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Abstract: Policies to reduce the carbon intensity of domestic living place considerable emphasis on the diffusion of low(er) carbon technologies - from microgeneration to an array of feedback and monitoring devices. These efforts presume that low carbon technologies (LCTs) will be accepted and integrated into domestic routines in the ways intended by their designers. This study contributes to an emerging qualitative energy research (QER) literature by deploying an analytical approach that explores comparison of data from two UK projects ('Carbon, Comfort and Control' and 'Conditioning Demand') concerned, in broad terms, with householder interactions with LCTs - primarily associated with the production and maintenance of thermal comfort. In-depth, and in many cases repeat, interviews were conducted in a total of 18 households where devices such as heat pumps and thermal feedback lamps had recently been installed. We discuss this comparative process and how a reflexive reading of notions of (and strategies associated with) credibility, transferability, dependability and confirmablity enabled new ways of working and thinking with existing data. We conclude by highlighting the contrasts, conflicts, but also creativities raised by drawing these connections, and consider implications for methodologies associated with qualitative energy research.

***Response to Reviewers**

FAO Editors, Energy Policy,

Our thanks, once again, to both reviewers for their continued support of this paper, and for their constructive comments. We have made a number of revisions in response, as detailed below:

Ref 1:

Research highlights: these have been amended to better reflect the academic and policy implications of the paper

Sample selection details have now been added (footnote 6)

We have elaborated in 4.1 and 4.2. the distinct theoretical and empirical expectations associated with the two research projects.

4.2.: We have added the missing quote from Rose and Scott

The minor typographical errors have been corrected.

Ref 2:

We have clarified use of acronyms (QER, LCTs)

Ref 2 raises the issue of the consistency in which the principles of rigour identified in Table 1 are applied in section 4 (and 5). We have sharpened our references to these principles in both sections. With respect to dependability we have, in sections 4.1 and 4.2, more explicitly recognised the links to existing QER work. However, our aim in 4.3. is to illustrate the power of such comparative work in enabling researchers to think beyond existing theoretical commitments. In our case, the focus on bodily engagements emerged very much from the reanalysis itself. Of course we do, in section 5, make clear some points of connection with existing QER work which support the dependability of our conclusions.

Sincerely

Karen Bickerstaff

Highlights

- We develop a robust strategy for comparing data from Qualitative Energy Research (QER)
- We apply principles of qualitative rigour to a reanalysis of two QER datasets
- We demonstrate how this approach can strengthen extant analyses as well as reveal new interpretive insights
- We highlight the academic and policy significance of developing comparative approaches to QER.

Living with low carbon technologies: an agenda for sharing and comparing qualitative energy research

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Living with low carbon technologies: an agenda for sharing and comparing qualitative energy research

Abstract: Policies to reduce the carbon intensity of domestic living place considerable emphasis on the diffusion of low(er) carbon technologies - from microgeneration to an array of feedback and monitoring devices. These efforts presume that low carbon technologies (LCTs) will be accepted and integrated into domestic routines in the ways intended by their designers. This study contributes to an emerging qualitative energy research (QER) literature by deploying an analytical approach that explores comparison of data from two UK projects ('Carbon, Comfort and Control' and 'Conditioning Demand') concerned, in broad terms, with householder-LCTs interactions – primarily associated with the production and maintenance of thermal comfort. In-depth, and in many cases repeat, interviews were conducted in a total of 18 households where devices such as heat pumps and thermal feedback lamps had recently been installed. We discuss this comparative process and how a reflexive reading of notions of (and strategies associated with) credibility, transferability, dependability and confirmablity enabled new ways of working and thinking with existing data. We conclude by highlighting the contrasts, conflicts, but also creativities raised by drawing these connections, and consider implications for methodologies associated with qualitative energy research.

Keywords: Qualitative energy research, comparative analysis, rigour, peer-review, sensing energies.

1. Introduction: the qualitative paradigm in energy research

This paper seeks to contribute to an emerging body of qualitative energy research (QER) by specifically addressing the methodological issue of comparing research across (often) small scale and idiosyncratic studies in ways that move beyond the confirmation of findings.

The application of qualitative methods in energy research reflects a growing interest in understanding and accessing narratives associated with people's everyday use of energy and the complex

evolution of (energy-related) social practices (e.g. Butler et al., 2014), as well as a recognition that people are not passive recipients of energy (services) but play an active role (alongside buildings, devices, infrastructures, policies etc) in conditioning demand and their thermal environments (Nicol, 2011; cf. Brager and de Dear, 1998; Cole et al., 2008; Leaman and Bordass, 2007). Domestic (energy consuming) practices are read not as a matter of individual choice, nor technologically determined, but relationally constructed though engagement with broader socio-technical systems. In this vein, many recent studies have provided detailed accounts of the ways in which people use energy in order to meet particular needs, notably for thermal comfort, lighting, food, cleaning and entertainment (e.g. Shove, 2003; Pink, 2005; Spinney et al, 2012; Gram-Hanssen, 2010, 2011; Hitchings and Day, 2011; Hobson, 2006; Strengers, 2010; Strengers and Maller, 2011). All display a concern with capturing the richness of context-dependent sites and situations, drawing on relatively small (and often varied) cohorts, but with the use of intensive, in-depth interactions with participants – often deploying a range of methods (interviews, logs and diaries, video or audio tours, workshops and so on).

