

Domestic Heating Transitions: A Literature Review

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Contents

1. Introduction	1
1.1. Overview of the project	1
1.2. Aims of the literature review	2
1.3. Review methodology	2
1.4. Methodology and concepts in the sources reviewed	3
1.5. Structure of the report	6
1.6. Historiographical review	6
2. Policy context and just transitions	7
2.1. Policy context	7
2.2. Policy focus on behaviour change	8
2.3. Just transitions?	9
2.4. Summary	13
3. Past heating transitions	14
3.1. Benefits of a historic approach	14
3.2. The transition to coal in Britain (sixteenth to twentieth centuries)	14
3.3. The transition(s) to gas in Britain (nineteenth to twentieth centuries)	15
3.4. Comparing past and prospective transitions	17
3.5. Summary	19
4. The spatiality of transitions	20
4.1. Scale and space	20
4.2. Rurality	21
4.3. The domestic sphere	21
4.4. Summary	22
5. Moving towards transitions	23
5.1. Expectations and needs around heating	23
5.2. Uptake of low carbon heating technologies	34
5.3. Personal histories of transition	36
5.4. Summary	38
6. Conclusions	39
7. References	41

Introduction

1.1. Overview of the project

This literature review forms part of the wider international research project, *'Looking back to move forwards: a social and cultural history of home heating'*, funded through the Collaboration of Humanities and Social Sciences in Europe (CHANSE) initiative. Within this project, we aim to understand how major changes to home heating and heating technology over the last 70 years have been designed, managed and experienced, how they have impacted our lives and what lessons we might learn for the current transition to low carbon systems.

This literature review and the development of a framework setting out all aspects of justice relevant to heating transitions forms Strand 1 of the project. Strand 2 will involve a policy and documentary analysis of historic and emerging documentation and formal accounts of heating transitions over the last 70 years at EU, national and local case study level, revealing the genealogy of current heating arrangements and decarbonisation plans and establishing the public discourses that participants will reference in the oral histories. Oral history interviews (Strand 3) with members of the public in case study locations around the UK, Sweden, Finland and Romania tell us in detail about their memories of keeping warm at home throughout their lives and the ways their lives have been affected by changes to home heating systems and routines. Artists appointed in each country will build exhibitions to show how heating has affected our lives in different ways over time and to start public conversations about a fair and progressive low carbon future for heating. We will work with communities leading, resisting and excluded from heating transitions to assemble a lasting archive of multi-media accounts of lived experiences of heating transitions, illustrating how they impact unevenly yet deeply on our everyday lives. These lived experiences will help put policy makers designing low carbon heating transitions in touch with their consequences for our everyday lives, helping to create a fairer future for home heating where the negative impacts of technological and digital innovation are understood and addressed.

The project revolves around the following research questions:

1. Can the concepts of just transitions and energy justice be effectively unified and together provide an adequate framework for understanding fairness in past and emerging home heating transitions?
2. What are the policy and popular narratives that have developed around past heating transitions in living memory? How were they informed, approached and implemented and with what effect? How have past transitions influenced present transition pathways?

3. How have past heating transitions and associated technological change played out within and impacted the lives of citizens emotionally, materially, socially, economically, culturally and politically over time? How have these experiences varied across places, time, gender and different social groups?
4. What lessons can be extracted from lived experiences of past home heating transitions to improve the fairness of transitions to decarbonised and digitalised home heating?

1.2. Aims of the literature review

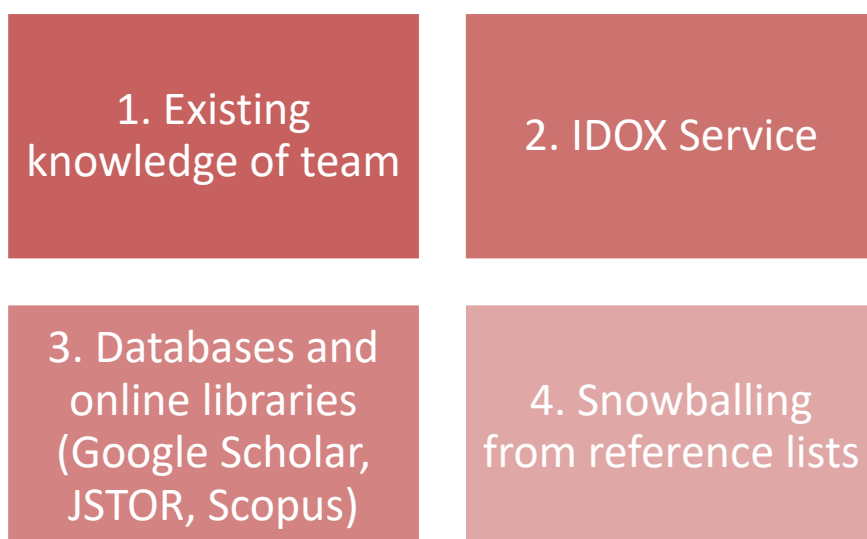
The main aim of this literature review is to identify the extent of existing literature – both academic and policy – on domestic heating transitions, and to explore the methods, theories and concepts applied. We were particularly interested in understanding what the existing literature around heating transitions tells us about:

1. How past and present heating transitions (anywhere in the world, but particularly in Europe) and associated technological change have played out in the home and impacted the lives of citizens emotionally, materially, socially, economically, culturally and politically? How have these experiences varied according to place, time, gender and different social groups?
2. To what extent does the literature deal with these themes? If it doesn't, then what related themes does it engage with?
3. To what extent does the literature take a historic approach, looking to identify the origins of contemporary domestic energy challenges and learning lessons for the present?
4. What theoretical or conceptual frameworks are used in the studies identified? How do understandings of heating transitions vary across the literature according to the different frameworks used?
5. What methods have been used to study lived experiences of heating transitions? How have the methods used affected the depth of insight achieved? Who is represented in these studies?
6. The extent to which concepts of justice and fairness have been considered specifically in relation to home heating transitions. Where this is the case, which definitions of justice have been used and what conclusions have been reached?

1.3. Review methodology

It is important to acknowledge that the subject matter of this literature review is broad-ranging and time constraints have meant that we have not been able to cover the considerable body of literature on heating and energy transitions and justice in its entirety. As such, this review should be seen as a synopsis which aims to identify and examine some of the key issues rather than provide an in-depth and comprehensive review of all that has been researched and written about the subject.

Figure 1: Search tools



As illustrated in *Figure 1*, relevant academic and grey literature was identified through the existing knowledge of the research team, an IDOX Information Services enquiry, database searches (including Google Scholar, JSTOR and Scopus), and snowballing from existing reference lists using the search terms 'heating transition(s)', 'energy transition(s)', 'lived experience', 'home', 'domestic', 'justice' and 'impact(s)'. To manage the evidence review within the given timeframe and resources, this study has focused on international literature published (or available) in the English language from the year 2000 onwards¹. This approach also allows for the inclusion of a wide range of evidence, taking into account the substantial growth of literature on energy policy during the last two decades. Documents included academic journal articles, policy documents, research reports, book chapters, books (where available online or to the wider research team), conference proceedings and doctoral theses. The titles and abstracts (or summaries where abstracts did not exist) of the studies retrieved after the searches were carried out were screened against the inclusion criteria. Following a full-text screening to determine the relevance of the sources against the questions for the literature review, a total of 133 sources were read, synthesised and included in the review.

1.4. Methodology and concepts in the sources reviewed

The 133 sources in the scope of the review employed a range of methodologies and methods, including a combination of ethnography, case studies, repeat/longitudinal interviewing, case biographies, oral histories or 'storytelling' methods, in-depth interviewing (with individuals and households), focus groups/workshops, photo methods, secondary data analysis, observation methods, document and primary/archival source analysis, drawing methods, diary and blogging methods, 'house tours', surveys and questionnaires, evidence/literature reviews, statistical modeling, regression analysis, user journey maps, 'talking methodologies', online methods (including monitoring of online forums) and interventions. Some of the sources reviewed were conceptual papers, journal editorials, or review papers in which no primary empirical data was included.

