



High Level Summary of Learning

Heat Pump Customers

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1. Introduction

Changing electricity demand, the electrification of the transport and heating sectors and the increase in distributed renewable energy sources all present challenges to distribution networks. The Customer Led Network Revolution project aims to improve our understanding of current and future electricity use patterns of domestic and commercial customers. Data was collected from customers divided into different test cells (TCs) or samples, each with a particular combination of metering type, electricity tariff structure and/or low carbon technology.

The CLNR project is designed around a number of ‘test cells’ each of which entails a different combination of households, SMEs, low carbon technologies, tariffs, smart meters and/or monitoring equipment. Additional parts of the project involve the development and testing of network technologies, models and management services. Overall, the project involves the participation of over 12,000 energy customers, with the majority forming a control group that includes approximately 9000 domestic and 1,800 SME customers, all of which have smart meters from which half-hourly energy consumption data is recorded.

This summary presents the **key messages** from the final analysis of the domestic heat pump group (test cell 3) in the Customer-Led Network Revolution (CLNR) monitoring trials. It presents outputs from the largest study of household electricity use in the UK and provides integrated socio-technical analysis of domestic customer loads and electrical consumption on the basis of interdisciplinary multi-method research.

The remaining customers are participating in various experimental trials and technology-specific ‘control’ studies including solar PV, ASWHPs, electric vehicles, micro combined heat and power (mCHP), smart white goods and a time of use tariff in various combinations. In examining how smart grid technologies might be designed and implemented, the aims of the social science aspects of the research are to study the ways practices respond to, evolve, change or resist the propositions such as new pricing regimes, smart appliances and low carbon technologies, remote controlled appliances and the combination of economic and technical interventions. Understanding why some household practices may adapt to the electrical landscapes created and why others remain unchanged and how these varying responses intersect will contribute significantly to knowledge of the co-construction of electricity systems and practices.

2. Methodology

This report draws on qualitative interviews and home energy tours conducted with 18 households recruited from the 331 domestic customers involved in the air-source-to-water heat pump (ASWHP) trial (Test Cell 3). Participants with ASWHP were contacted directly by one of the research team, using information provided by the energy retailer, which had previously identified households that were willing to participate. The semi-structured interviews focused on building rapport with the participant while discussing their energy use in general terms.

These conversations included information about occupancy, major electrical loads, heating regimes, washing and cooking practices, thoughts and feelings about electricity use, seasonality and other temporal factors as well as experiences of and responses to new technologies. Interviews were focused on two clusters within the regional network: social housing tenants in South Tyneside and County Durham. Social housing landlords had installed loft and wall insulation, where feasible, and retrofitted an ASWHP at no cost to the tenants. Interview participants had lived with the ASWHP for between 6-12 months, including the winter months. Interviews were conducted between January and March 2013.

In South Tyneside ASWHPs replaced electric night storage heaters, gas-ducted air and solid fuel/ back boilers, funded through the Renewable Heat Premium Payment, Carbon Emissions Reduction Target (CERT), Community Energy Saving Programme (CESP), and British Gas (South Tyneside Homes, 2012) as part of a programme to improve comfort, reduce fuel costs, and reduce CO₂ emissions. Installation of the air-to-water system, which distributes heat via a wet central heating system, took place following engagement with tenants of interwar housing in a suburban location, which included individual surveys, an invitation to attend a meeting at a local community centre, and visits to a fully operational Show Home so tenants could see an unfamiliar technology installed and experience its effects in an almost identical domestic setting. The refusal rate amongst tenants was reportedly low, mainly due to ill-health (South Tyneside Homes, 2012).