This qualitative engagement with everyday routines, meanings and contexts has undoubtedly invigorated social science contributions to energy research. However, there are questions that remain to be fully explored about the transparency of research designs and how sharing and comparing data and concepts from multiple projects might be meaningfully achieved and how such endeavours might enliven and extend the sorts of accounts being produced. Some have cautioned against analyses that transfer findings beyond the social, geographical and historical contexts in which they were generated (e.g. Hargreaves, 2012). However, we suggest there are strong empirical and theoretical grounds for developing rigorous comparisons that scrutinise dimensions of analytic continuity (and discontinuity) whilst retaining the depth and idiosyncrasy that makes case studies particular.

To explore these issues more fully we discuss the rationale for, and findings of, two UK QER projects - Carbon, Comfort and Control (CCC) and Conditioning Demand (CD). Although differing on many facets of project rationale, methodology and conceptual focus, both studies held an interest in householder engagements with low carbon devices following installation – specifically (though not exclusively) technologies concerned with heat generation and thermal comfort feedback. Reducing the carbon intensity of heating represents a particularly pressing policy challenge, since space and water heating account for about a quarter of UK energy consumption (LCICG, 2012). There are numerous technological options that have been developed to supply and manage heat demand, and our research is by no means comprehensive in this regard.

As part of the comparative strategy, we reviewed a sample of transcripts from across the two projects (9 post-installation interviews from CCC, and 3 longitudinal sets of [3] interviews for the CD project). Interviews involved people with often highly contrasting household structures, dwelling type and tenure, as well as relations to Low Carbon Technologies i.e. whether householders had an active (elected to have LCTs fitted) or passive (had no say, e.g. in the context of tenants) role in their installation. To aid the process of sharing and comparing data we explore and reflect upon debate, particularly in social geography (Baxter and Eyles, 1997; Bailey et al, 1999; Valentine, 2006), around rigour in qualitative research. From this we consider how sharing and comparing data might extend the scope and reach of qualitative energy research.

2. Exploring rigour in qualitative (energy) research: criteria and reflections

Qualitative research stands accused of being of little relevance or interest to policymakers because it involves small-scale case-study work (Valentine, 2006; 413). Such claims can be, and have been, challenged, recognizing how small-n (small number) research, in capturing the complexity of everyday life (DeLyser et al, 2010, 6; Shove, 2010), can offer vital accounts of meaning, perception, values, intentions, motivations and so on, as well as giving voice to those previously silenced (Fuller and Kitchin, 2004; DeLyser et al, 2010). Other prominent qualitative social scientists have argued in favour of adding quantitative measures to qualitative research projects, or using more rigorous sampling procedures, as a means of increasing confidence in the validity of results (Miles and Huberman, 1994; Silverman, 2011). In this paper, our intention is not to rehearse debate over the validity of small-n energy research but rather to suggest that issues surrounding rigour and comparing small-n data warrant fuller consideration, particularly in the context of increasing interest in and imperatives for research impact.

Influential work by Lincoln and Guba (1985) proposed a framework for ensuring the rigour of qualitative research, centering on four criteria. *Credibility*, that is demonstrating a true picture of the phenomenon under scrutiny; *transferability*, establishing sufficient detail of the context of the fieldwork for a reader to be able to decide whether the findings can justifiably be applied to the other setting; *dependability* seeks to ensure the study can be repeated, and *confirmability* requires researchers to take steps to demonstrate that findings emerge from the data and not their own predispositions. For each criterion the authors offer specific methodological strategies for satisfying qualitative rigour, such as the audit trail, member checks when coding, or confirming results with participants, peer debriefing and negative case analysis (Lincoln and Guba, 1985).

In the field of social geography, and drawing on Lincoln and Guba's framework, Baxter and Eyles (1997), in a widely cited review of 31 empirical and 18 substantive papers, call for the establishment, and

fuller use, of criteria – broadly following the principles laid out by Lincoln and Guba - to enhance rigour (see table 1). In doing so, they note the tension between the creativity of qualitative research processes and standardized procedures associated with evaluation. They conclude: "Deliberations on epistemology, ontology and practice, while necessary for enriching the findings of qualitative research, are not sufficient on their own for evaluation purposes. Principles for evaluation are needed to bridge the gap between the philosophical concerns of a qualitative epistemology and ontology on the one hand and the practice of qualitative methods on the other" (Baxter and Eyles, 1997; 510). In a response to Baxter and Eyles, and the detailed list of evaluative questions they set up, Bailey et al (1999) acknowledge the need for audit and transparency, but caution against the application of fixed criteria, which they argue could lead to a loss of idiosyncrasy in the research process and creative insight (cf. Crang and Cook, 2000). They call instead for greater reflexivity and transparency in the management of qualitative data at all stages of the research process.

Crucially, for our purposes, Valentine's (2006) commentary on 'rigour and relevance' considers the role of sharing and reusing qualitative data. She argues that sharing data – and the analytical process through which data were generated – would potentially extend the reach and impact of qualitative studies. Such synthetic work, which brings together different sets of data, generated through different research styles, theoretical approaches, and in relation to different sets of questions, does, of course, present difficulties in terms of epistemological commensurability. In responding to these challenges, in the context of QER, and in the remainder of this paper, we develop a commentary on our experience of sharing and comparing data, in a way that is both transparent in process and reflexive in practice. To do so we draw, in particular, on Baxter and Eyles' (1997) discussion of Lincoln and Guba's (1985) principles of qualitative rigour. Table 1 sets out these principles and how we interpreted and deployed them to develop our comparison.