In terms of who the empirical studies represented and included, the findings were also mixed and depended on the aims and scope of the investigations. Some were limited

¹ In some cases, sources that were published before 2000 have been included if they are considered the most appropriate to provide contextual or definitional information.

to professionals, including policymakers (Chappells & Shove, 2005), building practitioners (Chappells & Shove, 2005), energy researchers (Janda & Topouzi, 2015), consumer representatives (Neller et al., 2022), or a mix of professional stakeholders (Sandri et al., 2021). Where studies sought to include residents, there were both attempts to reflect diverse residential contexts and socio-economic status (Devine-Wright et al., 2014; Cupples et al., 2007; Groves et al., 2016; Mallaband & Lipson, 2020; Peterson, 2008; Shirani et al., 2013) and in-depth studies where participants were not intended to be sampled with notions of representativeness in mind (Butler et al., 2014; Tjørring, 2016). Some specifically sampled from low-income householders (Darby, 2017). Where specific sites were the focus of studies, this often meant the sample was skewed to participants with similar income levels, occupations, or housing tenures. For instance, Goodchild et al. (2020), in a study of Lochiel Park – a model green village in South Australia – acknowledge their sample likely consisted of relatively affluent people employed in or retired from professional, creative or business types of occupation. Samples were also determined by inclusion criteria limited to homeowners who had invested in improving the energy efficiency of their house and were thus relatively advantaged in terms of income (Ellsworth-Krebbs et al., 2019; Hards, 2013; Sopha et al., 2010). Most studies included a varied sample of age groups, whereas others focused on one age group in particular. Where this was the case, it was predominantly older people who were the focus (Day & Hitchings, 2011; Hitchings & Day, 2011; Tweed et al., 2015).

The review identified a number of gaps in terms of representativeness which are substantiated by other scholars, notably in terms of the experiences of people from ethnic minorities, women, the working class and disabled people.

“In the emerging literature on social difference, scholars pay attention to populations that experience injustice, pointing out that the interests and experiences of women, people from ethnic minorities, working class and disabled people are poorly accounted for in environmental policy and research” (Ivanova and Middlemiss, 2021, pp. 1188).

Further, given the many entry points whereby energy transitions intersect with race (Newell, 2021), gender (De Wilde, 2021), class (Patnaik & Jha, 2020), and other exclusions (Ivanova and Middlemiss, 2021), it is important to ensure any study on energy (or heating) transitions pays serious attention to these issues through an intersectional lens rather than a singularly focused framework (Johnson et al., 2020). Newell (2021) suggests a number of concrete ways in which this might be incorporated methodologically in relation to race: being alert to and asking about race in interviews; seeking to include diverse samples; and confronting ‘methodological whiteness’ by checking epistemological and ontological premises for Eurocentrism and racial connotations.

Of relevance to this project, several of the studies reviewed adopted a biographical approach in understanding energy transitions. Butler et al. (2014) apply biographical analysis to offer a grounded approach to understanding energy consumption and its transformation over time. A biographical approach, they argue, offers opportunities for understanding the active role of the person and the interconnections between agency and structure within the realities of everyday life. Through their presentation of case biographies, they show the agentive roles of their participants in challenging and (re)creating structures through ‘doing’.

The growing body of work around ‘energy biographies’ (Butler et al., 2014; Darby, 2017; Grove et al., 2016) highlights the value of close and detailed examination of transition experiences – and although there is a role for quantitative analyses too – they have much more to tell us about “stability and change, the significance of the physical and social, understandings, competencies, and agency” (Darby, 2017: 127) than

measurements alone. Going beyond studies which have used qualitative interviews or quantitative survey methods to investigate people's perceptions of their energy use or adaptation to new heating technologies, Goodchild et al. (2017) employ oral histories as a means to understand heating behaviour by encouraging respondents to articulate the past in terms of stories. They cite the value of oral history as one of foregrounding the ontology of personal experience. Oral histories evoke and tap into sensations around methods of heating the home that reveal a sense of place and architecture. In their study aimed at demonstrating the validity of oral history as a research method, Goodchild et al. (2017) draw on the oral histories of eight respondents from a variety of backgrounds to explore a range of scenarios in terms of fuel types and heating practices.

Similarly, 'storytelling' has also become a popular methodology in the field of energy research. This can be traced back to 2012 when a storytelling approach was adopted by an International Energy Agency demand-side management research programme on behaviour change (Task 24) to help relate theory to practice (Mourik and Rotmann, 2014). Janda and Topouzi (2015) focus on the use of narrative structure of these story types, noting how energy-efficiency 'hero stories' – tales that show how energy efficiency can be achieved and works in practice - are by far the most common (more so than 'learning stories'). The authors argue that telling more learning stories would help to balance and develop the inspiration provided by hero stories:

“Learning stories [...] provide support for explaining ‘unintended consequences in policy/initiative outcomes’ and may help in testing ‘the ethical nature of predictions in policy formulation and evaluation’” (pp. 529).

Through outlining a series of case studies to explore how researchers frame particular energy stories, they surmise that energy researchers generally interpret the facts optimistically, and tell a story that looks as heroic as possible, with a tendency to underplay deviations from predictions. They draw on the example of work on low-energy design commercial buildings which shows that assumptions about how people will use 'special' buildings can be overly optimistic (Lenoir et al., 2011).

Dubois and Sinea (2023) offer a comprehensive overview of best practices that can guide future qualitative research in the field of energy poverty. Firstly, researchers must acknowledge that households experiencing energy poverty encounter interrelated challenges in their daily lives, and should take into account the constraints that result from these situations. Secondly, they suggest that researchers should scrutinise their interviewee recruitment methods to avoid excluding individuals who are at high risk of energy poverty but are hidden or difficult to reach, and reflect on the impact that their exclusion may have on research outcomes. Thirdly, they emphasise the importance of building trusting relationships with interviewees to avoid reluctance and negative emotions resulting from the research being viewed as an invasion of privacy. Fourthly, conducting interviews at the interviewees' homes is preferred as it enables a better assessment of their living conditions and the challenges they face in accessing energy. Lastly, researchers should be aware of interviewees' attitudes, such as downplaying their difficulties or using humour to hide their despair.

The conceptual frameworks employed by the studies under review are flagged throughout the report as individual studies are discussed. In summary, while the studies offered distinct contributions from their particular focus, a number of common themes were identified in terms of the concepts they applied and advanced. Many of the sources draw on some variation of practice theory (Reeve et al., 2013; Scott & Powells, 2020; Shove & Walker, 2010; Watson & Shove, 2022) interested in understanding how practices (rather than individuals) emerge, change and connect as their primary topic of enquiry. Through this lens, heating (as well as the underpinning construct of comfort) is a practice that is generated and sustained by various

discourses and actors at particular times. Transitions to different ways of heating, then, require an understanding that goes beyond the mere technicalities and usability of technologies to an appreciation of the socio-cultural origins of practices of heating. Oral histories, as outlined above, are one such way of accessing this knowledge.

1.5. Structure of the report

The remainder of this report is structured as follows: chapter 2 sets the scene by introducing the current policy context as well as current and future policy challenges in terms of effecting equitable energy and heating transitions; chapter 3 turns to the literature on the history of previous transitions for the insight it provides for the contemporary context; moving from the temporal to the spatial, chapter 4 considers literature on the scale and geography of transitions; chapter 5 looks at how transitions have played (and play) out in the domestic sphere; and chapter 6 draws out preliminary findings and key points from the literature reviewed which are of particular relevance to the review questions and wider study. A full reference list is provided in chapter 7.

1.6. Historiographical review

This report is one of two reviews of academic scholarship to be produced as part of the wider international research project, *'Looking back to move forwards: a social and cultural history of home heating'*. Here, the focus is on social science and built environment literature published over the last two decades. Chapter 3 identifies key studies that have taken historical approaches to understanding past heating transitions and related this back to the current energy landscape. The second review will build on chapter 3 through a detailed historiography of the concepts, themes, and events that have shaped home heating since the Second World War.

The historiographical review will analyse scholarship across the fields of social, cultural, political, and economic history to explore moments and movements that impacted how homes in Europe were heated in the past and how this has changed. It will illuminate historians' understandings of ideas including domesticity, comfort, labour, leisure, health, consumption, and standards of living, considering these ideas in relation to class, gender, and identity. The purpose of the second review is to establish the historical debates in which the human experiences of domestic heating are situated, grounding the analysis of home heating memories fundamental to this study, in historical thinking.

