Customer-Led Network Revolution

Domestic Customers:

Energy Practices and Flexibility

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Introduction

The Customer-Led Network Revolution (CLNR) Project is the UK's biggest smart grid project and at the forefront of the move towards a low-carbon economy. The £54 million scheme is collaboration between academia and business led by Northern Powergrid, the electricity distribution network operator for the North East and Yorkshire. The project is part-funded by the Office of the Gas and Electricity Markets' (OFGEM) Low Carbon Networks Fund (LCNF). The other lead business partners in the project are British Gas and EA Technology. Durham University and Newcastle University provide an interdisciplinary team of researchers to bring academic rigour and insight to the project.

This paper provides a synopsis of the research findings produced by the social science team at Durham University in collaboration with the engineering research team at Durham and Newcastle Universities. The full findings of the research can be found in the Durham University Social Science Research Report released in April 2014 (CLNR-L052).[1]

The social science research conducted as part of CLNR has adopted a socio-technical approach to understanding the provision and use of energy services, in which energy systems are seen as constituted through the continual interaction of both social and technical entities and where demand for energy is produced through and essential to the workings of different practices in homes and businesses. We conceptualize energy use as shaped through the interaction of five different core elements, which together work to constitute energy-related social practices and the ways they are organised and distributed across spaces and time. These core elements we identify as follows:

- Conventions: constitution of what is considered to be normal energy use through, for example, standards, cultural expectations and design of appliances

[1] Full report available to download from the CLNR project website: http://www.networkrevolution.co.uk/wp-content/uploads/2014/05/CLNR-L052-Social-Science-Report-April-2014_2.pdf

- Capacities: the ability and potential for objects, artefacts, and techniques to use energy and provide energy services, constituted through their design, materiality, knowledge and craft
- Rhythms: the multiple temporalities operating daily, weekly, monthly, annually through which activities are organised and patterned
- Economies: disposition 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 and social class

Methodology

This paper draws on research conducted across the 5 test cells within the CLNR project for which data was available at the time of writing. Data available for analysis at the time of writing this paper are summarised in Table ES1.

Table ES1 – Consumption Data used in this Paper.

Test Cell	Description	Number of participants from whom data was available for analysis for this paper
1	Control Group	8649
3	Heat Pump Users	92
5	Solar PV	98
9	Time of Use Tariff	599
20a	PV used to automatically heat hot water	96
20m	PV users given an import / export IHD	101

In addition to the collection of consumption data through a range of monitoring and metering arrangements, Durham University's social science team recorded 250 face to face interviews as summarised in table ES2. Each of these interviews was conducted on the participants' premises and involved a semi-structured interview about electricity use and flexibility as well as a tour of the premises to record discussions of how different rooms and appliances were used as part of everyday life.

As well as this qualitative research the social science team designed and analysed the results of an online survey of domestic customers administered by British Gas. The data used in this paper come from the first survey of domestic participants to which there were 730 reliable responses.

Table ES2 – 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

Research Findings: Learning Outcome 1 (LO1)

Socio-Demographic Variation in Electricity Demand

Of all the socio-demographic attributes we have analysed to date, income has the strongest association with electricity demand with higher income households (combined household income of more than £30,000[2]) consuming on average 2.9 kWh per day in June and July and 4.7kWh per day in December more than lower income households (combined household income of less than £14,999). The proportion of electricity consumption concentrated in the evening period was also highest and most variable amongst high-income households and lowest and least varied amongst low-income households. Because of their overall contribution to demand in the peak period and the variability in their demand high-income households appear to be a key target group for future DSR.

For participants in Test Cells 1 where analysis of associations between demographic attributes and consumption has been possible, electricity demand has been found to differ by tenure, with owner-occupiers exhibiting, on average, higher demand than renters. Renters also consume a lower proportion of their total electricity use during the evening peak hours, whereas owners' tend to consume more during this period. Owners also exhibit greater variation in the proportion of total electricity consumption that happens during the evening period.

Households in rural off-gas areas have a substantially increased demand for electricity throughout the year compared to gas-connected households. As well as having the greatest average daily demand, rural off gas households who tend to use electricity for heating and hot water also consume a higher proportion of their total electricity in the evening period. The potential that new technologies will increase electricity demand in the early evening will need to be considered carefully if plans to shift away from gas to electricity as a source of energy for domestic heating move ahead.

