Entanglements with the fireside and responses to low carbon heating transitions: analysis using Actor Network Theory

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Abstract

This paper sets out early findings from the UK component of a European project seeking to establish a social and cultural history of home heating, in order to distil lessons for a more socially conscious shift from fossil fuelled to low carbon heating systems. Here we share findings from 30 oral histories of home heating (from 1945 to present day) gathered in the former coal mining town of Rotherham in the North of England. By analysing the findings through the lens of Actor Network Theory (ANT), we reveal the coal fire (or coal fired range) as a powerful actant shaping domestic life in the decades following the end of the second world war. We argue that relational-material entanglements with the fireside endure, despite many decades of gas central heating in the UK, and have implications for current policy efforts to transition to more abstracted and technological low carbon heating systems, such as heat pumps. These entanglements with the fireside hold important implications for the sensitive handling of the current heating transition.

Introduction

This paper reports findings from 30 oral histories of home heating (from 1945 to present day) gathered in Rotherham in the North of England, a former coal mining town, in the winter of 2022/23 (Ambrose et al., 2024). Through a novel application of Actor Network Theory (ANT), we reveal the coal fire (or coal fired range) – the dominant way of heating the home in the UK until around the 1970s- as a powerful actant shaping domestic life in the two to three decades following the end of the Second World War. Through this data, we explore relational- material entanglements with the fireside, finding them to endure through many decades of gas central heating in the UK, and drawing out the implications for current, urgent policy efforts to transition to low carbon heating systems, such as heat pumps. We reflect on the implications of this for the sensitive handling of domestic low carbon heating transitions. We also take the opportunity to reflect on what the highly novel combination of oral histories, art practice research and the application of ANT as a theoretical framework contributes to scholarship and policy making in relation to domestic heating transitions.

This paper is one of a series of outputs to flow from the international, interdisciplinary project *'Looking back to move forwards: a social and cultural history of home heating'* (JUSTHEAT), funded through the Collaboration of Humanities and Social Sciences in Europe (CHANSE) initiative, which began in 2022 and runs until 2025. Within this project, we aim to understand

how major changes to home heating and heating technology since 1945 have impacted our lives in diverse and often profound ways and how these impacts are experienced differentially across place, time, social groups and even between different members of the same household. Ultimately, we aim to distil learning from these historic accounts to promote a more user centred and just approach to the current transition from fossil fuelled to low carbon heating systems across the UK and Europe. In pursuit of this, the project employs a combination of oral histories, archival research, a network of fine artists and innovative approaches to bringing the policy makers and practitioners designing and implementing low carbon heating transitions into dialogue with the citizens they serve, particularly in relation to the social and cultural implications of heating. The project spans the UK, Romania, Finland and Sweden, but the focus of the present paper is on oral histories (n= 30) and archival research undertaken in the UK (Ambrose et al., 2024).

JUSTHEAT sits within and significantly advances a small subset of the literature on heating and energy transitions which seeks to examine past energy transitions to provide lessons for future shifts. While the focus within this body of literature is mostly on national and global scales (e.g. Allen, 2012; Arapostathis et al., 2013; Smil, 2005, 2010; Podobnik, 2006, Fouquet and Pearson, 1998), the domestic sphere also features. Energy historians have provided insight into social and political impediments to energy plans, as well as the social context in which people create, deploy and use technologies (Hirsh and Jones, 2014). Rarely, however, have relationships between humans and changing (heating) technology and the social and cultural implications of this, been explicitly in focus. We believe that in focussing in on this relationship, neglected cultural, affective and temporal dimensions of heating change are uncovered. In doing so, important insights are revealed in terms of how transitions to low carbon heating systems are likely to be received and how a more popular transition might be promoted, as will be revealed.

Structure of the paper

This paper comprises of four sections in addition to this one. The next section provides a brief history of heating in the UK by way of insight into the context in which the oral histories sit. We then introduce the theoretical framework for the paper (Actor Network Theory or ANT) and outline the oral history method application before explaining our approach to analysis. Relevant findings from the oral histories are then presented before the discussion analyses these findings in the context of ANT, drawing out the implications for the current transition to low carbon heating systems. We conclude by reflecting on the value of oral histories and analysis framed by ANT for understanding the social and cultural significance of low carbon heating transitions, as well as the specific implications of enduring attachments to the fireside for this transition.

Historical context

This section sets the oral histories in their historical context, enabling appreciation of the contextual factors shaping respondents' experiences and accounts. In recognition of the centrality of the coal fire in the oral history accounts reported here, the first sub-section outlines a brief history of the open fire, focussing in particular on its persistence in British culture and architecture. We then proceed to outline key events (political, economic, policy, infrastructural) shaping the fuels, methods, technologies and costs associated with home heating in the UK.

The persistence of the open fire in Britain

Our dwellings have always been designed around the fire. Indeed, the word hearth is derived from the Latin for focus or focal point and, until well into the 20th century, the fire was at the heart of daily life, as our only source of warmth, heat for cooking, light, and smoke for preserving food and fumigation (Flanders, 2014). When homes consisted of one room or 'hall', the fire was at the very centre, with smoke escaping through open roofs. Later, fires were built into walls, and chimneys carried away the smoke, making multi-storey homes possible. By the 1500s, most of our neighbours in Northern Europe had left us behind, having adopted stoves (closed units for burning fuel) whilst in Britain, we persisted with open fires fuelled by wood or peat (Ambrose, 2023). As coal was extracted on a larger scale from the 18th Century and became easier to move around and cheaper to buy, it became our primary fuel. Coal represented progress as a domestic fuel, producing more heat per tonne than wood. The extraction of coal came to dominate the economies and societies of coalfield regions from this point until around the end of the 20th Century and continues to be a strong feature of the identity and culture of those regions today, despite the demise of the coal mining industry in Britain (Strangleman, 2017). In such areas, there was little reason to hold back on coal consumption while the industry thrived: the more burned, the better it was for the local economy (Davies, forthcoming).