Primarily this project aims to use detailed understandings of how changes to the technologies and fuels we use to heat the home impact our lived experiences. We hope to utilise these lived realities to promote fairer, more humane outcomes associated with the current transition away from fossil fuels. Both the social science review set out here and the historiography to follow will provide vital context to inform the study from data collection, through to analysis and impact promotion. The two outputs should therefore be read and taken together.

Policy context and just transitions

2.1. Policy context

The UK Government's Heat and Buildings Strategy signals an end for gas boilers in Britain, with an aim to phase out new boiler installation by 2035. The House of Commons Committee report, *Decarbonising Heat in Homes* (BEIS, 2022), published in February 2022, notes that heating in homes in the UK will be decarbonised by one of three low carbon technologies: (i) heat pumps, (ii) hydrogen, and/or (iii) heat networks, alongside insulation upgrades. It recognises that more needs to be done to explain how, why and when residential heating systems will be required to change as well as the potential costs and benefits of this transition.

Within the EU, policy documents on the energy transition of housing and home heating focus both on decarbonisation and improved energy performance of buildings (European Commission, 2020). In the policy context of the Renovation Wave, buildings with low energy performance are targeted as a means to alleviate energy poverty. Depending on nation-specific contexts within member states, focus is either on both decarbonisation and improved energy performance, or leaning more towards one of them. In Sweden, for example, home heating has been close to completely decarbonised since the 1970s, and much policy focus over the past years has instead been directed towards improved energy performance of housing (Energimyndigheten, 2020). In addition, energy poverty has been a relatively minor issue in Sweden owing to several beneficial factors such as a generally well-insulated housing stock and a strong social welfare system (von Platten, 2021). As such, the strong policy focus on the worst-performing buildings, to a large extent coming from the EU, has not primarily been a means to combat energy poverty; instead, given that a low technical efficiency of housing and appliances tend to correlate with a low household income, it has been found in Sweden that a focus on the worst-performing buildings leads to structural injustices in the energy transition of housing where many of the costs and burdens of transition end up on households with limited abilities to afford, influence, and adapt to transition measures. This highlights the need to attend to nation-specific contexts and showcases the diversity of energy-related vulnerabilities among member states in general, and the varying exposures to energy poverty in particular (von Platten, 2022a).

However, in the ongoing energy crisis, energy poverty has emerged as an increasing issue in Sweden (von Platten, 2022b), and the severity of the problem has grown across the EU. Simultaneously, heating transitions are accelerating and adopting new characteristics. In Sweden, the energy crisis has not only enhanced incentives for the improved energy performance of housing, but has also led to new policy suggestions of conversion from direct electric heating in favour of more efficient electric heating systems or district heating.

2.2. Policy focus on behaviour change

The transition to low carbon heating is in part reliant on households being willing to make changes to their home heating, and therefore being fully informed about the potential benefits and how such transitions might affect them. An inquiry for the select committee report (BEIS, 2022) found that awareness of the required transition among consumers was very low (also see Hyde and Norman, 2020; Neller et al., 2022). The key barrier to a low carbon heating transition, the report argues, is consumer buy-in, to be addressed through behaviour change and ‘extensive public awareness campaigns’. For instance, the report cites the Climate Change Committee’s *Sixth Carbon Budget Report* which supports the role of Government in guiding people to ‘make the right choices and bring about behavioural change’. The report acknowledges that an important facet of such a public awareness campaign is building trust, i.e., communicating through trusted channels and providing support to vulnerable consumers, with a key role for local authorities in the delivery of consumer engagement.

The emphasis on behaviour change – such as that in the Select Committee report (BEIS, 2022) - remains one of the dominant positions on how (and why) social change happens in relation to heating transitions. This ‘human-centred approach’ (Orlikowski, 2007) understands the adoption and use of technology as a function of personal attitudes, values and choices, and assumes a degree of economic rationality in which actors, if equipped with the necessary technical information – and financial support or capability - will make informed and responsible decisions about their consumption practices. This position is critiqued by Bickerstaff et al. (2016), among others, as overly framed around individual choice to the neglect of socio-cultural and structural contexts of domestic life and the effects of technology on what people do and why.

The select committee report (BEIS, 2022) goes on to point out that increases in ‘general awareness’ do not necessarily effect large scale behavioural change. Results from the BEIS Public Attitudes Tracker (December 2020) show that respondents’ likelihood of installing renewable heat systems over the next few years was limited. The report goes some way to acknowledging how actions are needed that go beyond behaviour change and awareness campaigns in stating “it is clear that current technologies to decarbonise home heating lack widespread consumer awareness and are at price points that make transition costly for most households” (pp. 45). However, the report’s recommendation to address cost limitations only goes so far as suggesting more robust consumer protections to cover poor quality installations. While this may go some way to building consumer confidence and trust, it fails to directly address the issue of affordability, and the report also calls on Government to set out a plan for how it expects the industry and consumers to phase out the installation and use of gas boilers by 2035. The report recommends that the Government reapportions environmental levies to improve the financial attractiveness of electrified heat and encourage the uptake of electrified low carbon heating systems incrementally over several years, which is accompanied by mitigating the negative impacts on fuel poor and vulnerable consumers through targeted financial support programmes. Others have recommended the establishment of local-level plans to outline suitability of different forms of low-carbon heat by geographical location with a need for the Government to outline a timetable for the development of local energy strategies led by local authorities in partnership with relevant organisations, such as housing associations (Hyde and Norman, 2020).

In contrast, UK research involving public focus groups and expert interviews revealed that there might be more widespread support for ambitious and transformative policy than is often assumed (Upham et al., 2023). The public and stakeholders expressed a shared preference for 2-3 policy options that would impact energy and transport poverty. Both groups prioritised cheaper and simpler bus and train fares as their top-ranked option, followed by restarting bus services to pre-COVID-19 levels. Despite

some doubts, they also agreed on the importance of requiring landlords to improve the energy efficiency of rental homes as their first choice, followed by expanding an income supplement scheme and ensuring that new homes have at least 75 per cent lower carbon emissions (Upham et al., 2023).

2.3. Just transitions?

In the energy research literature, debates have arisen about the multifaceted concept of energy justice (Sovacool et al., 2019). These debates, for the most part, have been focused on national scales, such as how moving from a fossil fuel-based to a low-carbon energy system raises questions about equity (Sovacool et al., 2019). Laird (2013) argues that the term 'energy transition' (and by extension, 'heating transition') risks downplaying the social and political disruptions such changes bring about. Energy systems, Laird (2013) argues, are more than fuels and technologies; they involve everything from how individuals work, play, socialise and eat to how cities and economies grow. If energy systems embed social forms, it follows that changing such a system disrupts those forms and restructures the decisions that individuals, groups, organisations, and governments face. Energy policy should be alert to the social factors of energy transitions rather than having a sole focus on technology, then. Framing a revolution as a moment when new possibilities and opportunities arise, a low carbon revolution requires governments to act as benevolent stewards to ensure the transition brings about quality to people's lives (rather than causing damage or unequal benefit as some past revolutions have) (Hanmer and Abram, 2017). For instance, these social factors have been studied in relation to the phase-out of fossil fuels in the transition away from peat in Finland. Lempinen and Vainio (2022) use survey research to investigate the impact of phasing out peat on the livelihoods of those engaged in the peat industry. Further research on the Finnish energy system has emphasised that debates and rhetoric on peat are connected to wider changes in the international energy landscape (Lempinen, 2019).

Belleflamme's (2018) comprehensive review of energy justice literature emphasises the importance of prioritising people, local contexts, and needs over purely economic considerations in the transition to sustainable energy. To achieve this, Belleflamme advocates for a participatory approach to energy transition, such as community ownership and public participation, which would create a favourable environment for the development of renewable energy. By engaging communities in the decision-making process, transition would be more attuned to the unique needs and circumstances of each community, resulting in a more sustainable and just energy landscape.

Affordability

Belleflamme (2018) explains that affordability plays a dual role in ensuring a fair and equitable transition to sustainable energy. The first aspect involves setting prices at a level that allows energy consumers to access basic energy services, such as heating and lighting their homes, without undue financial hardship. The second aspect emphasises the need to ensure that energy costs do not disproportionately affect low-income households, with prices that are fair, stable, and do not require a significant portion of their income to cover essential services.