In rural County Durham, 24 ASWHP were fitted in a social housing retirement development of terraced one bedroom, single story dwellings. The properties were built as homes for retired miners and servicemen and their families between 1900-1910, and previously supplied by a communal gas boiler that provided piped hot water and heating to all the homes in the complex. As a result of these contexts, it should be noted that the participants from whom evidence is drawn in this paper are all social housing tenants from the north of England, and are representative of older and more vulnerable households. The majority are retired or semi-retired, living in small (1 or 2 bedroom) properties. Interviews typically lasted 60 to 90 minutes, included a home tour, and were digitally recorded.

Household details, audio recordings, photographs, and drawings were collected with participants' consent, and analysed together with field notes and interviewers' reflections. A qualitative data analysis (QDA) software package, NVivo 9, was used to organise and thematically code data. A set of nodes was developed to structure analysis of the qualitative data based on themes drawn from repeated review of the qualitative research process and literature. A node was also created for each interview and home tour, consisting of a collection of references. To further analyse the data, queries were constructed in NVivo to interrogate the data in systematic ways, and extract data that related to particular research questions.

3. Evidence from previous studies

This section reviews available published studies on retrofitting heat pumps in existing domestic dwellings. By 2010 an estimated 30,000 Air Source Heat Pumps (ASHPs) were installed in the UK; the majority being located in residential buildings and in situations where dwellings are without mains gas (Energy Saving Trust 2010).

Many studies focus on monitoring efficiency and technical factors affecting performance (e.g. Boait et al., 2011; EST, 2010). Apart from a few case studies and small scale surveys there is little available information on householders' experiences and practices of using heat pumps, despite users' affecting heat pump efficiency (DECC, 2013c; Miara et al, 2013; Stafford et al., 2012). The main UK evidence comes from the Energy Savings Trust (EST, 2010, 2013) and Caird et al. (2012), the largest UK heat pump study and comprised of both owner-occupiers and social housing tenants. The study by Owen et al. (2012) includes interviews with 12 owner-occupiers, of which five participants were retired, and three householders had significant health problems.

The remaining UK studies are predominantly concerned with social housing, where much current retrofitting activity is taking place. It was not possible to determine tenure in all other European studies. Previous studies (Caird et al., 2012; Pither and Doyle, 2005) indicate that social housing residents were more dissatisfied with their heat pump systems than private householders, particularly with regard to running costs, technical support and comparison with their previous heating system. In the survey by Pither and Doyle (2005), 33% of respondents gave the highest score for effectiveness of heating. However, 17% rated heating as average and 2 participants gave a very low score. Provision of hot water rated more highly than heating.

Forty per cent of occupants thought more instructions were needed, and 34% thought that heat pumps were too expensive to run. These findings are also reflected in a study published by DECC (DECC 2013b). Although the survey by Caird et al., (2012) found that most users were satisfied with the reliability, heating, hot water, and comfort provided by their system, significant differences were observed in efficiency between private dwellings and social housing. Private householders' greater satisfaction with space heating (79% satisfied) and comfort (91% satisfied) compared to social housing residents (67% and 71% satisfied) is attributed to interaction between differences in the systems, dwellings and users at the private and social housing sites. Higher system efficiencies were associated with greater user understanding of their heat pump system, and how users operate the system.

4. Qualitative findings

Discussions with participants revealed the importance of the legacy of existing heating systems in shaping the ways in which they related to the introduction of the ASWHP, an aspect acknowledged as significant by Owen et al. (2012) and Juntunen (2014). Participants with a communal system of heating and hot water reported that it was 'tip top' (Male tenant, DC031) and they 'never had no problems' (Male tenant, DC035). In contrast, for participants who had lived with electric storage heating systems, ASWHPs were regarded as a considerable improvement to a regime whereby they depended on various expensive forms of electrically produced heat:

'You had no heat. They [storage heaters] were supposed to stay warm all day but they were cold by 11 o'clock so you were freezing. I had to use the electric fire all the time... but now I hardly ever use it... Well, I was putting £35 to 40 a week on with the storage radiators but now I'm putting £20 on now. I couldn't have afforded the other. It was terrible'. (Rose)