Strong cultural and emotional connections to the fireside have been recognised for some time and commentators have noted the particular strength of this connection in Britain, as denoted by the fact that fireplaces have continued to form part of our architectural heritage – incorporated as ornamental features – beyond the point at which they were needed for heating (Flanders and Bishop, 2007). Imagery of open fires is particularly abundant around Christmas time in the UK and is often chosen to capture the very essence of homeliness (Ambrose et al, 2023).

Key events in Britain's heating history since 1945

At the end of the Second World War, most homes in the UK still used coal fires and/or the coal-fired kitchen range for heating and hot water provision, despite being highly inefficient in terms of fuel consumption and household labour. Ninety-five per cent of homes relied on coal (or treated coal products, such as coke) for heating (Ministry of Fuel and Power, 1946).

Around 70 per cent of heat for cooking at this time was fuelled by gas (Egerton, 1942) but domestic gas provision at this time was via 'town gas' which was produced from coal. Access to the critical resource of coal was, however, heavily mediated by a range of factors including the post-war fuel crisis which extended the war time practice of fuel rationing until 1958. The housing stock and the fiscal environment were also significantly reshaped in the postwar period through major municipal housebuilding programmes in response to housing shortage and a booming population, the birth of the National Health Service (free health care for all at the point of access) and re-invention of the welfare state with the aim of providing 'cradle to grave' welfare (Garland, 2016). The question of how people heated their homes was intimately connected to all of these national developments.

Throughout this social re-invention, the country continued to warm itself on coal (as it had for more than one hundred years), but change was on the way. From the mid-1960s, the country embarked on an unprecedented period of domestic energy transition, the scale of which has never been matched since (Hutchison, 1987 and Goodall, 1999). A combination of legislative measures such as the Clean Air Act (1956) - introduced to clean up poor air quality caused by coal burning - and the concurrent discovery of massive reserves of natural gas (methane) under the North Sea, fast-tracked a national transition to gas home heating and the rapid decline of coal. During the natural gas conversion programme (1968-1977), the heating systems of 14 million households were substituted at an astonishing rate with 40 million appliances converted to be compatible with natural gas supply, creating a shift from coal reliance to natural gas readiness over a period 10 years (Sovacool and Martiskainen, 2020). This enabled a comprehensive shift from coal fired heating to gas fires and gas boilers. This scale and rapidity of transition relied on strong leadership on the part of local and national authorities (the gas industry was publicly owned until 1986) as well as compelling public information and advertising campaigns on the part of the Gas Council (Goodall, 1999) that captured the imagination and confidence of consumers.

The 1970s brought further disruption. Unrest in oil producing nations caused massive peaks in oil prices, leading to economic crises and the rationing of energy once again (Parliamentary Group for Energy Studies, 2012). Households faced massive inflation in the prices of everyday commodities and regular blackouts to reduce energy consumption. Although the transition to natural gas helped ensure that access to fuel for domestic heating and cooking was unaffected by the volatility of oil markets, increased financial pressure on households restricted consumption during this period (*The Economist*, 1974). The direct impact on mining households was lessened by the domestic coal allowance (concessionary coal) that miners received as part of their remuneration package. Rural households reliant on oil-based heating systems were particularly vulnerable.

The pace of change showed no sign of easing as the 1980s dawned, with the decade bringing devastation to coal mining communities across the UK as the Conservative government sought to move rapidly towards deindustrialisation (Parliamentary Group for Energy Studies, 2012). Most of those interviewed in Rotherham were profoundly affected by

prolonged periods of industrial action (i.e. the Miners' Strike) that aimed to save UK collieries from closure. During strike action, wages and access to concessionary fuel were withheld.

By the 1980s and 90s, 95 per cent of households in the UK (mainly in urban areas) were heated by gas central heating, which uses gas fuelled boilers to heat water, which is then piped around the home to wall mounted, metal radiators which heat rooms via convection. Where households had fires, in most cases, these would have been wall mounted gas fires or imitation coal fires powered by gas or electricity. This era brought stabilisation of energy supply and pricing with sustained reductions in gas prices, although high interest rates pushed up other essential costs (DECC, 2009).

The 'New Labour' era from 1997 triggered further, albeit incremental, transition. The Kyoto Protocol of 1997 pushed climate change up the political agenda and triggered more ambitious standards for the energy performance of new homes, leading to increases in numbers of low energy homes (Department for Trade and Industry, 2003). Low carbon heating systems such as air source heat pumps (ASHPs) became more common during this period, with installations peaking in 2011 and tailing off as a new coalition government came into power (Oldfield, 2015). ASHPs are electric heating units that convert outside air into heat, which is distributed via either radiators (air to water heat pumps) or blown warm air (air to air heat pumps) and are operated quite differently to gas systems, needing to run constantly at a low level, rather than turned on when needed (as a gas system can be). However, these developments are unlikely to have impacted beyond the small proportion of the population living in new homes and certainly would have benefitted few households in Rotherham, where most housing was built prior to the Second World War, to house a burgeoning workforce of miners.

At the time of writing, the transition from gas central heating to low carbon heating systems (primarily ASHPs) proceeds slowly, despite the legal imperative for the UK to reach net zero greenhouse gas emissions by 2050. Decarbonising domestic heating represents a significant aspect of the challenge, accounting for 17 per cent of current emissions (DESNZ, 2022). However, dependency on gas central heating is creeping down slowly from a peak of 95 per cent being heated in this way in 2018 to around 74 per cent in 2023 (UK Parliament, 2024). A significant milestone in the transition away from fossil fuelled heating also passed during May 2023, when the burning of bituminous (house) coal was banned in the UK, effectively signalling the end of the era of coal fires. After this point, households that burn coal in the home must purchase clean burning coal, which is significantly more expensive (DEFRA, 2023).