In many countries, clean energy technology is considered a luxury so it is likely the benefits will accrue to households who can afford them rather than by those most in need (Lewis et al., 2020). In recent research, Corlett and Marshall (2022) consider how the next stage of the net zero transition will impact on living standards, particularly for households on lower incomes. They focus on the need to catalyse large amounts of upfront public and private investment that will reduce emissions from home heating. As the authors point out, meeting the *Sixth Carbon Budget* requires emissions from

homes to fall by 44 per cent by 2035, a quadrupling of the pace between 2005-2020. This will require two major changes: insulating leaky homes and replacing carbon-intensive heating systems (gas and oil boilers) with clean alternatives. The Government are placing greater emphasis on the clean heat strand of this challenge in the first instance: the 2021 *Heat and Buildings Strategy* outlined ambitions to install 600,000 heat pumps per year by 2028, offer voluntary £5,000 grants to homeowners keen to invest in clean heating systems, implement regulations on homebuilders and bring in a sales mandate on boiler manufacturers. The authors echo wider concerns, however, that the majority of the UK's housing stock falls short of the thermal efficiency standards required for a heat pump to heat a home effectively, and there is much less of a government plan to tackle it or policies supporting the required level of insulation for lower income households. The move towards alternative lower carbon heating systems means gas network demand is set to decline rapidly, which has implications for lower income households who are more likely to be slower to disconnect from the system leaving them to pick up the significant costs of increasingly high gas prices.

Affordability issues associated with low-carbon transitions span beyond the UK, and have been written about in regards to a range of international contexts. Sandri et al. (2021), for instance, through a literature review and stakeholder workshop, consider the potential implications of decarbonising Australia's residential gas with hydrogen in terms of energy vulnerability. Workshop participants recognised vulnerable households as having less flexibility in terms of energy use, often unable to upgrade appliances or other energy efficiency measures such as insulation. As such, these constraints – coupled with, they argue, a lack of energy literacy – are likely to leave vulnerable households 'stranded' and less able to benefit from electricity-based moves to decarbonisation. Transition to hydrogen was seen as impacting household costs through replacement of appliances and increased fuel prices, as gas companies would seek to recover the costs of development and implementation of new technologies, which would potentially have disproportionate effects on vulnerable consumers less able to make the required changes and left to pay higher energy prices as a result. Similar to concerns about energy transitions in the Global North, the review also found an inequity of access to low-carbon energy forms in the Global South due to high start-up costs (Johnson et al., 2020).

Social and political identities

Recognising that not all energy consumers have the same needs and resources is vital in the transition to a low carbon future. Low-carbon transitions, more broadly, have been discussed in terms of their uneven impacts on different societal groups, whether in relation to undemocratic processes in taxation, roll-out, ownership and implementation; workforce conditions and rights; or exclusion of marginalised groups who unfairly suffer the consequences of being left behind under fossil fuel regimes. Among the 19 recurring injustices surrounding smart meters in Britain, electric vehicles in Norway, nuclear power in France and solar energy in Germany, Sovacool et al. (2019) find that the low-carbon transitions under study exacerbate inequalities among already vulnerable groups, including older people, those living in poverty, with disabilities, mental health needs, in large families and in rural areas.

Studies have begun to look in-depth at energy transitions in terms of how they intersect with race. Newell (2021) suggests four areas of intersection between race and the study of energy transitions as entry points for further analysis. The first suggested entry point relates to the historically racialised production and contemporary reproduction of energy systems and regimes. This includes further work in uncovering the racialised ways in which wealth from the exploitation of energy resources underpins the current global economy, building on the work of historians who have described how the slave trade was central to the development of industrial capitalism in England in the eighteenth century. In terms of contemporary practices, Newell (2021) highlights

France's nuclear colonialism in the Pacific through nuclear testing in French Polynesia, China's role in energy extraction in Africa as well as 'climate colonialism', or the privileging of strategies of 'green grabbing' to secure land, forests and other resources in the Global South as sinks over the more challenging task of reducing emissions in the Global North. A second entry point concerns the governance of energy transitions through racialised governmentalities, and who is included and excluded from decision making around energy policy and projects. The third entry point suggested by Newell (2021) is around the socially uneven impacts of energy transition pathways – in terms of who is left behind by energy transitions, and how costs are displaced and benefits accrued in uneven ways. Newell cites work that reveals, for example, how the drive towards electrification may (inadvertently) intensify racialised economies of extraction of key minerals such as cobalt. The final entry point relates to the racialised politics of resistance, including how the tactics of environmental movements fail to take into account the lived experiences of marginalised communities of colour (Extinction Rebellion's strategy of mass arrest, for instance, fails to consider groups for whom there is a history of mistreatment by the police).

Adding to this body of work, and offering avenues for change, Lennon (2017) suggests reconceptualising 'Big-E' systems in ways that connect with lives obfuscated by industrialised transformations of matter, looking at large-scale renewable energy projects in Native American communities as being instructive towards this end. These communities go beyond simply democratising solar energy to offering insights on how to decolonise it, through "disentangling it from the historically intersecting colonizations of brown bodies and non-human nature" (pp. 26). Lennon suggests various ways of fostering relational energy in an industrialised context, namely black energy democracy activists cultivating relations with Global South activists protesting exploitative conditions of solar panel production; cultivating relations with our immediate environs by attenuating our dependence on industrialised energy; cultivating relationships with the land that sustains us, "the biospheric matter from which many blacks were displaced in the fossil fuel revolution" (pp. 26); and continuing to prioritise the development of energy systems that connect neighbours and communities together.

Lewis et al. (2020) consider the implications of energy transitions in light of gentrification and displacement, particularly for low-income African American communities. As more households are equipped with energy-efficient technology, the value of properties is likely to increase. While on the one hand, the improvement of housing stock and community infrastructure is a positive action, these changes may also drive up the cost of living in the area and price out original community members.

Recent research is also beginning to address the significant gap in environmental literature on the needs and experiences of disabled people, particularly in relation to transitions to a more sustainable future (Ivanova and Middlemiss, 2021). Recognising that disability covers a broad spectrum, and an inclusive approach to transition should consider the diverse impacts that disability has on people's energy use and requirements, Ivanova and Middlemiss (2021) nevertheless identify some common trends in disabled people's lives that have clear energy implications. These include observations that disabled people's energy use is likely to be lower than average given that they earn less on average than non-disabled people. However, since people in poor health travel less, their requirements for energy use in the home are likely to be high. They also point out that some disabled people have specific needs around energy use whether higher room temperatures, use of electrical equipment or access to a car. At the same time, they cite previous research which has shown that through a combination of low-income levels and high energy needs, many disabled people are unable to afford adequate energy services, often resulting in their disability being exacerbated. They conclude that energy transition policy needs to take account of the

needs of disabled people who may be at risk of further marginalisation by policies that require households to reduce consumption or increase investment.

In a review of literature to understand how the diffusion of low-carbon technologies impacts gender and social equity in intersectional ways, Johnson et al. (2020) uncover a number of implications. The majority of countries covered in the sources reviewed were Asia (45 per cent) and Africa (27 per cent) so the conclusions are more applicable to transitions in regions of the Global South. However, a key theme to emerge was around the consequences for women's labour. Despite the benefits, energy transitions can merely shift inequalities rather than eradicate them. While some studies show how solar and biofuel energy has a positive effect on women's empowerment in rural villages by decreasing workloads and allowing them to focus on other activities or on pursuing employment, it has also transferred labour from one domestic domain to another. In such a sense, gendered divisions of labour remain entrenched despite the introduction of a new energy source. In Denmark, Tjorring (2016) notes that women often self-exclude from decisions about energy renovations in the home, despite being concerned about the environment. To redistribute engagement with domestic energy decisions, Tjorring (2016) suggests campaigns that target women but also notes that the disconnect between campaigns and the reality of households' relationship with energy and technology needs to be redressed before gender barriers can be bridged.

