.00kW	High 30 min	90%	Very High	M/H/VH	Load intensity, possibly in peak
Vacuuming	Vacuum	Middle	2.00 kW	High 20 min	93.7%	Very High	M/H/VH	Load intensity, possibly in peak

Table 2 - Domestic energy uses with most potential for demand side flexibility

[4] Likelihood based on CLNR qualitative data analysis

[5] All figures (kW, kWh, minutes and % of dwellings are taken from CREST model of domestic electricity consumption other than Central Heating Pump. See http://homepages.lboro.ac.uk/~eliwr/

[6] Load Band Definition: Very Low = <0.99kW, Low = 0.1 – 0.2.99, Middle = 0.3 – 0.99kW, High = 1kw – 2.49kW Very High = >2.5kW

[7] Ownership Band Definition; Very Low = <10%, Low = 10 - 29%, Middle = 30 – 69%, High = 70 – 89%, Very High = >90% or more

4 Practices giving rise to energy use in SMEs

Our qualitative and quantitative research shows clearly that SME electricity demand is much more variable and more diverse than domestic electricity demand.

Key practices associated with electricity use across SMEs are: lighting, heating and cooling, refrigeration, and ITC. In addition, some business specific loads involve intermittent demand for high power, and these were found to be less fixed in time than lower power, day in day out processes and practices.

> ***"That's a plate maker, it makes printing plates, it probably does use quite a lot of electricity, but you don't have it on very long you just have it on when you need it."***
>
> ***"That's quite high power, talking about 6.5kW, and it's in use, on a good day about 20 mins a day in total. … This is whack bang, hits it with huge amounts of radiation then it's done."***
>
> ***"That's the large one, about 2.8kW, but it hasn't been used for … a week ago."***

These 'high power' processes were talked about as being completed at various times of the day and week and As not being strongly associated with set times. As such they may be flexible if successfully engaged by an intervention.

Connectedness is seen by SMEs as a vital service that energy use provides, with servers and mobile devices often reported as being among the most critical appliances to the businesses who took part it he research. **Ensuring connectivity between employees and data and between staff and customers should be recognised as critical to business. If ensured as part of an intervention this could open up other possibilities to interest customer-facing SMEs in demand side interventions**.

4.1 Variability and flexibility in SMEs electricity demand

Variability and flexibility in electricity use among SMEs is related to diurnal (e.g. opening hours), weekly (e.g. shift schedules) or seasonal patterns of activities in pursuit of business goals with periods of flexibility and inflexibility being distinct for each SME. Seasonal patterns were more multi-faceted than the seasonal variation in household consumption - with different SME having different levels of 'business' and intensity throughout the year.

For SMEs, the potential to provide valuable demand flexibility centres on the scheduling, and interruptibility of practices. While it is possible to differentiate between business processes which can be re-scheduled, it is also possible to differentiate between processes which are interruptible and those which cannot be stooped once underway. This creates a 2 dimensional framework (see Table 3) for identifying processes which could be engaged by demand side interventions in different ways. For example, some processes were described as being re-schedulable if they could be done at any time in the day or week without inconvenience but may not be interruptible once started (as doing so would waste materials or heat, for example). We conclude that interruptible practices can

respond at short or no notice to an intervention whereas re-schedulable ones can be moved in time in advance if a network intervention can be planned in advance.

	Interruptible processes	Uninterruptible processes
Re-Schedulable processes	*Can deliver flexibility through unplanned or planned interventions*	*Can deliver flexibility through planned interventions*
Fixed processes	*Can deliver flexibility in exceptional unplanned interventions but cannot be moved as part of planned or regular interventions.*	*Cannot deliver demand flexibility*

Table 3 – SME processes flexibility framework.

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