Table 1: Evaluative principles and strategies adopted for comparative analysis

Criteria of rigour	**Comparative strategy adopted**
Transferability of the material: making what occurred intelligible and transparent to the audience; the history of the research;	Stage1: The two project leads[1] met (one meeting) to discuss (differences and similarities in) the study rationale, case study

[1] Project lead refers to the PI on each of the two QER research projects

description of the study context and the interpretive strategy.	contexts and interpretive strategy. Reflection on these issues served to clarify where comparing data might be fruitful.
Credibility of the account: The plausibility of connections between the experiences of groups and the concepts developed to describe or simplify them. Achieved through (for instance) purposeful sampling, prolonged engagement, triangulation, peer debriefing (exposing data and interpretations to a respected colleague)	Stage 2: The two project leads shared a sample of anonymised transcripts reflecting the range of interventions studied, to identify ideas, patterns and concepts within topic domains selected for comparison. Two subsequent meetings reflected on the findings of interpretation – explored in/consistencies in analysis and interpretation - and identified key analytic themes.
Dependability of the interpretation: consistency with which the same constructs may be matched with the same phenomena over space and time, ensuring that the logic of the interpretation is not partisan. Achieved through (for instance): multiple researchers, peer examination (peer debriefing) and other methods of introducing alternative perspectives in data analysis prior to finalizing the set of theoretical constructs.	Stage 3: The final (fourth) meeting including a 'critical friend', a colleague that acted as a peer reviewer of the comparative data and interpretation (the annotated scripts, the data-theory links, and the degree to which they made sense). This provided a check on the dependability of interpretation and any prior commitments that might have impinged on the outcomes. The central analytical themes of the analysis were modified as a result[2].
Confirmability of the study: the ability to audit the process through personal reflection of how decisions are made; reflection on the extent to which biases, motivations, interests or perspectives of the inquirer influence interpretations.	

[2] Here we would like to acknowledge the role of the reviewers in prompting fuller reflection on these principles and the resulting analysis.

Based on Baxter and Eyles (1997)

Discussion of the fieldwork context and the data reanalysis through this three-stage comparison allowed us to better understand how the two research contexts related to one another and how the findings might be connected, and viewed differently, in light of the other project. We discuss below the first stage of this process, reflecting on the research objectives of the two QER studies, their theoretical framing (and ambiguities), the methodologies pursued and the data collected.

3. Research history: transparency and transferability

In this section we reflect on the research histories of the two QER studies – to provide an account of their conceptual, methodological and interpretative origins and progression, as a strategy for exploring and identifying opportunities for data comparison. The initial meeting between the project leads (stage 1) generated reflections on the original aims and expectations of the studies. In both cases the QER fitted into a wider multi-institution project, a context which set – to a degree - conceptual and methodological parameters (e.g. in terms of sample populations, LCTs of interest, the overarching objectives of the study).

Carbon Control and Comfort – CCC - (see table 2, reported more fully in Bickerstaff and Hinton, 2013) was a multi-disciplinary project (engineering-led, with design, architecture and social sciences contributing) which at its core sought to design and test novel domestic heating control systems that would deliver comfort expectations as well as substantial reductions in overall energy consumption. The role of the QER was to develop an understanding of the comfort expectations and practices of a group of social housing tenants, which would inform the development of prototype devices (described below in relation to the Merthyr Tydfil case study). Conceptually, the QER addressed householder narratives of comfort, the spatial, social and material constitution of comfort and how novel LCTs intervened in and reconfigured everyday routines associated with energy consumption (c.f. Gram-Hanssen, 2010; Shove, Pantzar and Watson, 2012). It must be recognized that the overall project had subtly different aims that were centred on more applied goals of developing and testing LCTs that would deliver reductions in energy use. For the QER work, semi structured interviews took place between 2010 and 2011, and built up a picture of the meanings, expectations and materials associated with comfort practices across the space of the home (and over time). The data collection and was based around two UK case studies; Merthyr Tydfil and London.

Merthyr Tydfil, South Wales (6 households). This study involved three in-depth pre-intervention interviews with householders (all in the social housing sector) and one post-installation. The QER findings fed into the design of prototype LCTs aimed at delivering on comfort and efficiency goals, as well as providing baseline data against which post-installation comfort practices could be compared. Two categories of LCT – Thermal Feedback Devices and the Wattbox – were trialled for a period of between six and twelve months (one intervention per household) as outlined in table 2[3]:

For the thermal feedback device[4] three different types were developed. Two of these were table lamps that linked a 'warm' orange glow to an 'ideal' temperature (18-21C); a reduction in lighting or a change in colour signalled an increase in room temperature. A further device indicated radiator temperature; a white light signalled the radiator was warm, an orange light that it was hot, and a red light that the radiator was hot at the same time as a window (in the same room) being open. The proposition of the team, drawing on early QER findings about the relationship between light and comfort, was that the visual feedback would prompt change with respect to taken-for-granted (and wasteful) comfort practices.

By contrast, the Wattbox[5] is a heating system automation technology, bearing some similarities to traditional heating controls, such as programmers, timers and room thermostats. The Wattbox, which is engineered to control central and water heating, automates (i.e. manages) domestic heating on the basis of monitoring patterns of heating use over a defined period.

London (3 households). Householder research in London involved interviews with three owner occupiers who had participated in British Gas's Green Streets 2 initiative, a scheme that aimed to deliver domestic emission reductions through an emphasis on the (free or reduced cost) provision of microgeneration (specifically solar PV) and / or devices to increase energy efficiency (eco-kettles, draught-proofing and energy feedback devices). Single interviews were conducted in 2011, some time after the take-up of the LCTs.