The extent to which energy policies address exclusion based on caste, class and gender in India was the focus in a paper by Patnaik and Jha (2020). They analyse a recent initiative by the Government of India for the provision of clean cooking energy – Pradhan Mantri Ujjwala Yojana (PMUY) – and the extent to which it was able to enhance use of liquefied petroleum gas (LPG) by overcoming existing caste, class and gender-based exclusion. While PMUY has recognised inequality across social groups in terms of access to clean cooking energy, less attention was paid to affordability of the fuel for historically deprived castes, races or tribes who have faced extreme social isolation in India on the basis of their social identity, as well as for female-headed households. Nor did the scheme focus on the gender dynamics within households with respect to decision making and payment for the subsequent refills. The authors recommend that schemes need to break the stereotype of women as the only users of LPG, and include men in the conversation, both as users and beneficiaries, and that marginalised caste groups are given greater and specific forms of financial as well as social support to access the same quality of energy as others.

Older people are another group vulnerable to heating transitions, as noted by Sovacool et al. (2019) in their analysis of low-carbon transitions in France, UK, Norway, and Germany. The authors identify job losses, specifically for older individuals who have received training in the nuclear and coal sectors, as an example of injustice in these transitions.

In line with the above discussion, Sovacool et al. (2023) critique the majority of energy justice scholarship for its over-reliance on western theories and applications, and its failure to consider how global decarbonisation pathways will affect multiple oppressed groups. They argue that feminist, anti-racist, Indigenous, and postcolonial approaches can offer fruitful foundations by which to pursue future energy justice work. Feminism sheds light on patriarchy, gender-based disempowerment, and the exploitative facets of capitalist relationships, while also highlighting how different forms of inequality can intersect to produce marginalisation on various levels. Anti-racism brings attention to racialised structures, racial capitalism, and the prevalence of white supremacy. Indigenous theories focus on genocide, injustice regarding land and water, and the consistent patterns of dispossession, frequently instigated by the state. Postcolonialism illuminates the perils of geopolitical and internal colonialism, in addition to imperialism. From these intersectional and transformative understandings of energy justice, Sovacool et al. (2023) argue, numerous research questions arise,

which future studies of energy justice should prioritise. For instance, how can decision-making regarding energy transition be both inclusive and pluralistic while still being efficient and not overly resource-intensive, given the pressing nature of the climate emergency? How can we instigate a de-growth mindset on a large enough scale to prioritise smaller-scale energy systems that are publicly owned and distributed over capital-intensive and profit-driven forms of production? Additionally, how can we ensure that community empowerment and the reversal of marginalisation do not result in an increase in fossil fuel consumption, thus creating a conflict between sustainability and justice? Furthermore, how can we respect Indigenous sovereignty and their rights to free, prior, and informed consent without being seen as obstructing energy transition "progress"? Finally, how can we price externalities more effectively, take into account injustice, and implement rectificatory justice in ways that do not excessively increase the price and cost of energy or make energy services unaffordable for lower-income groups?

2.4. Summary

This section has outlined the current and future policy challenges in terms of effecting equitable heating transitions in the UK and beyond. Although policy documents focus primarily on behaviour change as the key route to successful transitions, with a corresponding emphasis on increasing trust and awareness of new energy technologies, this oversimplifies the complexity of the challenge. A range of international literature highlights a number of real and potential justice implications of transitions and how they will impact on different social and political identities. Before looking more closely at how contemporary transitions play out in the home context, we turn to the literature on the history of previous heating transitions for the insight it provides for today's context.

Past heating transitions

3.1. Benefits of a historic approach

In taking a historical approach, a subset of the literature on heating and energy transitions provides lessons that are instructive for present day and future shifts. While analyses of past transitions cannot provide exact synergies, they show how an understanding of historical processes can inform our ability to shape and interpret future pathways. Within energy studies, transition is employed analytically to assess major historical shifts in energy systems. While the focus is mostly on national and global scales (Allen, 2012; Arapostathis et al., 2013; Smil, 2005, 2010; Podobnik, 2006, Fouquet and Pearson, 1998), the domestic sphere also features as a focal point. 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 (Hirsch and Jones, 2014).

Hirsch and Jones (2014) present a convincing account of the benefits of historical analysis for understanding the challenges of contemporary energy transitions. The comparison of earlier events and contemporary challenges may help to identify previously neglected factors or forgotten considerations. Further, examining the cultural dimensions of energy systems' creation and use can help policymakers and analysts appreciate differences in responses to energy challenges:

“The historical view can help us appreciate the energy policy preferences of stakeholders and perhaps navigate around policy obstacles that result from social concerns deriving from events occurring long ago and in an unfamiliar context” (pp. 108).

In their examination of circumstances that play into the creation of past events, historians are adept at understanding long-term trends and changes in them. For instance, historical analysis has expanded the term, 'energy transition' beyond its narrow definition of a change in fuel and associated technologies, to switches from centralised to decentralised electricity production, the building of new power plants and employment of energy-efficient techniques, and the changing access to energy resources across social class.

3.2. The transition to coal in Britain (sixteenth to twentieth centuries)

Focusing on the first energy transition to coal (from animal, water, wind and firewood) between the sixteenth and twentieth centuries in Britain, Allen (2012) highlights some of the complex domestic energy challenges presented by this switch. The first concerned the design and layout of the typical medieval house which was built to accommodate an open hearth. The transition to burning coal required an entirely different architecture to support this new heating system. Allen (2012) notes how the typical medieval house had a large hall or room that extended from the ground to the rafters. In medieval times, the fire for cooking and heating was typically constructed

on a low hearth located in the middle of the room. Smoke from the fire would escape through a hole in the roof, while the space above the hearth would fill with smoke. However, burning coal instead of wood in such a house would have had disastrous consequences. Coal smoke contains sulphurous fumes that could have made the dwelling uninhabitable, and the open hearth was not conducive to efficient coal combustion. As a result, a new style of house was required for burning coal, one with a chimney to vent smoke and confine the coal for high-temperature combustion. Initially, stone or masonry walls were built to contain the fire, and a hood was placed above it to collect smoke and channel it out through the chimney. Later, an enclosed fireplace or metal chamber with a grate was needed to efficiently burn coal, while a tall, narrow chimney was necessary to vent smoke and increase oxygen supply. The house design eventually evolved to a central chimney with back-to-back fireplaces on the ground and first floors, allowing for efficient coal burning and heating without smoke-filled living quarters. The journey to perfect these engineering challenges was slow and relied almost solely on experimentation financed through commercial construction. The rapid building boom in London ultimately created the incentive to shift to coal and subsidised the experiments that were needed to solve the technical problems that arose. Allen (2012) argues that cooperation - the sharing of knowledge and the chance to build on other firms' experience - was as important as competition in developing the coal burning house.

3.3. The transition(s) to gas in Britain (nineteenth to twentieth centuries)

Arapostathis et al. (2013) explore the market-led transformation of the manufactured gas regime from 1877 to 1914, which developed the end-uses of gas beyond lighting to include cooking and extended access to working class consumers; and the cultural embeddedness and growth of space and central heating in Britain in the period between 1948 to 1977. In the first transition, the authors describe how the switch to other energy services than light was a crucial element of the transition. They trace the shift from 1886 when few gas appliances were used due to the high cost of gas compared with coal and the cultural importance of having an open fire, to the entrance of gas in the cooking market for middle and upper-class customers in the late 1880s. This was achieved in part by female demonstrators present at trade exhibitions who later gave cookery courses and home visits, a tactic which successfully feminised and domesticated the use of gas cookers. This was not the case at this point for the working-class market, for whom the initial costs of becoming a gas customer were too high. Also, a gas central heating system requires much more energy to heat the house and thus is more expensive to run, as compared to a radiant system (Peng et al., 2019), such as coal-fire. Open-fire is mainly a radiant based heating system, meaning the radiation heats the person/s near the source of fire, while the background room temperature is quite low (Zhang et al., 2015). Thus, an open fire system requires a limited amount of energy. In contrast, gas central heating is convective heating, which is a space heating approach. In this case, the radiators heat the air in the building and around the person, which eventually warms the person. This process requires more energy (Allen, 2005). Also, the speed of heating a person via coal-fire is much higher than the speed of heating a room via a convective system from a cold start (Rudge, 2012). Thus, coal-fire is more affordable for a rapid response, rather than keeping the house warm. The speed of the transition began to change in the late 1880s and early 1890s when the availability of prepayment meters made gas financially viable for working-class customers. These undertakings, the authors argue, led the manufactured gas regime to undergo a transition between 1877 and 1914.