'You had no control over them ... when I come in in the evening, the place was cold. They only have bricks with a heating element, so once they switch off at 7 o'clock [in the morning] they start cooling down, so by the time I'm getting here in at 7-8 o'clock [in the evening] or whatever, the place was cold and I can't do anything. I can't turn the heating on cause they won't switch on again until midnight, and I've got no control.' (Mark)

Once in place, optimising the performance of the ASWHP requires users to adopt different patterns of energy use based on its continual, low level provision (Cantor, 2011). Users' expectations and practices are critical in shaping how the system is operated. For some, existing daily routines overrode the system imperatives, and users played an active role in reshaping the technology to their needs:

'When I'm working shifts what I normally do when I go out first thing in the morning I'll switch it off completely. ... so then put it on auto for 5 o'clock, or if it gets too cold, like the last few weeks, I'll just come in and put it on' (Mark)

Many participants found the system operating instructions difficult to grasp and the controls made little sense. Recounting the advice received from the social housing provider on re-setting the system, householders remained confused:

'If it goes off and needs reset... Switch it off from the inside, then switch it off from the outside. Give it a couple of minutes then switch it back on from the outside first, then come in and switch it on from the inside. And that should re-set it. ... The people I am asking information off I don't think they are fully aware with it being a new system and that. ... I'm not sure whether they know that much about it.' (Mark)

For others, the ASWHP necessitated a new mode of operation and patterns of use surrounding domestic space heating and hot water. Householders with electric night storage were familiar with the Economy 7 tariff and this enabled understanding that the ASWHP heated water during the early hours of the morning. However, some were advised they could not continue the cheaper nighttime tariff for the AHSP, which led to confusion amongst participants.

'We try not to have the water and the heating on together because it pulls too much, so the water comes on a morning then it goes off for a little while. It's not that it's expensive, it's just my husband being careful. If you've got heating and hot water on the water doesn't heat up as much ... so we just don't put the heating on.' (Dave)

Several informants had concerns about whether running the system all day—technically the most efficient usage—would incur additional costs (see also Owen et al., 2012). Others sought to distance themselves from the technology, fearing their actions may lead to the breakdown of the system and loss of heating and hot water:

'That's the control which I do NOT touch. I operate it from the thermostat.' (Lara)

'I don't let anybody touch anything. I don't want to know. As long as it's working, I don't want to know.' (Linda)

At the time of the interviews, most householders had reached a point where they were able to operate the system at a basic level using the up and down arrows on the thermostat (Figure 1(b)), but they stuck to the programme set initially on installation:

'They just put it in and I've left it as it was ... I wouldn't know what to do. That's the only trouble. They didn't really tell you much about anything.' (Rose)

A few more technically literate had changed the programme settings to suit their own preferences or understandings, however, even the more competent had some difficulty with the technical information supplied, as illustrated by the comments from a recently retired electrical engineer:

'I wasn't happy with the times they had set. So I tried to set the timer myself. So eventually I got there eventually. Reading the book over and over and over again.' (Andy)

Others found they had little understanding of how the system operated and what to do, particularly outside of normal operating conditions:

'The red light starts flashing and I just do not know why. And I think, 'Oh God there's something wrong.' Nobody told me that the light would go flashing red, you know. When you don't know, naturally I am the age that I worry.' (Linda)

How installation and instruction are undertaken is critical in shaping the initial reception of ASWHPs and the extent to which users become willing participants (Owen et al., 2012). It also echoes the finding that the scope for autonomy, which in turn appears to shape the extent to which users are able to reconsider their roles as passive consumers and engage in forms of co-provision, is shaped by the degree providers are willing to delegate responsibilities or instead serve to import their own notions of 'sustainable living' through interventions (van Vliet et al., 2005). Through these means, the deployment of ASWHPs appears caught in an uneasy tension between new patterns of energy use and modes of operation required from users on the one hand and the continued focus on consumers as passive recipients of energy services on the other.