Methodological approach and case study background

The case for oral histories of domestic heating

Narratives of past heating transitions tend to operate at the grand scale (Darby, 2017), overlooking detailed and diverse social and cultural impacts and lived experiences of changes to heating technologies and fuels (Ambrose et al., 2024). They focus instead on the triumphs of technological innovation in terms of improved cleanliness, efficiency and health (Hernández, 2016). Grand narratives neglect personal stories that reveal more complex and nuanced individual and household realities, which Darby (2017) argues offer deeper understandings of how high-level policy and technological change play out in often complex and unanticipated ways in everyday life.

Personal stories about the past constitute oral histories (Goodchild et al., 2017), a method offering multiple benefits in the context of studying domestic energy transitions, including insights into both the pain and loss but also the excitement and hope of energy transitions (Perlaviciute et al., 2018; Martiskainen and Sovacool, 2021). They also reveal the entwinement between communities and their energy sources (Rohse et al., 2020). Oral histories reveal previously undocumented phenomena in the private world of the home and family, which technologists and policy makers rarely access, revealing the richness of human experience and how structural change impacts the personal (Goodchild et al., 2017).

Agar (2018) reminds us that advancements in heating technology solve some problems, whilst at the same time creating others in the form of societal and cultural interruptions and inequalities in relation to comfort, cost, familial relations, the sensory experience of home, gender roles and the structures and routines of everyday life. This level of insight gets lost within grand narratives and the impacts on everyday lives remain stored in the memories of those who lived through and with them. This makes it difficult for those shaping current transitions to understand the true impacts of past decisions, to avoid repeating past mistakes and to address injustices wrought (Ambrose et al., 2024). Oral histories offer a means of unlocking and capturing these insights, which may seem mundane and insignificant, but which are *"more than peripheral to the serious business of energy policy and transition"* (Darby, 2017).

JUSTHEAT responds to critiques of grand narratives (Darby, 2017) regarding our heating histories and advances an ambition to use oral histories to re-tell them as, what Foucault terms 'effective histories' that acknowledge diversity in the way history is experienced, revealing its inherent messiness and "crooked contours" (Veyne, 1997).

Application of oral histories

To prepare the ground for the oral history collection in Rotherham, the JUSTHEAT team made connections with community leaders who could champion the project across three different areas within Rotherham: Maltby, Whiston, and Wentworth. The reasons for focussing on these areas are outlined below, but the rationale behind pinpointing specific settlements was to help ensure the oral histories captured a variety of experiences and different heating pathways, and to give clear starting points for the recruitment of participants. The research team worked with the Community Coordinators, local councillors

and church councils. We also worked through community centres, local libraries, leisure centres, and a local history initiative. Spending time in these spaces and engaging in conversation with different groups at community events was fundamental to building the trust and project interest required for gathering personal stories.

The oral histories were recorded in participants' own homes, where there was consent to do so. This helped to situate participants' minds and memories within the domestic space, as well as to feel more at ease and open to sharing their stories. Each interview began with a standardised question that helped the narrator to position their thoughts temporally and centre thoughts on the topic at hand: "tell me about your earliest memory of keeping warm or feeling cold at home". In line with the principles of oral history, researchers intervened minimally in the narrative to keep the conversation on topic. The freedom afforded to participants to share what felt important to them led to coverage of a wide range of themes and topics in relation to home heating: heating technologies and fuels; supplementary heating; place identity; gender relations; domesticity, family, and everyday life; work and local economy; politics and policies; sensory experiences; and their own feelings and emotions in connection with home heating. Interviews lasted between 40 minutes and 3 hours. The accounts were recorded, with permission, and transcribed verbatim. Both the recordings and transcripts will be preserved for future interpretation and for posterity.

The case study location

The first of two JUSTHEAT UK case study locations was Rotherham, South Yorkshire. The town was chosen because of its strong connection with the extraction of coal – which, for over 100 years was the first fuel for domestic heating and industry in the UK and beyond. It is also of interest due to its current above national average use of gas central heating systems – as the prevalence of such heating systems declines across the UK, seemingly Rotherham is being left behind. The oral history research focused on three settlements within the broader conurbation: Wentworth, Whiston, and Maltby, described in turn below:

- **Wentworth** is a small rural village at the centre of a privately owned historic estate. Much of the wealth of the estate was derived from the mining industry. The estate owns the majority of the properties in the village and the practice of solid fuel burning in tenanted estate houses endures to the present day. Many of the properties in the village date from the early 1800s, are stone built and energy inefficient and do not have gas central heating.
- **Maltby** is a large township east of Rotherham, first developed around the Maltby Main Colliery in the early twentieth century. Maltby's economic entwinement with coal was severed following the (relatively late) closure of the mine in 2013, but its cultural heritage remains intimately linked to the industry. Maltby is a planned industrial settlement built between 1910 and the 1960s.

- **Whiston** has fewer direct connections to coal mining (although miners lived there), nevertheless, oral histories recorded in the area still highlight the historic centrality of coal in everyday life and the community. Whiston was a rural village until the interwar period when it expanded through municipal housing development.

The oral history participants

Ten oral history participants were recruited from each of these locations. Participants were self-selecting and were exclusively aged 56 and over. There was an even split between male and female participants in Wentworth and Whiston, but a higher proportion of women participated in Maltby. All participants described working-class backgrounds in their oral history recordings. Most lived in social rented housing as children, had fathers who worked as miners or steelworkers, and mothers who worked as cleaners, in retail, or as farm labourers, in addition to unpaid domestic labour. Across the three focus areas, however, Maltby was the only one that reflected some continuity in this socio-economic status. While all participants were now retired, employment for participants in Maltby had largely consisted of nonprofessional roles and only one participant out of ten was educated to degree level. Moreover, all participants from Whiston had held professional roles, and four out of eleven were educated to degree level or higher. Wentworth participants also held professional or semi-professional roles. Whiston particularly reflected the highest level of social mobility of the three areas in focus.