The second QER project, *Conditioning Demand* – CD - *(table 3)* was rather different in its conceptual and epistemological origins. A multidisciplinary, though very much social-science led, project, CD involved a

[3] In each case the designer met with participants to outline the purpose and functionality of the device

[4] Developed by the Loughborough Design School

[5] Developed by a team at DeMontfort University, prior to commencement of the project, and in 2011 bought by the Smart Home technology company AlertMe.

series of four studies addressing older people's comfort experiences across a range of places, locations and living arrangements (i.e. care homes, sheltered housing, rented and owned homes). The QER that we draw upon here was concerned with developing a rich empirical understanding of the ways in which certain demographic characteristics – in this case associated with old age (people aged 60+) - impinged on thermal comfort and use of low carbon technologies in rurally based, owned homes in southwest England that were off the gas grid. The project was interested in the motivations for uptake of technology amongst this demographic and their experience of living with novel LCTs.

The data collection period commenced in November 2011 and was completed in August 2012. In-depth, seasonal, interviews were conducted in nine households (winter, summer, and either autumn or spring depending on when the households were recruited). A semi-structured interview guide was used which was divided into areas reflecting the broad scope of the project as a whole: notions of the home, day to day activities/routines, characteristics of the dwelling, decision-making relating to choice of thermal comfort technologies, personal thermal comfort preferences, use of heating/cooling technologies across different seasons, other strategies used to achieve thermal comfort, and energy use. By and large, householders, as owner occupiers, had (personally) invested in low carbon heat technologies, which had very much contributed to a reconfiguring of domestic practices relating to warmth and comfort.

A data-theory link that emerged from early (stage 1) discussions focused on the variable ways in which LCTs were or were not integrated (their effects and how they were transformed) in relation to existing domestic routines, family structures, and in the context of the material fabric of dwellings – and how these 'outcomes' often diverged from institutionally determined performance expectations. Whilst capturing these post-installation shifts was not an explicit objective of either project, we felt that it offered an avenue for developing conversations across the two studies, and exploring the different ways in which both project leads had engaged with and conceptualized this process of 'LCT integration'.

4. *Developing data-theory links*

Initial discussion of the two research designs and contexts highlighted a point of connection broadly around the variability of resident-LCT interactions post-installation, findings which had been interpreted through rather different conceptual approaches. The CD project had been oriented by a contextual approach to thermal comfort (e.g. Cole et al., 2008) and the adoption of low carbon technologies (e.g. Caird and Roy, 2010). This interest in context was reflected in theory and research around the making of, and meanings associated with, 'home' (Easthope, 2004; Sixsmith, 1987), specifically how novel energy technologies become 'domesticated' in household contexts (Aune, 2007; Peterson, 2008; Hargreaves et al 2013). For

example, Silverstone and Haddon (1996) have described how, in the context of ICTs, domestication involves the consumer in appropriation: in taking technologies and objects home, and in making, or not making, them acceptable and familiar (cf. Silverstone et al., 1994; Silverstone and Hirsch,1992). By contrast, the CCC QER had developed a particular analytical focus on the role of LCT objects, their form, capabilities, and affective capacities, in reconfiguring energy-consuming practices (Bickerstaff and Hinton, 2013) – i.e. how the presence, and components, of LCTs can have effects in terms of peoples' understandings and consumption of energy (cf, Pierce and Paulos, 2010; Strengers and Maller, 2012; Marres, 2011). These rather different orientations informed the early data re-analysis (stage 1 and 2).

In what follows we discuss three themes that chart the progression of our reanalysis, pointing to the ways in which it enabled us to extend beyond these prior (empirical and theoretical) interests: domestication in practice, making energies, and sensing energies. The re-analysis draws on a sample of 18 interview transcripts - 9 scripts from each project, including the full 9 households for CCC, and 3 households for CD where the research was conducted longitudinally[6]. For each section we use two or three extracts to highlight key ideas and analytic processes, and to demonstrate the further insights that emerged from reanalysis of data collectively. Throughout we embed in our processes the principles of rigour in qualitative research set out in table 1 (Baxter and Eyles, 1997; Lincoln and Guba, 1995) with a view to prompting reflexivity and transparency in our practices of comparing data and findings.

4.1. Non-ideal domestication or 'domestication in practice'

> "We turn it [the heat pump] off in autumn, turn it on in spring, er as soon as the Rayburn goes.... you know corresponding with the Rayburn going on and off really because there's no need for the heat pump when the Rayburn's working" (Jeff, air source heat pump, Rayburn range, CD)

> He [the Wattbox designer] still locks it, constant[ly]. Every couple of weeks it kept knocking itself off when we were trying to use the Wattbox, and you just can't use it. I have tried to use it [the heating] at night but it just stays on for about five minutes and still knocks off. (Julie, Wattbox, CCC)

[6] For CCC this involved all interviews conducted post installation of LCTs. For the CD study, three sets of household interviews (from the full nine) were selected to cover the range of installed devices (particularly relating to heat generation).

In the first quote, from the CD project, Jeff reflects on the particular heating arrangements that formed in his household following installation of a Rayburn stove and an air source heat pump (the latter, to provide heat in the summer). Jeff and his wife had, over time, developed a set of seasonally appropriate comfort practices that integrated different (energy and heat) generation and control systems. However, the envisaged heating system of the Rayburn in the winter months and heat pump in the summer months became problematic with uncertain or erratic weather that did not conform to this neat seasonal pattern, leading to instances of sustained thermal discomfort, specifically when it was too cold to put on the heat pump, but not cold enough for the Rayburn.