In the second transition, Arapostathis et al. (2013) describe how the coal-fired house with an open hearth was still deeply ingrained in English domestic life and permeated both architectural practices and energy consumption patterns before the end of WWII to the extent that in 1942, 95 per cent of working-class dwellings used coal to heat their kitchens and sitting rooms. The gradual 'social legitimization' of central heating in

the aftermath of WWII, they argue, coincided with an increasing standard of living and the increasingly interventionist role of the state in matters of public health and housing. As such, perceptions around appropriate levels of comfort also changed. A gas central heating system provides a uniform thermal environment in the house (Rudge and Winder, 2002). However, in an open fire system, the room temperature may change from one room to another depending on the number of rooms equipped with this heating system (Zhang et al., 2015). The varying temperatures can significantly impact health conditions through cold stress and the impact on respiratory and cardiovascular conditions (Rudge and Winder, 2002). Also, the smoke and air pollution produced via burning coal has health implications (Yoshihara et al., 2016, Badarch et al., 2021); and thus, high ventilation rates are required (Rudge, 2012). Social change was further reinforced by the introduction of specified indoor heating standards by the publication of the Ministry of Housing and Local Government report, *Homes for Today and Tomorrow*, in 1961. The proliferation of advertising and marketing campaigns by the Gas Council in the 1960s, which promoted the efficiency of gas appliances, appealed to the public. Quick and easy ignition in new gas appliances made cooking and space heating faster, which it is argued, was valued particularly by working women.

Crucially, the authors conclude that both transitions were underpinned by issues of trust: in material technologies (gas burners, prepayment meters and gas technologies); people and social relationships (the female demonstrators and the fitters who entered homes); and institutions (private and municipal undertakings in the first case and state and regional organisations in the second). Providing an important lesson for future energy transitions, the authors identify trust as a sociotechnical quality inherent in the energy services sector as well as in institutions. The trustworthiness of new technologies, such as smart meters/controls and heat pumps, as well as the organisations that supply and use them, will influence the transition to a low carbon future and alternative heating systems.

Hanmer and Abram (2017) focus on the latter stages of the coal to gas heating transition, which saw the dramatic increase in the use of gas for home heating as the supply was converted to North Sea gas in the late 1960s through to the 1970s. Taking a socio-technical approach, they explore the 'dramatic transition' in domestic heating in Britain, involving both the change from single room heating to central heating of the whole house and from coal to gas as the predominant heating fuel. The authors point out that the conversion from town gas to methane from the North Sea between 1967 and 1977 was a centrally-coordinated and state-led transition as opposed to the gradual sales-led process that had led to the expansion of central heating up to that point. But far from being a straightforward process, the conversion to natural gas involved large-scale changes in both physical infrastructure and social organisation riddled with uncertainty and difficulty (Hanmer and Abram, 2017). A historical paper from 1966 (cited in Hanmer and Abram, 2017) highlights some of these initial concerns, including impacts on heating engineers; issues relating to gas and how to match supply and demand; the likely future demand for gas; and uncertainty around the chemical composition of North Sea gas and the changes needed to gas appliances to allow North Sea gas to be burnt. Watson House, the central research and information facility of the Gas Council, played a crucial role in ensuring appliances were safe for conversion to North Sea gas as well as supplying information to professional networks affected by the conversion. For instance, following complaints from some consumers that gas was difficult to ignite, Watson House started work on new ignition systems. A significant complication concerned the modifications needed to many thousands of different appliances to accommodate the new fuel, which involved inspecting every gas appliance in the country. The inability to convert every appliance due to safety reasons meant some customers felt they had been harshly treated.

Beyond converting existing appliances, the gas industry – looking to expand sales in line with the supply available from the North Sea – focused their attention on building

demand for central heating. In the late 1960s and early 1970s, as central heating became an affordable option for a wider proportion of the population, Gas Council figures show a rapid rise in central heating installations. The article highlights an observation from the Director of Sales for NW Gas that describes the 1969 'Guaranteed Warmth' marketing campaign as the greatest single event to influence the development of central heating since its inception:

“The availability of cheap, convenient and abundant fuel, aligned with trained fitters and secure supply chains meant that gas boilers (or oil for those off the gas grid) packaged together with radiators becoming the obvious choice, with little need for persuasion” (Hanmer & Abram, 2017, pp. 181).

As Hanmer and Abram (2017) explain, the transition to make gas central heating more efficient through the introduction of condensing gas boilers was a more straightforward process given the heating system required little to no alteration. The history of the introduction of central heating systems outlined in Hanmer and Abram (2017) shows how novel heating systems can rapidly become popular and widespread. Compared to other parts of Europe, however, Britain's take-up of gas central heating has been relatively slow, where reliance on inefficient open fires seemed to persist for longer, and it was only until the Clean Air Act was passed in 1956 that there was a total switch from solid fuel to other alternatives (Rudge, 2012). In continental Europe, where timber was plentiful and coal was scarce, brick stoves were used as the primary form of heating from the Middle Ages (Watson in Rudge, 2012). The scarcity of coal, and the fact that wood is less efficient, may have provided the impetus for the development of more efficient appliances in Europe than in Britain (Rudge, 2012). Climate may also have influenced heating methods, as Rudge (2012) suggests. Stoves could generate substantial amounts of heat at a relatively low temperature, perhaps explaining their use in parts of Europe known for long cold winters. In a country such as Britain with a milder and more changeable climate, an open fire was more suitable for providing quick and direct warmth.

Considering the Finnish case, Lauttamäki and Hyysalo (2019) explore the proliferation of ground-source heat pumps from the 1970s to 2015. They show how the uptake of ground-source heat pumps followed a discontinuous development pattern whereby external pressures in the form of the energy crises of the 1970s supported an initial uptake that was unable to sustain itself in the face of more established solutions once the crises subsided. The second uptake from the late 1990s onwards was accompanied by a combination of different factors, including increasing fossil fuel prices; increased efforts to target support for energy efficiency, energy performance of buildings and renewable energy; as well as technology and market maturity. Further, the development of air-source heat pumps fostered awareness of heat pump technology and supported their overall uptake.

3.4. Comparing past and prospective transitions

Others have attempted to identify the similarities and differences between past and prospective transitions (Fouquet and Pearson, 2012). As Heiskanen et al. (2022) note, a stronger focus on investigating past failures and challenges in energy experiments, and disseminating learning from these experiences, can support systematic learning in future energy transition initiatives.

Crucially, Fouquet and Pearson (2012) observe that in past transitions, there were clear private benefits for consumers in switching to new energy sources and technologies, whereas the benefits are less obvious for low carbon energy sources and devices today. Similarly, others have noted how district heating and heat pumps provide similar, rather than improved, services at a significantly higher investment cost (Hanmer and Abram, 2017). Another important lesson from the history of transitions

to new systems is how easily they can be incorporated into the building fabric (including the space available and the amount of disruption caused). Infrastructural considerations also come into play as a move to electric heat pumps will significantly increase overall electricity demand and require significant network reinforcement (Hanmer and Abram, 2017). In the case of the switch to central heating, there was a state-controlled, centrally directed programme with strong coordination between the actors involved. As Hanmer and Abram point out, “today there is no obvious UK organisation with the scope or authority to effect major changes at a system level, as there was in the days of nationalised energy industries. Instead, a new set of alliances and alignments must be built if any such transformation is to be effective” (pp. 182).