In terms of housing circumstances, the percentage of owner-occupiers within our sample in Maltby was high (80 per cent of participants) but 20 per cent were living in social rented housing. In Wentworth, the number of renters was significantly higher (50 per cent), but these properties were privately rented from the Estate. No residents in Wentworth were living in social housing and Whiston participants were exclusively owner-occupiers.

Only two of the oral histories were collected from participants from non-White backgrounds – they were both members of the same family. The research team hope to gain further insight into the experiences of people from non-White backgrounds by expanding the oral history collection for Rotherham.

Approach to analysis

As an interdisciplinary team, we needed to find an approach to analysing the oral histories that was accessible to all of us and integrated our disciplinary perspectives. As such, we took a highly inductive, immersive approach which involved each team member listening to all of the oral history recordings in full and noting what seemed particularly significant from our respective vantage points, as social scientists, historian, artist and architect, enabling the data to be viewed through a range of disciplinary lenses and avoiding a narrow or skewed

interpretation. While listening to the oral history accounts, the artist also drew them, a process of translation into movement and marks that adds an additional way of experiencing the stories for the drawer and for other researchers. We presented our analysis in a detailed research report, where we provided both a descriptive account of the oral histories gathered and also left intact our respective interpretations of the data as a starting point for future intermeshing as part of an interdisciplinary analysis. The potential relevance of ANT arose through this exercise, as a means of understanding the dominance of the coal fires in the oral history accounts.

Applying Actor Network Theory to the study of home heating

This section provides an overview of the theoretical framework that we have applied, for the purposes of this paper, to aid our analysis of the oral histories gathered in Rotherham: Actor Network Theory (ANT). As will be revealed, the oral histories reveal interdependencies between human and non-human actants and how they must act in concert (as a network or assemblage) to achieve an outcome, whether that is a warm room or the successful introduction of a new heating technology. This observation brought to mind the concept of the actor-network, as a concept that links both technical and non-technical elements to reveal the relationships between all of the actants involved in any given task. An earlier publication associated with JUSTHEAT – McCarthy et al (2023) – confirms that ANT has rarely been applied to the study of domestic heating or heating transitions and where it has (most notably by Hanmer and Abram, 2017), the theory has been used to understand how (primarily macro level) actor networks enable (or obstruct) social technical transitions, including adoption of new domestic heating technologies.

Here we apply ANT to the study of domestic heating at a different scale: that of the household and we use ANT to focus in on the intricacies of the crucial relationship between humans and their heat sources. A key motivation of doing so is to understand in more precise terms than we currently do, our relational - material (Ritzer, 2004) entanglements with our heat sources and to use this insight to consider how these entanglements might impact upon and fare during heating transitions.

ANT is primarily used for exploring socio-technical processes. It recognises and embraces complexity and entwinement, contending that the social, technological and material are interwoven. Within ANT, there is no division between society and nature, truth and falsehood, agency and structure and micro and macro level phenomena, amongst other things (Ritzer, 2004). This philosophy resonates with our project, within which we accept all respondents' accounts as their truth and where we see social and cultural factors, technology, agency, structure, and micro and macro level factors fusing together in complex and sometimes awkward and uncomfortable ways within participants' accounts of how they have kept warm at home over the years. Further, and particularly significantly within the context of this project, ANT regards human and non-human actants as equal in value and agency (the principle of generalised symmetry) and contends that it is the relationships

between human and non-human actants that create phenomena. It also resists strict delineation between the material and the relational, advancing a relational materiality that recognises that the material only achieves significance in relation to others actants (Ritzer, 2004). For example: a manual heating device remains inert until fuel is available and a human with the relevant skills interacts with the device and the fuel, giving it reality and form and enabling the generation of heat.

Another relevant feature of ANT is that it recognises that every actant within the assemblage or network, is in its own right an assemblage. For example, the human attempting to light the fire is comprised of multiple actants such as hands and dexterity to handle the fuel and the device, prior experience of performing the task, capacity to think and adjust their practice if they need to, and so on. The fuel and any tools that they use in the process are separate actants, made up of their own assemblages.

Reflecting the philosophy of oral histories (which afford maximum agency to research participants to tell their stories in the way they choose), ANT encourages the observer (in this case, the researcher) to open space for inquiry, rather than closing it down and attempting to reduce analysis to something more manageable and familiar (Latour, 2007). In this sense, ANT is the opposite of deconstructivism and encourages the observer to resist scrabbling to unpick the power dynamics and attribute the phenomena reported or observed to underlying forces (Collier, 2009). Instead, we are encouraged to consider who or what are the actants? How are the actants constituted (remembering that they are an assemblage in their own right)? How are the actants connected to one another and what is the strength of that connection? And how are they acting collectively (as part of an assemblage)?

Another aspect of ANT that is relevant to our analysis is translation, which concerns the ongoing process by which certain actants come to dominate the network and (whether deliberately or unwittingly) assure their position (Callon, 1984). Where that actant(s) is not effective as the dominant force or are deposed in some way, then the network may disintegrate or be reconstituted (Callon, 1984). For example: the coal fired range could be seen as the dominant actant in UK households at one point in time, becoming an obligatory ‘passage point’ (Callon, 1984) for access to warmth, hot water and heat for cooking and defining the roles of other actants within the network (i.e. mother stayed at home to keep the fires going). Yet, as time goes on, the range becomes dissatisfactory to the other actants in the assemblage, perhaps because cleaner, less labour-intensive alternatives are emerging and/or the skills to operate it are not passed on, then change begins to occur through network reinvention. Multiple assemblages might also operate in parallel, not least in the context of home heating, for example where a human might be part of an assemblage involving more primitive heating technologies and more sophisticated technologies at the same time (i.e. having a wood burner and a central heating system together).

