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People and Energy: A design-led approach to understanding everyday energy use behaviour

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Reducing home energy use is a major societal challenge, involving behaviour change alongside infrastructure improvements. However, many approaches lump 'energy demand' together as something homogeneous, addressable primarily through quantitative feedback, rather than basing interventions on an understanding of why *people use energy as they do. Our contention is that people don't set out to 'use energy': its use is a side effect of solving everyday problems, meeting needs for comfort, light, cooking, cleaning, entertainment, and so on.*
Design researchers at the Royal College of Art have been carrying out ethnographic research with a diverse range of householders, investigating nuances of daily interactions with heating and lighting, meters and appliances—alongside people's understanding of energy and how their actions affect its use. Insights, integrated with household monitoring data, will inform the co-design of prototype products and services to help people reduce their energy use while meeting needs.

> "...those of us who call ourselves energy analysts have made a mistake... we have analysed energy. We should have analysed human behaviour."
> Lee Schipper, Precourt Energy Efficiency Center, Stanford, quoted in Cherfas (1991).

WHAT WE TALK ABOUT WHEN WE TALK ABOUT ENERGY USE

While Schipper's quote (frequently cited in work on reducing energy use) is refreshing in its call for analysis of human behaviour, there is a good argument that the concept of 'behaviour'—at least as commonly expressed in the current 'behaviour change' discourse—is itself still too far abstracted from *really* understanding energy use (Wilhite et al, 2003).

Programmes framed as being about behaviour change, such as the UK government's mandated smart meter rollout (Department of Energy & Climate Change, 2013) make many assumptions about the homogeneity of energy-related behaviour, particularly around householder responses to feedback on pricing changes for electricity and gas. Even the more psychologically informed approach of the Behavioural Insights Team's work on energy (Cabinet Office, 2011) nevertheless focuses mainly on applying behavioural economics effects to frame costs and social norms differently, rather than attempting to address the intricacies of energy-related decision-making in everyday life.

Contextual insights

This work has its place, but largely fails to benefit from the contextual insights that an ethnographic approach can bring. What are people *doing* when they are 'using energy'? They are rarely, if ever, setting out with that intent. 'Demand' is not 'people demanding energy': it is a side effect of people, in all their diversity, meeting family and household needs, solving everyday problems, and enacting social practices (Shove, 2003), often with emotional contexts attached. It is people trying to make their homes comfortable in different ways, having a cup of tea with a friend, cooking meals for their family, putting the light on to read a book, leaving the light on because the switch is difficult to reach, running a bath to relax after a difficult day, turning up grandma's heating because they worry about her, and even people putting the radio on to keep their pets company. Much of this is eminently discoverable through ethnography, and all of it has consequences for energy use.

People use energy differently—the UK's highest 10% of gas users use four times as much as the lowest 10%—yet purely quantitative modelling based on income and property characteristics explains less than 40% of the variation (Department of Energy & Climate Change, 2012). Understanding people's daily routines with energy-using products and services potentially offers answers to both understanding variation and helping to address it in ways which are appropriate to different needs (Fell & King, 2012).

Design details

Many approaches to this area also understate the importance of the *details* of the designed systems which people use in everyday life. For example, as Froehlich et al (2010) note in a review of research on 'eco-feedback' systems, even in environmental psychology research specifically focused on trialling energy feedback interfaces, few authors make any reference to research in interaction design. Only half of the psychology papers in their sample even included an image of the feedback device or interface, despite it being the primary way in which participants would be receiving the information on which the trials were predicated.

Figure 1 shows a common model of household electricity monitor real-time display in use in the UK, often provided by a householder's electricity supplier—a monochrome LCD showing numerical data about power, cumulative energy use, and other information.

FIGURE 1. ***An example of an OWL electricity real-time display in use by two of our participants, Jerry and Amy. The device shows real-time and cumulative electricity use (in kW and kWh), time, air temperature and can also show costs and carbon footprint in kg CO_2 equivalent.***

It is not simply visual or aesthetic design details that are important. The design of products and services influences how they are used. For example, with heating controls, Combe et al (2010) found that 66% of occupants of an award-winning 'low energy' housing development could not programme their heating controls due to interface complexities, including both physical and cognitive issues.