Users, puzzled by the control and operation of the system, turn to a range of trusted providers for support but often found they too had limited understanding of the system and effective solutions:

'Got the plumber in and the plumber looked and says, 'I don't know anything about this system' and he's gone. Why didn't they train these people? ... I'm still worried about that' [leak from the tank] (Dave)

'He [housing maintenance operative] was here about an hour and a half. They hadn't been trained. He didn't know what to do. He felt awful. I got all the brochures out, he looked through them and studied them, he went out the back. He didn't know what ... so he got onto his boss. ... Then [the installer] come out on the Monday ... so I'd had no hot water and heating since Friday. The [IT engineer] had turned the electric off and hadn't put it back on... I was having to boil a kettle to have a wash ... It was like the 1920s.' (Kate)

While households could marshal different coping mechanisms, several reported that the breakdown of the system, both technically and in terms of the usual means through which energy services were provided, repaired and restored, had led to significant disruption:

A lot of people still do not understand the heat system... I was without heat for a week. I don't know. It just went off. It just didn't work. And I was freezing, absolutely freezing.' (Lara)

'I had three air source heat pumps put in. The first two were no good. I was without heating for a month... They were broken when they were first put it. ... It was February/March, so it was pretty cold, like.' (Rose)

Users of ASWHPs found themselves dependent on a new constellation of providers. Social landlords and utility companies were reliant on manufacturers and specialist repair services that were

misaligned in the management and repair of this particular technological innovation. At the same time, providers and intermediaries regarded users as critical to effective operation of the system to deliver energy services. Having lived with the ASWHP for several months, many householders were still uncertain about the performance of the ASWHP:

[We] still really don't know if we're saving anything. We've got this wireless system in that sends information to [electricity retailer] but we haven't had any reports back or anything like that.' (Dave)

The interview data indicates that householders do not 'actively' manage electricity consumption or read their electricity meter regularly, but continue to rely on their electricity provider to provide this information through periodic, usually quarterly, billing. For most householders interviewed, consumption is evaluated based on cost, not kWh used. These responses echo the findings of the wider UK EST trial by judging the operations and controls of their ASWHP systems as 'baffling'.

Householders who converted from gas-fired central heating tended to conceptualise the newly installed ASWHP as a boiler, anticipating a similarly rapid response only to find discrepancies between cooler running radiator temperatures produced by an ASWHP and higher running temperatures of boiler fired radiators (cf. Owen et al., 2012). Comparison with the old system of provision can lead to resistance to the new:

'The radiators never get hot ... When I first set the timer. I'm getting up half past six and they're freezing cold. It takes an hour for the pump to run to get them warmed up.' (Andy)

Where dwellings previously had electric night storage heating, the main change noted after installation of ASWHP occurred around using supplementary heating. Some people gladly gave up supplementary heat sources. However, householders retained an electric heater with a flame effect for the cosy 'glow', and because it acted as a 'focal point'-valued features that the ASWHP could not provide. It also served as back-up in case of technical failure.

Householders shifting from storage heaters (with or without supplementary heating) and electric hot water systems make adjustments that sometimes result in lowered awareness of their energy use and lead to high rates of electricity consumption. 'The booster is brilliant. ... if we've let the water get too cold. It takes less than an hour' Couple (Dave). The potential for ASWHPs to actually increase energy consumption (e.g. Winther & Wilhite, 2014); this has led some researchers to conclude that depending on context, installation procedures and demographic factors, as well as variations in dwellings and the purposes they serve, a heat pump can be viewed as 'a wolf in sheep's clothing' (Christensen et al., 2011).