The application of ANT to our analysis allows us to draw out and focus in on the significance of the relationship between human and non-human actants in the context of domestic heating. Understanding this fundamental relationship, through ANT, provides the starting point for analysis and can be expanded out to reveal which other actants are enrolled into the assemblage involving heat source and human, and how these networks respond to and challenge heating transitions. Through this process, neither the material nor the social takes precedence, which is important in avoiding either a socially or technologically deterministic position where the researcher is expected to choose between a social or technological explanation for the 'problem' (Latour, 1987). Doing so can risk losing sight of the deep interdependencies that exist between the material and the relational, in the context of home heating.

Our application of ANT is modified and informed by the novel team behind JUSTHEAT, that includes social scientists, historian, artist and architect. All of these perspectives open up different capacities in the ANT process. Significantly, the composition of our team enables us to understand some of the limitations of ANT in the context of a study that takes a long view of a particular problem, over decades. For example: the historian and the oral histories themselves allow a temporal stretch to the concept, recognising that our experiences are shaped by more than the present. The artistic process also bears similarity to ANT, being a compositional medium inherently able to hold together different elements and find forms for multiple and diverse relationships. To reflect this, we include a small example of the drawings made during listening and which formed part of the analytical process. These drawings reflect and visually represent the assemblages in focus within this paper.

The next section of the paper provides an account of key findings from the oral histories before analysing them using ANT in the Discussion.

Findings: memories of keeping warm at home

The 30 oral histories recorded in Rotherham reveal detailed and personal memories of home heating systems, processes, routines and methods of keeping warm, as well as feeling cold at home. The recordings particularly demonstrate the significance of the coal fire in the home in the immediate decades after the Second World War and how the transition to gas central heating reshaped domestic life and relationships in the later decades of the 20th Century.

Participants rarely reflected on life beyond the households that they grew up in and subsequent households they have been part of. External factors which determined the fuels, heating technologies and methods that they used to heat the home and the cost and availability of fuel were rarely mentioned, i.e. the national shift from town to natural gas, the miners' strike. Major events like The Clean Air Act (1956), which was pivotal in initiating the phase out of coal, and the energy crisis and rationing of the 1970s were explicitly recalled by very few participants, although some participants recollected the impact of these events (i.e. having to buy smokeless fuel, power cuts).

The oral histories firmly establish the coal fire (whether an open fire or a fire powering a range) as the historic centre of the home in Rotherham in the immediate post-war era. It was depended upon for heat, hot water and cooking and daily life revolved around the immediate, warm space surrounding it. Keith (Wentworth), for example, recalled that the fire was "crucial to the household". Usually only one main fire was maintained in each home, perhaps two and these were usually in the main living area(s). Memories of home heating in the era of the coal fire were abundant and intricate. It was where participants went to first in their recollections and lingered the longest. As they moved into more recent eras of heating (i.e. gas central heating), recollections became more vague, beyond remarking on improved levels of comfort and reduced labour and some references to disappointing experiences of early central heating systems.

Coal fires were remembered as comforting, bringing companionship, family togetherness and watching the flames brought a sensory, meditational quality that was widely enjoyed. The fireside was remembered fondly by most participants, particularly those who experienced them as children and were therefore shielded, to some extent, from the labour of maintaining the fires.

> "Everything happened around the fire, it was the centre of the universe. It was the centre of family life. Food. Smell. Laughter." (Female participant, Maltby)

> "Obviously it [the fire] was the central point. As a treat, we used a long toasting fork to toast some thick bread. Toast has never tasted as good as that." (Lynne, Maltby)

[INSERT] Image 1: Stories by the fire. Drawn in response to oral histories from Rotherham by Becky Shaw.

The practicalities of moving and handling fuel, building the fire, lighting it and maintaining it, were explained in intricate detail by participants. Recognition of the fireplace as a 'focal point' which facilitated social and emotional connections were pervasive, although the labour and grime of maintaining the fire and the discomfort of the cold space beyond the fire, were also widely recognised. The following quote from Mary, the only participant who still relies on a coal fire in the present day, illustrates the labour involved in maintaining an open fire:

> "I get up at 5am and I put the kettle on to boil. While the kettle boils, I get the fire cleaned out in the time it takes me to boil the kettle. I wear a mask and use a long brush. I've got it down to a fine art. Once a week, I brush out all the soot from behind those two doors, there are pipes which pump water round and heat the house. This fire heats the house. We have a chimney sweep once a year and I try and do it myself in between times. The soot is unbelievable. It makes such a lot of dirt. I am always cleaning. Soot everywhere. Not an easy method of heating but it is warm." (Female participant, Wentworth)

Lighting the fire and getting it going was recalled as a source of anxiety for some and it seems that few took it for granted that they would be able to get a roaring fire going. The pressure to do so was considerable, when the household relied on the fire for survival. Most participants described the same techniques for starting the fire, suggesting a shared understanding between households of the most effective approach. There was a sense of pride in the application of fire making skills and techniques and participants remembered parents being keen to upskill their children in relation to fire making, which was considered a vital life skill at the time. Graham (Whiston) proudly recounted how he was taught by his parents to make 'spills' out of rolled up newspaper, tied in knots so that it would 'burn slower' and help ignite the coal. He explained that he would hold a sheet of broadsheet newspaper over the fireplace so that air could only enter from the bottom, which would 'draw' the fire up and 'get the flames going'.

Graham remembered that as a child it was 'a bit dangerous', because, on occasion, the newspaper would quickly start to burn, but that just added to the sense of fun and excitement of being involved in lighting the fire. Small sticks (kindling) were also used, when available, for getting the fire going and was often foraged by children locally on behalf of their households. Several people also recounted the thrill of, as a child, being permitted to throw rubbish on the fire, to both fuel it and enable disposal.