Aside from social and environmental benefits, there are commercial design opportunities arising from better understanding people's interactions with energy-using systems, and developing new products and services taking account of these insights. Some early market entrants (e.g. the Nest thermostat) are already focusing on a design- and user experience-led approach, and sound research can help define and grow the market. We believe that a design-led ethnographic investigation of everyday energy use, paying attention to details of interaction with systems such as heating and lighting, meters and household appliances, will provide insights which are of direct use in the design and development of new products and services to help people reduce their energy use while still meeting everyday needs.

Understanding understanding

Another significant area which ethnographic research (with an eye on design) can explore is people's *understanding* of the systems and concepts which they encounter and interact with in relation to energy—particularly where that understanding may relate to the actual ways in which systems are used. *Units* are a major area of potential confusion; according to a 2010 OnePoll survey of 2,000 people in the UK:

> "1 in 5 people don't know what kWh (kilowatt hour) stands for—some thought it was a make of Japanese car, a type of heavy goods vehicle or even a boy band." (E.ON, undated)

Van Dam et al (2010) also make similar observations about householders' understanding of the use of m^3 (cubic metres) for gas, while Kidd & Williams (2008) include a variety of quotes from participants in an energy display study about their understandings of units. While an understanding of units may not necessarily be vital for reducing one's energy use, design choices of how quantities are represented on interfaces and displays need to be made in a way that is informed by public understanding, particularly if the assumption is that people will behave differently as a result of such quantitative feedback.

Research on *mental models* of concepts such as electricity (Gentner & Gentner, 1983) and heating systems (Revell & Stanton, 2013) also reveals a rich seam of different kinds of understanding and interaction, at least some of which (e.g. Kempton, 1986) can be directly connected to household energy use. There is clearly an opportunity for energy-related interface design which seeks either to *match* existing mental models—designing systems that work like people *think* they work—or helping to *shift* them (Burns & Hajdukiewicz, 2004), for example via a series of analogies bridging two models (Clement, 1991), or by increasing the repertoire of different kinds of models people have available to them in other ways (Papert, 1980). Understanding of systems could be revealed more concretely through qualitative investigation of the self-imposed 'rules' or *heuristics* which people may use when interacting with systems (e.g. Lockton et al, 2013)—especially useful where there are obvious links to relevant design techniques.

More abstractly than mental models, there is an ethnographic opportunity to investigate aspects of mental imagery and conceptualisation of energy, including the use of metaphors (Lakoff & Johnson, 1980) and symbolism. Again, this is particularly relevant where it might link to design implications, e.g. making use of different kinds of (non-numerical) imagery to represent energy on a display.

THE PROJECT CONTEXT: SUSLABNWE

At the Royal College of Art, the Helen Hamlyn Centre for Design and SustainRCA are partners in SusLabNWE (2012-15), an INTERREG-funded European collaboration between research organisations in the Netherlands, Sweden, Germany and UK. The overall theme of the project is reducing domestic energy use through behaviour change, via developing and

testing new products, services and interfaces—a theme which covers quite a broad scope of work and expertise, including environmental scientists, civil engineers and architects alongside design researchers.

The project benefits from 'Living Lab' instrumented houses in each country, which will provide a platform (albeit artificial) for demonstrating and trialling the interventions developed, before they are deployed in people's homes across north-west Europe for larger field trials. In London, our Lab will be a modern three-storey townhouse being built by the Institute for Sustainability in the London Sustainable Industries Park, in Dagenham, Essex, with monitoring equipment installed by partners at Imperial College London.

Integrating qualitative and quantitative research

One goal of the project potentially of particular interest to the ethnographic community is an attempt to integrate qualitative and quantitative research usefully. Energy use is an area where there is a lot of 'Big Data' being collected around resource use, temperatures, household occupancy—even down to the level of sensors on windows and doors, potentially affording something like Anderson et al's (2009) *ethno-mining*—but much less which takes account of context and meaning, the 'Thick Data' called for by Wang (2013). We know *what* energy is being used, but we don't necessarily know *why,* on a human level.

Some qualitative ethnographic work has focused on particular aspects of energy use, e.g. battery charging practices (van Dijk, 2010), but ideally, qualitative and quantitative insights need to be integrated, exploiting opportunities afforded by energy monitoring and sensors to link the data with insights from ethnography. The final section of this paper returns to these questions.