Households with young children (under 5) or older people (over 65) have a lower than average daily electricity demand. Existing research suggests that such households tend to consumer more energy than average, so this finding points to important social differences in the use of gas and electricity by households. These households also consistently consume a lower proportion of their total electricity during the peak period of 4-8 pm.

Electricity Use and Everyday Practices in Households

The practices that are most associated with the bulk of electricity consumption in the home are cooking, heating and hot water, lighting, bathing, chores, entertainment, standby and 24 hour loads. The everyday household practices most directly relevant to demand side management are: those with a likelihood of being performed during the 4pm - 8pm period; those which include appliances owned by many households; and those which have a high electrical load. On this basis, we focus on: household chores, cooking and dining, laundry and dish washing.

The Impact of Smart Meters and In-Home Displays on Electricity Use

We found that the IHDs are a valued part of interventions for managing energy within the home. It was found that people used the IHD in at least three distinct ways: (a) to manage the household economy; (b) to provide oversight on what families are doing; and (c) to challenge themselves to save energy – each of these lead to the identification of energy saving potential.

[2] The customer sample was stratified by household income as follows: "Low" (up to £15k p.a.), "Med" (£15k-£30k p.a.) and "High" (above £30k p.a.). These are defined in the CLNR test cell design document, "CLNR-L107 CLNR Test Cell Protocol".

Participants reported thinking of smart meters and IHDs to be the 'same thing', or at least two parts of a whole. For the vast majority the IHD is the smart meter because it is the means through which they are provided with information, and it looks 'smart' because of its digital display, its real time information and the way it physically resembles other devices associated with domestic ICT (smart phones, portable consoles).

The Effects of Low Carbon Technologies on Electricity Use

Successful heat pump (HP) installation and their ongoing effective use was greatly affected by the previous history of heating systems that households had experienced and the way in which the transition was communicated and managed. Those moving from individual night storage systems were much more positive about the new systems than those who had lived with district heating systems. Evidence highlights both the positive potential of heat pumps to improve heat services while reducing bills as well as the potential risks to customer experience and well-being. Key benefits were found to be: (a) the quality of the heat provided and its use as a source of drying clothes as well as providing comfort; (b) reduced bills; and (c) the hot water service provided.

Our research found that solar photovoltaic (PV) ownership leads to more active ways of relating to energy, whereby individuals engage in the calculation of their own energy use and production, as well as in monitoring and managing their use to a greater extent than in other households. We find that the uptake and use of PV is being shaped by a new conventions focused on investment and the potential financial returns that PV can bring based on a logic of 'exporting' electricity to earn a return from the feed-in tariff. As a result, on-site use of power is not widely recognised as a way to maximise financial benefits for PV owners. This creates a considerable opportunity for network operators to engage with consumers to identify the potential and value of using PV power on site.

Social Trends and Electricity Use

Our findings evidence the impact of wider social trends relating to economic downturn, housing shortage, unemployment and the incidence of divorce on energy use and patterns of consumption. Increased sensitivity to the cost of energy has led 49% of participant households to change their use of energy. While there is no single new approach, we found that domestic customers judge that managing energy to keep costs down has become an increasingly significant feature of mainstream home energy use.

Most apparent are the effects relating to increase in the numbers of adult offspring returning to live in the parental home, while others are unable to leave. Common to all these households, is a tendency for tensions to cohere around how people use electricity. The difference between members' work patterns is a major variable that dictates the timings and extent of footfall within the home making it difficult for members to rationalize and harmonise their energy use. Even when maintaining separate households, family homes can remain open to adult sons, daughters and grandchildren to return regularly to receive hospitality sometimes often at short notice. These fluctuations in household composition and provisioning mean that it is difficult for people to create routines that are amenable to interventions such as time-of-use tariffs.

For 59% of all households visited we found evidence that time and space boundaries between home and work are also 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 shifts also suggest opportunities for new routines for electricity use associated with practices traditionally done when returning 'home' from 'work'.

Research Findings: Learning Outcome 2 (LO2)

Flexibility and Variability in Electricity Demand

Flexibility can be seen as a property of everyday practices and takes four forms: shifting the time at which a practice is done, its location, how it is done (e.g. heating food by gas or in the microwave), or by stopping the practice altogether. Our analysis focused on the flexibility of practices in the early evening period, reflecting the fact that the peak demand for electricity in the UK occurs between 4 and 8 pm.

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 households have diverse degrees of variability in different test cells. For households in Test Cell 1 (n = 8649), analysis of electricity consumption data shows that evening demand varies by 51% on average. This indicates that evening demand varies considerably for each household on a daily basis.