[INSERT] Image 2: Throwing rubbish on the fire for fuel and play. Drawn in response to oral histories from Rotherham by Becky Shaw.

The coal fire or range were manual systems that did not evolve rapidly, meaning that knowledge about how to build and maintain a fire was passed between generations through repeated demonstration. It was widely remarked that the speed at which heating and domestic technology moves on now feels hard to keep up with and involves a constant process of upskilling.

> "You realise how much your parents did to keep you warm. The things they instilled, teaching us to keep warm. That sticks in my mind. It's not that I don't appreciate advances in heating but probably because later on you realise just how much was put into it and appreciate it a little bit more." (Female participant, Whiston).

[INSERT] Image 3: Families together round the fire, seeking warmth. Drawn in response to oral histories from Rotherham by Becky Shaw.

Life was lived out in one room in working class households, around the fire, until the transition away from coal began from the 1960s onwards. Fires were not generally lit in bedrooms, so other means of keeping warm at night had to be found: blankets and clothing were crucial, and coats were often used as bedding where families could not afford blankets or where extra layers were needed. Stewart (Whiston) recalled this practice. He described the coat as his 'companion on top of the bed'. Hot water bottles were also commonly used to help warm the

bed and in the 1960s electric blankets became more common and were remembered as a revolution in comfort.

There was great inequity in terms of access to fuel between those working as miners (who received concessionary coal) and those outside of that sector. To help overcome this, coal was shared within families and an informal economy of selling on surplus coal between households was established. Keith (Wentworth) recalled his father, an ex-miner, purchasing 'spare load'. He explained that 'everybody did it' - it was 'how it worked'. Stewart (Whiston), whose father was a steelworker, remembered cycling to his grandfather's house (about a mile away) to collect a sack of coal and wheel it back on the cross bar to his parents' house. He also had a trolley for collecting the excess coal from extended family members.

Coal merchants were relied upon in everyday life and were associated with some underhanded practices (e.g. underfilled bags, wet coal to maximise profits). Stories of sexual exploitation emerged in relation to households who could not afford to pay the coal man. Desperate times were widely recalled (due to economic crises, industrial action), where the coal man had to be placated, furniture was burnt to make a fire or families scrabbled around on waste heaps to find discarded lumps of coal.

The concessionary coal allowance received by miners, which outlived the decline of the mining industry by some decades, undoubtedly acted as a disincentive to transitioning to gas central heating in former mining communities. One participant (Christine, Maltby) recalled her family receiving concessionary coal well into the 1990s, due to her father's former employment as a miner. After her father died (his death reduced the coal allowance), her mother made the decision to transition to gas central heating. Many households in Maltby moved to gas central heating 20 to 30 years later than most urban households and many in Wentworth have still not made this change. For some households, gas central heating had taken some adjusting to, not least because it could not be budgeted 'by eye' (looking to see how much was left in the coal store) and because it does not offer the same intensity of heat, with several participants describing the nature of the heat from gas central heating as insipid or dissatisfying by comparison to the radiant heat of the fireside.

Decisions about who was responsible for lighting the fire often depended on the work patterns of the household, with some participants describing their fathers building the fire before leaving home for paid work and then mothers igniting it before the children got out of bed. Many recalled the hard life their mothers had lived specifically in terms of maintaining the fire(s) and being responsible for the thermal comfort of the family, regardless of the resources available.

> "Mum, bless her, had a life of drudgery trying to keep us all warm and fed. Must have been horrendous. Five children under ten and having all that to do. Mum was at

> home all day- that's all she did, looked after the fire, looked after the food. Lovely cosy memories but it was blooming hard work." (Female participant, Maltby)

Care is imbued in the recollections participants shared about the domestic work their mothers' and grandmothers' did. Deep enveloping care in the form of maintaining warmth through tending to the fire and knitting warm clothes, as well as cooking, baking and teaching children how to make a fire.

> "The fire in the kitchen, the black range: it had a space above the oven where Mum put our gloves to warm them." (Gillian, Whiston)

The lives of some mothers were recounted as being transformed by the advent of gas central heating and the critical mass of more affordable labour-saving appliances that emerged around the same time (from the 1960s onwards), including: plug in heaters, gas fires, gas cookers, fridges, electric blankets and later, central heating. There are recollections, though, of people finding long established ways of doing things and ways of structuring and organising domestic life, hard to part with. There was, however, limited recognition in the oral histories of the emergence of the 'double burden' that was placed on women following the advent of domestic labour-saving equipment, which resulted in more women having to balance unpaid domestic labour with paid employment. This was probably not remarked upon because the mothers of many of our participants had always carried this dual expectation.

Participants born in the 1940s and 1950s recalled childhood memories that resembled a Victorian childhood, with little change to the way homes were heated between their generation and that of parents and grandparents. Homes then modernised rapidly for many from the 1960s onwards with the diffusion of central heating systems and explosion of increasingly affordable domestic innovations entering the home. The enormity of this change meant that it was remembered in detail.

In the quote below, one participant describes how a move to a home with an early form of central heating, powered by coke (a byproduct of coal), liberated the family from the intensity of the daily regime that accompanied life around the coal fire. This change was brought about by a move to a modern home and provides an example of how a new form of heating system coalesced with other labour saving (i.e. washing machines) and portable devices (i.e. electric free-standing heaters) to seemingly make domestic life more joyous:

> "I was then 17 (1967) when we moved to the Rockingham Estate. A new council estate. It had central heating but that was a coke boiler- not gas. It was like another Universe! It was comfortable. Everything became less intense- you didn't need so much clothing. Everything was light and airy and warm. Bright and lovely. The days of cooking on the fire were gone. We had carpets! Not just peggy rugs we'd made. It was like living in a palace. Fabulous! Someone still had to fill the coke bucket up but it was less intense. The boiler could run all day without anyone doing anything. They