Kuijer and Watson (2017) offer an analysis of the co-evolution of domestic heating provision and the demand for heat, arguing that it is only through further understanding the processes by which levels of domestic demand for heat have increased that policies around reducing consumption and effecting transition can have the most success. Their empirical work combined archival material with oral history interviewing in council housing in Stocksbridge, a medium sized town on the outskirts of Sheffield in Northern England. The interviews focused on capturing changes in daily life over time by asking people from different age groups to talk about the time in their life when they were between 20 and 35 years old. The findings provide a detailed narrative of interrelated changes that took place between 1920 and 1970 which produced a spreading of demand for space heating throughout domestic space and time. From the 1920s onwards the majority of council houses in Stocksbridge had open fireplaces in multiple rooms of the house but most of these provisions were hardly used except in the living room. The spread of heating use throughout the home, and temporally, from evening time to morning, daytime and night-time is attributed to a number of factors. The first of these is the materialisation of ideals of separating domestic functions in the design of housing layouts. Such changes included replacing the living room cooking range with a single purpose heating device and providing gas cookers in sculleries. This meant the living room changed from being a space associated with cooking and mealtimes to one allowing study, social interaction and recreation. Further ideals around the separation of cooking and eating led to some larger houses in the post-war Stocksbridge estates being fitted with dining rooms. In the early 1960s, the recognition that more domestic space was needed for privacy led to bedrooms changing function from ‘sleeping-only’ to ‘bed-sitting-rooms’. The council committee thus recommended background central heating to be provided by a coal fired radiator system fed by the kitchen stove. Changes to infrastructure and appliances over the same period also facilitated a spread of space heating and heat-dependent activities throughout the home. Delegation of tasks previously undertaken by humans to machines, i.e. the connection of homes to electricity and gas infrastructure, entailed a major change in everyday life and also contributed to the spreading of space heating throughout the home, and notably, a spreading of heating in time, to ‘short term’ pockets of heat demand such as the time between getting up in the morning and leaving for work, and to times of people’s absence or sleep. Demand for domestic heating was also influenced by changing patterns of domestic practice, including co-evolving trends of increased time spent on homework and study by young people, television-watching and a decline in outdoor play coupled with technology development and collective norms of parenting. This research adds to the body of evidence on how current energy use came to be, and suggests avenues for change, in this case around curbing or reducing the spatio-temporal spread of demand for heat in the home.

Also interviewing people in Stocksbridge, regarding their experiences of the transition to gas heating in the 1930s to the 1960s, Watson and Shove (2022) illustrate how infrastructure was impacted by gradually accumulative shifts in practices and expectations in the home. Consequently, they argue that it is the aggregation and integration of conventions and desires that drives demand for infrastructure change.

The urban density of the council estates in Stocksbridge is noted as key to the spread of demand. The authors note that heating systems are experienced in more complex ways than merely the provision of warmth, effecting spatial and temporal practices at home including sleeping, leisure time and eating.

While acknowledging that reference to other technology phase-outs may offer useful insight and familiar narratives, Kerr and Winskel (2022) caution that partial and anecdotal analogues may mislead rather than inform. They therefore attempt to draw more fully on experiences of technology phase-out in the energy sector through a review of international technology phase-outs from three different energy sectors, including five cases across twenty national contexts. They provide an interpretive framework in which phase-out is understood as an outcome of three distinctive but interacting forces: techno-economic factors; socio-institutional factors; and policy design issues. Within this, they identified seven factors shaping technology phase-out: relative cost and performance; infrastructure and system context; stranded asset risks; public engagement and acceptability; stakeholder engagement and incumbent interests; overall policy mixes and rationales; and voluntary or mandatory policy and the pace of change. They argue that the effectiveness of emerging proposals in the UK to ban fossil fuel boilers depends on replacement technology cost and performance, system and infrastructure context and the distribution of costs and benefits across society, and how that is perceived by the public. The home heating technology phase-out resembles other technology phase-out in some respects but also presents particular challenges and opportunities.

3.5. Summary

This chapter has outlined the body of literature which draws on historical case studies of previous key transitions to different fuel, energy and technology types, including coal and gas. It draws out lessons and challenges which may be of relevance to current and future shifts, acknowledging the need to take into account differences in socio-political contexts. While this chapter draws on literature that focuses more on macro-scale factors of transition, chapter 5 concentrates on how transitions play out in the home and are experienced by individuals and groups across different social contexts. But first, the next chapter turns to the small body of literature which has conceptualised transitions as spatially constituted.

The spatiality of transitions

4.1. Scale and space

While there is a substantial body of work on the temporal shifts in energy systems, there has been somewhat more limited attention paid to questions of scale and space. The temporal approach, while contributing to understandings of how energy transitions have unfolded over time – or “the identification of factors that cause some niches to evolve, or be incorporated into regimes” (Bridge et al., 2013: 333) – has tended to neglect issues of space, place and geographical scale.

Addressing this gap, Bridge et al. (2013) focus on transition through a geographical perspective, understanding energy transitions as spatially constituted. By ‘geographies of energy transition’ they are referring to the distribution of different energy-related activities across a particular space and the underlying processes that give rise to these patterns; as well as the geographical connections and interactions between that space and other spaces. Neither denying the importance of other dimensions nor insisting on the primacy of the spatial, Bridge et al. (2013) provide a conceptual language for working through the spatialities of energy transition. There is, they argue, geographical variability even within the definition of ‘energy transition’ itself, as different countries frame and understand it. In parts of the Global South, for example, energy transition implies an increase in the availability and affordability of modern energy services, which may mean an increase in carbon intensity (Bridge et al., 2013).

The authors outline six geographical components of energy transition. First, they point to the need to understand the basic concept of ‘location’ in relation to energy transitions – both in terms of energy demand and energy production. ‘Landscape’ they use to describe the constellation of activities and socio-technical linkages associated with energy capture, conversion, distribution and consumption:

“For many people [...] ‘low carbon energy transition’ is experienced as the transformation of landscape—i.e., the extension of industrial and extractive components of the energy system into places and communities that previously were unaffected” (pp. 335).

‘Territoriality’ refers to how social and political power are organised and exercised over space, specifically how infrastructure systems for energy capture, transmission and distribution have been territorialized in different ways over time. For instance, in the electricity sector, a series of isolated ‘islands of power’ have been replaced by integrated national and continental scale grids. A central aspect of territoriality is centralisation, or the degree to which capacity and supply decisions are centralised and co-ordinated by a single body. The fourth component – ‘spatial differentiation and uneven development’ – considers how energy transition will generate new patterns of uneven development. They suggest how some aspects of energy transition may enhance the degree of difference between places – how for example the capacity to take up renewable technologies is mediated by geographical conditions. In their fifth

component – ‘scaling’ – Bridge et al. (2013) describe the different geographical forms in which different energy technologies can be deployed – from the household scale to entire landscapes – as well as the geographical reach of different political structures:

“As an analytical lens, scaling can illuminate significant questions about who is affected, who has the capacity for action, and where the boundaries of responsibility lie” (pp. 338).

Their final concept – ‘spatial embeddedness and path dependency’ – are introduced as obstacles to a low-carbon transition. This encompasses the economic, material and cultural aspects of energy systems – the degree to which fossil fuel consumption is ‘built into’ the urban landscape and how this demonstrates wide geographical variation. In parts of the developing world with historically limited energy service provision, there may be more opportunity for faster uptake of renewables since fossil fuels are not embedded in the same way.

4.2. Rurality

Phillips and Dickie (2014) focus on another aspect of energy transition as spatially constituted: that of imagined geographies of rurality. They draw on empirical data from research that investigated how people in rural communities respond to issues of climate change mitigation and adaptation focusing on four rural villages in three contrasting rural districts in England. Their first set of narratives revolved around stasis, or non-transition, whereby people provided arguments as to why they or others would not change. Notions of the rural as being the anti-thesis of change was found to be widely enacted in interviews with residents. A similar narrative involved people’s desire to keep things as they are; that many residents had invested materially and psychologically in their current lifestyle and place of residence and did not wish to see this changed. In other narratives, people accepted the notion that some form of transition was needed but could not connect this with how they might personally enact the required level of change. Where residents were more accepting of transition this encompassed accounts where change was not necessarily welcomed but seen as an inevitability; a utopian view where they saw change as making conditions better despite not being advocates of change themselves; and where people argued explicitly for change related to climate change (who were in the minority in the study). The study concludes by suggesting the degree to which narratives of stasis were present in the rural communities indicates major challenges in facilitating transitions toward low carbon futures perhaps especially so in rural contexts where imagining change is impeded more so by deeply-embedded rural imaginaries.