One potential counteraction to increased electricity consumption following installation of heat pumps in dwellings previously fitted with electric night storage heating are changes to the use of

supplementary heating. Some householders discontinued supplementary heating altogether - 'I don't use that [electric fire] now... I used to when I had the storage heaters though' (Mark). However, this energy saving effect is not universal as others are more reluctant to depend solely on AHSP 'I was thinking about getting one of those gas ones, just in case ... I used to have a one but got rid of it. I wish I'd never have done now' (Steve). In this case an old resource and associated practice is resurrected out of apprehension about the new technology.

Constructing a satisfactory fit between established practices and emerging ones comes more easily to some householders and in relation to certain practices. For example, the fact that the ASWHP generates a different kind of heat to her old system led one woman to declare: 'I'm glad I've got it in now because it dries the washing beautifully' (Jane). Hot water provision is considered the least problematic change. Householders judge the service provided by the ASWHP to be equivalent or better than previous systems.

Overall, hot water practices remained largely unchanged mainly because the new system meets users' expectations and exerts no adaptive pressure.

Many tenants felt disempowered by their landlords' decision to introduce the new heating and water heating technology and did not know how to adjust household practices accordingly. Some were afraid of the ASWHP and tried to distance themselves from it while living apprehensively with the unavoidable consequences of its presence. The most alienated and troubled users in our sample are elderly women, living alone who regarded themselves as technologically ignorant, although problems are not restricted to these users.

These findings point to the importance of attending to the ways in which such technologies can be more productively introduced and interwoven into household practices. As well as landlords, installers and suppliers fail to enact their necessary new role as effective innovation intermediaries between users and the new technology. Users receive insufficient explanation and interpretation of the ASWHP and lack post-installation advice and oversight. Better follow up services tailored to the specific user groups could have enabled installers to also act as intermediaries between housing tenants and landlord. The latter are not as familiar with or well informed about ASWHP performance as installers. Installers are in the best position to assist tenants to make the transition to a new technology with a user interface that appears complex to people with low levels of technical know-how.

5. Conclusions

Our research provides insights into the practical details of installation and use, and reveals the number of different actors and diverse interests that need to come together to make heat pumps work. This becomes critical in a context where, as in the UK, housing and energy are separately organised and structured, and without the integrated policy contexts (e.g. of municipal ownership of both housing and energy systems, of fuel being paid for through rent etc.) that exist in other countries where HPs are taken up widely.

In the UK a newly installed domestic heat pump stands at the interface between new and old practices and wider systems of provision, which include energy infrastructure and housing providers. While the sample included in this study may have experienced particular challenges, given their socio-demographic background and their position as tenants in social housing with implications for engagement with the technology, these findings accord with the results of other studies which have found that ASWHPs do not perform as expected once placed within households.

The challenge involved in reconfiguring systems of provision and re-ordering practices is further illustrated by the complexity of relations involved between tenants, social housing landlords, suppliers, installers and electricity providers. There is a clear need for user-side intermediaries—to bring together the social and the technical. Inadequate information, different levels and types of knowledge, suggest a role for different forms of intermediaries: whether to provide user-side support to recruit occupants to new practices, installer training on engaging with users, and chain of support from manufacturers.

Although the number of households may be a limitation of the study, results suggest that the social response to ASWHPs is far from homogenous, varies considerably even within similar socio-demographic and housing tenure contexts, and are shaped both by the legacies of the systems of provision that are removed to make way for ASWHPs and the forms of everyday practices within which these technologies and the energy services they provide are enrolled.

As well as landlords, installers and suppliers are implicated in fostering forms of inertia that countervail the technological innovation. They fail to enact their necessary new role as effective innovation intermediaries between users and the new technology. Users receive insufficient explanation and interpretation of the ASWHP and lack post-installation advice and oversight. Better follow up services tailored to the specific user groups could have enabled installers to also act as intermediaries between housing tenants and landlord. The latter are not as familiar with or well informed about ASWHP performance as installers. Installers are in the best position to assist tenants to make the transition to a new technology with a user interface that appears complex to people with low levels of technical know-how.

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