A qualitative methods toolkit for energy use research

Central to the project is the development of people-centred research methods that can provide insights to other partners about the contexts of energy use, and be adapted and adopted in other sustainability-related research where qualitative methods have historically played less of a role. The RCA has led, with contributions from researchers in Sweden, the Netherlands and Germany, on the development of a common methods toolkit (Greene et al, 2013)—including observational and self-reporting techniques, and product and service prototyping. This has been disseminated to all project partners to inform their research, and a revised version will be published publicly later in the project.

ENERGY & EVERYDAY LIFE: INTERVIEWS

In the first phase of our research in London, we have been carrying out home visits and interviews with householders (Figure 2), followed by a probe/logbook study. Following established research methodologies, developed in the context of inclusive design (Helen Hamlyn Centre for Design, 2010), in this work we are focusing on lead users in one form or another—people who have particular needs around, or interest in, energy use at home, and who are indeed often self-described 'edge cases'.

In our initial group of nine participating households (Table 1), of a range of ages, backgrounds and family situations, we have: social housing tenants on limited incomes, some already part of existing programmes aimed at saving energy (via home energy displays and online monitoring), and some who have taken it upon themselves to cut their energy use without using any kind of display; people with medical needs which mean they use higher than average amounts of gas for heating; people with environmental motivations and people much more focused on cost; and people from the Internet of Things and Quantified Self communities, who have set up their own home energy monitoring systems for their own interest, and have incorporated using the systems into their everyday routines.

TABLE 1. ***Some basic details of our nine participating households.***

Name	Location	Housing type	Energy monitoring	'Lead user' notes
James	Poplar, East London	Social housing, housing assoc'n, urban	Participant in housing assoc'n monitoring scheme	Retired, married
Edith	Bethnal Green, East London	Social housing, housing assoc'n, urban	Uses electricity monitor provided in council scheme	Retired, lives alone
Fiona	Bow, East London	Social housing, housing assoc'n, urban	Participant in housing assoc'n monitoring scheme	Member of local community ecology groups
Debbie	King's Cross, North London	Social housing, council-owned, urban	Not monitored	Uses wheelchair; uses heating to alleviate pain from medical condition
Ron	King's Cross, North London	Social housing, council-owned, urban	Not monitored	On very low income; aiming for self-sufficiency
Alice	Cambridgeshire, eastern England	Owner-occupied, rural	Uses own energy monitors	Interested in technical challenges of monitoring
Jerry & Amy	Brixton, South London	Privately rented, urban	Uses own energy monitors	Interested in reducing their energy use for financial reasons
Jonathan	Peckham, South London	Owner-occupied, urban	Uses own energy monitors	Monitors appliance use as part of own research project
Tamanna	Poplar, East London	Social housing, housing assoc'n, urban	Participant in housing assoc'n smart home scheme	Interested in reducing family energy use for religious reasons

FIGURE 2. ***Dan and Flora interview Debbie, who uses heating all year round to alleviate her pain from a medical condition. Photo: Karolina Raczynska.***

Some of our 'early adopter' lead users could be in the vanguard of coming trends around technology use at home, but equally, trends also represented in the group—such as ageing populations and more people living alone—will have other effects on energy use.

The idea is that through learning from these interested users—understanding their routines, their motivations, their interactions with technology (and in most cases having quantitative data about their actual energy use to integrate with the qualitative insights) we can identify design opportunities for interventions that take account of the real contexts of everyday energy use.

The interviews

In initial interviews lasting around 90 minutes each, we visited participants at home and asked them a range of questions about everyday routines, use of appliances, the strategies used for managing and paying for energy (electricity and gas for all participants), and how people understand energy. The home environment enabled participants to show us things—appliances, routines—*in situ*.

To understand everyday routines better, we asked participants to take us through a 'typical' day—or to talk about the differences between days—via filling in a timeline (Figure 3) which afforded us the opportunity to ask in more detail about particular aspects or details.