A complex pattern of 'juggling' practices were established over time, leading Jeff to install a temperature sensor in the airing cupboard "to keep an eye on the temperature in spring and autumn and when it falls below about 15 degrees in the air temperature in the loft, when to my mind it's just not worth putting the heat pump on, I'll bang the immersion heater on [instead]." This account offers a qualitatively different experience of LCTs from that presumed on the basis of the performance of a single device, and reflects the complex array of systems in place (and their operating demands), comfort practices and domestic expectations, as well as the variability of external weather conditions.

The experiences of the two households who trialled the intelligent heating system (the Wattbox) in the CCC study offer a connection to these insights regarding what we might term non-ideal domestication. In the case of the Wattbox, the occupants had not had a direct say in the selection of a prototype intervention, and although the householders had been provided with some background information on the operation of the system, they had retained little of the detail and remained confused about its purposes. As such, their engagement with, and experience of, the LCT differed considerably to that of the CD participants who had, in all cases, carefully researched the pros and cons of their new heating system. Crucially, the Wattbox offered very little scope for household repurposing of the device to fit established routines – it was at core an automation technology engineered to (forcibly) deliver efficiency improvements in household consumption of energy. What was clear in interviews from the two householders was a feeling that the technology was *forcing* them into greater inefficiencies, and that the heating was on far more than if manually controlled.

Gemma (CCC) described a couple of occasions when the Wattbox turned on the heating when it was not wanted: when nobody was at home; and at night, when the household had gone to bed. On another occasion, it turned the heating on and the householders found it uncomfortably warm, but they could not turn the heating off again and had to open windows to try and cool down. Ultimately, the device challenged firmly established domestic expectations regarding control - it did not and could not 'fit in' - and

as a result was removed early on in one case, and in the other case a manual override switch had to be fitted (which enabled the householders to increase their manual control of the heating system). In both trial cases this rigid automation of control via technology precipitated a reading of the Wattbox as dysfunctional: Julie – who trialled the Wattbox for eight months - referred to persistent "breakdowns" and of constantly being "locked out" of the heating system.

The two quotations are striking in their differences in terms of the relative 'fit' of the new device(s) in the home and associated shifts in household practices around energy use. In spite of these contrasts our comparison articulated some clear (and important) connections around the unexpected (and in some senses problematic) ways in which the purposes of LCTs are negotiated in relation to pre-existing domestic contexts comprising already installed systems and devices, longstanding routines and culturally embedded expectations of home comforts. These tensions around 'fit' were more visible in the findings of the CCC project where many of the trialled feedback and control technologies lacked a strong resonance with established comfort meanings and practices, undermining anticipated transformations in energy consumption. In accounting for these discrepancies, the reanalysis specifically addressed the materiality of LCT's and the energies they made (or failed to make) tangible. In the following discussion we review this analytical theme and reflect on how comparison both extended and troubled our initial approaches to reanalysis.

4.2 Making energies

> Rose: Yes, but unfortunately we looked at putting in underfloor heating up here [referring to the first floor] but there's just not enough room.
> Scott: There's not enough space, the beams are only about four inches deep so there wouldn't be enough room. That's really why we had to go to LEDs in here (Scott and Rose, ground source heat pump, CD)

> My son-in-law would open the window and shout out to somebody and you could see the colour changes straightaway, and then when you shut it, it clicked back on to a different heat. It does make you more aware of the temperature in the room like. Yeah […] Well, you can see the difference when you opened the window how your energy is flying out of the window. (Hannah, radiator feedback, CCC)

> When it comes burning wood as long as it's seasoned properly… and also scrap wood I mean we burn […] almost as much scrap wood as we do our own seasoned wood if not more [….] Each evening at five or six o'clock in the winter, if it's very cold I might do two burns a day. It's a batch boiler you see, it's not running all the time – you fire it in batches and in the winter if it's very cold I do perhaps two burns a day of maybe 18 kilos of wood, maybe thirty-six kilos altogether (Mark - interviewed with Ann, biomass boiler, CD).

As noted in section 4, the researchers came to the reanalysis with certain (perhaps not fully articulated) empirical and theoretical commitments regarding how (and why) LCTs impinged on the day-to-day routines of households, reflecting fundamental differences in the rationale for and design of the two projects. The CD project was primarily concerned with the role of demographic (age) and geographical (rural, off-grid locations) characteristics in the domestic use and integration of LCTs, and in interpreting findings had drawn upon theories of domestication and the home. The CCC project was informed by an engagement with practice theory (e.g. Shove et al, 2012) and the material politics of energy reduction experiments (e.g. Marres, 2011). In this regard the study was strongly oriented to exploring energy consumption in relation to comfort expectations and practices, with a view to foregrounding the play of low carbon devices and their variable materialities.

Much of the early comparative discussion focused on the (considerable) differences between householders and what they talked about in relation to heating and (their interaction with) associated infrastructures and devices and left relatively untouched the substantial conceptual differences between the two studies. The three quotes that open this section, illustrate how reanalysis served to confirm and extend findings developed as part of the CCC project. These findings related to 1) how technologies, as well as the wider fabric of the home, played a constitutive role in enabling (or constraining) the production of certain kinds of energies and 2) how the material constitution of LCTs (appearance, demands for interaction, aesthetics) had consequences for the ways people made sense of and engaged with energy (for related concepts see Marres, 2011 on the materialization of participation and Strengers and Maller, 2012; Strengers, 2013 on the materiality of energy making practices that constitute distinct and variable energies).

For instance, Scott and Rose's (CD) decision to install a bore-hole ground source heat pump to provide space and water heating (but which also provides water if their off-mains well becomes dry), had been strongly influenced by a number of fundamentally material conditions rooted in the building fabric – a cob house with three foot thick walls that is over 400 years old. In other words planning issues (regarding listed buildings), structural limits with the first floor (which prevented underfloor heating) and the fact that they

are off mains water supply, all contributed to the mix of heating system components installed and the types (and qualities) of energies they could make.