> got a washing machine! Mum used to have to wash by hand. It totally changed everything. We felt like millionaires. Life was good. We had electric heaters in the bedrooms if we needed them and a gas fire in the front room. The boiler heated the water but we could use an immersion heater in summer. The boiler didn't have to go all the time- the gas fire could take the chill off. We got a fridge at that point- that changed life as well." (Sue, Whiston)

There was strong recognition of the benefits brought by central heating, especially when powered by reticulated natural gas and required no manual handling. It was praised for its cleanliness and for heating the whole house, rather than one room. But, at the same time, there was much less enthusiasm for this era of home heating and the experience it produced, than there was for the era of the coal fire. Liz (Maltby) remembered the change to gas central heating as 'absolutely incredible', describing it as a shift from 'hard work' and being reliant on fuel deliveries, to 'all of a sudden' using a switch for instantaneous warmth. She had no desire to return to a coal fire, but shared that she missed the 'glow from a fire' and had considered having an electric imitation fire installed to recreate this.

[INSERT] Image 4: the transition to gas heating felt like the arrival of the future. Drawn in response to oral histories from Rotherham by Becky Shaw.

Some participants, brought their accounts right up to the present day, discussing the changing climate, some experimentation with modern, low carbon energy systems (i.e., ASHPs) (in Whiston) or discussing their fears about having to lose the comfort and convenience of gas central heating, as part of the low carbon transition. But the era of the coal fire was indelible in the minds of all those we spoke to.

> "Fires have been with me all my life. In the next house, we had a wood burning stove put in the summer house- we had it on even in the summer. Loved it. You can't get fires out of your blood." (Sue, Whiston).

Perhaps this is why, in Whiston, multiple participants had log or multi fuel burners installed in addition to modern heating systems and described how they derived comfort and enjoyment from them.

Graham (Whiston) explained that he made 'a conscious choice' to invest in a multifuel burner because they wanted to 'marry' having the efficient 'tucked away' central heating system that gave them thermal security, with 'a nice cosy warm fire' in the living space. Because of the effectiveness of the central heating, it did not matter to Graham if the fire in the living room could heat the whole house. Lynda added that the decision to install a multifuel burner was partly due to liking 'the look' and liking 'the idea of having the fire'. Graham describes his burner as a 'regression' but also 'lovely' and 'beautiful'. Graham thought his burner, in comparison to central heating, was 'more natural'.

Discussion

The Actor Network surrounding the coal fire

Oral histories are agentic and afford the participant freedom to focus on what feels significant for them. Given this freedom, all participants who remember the era of the coal fire (whether an open fire or a range) chose to foreground and prioritise the relationship between their household and the fire, throughout the interview. The fire was, as many participants expressed one way or another, 'the centre of the universe' to them.

Interestingly, the focus within the oral histories was rarely on the relationship between the participant themselves and the fire but tended to spotlight other household members and their roles. Often Mother and fire are central to the accounts, with these actants identified as being at the very heart of this vital, life enabling assemblage. Together, Mother and fire form a staunch 'passage point' (Callon, 1984) to warmth, hot water, food and feeling cared for. And, as a consequence of the need to co-locate around the fire, Mother and fire also became the passage point to family togetherness (for better or worse) – an excellent illustration of a relational-materiality in practice.

Mother and fire were not the sole members of this critical network, far from it, but they are portrayed as dominant within it. They each bring their own assemblages: for Mother, the heuristic skills passed down through generations by repeated demonstration, her hands, her time and so on. For the range: the metal it is made of, the systems and apparatus built into it also form part of the assemblage. Also crucial was the fuel: the coal delivered by the coal man and provided by the employer or other family members and the kindling gathered by the children – all actants within the network. The fuel was the vital, bonding actant that could unlock the heat making potential of the alliance between Mother and range.

[INSERT] Image 5 and image 5(2): inter-related forms of fire-making and -using from two different oral history accounts

An important distinction between human and non-human actants is highlighted. The fire place had no significance, beyond potentiality as a heat source, without the human actant that was often Mother, but Mother had significance beyond the network that her and the fire were dominant within – she was enrolled in a multitude of other networks, too numerous to list, as were other members of the household. Yet, regardless of how many other networks actants were enrolled within, every component of the assemblage linked to the fireside is indispensable and if one component is lost then the survival of the household is in peril. We heard that there were many times when this was the case – mainly due to interruptions to fuel availability caused by external events, including economic crises and industrial action. During these times, some actants fell dormant (i.e. the coal man) and additional actants needed to be enrolled into the network temporarily – for example, neighbours and members of the wider family and a share of their fuel, the doors and furniture in the house to be burnt in lieu of coal. Throughout all of this, the network appears to remain intact and flexes in response to the challenge. Once the crisis passes, the dominant configuration appears to return.

The oral histories almost exclusively operate in the minutiae of everyday life, making an ANT analysis possible due to the detailed insights into the make-up of the assemblages in place. Within them, the strength of the interdependency between fire, fuel and household is so fierce that exogenous factors feel greyed out within the accounts – present and at work within the network, but unspoken. This tendency appears to vindicate the contention within ANT that the micro and macro are fused, almost indistinguishable from one another. Many of the drawings made in response to the oral histories reveal this, with each page connecting extensive activities, both those seen as important (fire lighting, keeping babies warm) and those considered less so, such as children's 'play' with the fire.

Also present in the oral histories is a clear sense that the stability of this network in the decades following the Second World War, whilst delivering consistency to family life and ensuring the basic needs of human actants were met, effectively imprisoned Mother, locking her into a seemingly never-ending cycle of repetition and grime. We heard how children (in anticipation of their succession of their parents) were enrolled as more significant actants within the network when they were shown, as a rite of passage, how to light and maintain a good fire – skills that, in many cases, became redundant before they could be fully enacted, due to the transition to gas.