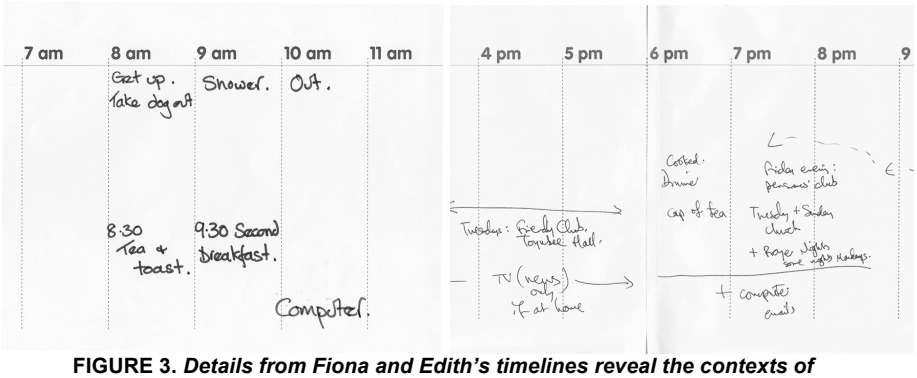

FIGURE 3. ***Details from Fiona and Edith's timelines reveal the contexts of energy use, e.g. Edith leaves her TV on, on a news channel, almost all the time when she is at home on her own, "to feel connected to the world".***

FIGURE 4. ***The kind of energy and temperature timeline data available for some of our participants who are part of existing monitoring schemes, via a tablet or online interface.***

Where participants are already using some form of energy monitor, or are part of monitoring schemes (e.g. Figure 4) we asked more about this—in particular asking them to show us how they use it, where it fits into their lives, whether they believe it has made a

difference to their behaviour, why they got it in the first place, and what they would change about it. We also introduced a series of 'provocations'—flashcards with possible new products or interfaces for visualising energy use in different ways, or for enabling householders to access energy, or exert more control over their energy use (Figure 5).

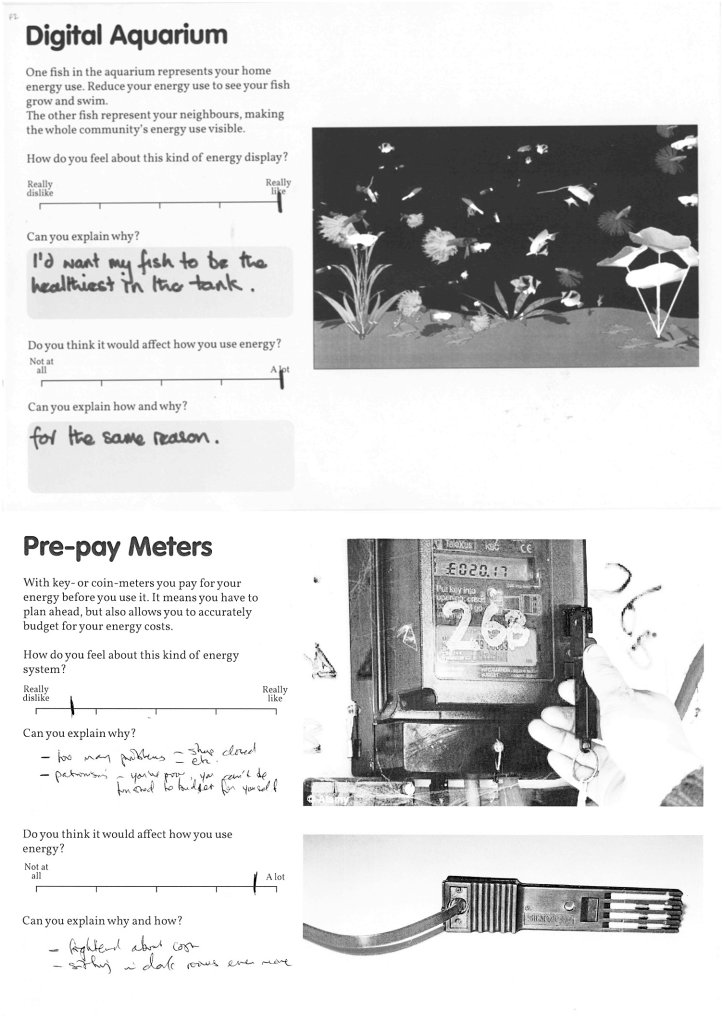

FIGURE 5. ***Examples of provocation flashcards. Fiona likes the social 'digital aquarium' energy display (inspired by a prototype by our project partners at TU Delft). Ron dislikes pre-pay meters because they are inconvenient and "patronising", but nevertheless believes they would affect his energy use by making him "frightened about the cost".***

The idea was to get participants' reactions as to both whether they 'liked' the products (and why), and whether they believed that they would change the way they used energy if they were introduced (and why). These also served as a starting point for discussions around behaviour change, and what participants believed would 'work' for them, and for other people.