The extract from Hannah (CCC) offers a different perspective, revealing how objects and devices prompted reflexive engagements and insights within households. Although Hannah noted that the practice associated with the radiator feedback device (window opening whilst the heating was on) was rare in her household, she does describe, in very concrete terms, how this LCT made visible the idea of heat or energy wastage. The changing colour of the LED light on the radiator constituted energy as a physical and dynamic entity that could be conserved or lost - energy 'literally flying out of the window'.

In the final extract, Mark talks about their 30KW biomass boiler – a system fuelled by wood supply from their own property, as well as 'scrap' wood from the area[7]. By its very nature this heating system requires (finite) resources which can be seen, cut and weighed. They need to be prepared and made into energy services like heat (also Rinkinen, 2013). Mark, in particular, was engaged in a diverse set of practices - their own woodland required regular harvesting, cutting with a chainsaw and log splitter, and the drying, weighing and storing of wood. Mark had to learn the technicalities of the calorific content of different wood types in order to gauge what amount of fuel would be needed at different times of year to fuel the boiler sufficiently to provide for their space and water heating needs. In this sense the demands of the solid fuel system necessitated a set of material practices - interactions with artifacts, fuels and tools implicated in preparing, making and using energies - which in turn recalibrated routine expectations, doings, establishing a very rich, particular and located understanding of energy.

In sum, the reanalysis served to confirm and finesse existing accounts (Bickerstaff and Hinton, 2013, Strengers and Maller, 2012) and provided the basis for a stronger belief in the dependability of findings given that the insights held up in contexts with considerable differences (study design and objectives, sample population, technologies being studied). In Baxter and Eyles' terms the comparison can be seen to have generated improved credibility and validity as the connections across the two studies made sense to both lead researchers, there were multiple examples across the corpus of the sample reviewed, and agreement on interpretations. However, it became clear to us, that this approach to reanalysis (organized around pre-existing interests) offered a rather compartmentalized – and theoretically inconsistent - reading of the data. The process of bringing in a peer with no historical association to either project (stage 3), to reflect on our account, served to open up discontinuities in the analysis and trouble the dependability or completeness of our interpretation. Identifying some of these inconsistencies – around conceptual interests and meanings as

[7] Mark and Ann had also installed solar PV and solar thermal.

well as data anomalies - helped to flesh out a way of thinking data-concept links anew. We focus here on discussions that developed around reading data across bodily or sensory engagements.

4.3 Sensing energies

> Scott: so we always light a wood burning stove in there, and during the Christmas period we always lit the wood burning stove in here in order to make it comfortable during the day.
>
> Rose: But I mean I can see that we will run the wood burning stove really 'cos they're nice to sit round it's nice to sit round a fire.
>
> Scott: And at Christmas I mean when you're sitting round the table in there with the other wood burner on it's lovely to – you've got the smell of the you know put some nice logs on and you get the smell of a um a wood burning stove and so it is lovely. (Scott and Rose, ground source heat pump, wind turbine, CD)

> Now, sometimes I notice, we'll be sitting here and I think: oh, the white light is on there. And for some reason the radiator was going off. So, it was good because otherwise perhaps you wouldn't notice. And then you think: oh, I don't feel so warm now and the heating's on. […] I'd turn up the thermostat for a bit. And when I see it come back then onto the orange then I'd know it's okay now (Gemma, radiator feedback device, CCC).

> Because I saw it as a lamp rather than anything. I think it would need to have, I don't know what it would need to be but something different than a lamp. I just looked at it as a light thing although you couldn't sit and read by it, but it didn't trigger in me that it was anything to do with heat and all that. I don't know why, but it didn't…. Probably it's too pretty as well. I think it'd have to be more gadget, […] Because that is just, it just sort of fits in as part of my house and not something, a useful gadget that would tell me anything. […] I'm sorry I find it a pretty lamp (Jenny, thermal feedback lamp, CCC).

A theme that cut across our analysis of how people made sense of and interacted with LCTs, and proved powerful in accounting for their fit or place within homes, was the role of bodily, sensory and aesthetic engagements. The consistency of this core theme, in our reflections (stage 3) - despite different researchers, project rationales, methodologies - highlighted it as an alternative, and credible, way of reading findings that

was transferable across and beyond the two studies. In the reanalysis this theme was explicated along two key lines; 1) as related to the sensory registers through which heat and comfort were articulated and 2) the role of physical bodily encounters with stuff in the domestic integration of LCTs.

Taking the first of these themes, Scott and Rose (CD) had recently installed a ground source heat pump and (ground floor) underfloor heating. Whilst both were enthusiastic about these changes in terms of delivering on their (thermal) comfort needs and expectations, they also talked about how wood burning stoves had been retained. What is particularly interesting about this case is the ways in which different parts of the modified heating system (and as such different energies) delivered particular types of comfort,associated with a set of embodied practices. Rose, for instance, talked at length about the comfort benefits of the underfloor heating; in wet weather her riding boots, left next to the front door, would dry overnight and the experience of putting on warm boots in the morning was clearly something she strongly associated with personal comfort. For this couple, the retention of the wood burning stoves was not about bridging gaps in heating provision but rather delivering on a wider conception of comfort, articulated in terms of ambient light and conviviality (Devine-Wright et al, 2014).