From this point onwards, we see an explosion of the number and range of actants involved in the networks that enable thermal comfort – with a plethora of electrical and gas powered devices becoming available and affordable. The dominance of the range or open fire begins to wane. Innovations like, for example, electric heaters, can be used in lieu of the fire on milder days and anyone can operate it, not just Mother. As household members become enrolled into multiple networks involving the range of new devices entering the home, Mother is remembered as entering different networks entirely at this time, such as those surrounding employment beyond the home (if she was not already concurrently engaged in those networks). Networks based around the range or fire waned further as new actants emerged, such as local government officials, gas boilers and associated central heating systems, pushing forward the substitution of coal devices for gas or electric.

Yet, crucially, many of the participants in this study have re-enrolled (by buying a log burner), at least partially, in the assemblage of human, fuel and fire, because, seemingly, this offers them access to the joy, intense warmth, and emotional comfort of the fireside that they crave. For others, this assemblage remains a necessity and it is noteworthy that in Wentworth, many households remain dependent on coal, which is rapidly becoming unaffordable since house coal was withdrawn from sale in the UK in May 2023. Here, there is another actant at work – the private landlord, who blocks the passage point between householders and the benefits of modern heating systems. However, it is clear that, aside from the escalating cost of coal, many households in Wentworth do not feel entirely dissatisfied with this arrangement.

In most cases, log burners or multi fuel stoves have replaced the range and have become supplementary rather than the main heat source, but the assemblage between device, fuel and humans remains, albeit mediated by a broader range of standards, legislation and restrictions, which are all also part of the network. And whilst it might be assumed that these networks will disintegrate once the generations for whom the fire was significant have gone, we suggest that the prominence of romanticised notions of life by the fireside in popular culture (particularly around Christmas time), mean that the desire will persist in future generations.

Future Actor Networks of low carbon home heating

In the pre-central heating era, there exists a tight and steadfast assemblage based around the fire. Ideas of generalised symmetry (the notion that human and non-human actants have equal value and agency) and relational-materiality (the critical co-dependency of humans and material things) remains intact in this manual heating scenario utilising relatively primitive technology (the range or open fire). However, as technology evolves, these principles arguably become diluted, with human agency and input reduced and all actors no longer equally interdependent. Human and heating apparatus are no longer the passage point to heat. This can be seen in relation to gas central heating supplied via the gas network, where we have the non-human actants of, *inter alia*, the boiler, control panel, radiators and gas supply (a fuel source requiring no human handling at point of use).

[INSERT] Image 6: examples of descriptions of gas central heating and operating systems within different oral history accounts

Once installed, the control panel requires a minimum of one interaction with a human and without further interaction will continue to provide heat until the equipment fails. The option of exerting more agency over the system is available and desirable but not essential until the point that the system fails. One participant illustrated this point, by explaining that her grandson had set her thermostat on a pattern that works for her and she does not need or want to touch the control panel. The same is largely true in relation to air source heat pumps- the method of domestic heating advocated within heating transition policy in the UK.

Looking deeper into the workings of the system, human actors are still heavily involved in enabling the gas network through the extraction and distribution of gas and so on, but under future Artificial Intelligence (AI) scenarios, our roles are likely to become diminished further (Ntakolia et al., 2021). It may be argued that the principle of generalised symmetry remains intact until the point where human agency is superseded, because we have the potential to interact with our modern heating systems (i.e., GCH and ASHPs) more than the minimum necessary, yet they are capable of functioning without our input for extended periods of time.

From an evolutionary perspective, if we feel in control of our environment then we have a better chance of survival (Leotti, 2010). When things feel out of control, biochemical

processes kick in that signal to us that we are facing some kind of danger (Inesi et al., 2011). So, where we are not of at least equal value and agency to technology within a network, this may feel unnerving and unfamiliar. Applying ANT to the case of domestic heating reveals how the long-established assemblages between human and non-human actors are disrupted by advancing, increasingly independent technologies.

To make the march of technological advancement in heating systems more acceptable and less likely to evoke feelings of losing control, do we need to integrate a more manual component, even if it effectively amounts to a placebo? Our participants seemed to take comfort in having multiple options for warming a space. We need to know there is always a route to warmth, even if the technological systems on which we depend break down or feel outside of our control. The multi-fuel stoves that more affluent participants enjoyed offer this potential and this may be part of the appeal of supplementing central heating systems with a simple manual heat source that we are confident with, particularly if we have been equipped with the skills or are willing to master them.

It is hard to avoid increasingly complex technological solutions to home heating. Turning solid fuel into heat is a physical and chemical process and requires little more than an operator and a container for the fire. Harnessing the heat in the air or the ground to heat buildings requires additional actants in the form of technology that translates a latent heat source into warmth in the home, but reduces our agency in the process. This technologically dependent route to warmth favours the digitally included – those with the assemblages in place to enrol effectively in networks with these technologies.

Conclusion

Heating transitions play out in the personal and private space of the home, an environment saturated with complex relationships and entanglements, between humans and other humans and between humans and material things. Due to their agentic nature, oral histories provide research participants with the space and opportunity to lead the researcher towards the relationships (or assemblages) that are most significant for them. Examining these relationships provides a helpful steer to those charged with designing and implementing domestic heating transitions, regarding the likely obstacles and opportunities from the perspective of the end user. The combination of the intricate, participant led accounts generated through oral history and processed through drawing and the detailed examination of those relationships which emerge as significant through ANT, reveals that heating innovations are not just a technological or a social challenge but a complex relational-material one. As Hargreaves and Middlemiss (2020) assert, in a domestic energy context, we do not act rationally, we act relationally. Yet, based on the evidence presented here, we contend that, in the context of home heating, these relational instincts cannot be easily separated from the relational-material entanglements they are bound up with. Policy

promoting heating transition must take account of this and policy makers themselves must take care not to the view the challenge from the confines of their own entanglements.

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