Next stages: probes and co-creation

Each householder was subsequently given and introduced to a 'logbook', together with a disposable camera, as part of probe studies (Gaver et al 1999), which are ongoing at the time of writing. The logbook activities build on the interviews, exploring aspects of everyday routines, social influence on energy use and householders' understanding and mental imagery around energy in more depth. The probe studies are being followed up with second, 'debrief' home visits and interviews, enabling further exploration and elaboration.

Participants will then be invited to take part in a co-creation 'hackday' this autumn, bringing them together with the energy monitoring and 'maker' community of designers, developers and researchers. The hackday, and follow-up development, will translate insights from our ethnographic work into co-created prototype interventions (which could be new products, services or interfaces, designed to help people reduce their energy use), which will be trialled in the Living Lab house in Dagenham, as well as in participants' homes themselves during 2014.

Selected insights so far

What we've learned so far has already given us much deeper insights into phenomena such as the everyday strategies people have around energy use, how they categorise and separate activities, self-imposed rules, payment schedules, household 'policies', unexpected use-cases for energy displays, and some intriguing conceptions of 'what energy looks like', which are being followed up via the logbooks.

In particular, insights have emerged in the following areas, some of which start to suggest a range of ways of framing 'energy use' problems from a design perspective:

Payment strategies – In Great Britain[1] prepayment key and card meters for electricity and gas are often associated with customers who have run up large debts in paying for their energy use, forced into having one by their supplier (Lunn, 2013). The majority require 'topping up' at a participating shop, which reduce their convenience. Given the estimated 3-4 million UK households in fuel poverty (Hills, 2012), the issue is politically sensitive.

However, both Fiona and Edith had *voluntarily* chosen to have prepay gas meters installed, to manage their payments according to their own strategies. In Edith's case, a dispute with her previous gas supplier led her to switch to a system over which she had full control: paying, in advance, to put money on her gas card, and then only being able to spend

[1] The situation in Northern Ireland is different, with some energy companies offering customers a discount for using a prepayment meter.

that. Fiona told us that she in fact usually overpays, paying an *equal amount* each month to top up her gas key, 'storing up' credit to ensure that even in the coldest winter her gas never runs out. If the winter is less severe, then she might have a 'bonus' month where she doesn't need to pay. It's worth noting that Fiona has an Android tablet with a near-real-time display for gas and electricity use, but this does not enter into her gas management strategy at all.

These insights call into question the presumptions that *all* householders will pay attention to pricing information on real-time displays and 'adjust their demand' in response to feedback: there is possibly even potential for a service based around a fixed fee for energy.

Different use-cases for displays – Where participants had energy displays, they were making use of them in quite different ways. Jerry and Amy described using theirs as part of a kind of 'detective' process of going round the house, trying to achieve as low an electricity use as possible. It sat in a prominent shelf in their kitchen. Alice has hers sitting on the arm of her living-room sofa. Debbie, who had an electricity display which had been disconnected by workmen, had previously used it primarily to "tell off" carers and neighbourhood children who visited and left the lights on—not for monitoring *her own* electricity use, but other people's. Fiona admitted to using the tablet provided for her energy display mainly to play 'Angry Birds', and could not actually show us the energy graphs.

Edith's display (Figure 6) was set to the 'kg CO_2 equivalent' mode, showing her estimated daily carbon footprint from electricity use. She explained that she did not know what the numbers meant (and rejected our offer to show her other modes such as cost or power), but that she was happy with this mode since she could see the numbers going up when electrical devices were switched on, and knew that a higher number meant she had used more electricity that day. She used it together with a 'Watts Clever' remote control enabling her to switch off multiple devices at once. For Edith, the carbon footprint display had no particular environmental connotations, but was simply a number she found useful.