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. Cooking and dining were reported to be less flexible by participants in the qualitative study.

Interventions and Changing Practice

In Test Cell 20m (Manual) participants with PV panels were recruited and equipped with an IHD which indicated whether they were currently exporting or importing power. For many of the participants to whom we spoke (n = 10) investment logics are still invoked to describe and explain the ways in which practices have been modified to make more use of solar power. However, participants referred to the use of colour coding in the IHD display as being particularly powerful in reshaping practices such as dish washing, showering and laundry such that they are undertaken when power is being generated on-site.

Often changes to electricity use had been made as a result of the original PV installation, but the IHD is associated with undertaking further changes that participants are aware could be beneficial but which had not been fully realized before its introduction. For others the IHD identified new optimal alignments between PV power and their practices which they had not previously recognized. Overall, we find that the IHD is able to shift practices in ways that support the consumption of more electricity on site. Further analysis of the electricity consumption data is required to verify how widespread such shifts were across this test cell.

In Test Cell 20a (Automatic) participants with PV panels were recruited and equipped with a system that automatically heats a hot water tank using a 3kW heating element whenever the PV panels generate power that would otherwise be exported to the grid. Most of the 8 we visited households reported only modest changes to practices as a result of the automated hot water system intervention and not all participants in this group attributed changes to the intervention.

The small changes reported were mostly related to times when showers were taken. However, more participants are motivated to use the power for use of appliances to a greater extent than they are motivated to use it to fill the hot water tank. Further analysis of the electricity consumption data is required to verify how widespread such shifts were across this test cell and their implications for demand.

Conclusions

Households involved in the CLNR project have shown that they can be flexible in their electricity use. Participants who have trailed a time of use (ToU) tariff have shown sustained shift in their electricity use in the early evening peak period together with an overall reduction in electricity use. Participants with solar PV who were provided with an Import/Export meter also showed a shift in their electricity use, though this was smaller/larger than those with automated hot water storage.

We find that some households are able to be more flexible than others, particularly those with fewer or less rigid commitments to work and family and those with a higher degree of know-how about appliances are more able to be flexible about their energy use. This has important implications for how the electricity supply industry might seek to engage with households and communities in order to realise flexibility in energy demand and reduce peak loads. If new business models were to be developed to tap into this flexibility, care should be taken to consider the social impacts on those who are excluded from participating and benefiting from such schemes, particularly given our work suggests that a lack of flexibility is created through wider social 'structures' and household economies over which individual households may have little control.

The household practices that contribute most significantly to electricity use in the evening peak period are those which have the most load and which are most commonly undertaken at this time. From our research we suggest that the practices of most direct interest in terms of their potential ability to play a part in demand side management of the electricity distribution network are household chores, cooking and dining, laundry and dish washing. Electronic entertainment and cooking, although often undertaken in the evening peak period either have low electrical intensity (entertainment), or are perceived by respondents to be less flexible (both).

Our findings suggest that these shifts occur as a result of changes in everyday practices – particularly laundry, dish washing and chores, with a more limited shift in cooking and showering practices. These practices are shifted as households discover the 'capacities' of their appliances to work on timers and more economical cycles, change the 'rhythms' of their day in relation to their resource (e.g. PV produced by the sun) its cost (e.g. the TOU tariff), and their evening routines, and adopt new 'conventions' concerning how, when and by whom household work is undertaken.

Our analysis reveals evidence of the impact of wider social trends relating to economic downturn, housing shortage, unemployment and the incidence of divorce on energy use and patterns of consumption. 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. Households are thus often in flux; their composition amalgamating and re-amalgamating according to the comings and goings of members. 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 and that this emerging situation presents opportunities and challenges for the management of electricity systems.

We find the presence of low carbon technologies also has significant potential to change energy practices, with smart meters, IHDs, and solar panels in particular having a strong influence on how households think about and manage their electricity use. Taken together, we conclude that interventions such as heat pumps, IHDs and Solar PV represent very different facets of a transition to electrification of low carbon energy services. While IHDs were almost universally welcomed and were often integrated into domestic life, heat pumps were found to be more challenging for end users and their successful domestication was more sensitive to context. Participants' and installers' lack of 'know how' with regard to optimal heat pump configuration and use also resonates with householders' lack of understanding about the workings of PV panels and the possibilities for on-site use of power in a Feed in Tariff (FiT) investment package.

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