On the second theme, and as visible in the earlier discussion (4.1), interacting with LCTs was very much tied to tactile and sensory experience – e.g. monitoring screens, preparing and moving fuel, touching (heated) surfaces (see also Strengers and Maller, 2012). It is an observation which chimes with comments from CCC participants who had actively chosen to install solar PV, and who talked about how the closeness of electricity generation infrastructure, and the capacity to see production (via a monitor) led to an affective and more 'caring' relationship with (solar) energies. Sarah, for instance, drew the analogy with farming - and the way a farmer would relate to crops: "you don't waste what you produce", causing them to be more 'careful' in when they used appliances (in relation to when the sun was shining) and how (much) they used appliances.

Gemma talked about her embodied response to the visual cues of the radiator feedback device which differed markedly from the design expectations. Whilst the white light on the device (attached to the radiator) had been designed to indicate 'cooling down' (and to prompt 'appropriate' window opening practices), Gemma had responded to the LED in a very different way. Not only did she not recognise this problem (i.e. leaving windows open in a room with the heating on) in her own practices, but when she saw the white light on the radiator, this would quite often cause her to question her thermal comfort. The most common response was for Gemma to then 'potch about', altering the room thermostat and TRVs to attempt to get the radiator to warm up.

Jenny was more explicitly critical of the thermal feedback lamp, designed to make visible (excessive) room temperatures through changes in the number of lamps lit up. In discussing her confused (and non-ideal) interaction with the device, Jenny located the problem in the form and aesthetics of the lamp. Whilst she found it visually pleasing as an object, this (re)design of a lamp as a 'gadget' conflicted with her conception of what a feedback technology (and indeed a lamp) should look like and how it should perform. In a qualitative study of disruptions in domestic heating, Rinkinen (2013: 5) similarly points to concerns expressed by one household about the aesthetics of air source heat pumps and "uncertainty over whether it would 'fit the house'".

The point that we have sought to make here is that this critical scrutiny of the reanalysis (what we might describe as confirmability) worked to highlight prior intellectual commitments in the original analysis and point to an alternative, if not necessarily fully developed, way of thinking about processes of technology integration and accommodation. Our approach to comparing and sharing data and findings, and in particular use of forms of peer review, enabled us to collectively articulate the critical role of sensory and embodied practices in how people experience comfort and how they interact with and respond to (the often instrumental designs of) LCTs.

5. Concluding Discussion and Policy Implications

In this paper we have explored two qualitative energy research projects ('Carbon, Control and Comfort' CCC and 'Conditioning Demand' CD), with a view to better understanding how sharing and comparing data can extend the interpretation and reach of such work.

Whilst the two projects had notable similarities – an interest in the performance of LCTs post-installation and the research methods deployed – we must also be clear on the considerable theoretical and empirical differences and thus limits to direct transferabilty. The CCC project was concerned with concepts of comfort and practice as well as the material capacities and effects of low carbon devices, whilst the CD project was focused on the experiences of older-people in relation to heating LCTs and the domestication of these devices. Importantly, a proportion of the CCC households (Merthyr Tydfill) lived in social housing and had little say in the LCTs fitted or (temporarily) trialled in their homes. Participants in London (CCC) and rural Devon (CD) owned their homes and had actively chosen to have microgeneration and low carbon heat devices fitted.

Through an exploration of Baxter and Eyles' (1997) discussion of qualitative rigour we have reflected on the research contexts and histories of the two studies, particularly to convey more of the 'real life' settings and constraints of data production, and as such the scope for transferability across and beyond the case

studies. It was possible, in this way, to confirm and generate a greater sense of the dependability of findings across the two projects and building on established QER. At the same time exploring (albeit loosely) the meaning of credibility, dependability and confirmability for strategies of sharing and comparing research enabled us to think creatively and critically with the combined data – to build insights into issues that had either not been well-developed or were simply not visible as part of the original analyses. Looking across the two projects, the reanalysis provided support for the view that conceiving the installation of LCTs as a simple or straightforward process of 'installation' in built environment contexts is misleading. Instead, both sets of data illustrate how devices become appropriated into pre-existing spatial and social contexts, but also how these material interventions impinge on and intervene in established practices and arrangements. In important ways, then, the process of sharing data enabled us build more nuanced and credible accounts around LCT integration (non-ideal patterns of LCT domestication and the material capacities and constraints that shape the meaning and constitution of energy) that, when set alongside existing research, offered clear insights regarding the potential to draw wider (or transferable) conclusions, cognisant of contextual differences in case studies. In and of itself this was a powerful outcome of the process. However, through peer reflection and debate we were able to articulate, albeit provisionally, a broader concern with the role of corporeality and sensory engagements in accounting for how LCTs do, or do not, fit in place.

Bodily activities, competencies and doings are, of course, discussed in the literature, notably in relation to the reproduction and performance of social practices (e.g. Shove et al. 2012). In a discussion of discontinuities and disruptions in domestic heating during long blackouts, Rinkinen (2013: 8) argues that power cuts serve as spaces for reflexivity on the heating practice – a reflexivity that is bodily and material. Anthropologist, Sarah Pink (2005) goes further; her work on everyday practices of laundering underlines how sensory evaluations not only informed practices, but were also constitutive of ideas of morally appropriate and justifiable actions. The distinct conclusion arising from our own reanalysis, when set alongside the more or less explicit accounts of sensing energies in the literature, is the considerable potential of a more thoroughly corporeal reading of the relationship between LCTs and domestic settings in accounting for the transformation (or not) in everyday sayings and doings. Further sharing and comparing of existing QER could offer a great deal in this respect.