The different use cases concur with van Dam et al's (2010) observations about householders' different uses of home energy management systems, including the example of consulting the display last thing at night to check that (most) appliances are switched off before going to bed. They suggest that a 'one size fits all' design of display is not necessarily suitable. Interfaces need to reflect and accommodate the range of ways in which people appropriate them and fit them into their lives.

Disconnecting things – Both James and Jerry and Amy described having disconnected devices permanently or semi-permanently as a result of realising how much energy they used or would use. In Jerry and Amy's case, they disconnected half of the halogen spotlights in the kitchen of their (rented) flat, to reduce electricity use. James removed a number of radiators from a workshop unit he rents, upon taking over the unit, since he felt they were wasteful and provided more heat than he needed.

FIGURE 6. ***Edith uses her OWL electricity display in the 'kg CO_2 equivalent' mode, showing her estimated daily carbon footprint from electricity use.***

Heating interaction – Fiona described her self-imposed rules around using her heating—switching it ON in October and OFF in April, unless it is particularly warm or cold. She does not interact with the radiator valves or thermostat themselves, preferring to use a single switch on the boiler itself to control everything in one go. Other householders described 'zoning' their houses, controlling individual radiators separately. Jonathan and his wife use a portable wireless thermostat, taken into whatever room their 2-year old daughter is in, to make sure that the house is adequately heated for her. Tamanna and her family use their PassivLiving Smart Switch both via the interface and through a mobile app, telling it that they're IN or (going) OUT, so that the system switches the heating or hot water on or off.

Debbie uses heat to reduce pain from a medical condition. She has all radiators in her house switched on all year round; her gas use is included in her rent for a fixed fee regardless of usage. If it is very cold in winter, she turns on her gas oven and opens the door to warm her open-plan living area, using a deflector she has made to prevent her cats climbing into the oven.

These differing forms of interaction reflect the 'typology of home heating behaviours' suggested as worth exploring by Fell & King (2012). Each has particular design implications.

REFLECTIONS FOR ETHNOGRAPHY

This paper has discussed work in progress—the early stages of a larger project, in which a number of disciplines are participating, across countries and organisations. Ethnographic insights are here part of a process involving designers, technologists and environmental scientists among others, rather than the main focus, but crucially, the insights will, as far as possible, be woven throughout. Even at later stages when new products and services have

been developed, the aim is to repeat the research with householders using the new systems, to ensure that the quantitative energy data collected are usefully integrated with qualitative insights—Wang's (2013) Thick Data, as well as Big Data (Slobin and Cherkasky, 2010). There could be obvious synergy in the use of a form of *timescape* (Ladner, 2012)—combining a household's daily electricity and gas use and temperature graphs (often automatically generated by monitoring equipment) with householders' own take on the day, explanations of routines, emotional values attached to particular activities, and the effects of other members of the household or visitors on the actions taken. This form of timescape—explanatory but also potentially predictive—is something we aim to develop. As Ladner puts it (emphases added), we can:

> "[a]llow Big Data to collect information on the **whens** and **how longs** of time, timing and tempo, while ethnographers collect data on the **hows** and **whys** of time, timing and tempo." (Ladner, 2012)

Expanding collaborative boundaries: understanding each other

More generally—and this is not uncommon among qualitative researchers—we also sense the need to demonstrate the value of ethnographic research to project partners focused on quantitative approaches. This challenge means that *internal*, as well as external, presentation becomes increasingly important—ensuring that we present our data in a way which enables other project partners to see how the insights fit into their own parallel streams of work. For example, in a recent international partner meeting we attempted to 'bring some of our householders to life' by using edited video of interviews to introduce specific insights (around thermal comfort) to the full group of technologists and environmental scientists, then setting a quick exercise to devise possible interventions to test *with those particular people*. The aim was partly to engender empathy, but also to demonstrate practically the ways in which qualitative insights could usefully inform quantitative studies.

Expanding collaborative boundaries means making the worth of ongoing people-centred research clear when working *in conjunction* with practitioners with other priorities, rather than being seen as a stand-alone piece. Collaboration means understanding other: indeed, we perhaps need an ethnographic approach to understanding our project partners' priorities, and how we can best work together. We should, at least, be well placed to do that.

NOTES

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