As has been argued in relation to qualitative secondary analysis (Savage, 2005; Irwin and Winterton, 2011), analysing data in ways that the original research did not, exposes absences and new lines of enquiry, that were obscured in (and by) the original research framing. We argue here that this can also be an outcome of the approach taken in this paper to reanalysis and combining data sets. Moreover, we suggest such efforts, and there are certainly other strategies that could be adopted to organize comparisons, can

also enhance the power of the lines of enquiry that were examined and exposed within the original projects, bolstering existing key findings by identifying their significance across different studies and research teams.

The rapidly expanding field of QER clearly has important policy implications. Authors working within the social practice theory tradition have certainly contributed to reframing policy debates around the energy problematic and what constitutes evidence (Shove, 2010, Spurling et al, 2013) and there are a number of examples of how this work is having effects (e.g. Chatterton, 2011). However, messages from QER (particularly small-n research) can be challenging to distil for, and convey to, energy policymakers. We suggest that comparative endeavours that critically explore and think across a range of QER studies offer something distinctive in speaking to energy policy questions (for instance about the take-up and performance of LCTs). This is not a call for the scaling up of data or greater aggregation of findings, but rather for qualitative energy researchers to make fuller use of opportunities to reflect on and with a wider and more varied corpus of data - to bring together findings in new ways that may indeed challenge (mis)conceptions about the scale and specificity of QER.

Beyond a concern for policy traction, we suggest that comparing and sharing analyses and findings has much to offer energy researchers, and indeed qualitative researchers more widely. Qualitative research is labour intensive and frequently produces a wealth of data that does not get used in analyses. Rigorous strategies for comparing studies or indeed working with secondary qualitative dataoffers a potentially important avenue for expanding and enriching QER[8]. Wider exploration of sharing and comparing data would of course require qualitative researchers to be more transparent about the whole process of data collection, analysis, interpretation and the imperfections of research processes (Valentine, 2006; Irwin and Winterton, 2011). Such an agenda poses particular challenges for an academic culture which fosters competition, and likely concerns about findings arising from reanalysis of datasets (Valentine 2006). Political calls for scientific data to be fully disclosed and made publicly available (Jump, 2011) serve to reinforce the need to grapple with these issues and encourage experimentation with comparative analyses.

Of course there are limits and frustrations to this kind of work, linked to the (inevitably) considerable areas of theoretical and empirical divergence and the often narrow scope and terms of comparison. That said, the process of opening up and discussing data collection and analysis can be a powerful tool for articulating, challenging and corroborating findings – reinforcing policy messages and highlighting research needs. This is, of course, not just an agenda for qualitative energy research or indeed qualitative research

[8] Indeed the UK's Economic and Social Research Council has for some time expected its funded researchers to archive and make accessible qualitative datasets.

per se. However, in light of the history of energy research, and the (research and policy) dominance of the physical and engineering sciences, relative to the social sciences, there is a compelling case for a fuller debate around the (potential) ways in which qualitative data might say more – or say differently - by being reused, shared or re-examined. In doing so, this might also provide a productive opportunity to 'take stock' of the breadth and diversity of current methods, reflexively engage with our own working practices, and consider new directions in *doing* qualitative energy research.

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Table 2: Carbon Control and Comfort - participants and interventions

Interviewee(s) [a]	Location	Household (age)	LCTs trialled or installed	Installation	Interview(s)
1. Jenny	Merthyr Tydfil	50-59	Thermal feedback light	Research team (selected and installed)	3 prior, 1 post installation
2. Hannah	Merthyr Tydfil	60-69 (1) 30-39 (1); 20-29 (1); 9 or under (1)	Radiator feedback device	Research team	3 prior, 1 post
3. Louise & Steve	Merthyr Tydfil	50-59 (x2)	Thermal feedback light	Research team	3 prior, 1 post
4. Gemma & Jason	Merthyr Tydfil	50-59 (x2)	Wattbox (for 1 week); radiator feedback	Research team	3 prior, 1 post
5. Julie	Merthyr Tydfil	50-59 (x2)	Wattbox		3 prior, 1 post
6. Amy	Merthyr Tydfil	20-29, 9 or below (x2)	No intervention		3
7. Sarah	London	50-59 (x2)	Green Streets: Solar PV, energy monitor	Participants in the British Gas's Green Streets 2 initiative, which sought to achieve emission reductions through an emphasis on the (free or reduced cost) provision of microgeneration and efficiency devices	1 post installation
8. Fiona & Paul	London	60-69 (x2)			
9. Vicky	London	30-39 (x1) 10-19 (x2)	Green Streets: Solar PV	Green streets	1 post installation

[a] Names have been changed to preserve anonymity

Table 3: Conditioning Demand - participants and interventions

Occupants[a] ( ) = did not take part in interview	**Age of oldest Person**	**LCTs installed**	**Installation**	**Interviews**
1. Scott & Rose	66	Ground source heat pump, wind turbine	Household choice	3 post-installation
2. Keith (& Fran)	60	Ground source heat pump	Household choice	3 post-installation
3. Mark & Ann	65	Biomass boiler, solar PV, solar thermal	Household choice	3 post-installation
4. Dave & Stella	62	Biomass boiler		
5. Phil & Carol	78	Air source heat pump	Household choice	3 post-installation
6. Martin & Gay	68	Wood burner, solar thermal	Household choice	3 post-installation
7. Dan (& Joyce)	89	Solar thermal	Household choice	3 post-installation
8. Jeff & Clare	67	Air source heat pump	Household choice	3 post-installation
9. Paula	73	Wood burner	Household choice	3 post-installation

[a] Names have been changed to preserve anonymity.