4.3. The domestic sphere

Understanding how new thermal technologies are integrated and accommodated in domestic routines and environments requires, as some scholars argue, a conceptual approach that recognises technological change as inherently social and embedded in a particular kind of space – that of the home. A contextualised socio-technical perspective views the home as more than the bricks and mortar within which energy devices are installed, but as a complex construct that combines physical, emotional, and behavioural dimensions (Devine-Wright et al., 2014). In a similar vein, Ellsworth-Krebbs et al. (2015) contend that the past several decades have seen a dominant research and policy focus on the ‘house’ rather than the ‘home’. Employing scholarship on the concept of home to domestic energy research would help researchers to understand the complex social expectations (beyond control of temperature, air quality and lighting) attached to everyday activities and to what energy is used for. As Goodchild et al. (2017) state, energy saving technology must be ‘domesticated’, or

brought in line with daily activities and cultural expectations around 'home' if it is to be accepted more widely.

4.4. Summary

This chapter has drawn on literature which incorporates and highlights the importance of spatiality in considering past and prospective heating transitions. Bringing spatiality into studies as a key analytic lens may reveal hitherto neglected insights and questions which studies solely focused on the temporal may not have found. The scale at which transitions are analysed also matters as literature suggests distinct challenges for particular spaces (between rural and urban, for instance). It is also of critical importance to pay appropriate attention to the space in which transitions play out – that of the home – and to give weight to the complexity of conceptualisations of home as a physical, emotional and social space rather than simply the 'bricks and mortar' of the house.

Moving towards transitions

5.1. Expectations and needs around heating

A number of studies have explored individual and household preferences and needs in terms of domestic heating systems and practices, including how they use their heating, what they use it for, and how various low carbon heating systems have been received. The goal of effectively replacing fossil-fuel-based systems with low carbon alternatives relies on a full understanding of habits, values and preferences for the experience of home heating systems, as well as their origins. Researching domestic routine and energy practices in the home has been positioned as being of greater value than focusing on perceptions of different types of energy, which some have argued has rendered existing literature on energy and heating transitions insufficient (Scott and Powells, 2020).

Changing needs over time

Mallaband and Lipson (2020) focus on what households might want from low carbon heating solutions, and how their behaviour and lifestyles affect this. They found that occupants were trying to use heat to meet a far broader range of needs than is often assumed by those trying to decarbonise domestic heating use, meaning often, occupants' needs are likely being unmet. This category of needs included wellbeing (health and comfort), resources (cost and waste), ease of use (control and convenience), and relational dynamics (harmony and hospitality). The extent to which different households prioritised each of these needs varied, with participants using their heating to meet their core needs first and peripheral needs once these had been met. The longitudinal research also showed that households' priorities changed over time depending on their sociotechnical situation, which made some needs more prominent than others at different times. For instance, the onset of an illness or arrival of a partner revealed the importance of health and harmony.

According to Tweed et al. (2015), the home environment allows for freedom of movement and the ability to make changes to the thermal environment without having to conform to social norms regarding clothing and behaviour. However, the limited control provided by an open-fire system, which was often confined to certain rooms like the kitchen, had a direct impact on lifestyle and activities. In contrast, a centrally controlled system can be fine-tuned and used in every room of the house, resulting in a change in lifestyle and expectations (Kuijjer & Watson, 2017). As Moezzi (2009) explains, people's expectation of comfort has increased from basic needs like food and shelter to almost everything, including a controllable and refined thermal environment. In the past, people were more willing to adapt to their environment and accept a degree of discomfort, such as by changing clothing layers. However, the expectation of comfort has changed people's perception, and they now expect the thermal environment to adapt to their needs, which directly affects their acceptance of it (Indraganti et al., 2013). There is a growing body of work identifying life course 'transitions' as vital moments in which practices and use may undergo transformation (Hards, 2011, 2012; Maller and Strengers, 2013; Shirani et al., 2017), if they are taking

place amid a general disruption of routines. In their experimental study, Schäfer et al. (2012), for instance, found that everyday routines and consumption patterns change during life-course transitions, but with heterogeneous results regarding sustainability. Their findings revealed that the preparation phase preceding life events and a short period of time thereafter were decisive moments for changes in routine. Groves et al. (2016) further question whether life course transitions should be treated as homogeneous opportunities, or if in fact, some kinds of transitions may constitute obstacles to change. They explore the importance of clashes between dominant narratives and individual experience for understanding practices of energy consumption. Their analysis of life course transitions evoked within personal narratives relating to changes in energy use highlights how experiences of transition contain dimensions of conflict relating to identity. Examples of such conflicts are highlighted in Lucy's narrative. Lucy moved from London to a house in an affluent commuter village in South Wales. She had long prided herself as upholding ethical values around energy efficiency but after the move, these came into conflict with new thresholds of comfort and enjoyment of life in the family's rural setting. Purchasing patio heaters, for instance, was acknowledged by Lucy as 'wasteful' but also contributed to her new identity as a generous friend and hostess, extending the warmth of the inside to the outdoors. In order to effectively bring about more sustainable heating transitions, Groves et al. (2016) argue for the creation of spaces for "difficult conversations" in order to address the 'unspoken troubles' "that obstruct and undermine the fit between narratives of change and the ways in which individuals make sense of their own life-course transitions" (pp. 504).

In the case biography given of Roy (Butler et al., 2014), there are examples of his current practice both challenging and continuing socio-technical structures associated with energy systems. Roy made a major change in moving to an eco-village where he lives 'off the grid', a choice that was brought about through his environmental consciousness developing via travel experiences that brought high consumption practices into focus for him. At the same time, Roy also emphasised the importance of the car for driving his children to activities outside of the eco-village demonstrating continuities relating to the social structure of the family can run alongside (and take precedence over) long-term environmental concerns. Of relevance to domestic heating practices and how transition may occur, Roy describes how some sustainable practices are also endowed with tradition and as such, are perceived differently across generations. Bathing their children in a tin bath by the fire, for instance, was familiar to visitors from older generations but may be seen as 'weird' to those from younger generations. However, he also describes these perceptions changing as societal norms shift and 'off grid' sustainable lifestyles become more glamorised.

Control

Thermal control, or adaptive opportunity, refers to the adaptability of a building's environment to meet the needs of the occupant (Baker and Standeven, 1997) by providing control for users to adjust the thermal environment (Humphreys, 1996, Leaman et al., 1998). Thermal control is likely to increase occupants' comfort, as they will benefit from the actual and potential variations in the room temperature (Baker and Standeven, 1995, Humphreys, 1996). Thermal control is also reported to increase occupant satisfaction (Newsham et al., 2009, Shahzad et al., 2017), health (Rollins and Swift, 1997, Rayner, 1997, Shahzad et al., 2016) and productivity (Kroner, 1999, Seppänen and Fisk, 2006, Akimoto et al., 2010). In contrast, lack of thermal control is associated with dissatisfaction (Bauman, 1999).

Drawing on three contrasting low carbon energy technology projects in the UK, Bickerstaff et al. (2016) foreground a more experimental, ad hoc and provisional mode of governing with domestic energy technologies. Their case studies involved 'testing' the capacity of household objects to transform domestic energy-consuming practice.

One such intervention included the 'Wattbox' heating control system, a device for automating a gas central heating system with similarities to a traditional timer and thermostat. It controls central and water heating on the basis of monitoring household patterns, derived from electricity consumption and temperature preference data. The intention is to increase efficiency through constraining scope for manual control of the heating system (with the exception of two buttons on a touch screen to indicate more (or less) heat or hot water). Far from achieving its intended purpose, the households involved in the trial described how the Wattbox had forced them into greater inefficiencies than if the heating was controlled manually. They were critical of their personal control and determining of heat and comfort levels being reallocated to a technological device which rendered them passive consumers. The findings from this particular intervention show that smart technologies often fall short of transforming householder expectations, norms and practices. However, their findings from an intervention involving solar PV units offer a more optimistic reading. In households where solar PV electric units has been installed they saw sustained changes in relation to everyday practice (reducing energy demand) as well as a shift in the conception of energy as a concrete entity: "this direct and proximate relationship with systems of production made a particular form of energy that was both present and scarce, that engendered a form of care, with consequences for the reconfiguration and demise of certain practices" (pp. 2018). Bickerstaff et al. (2016) argue for more experimental energy demand-related designs which transform the meaning and experience of energy which enable people to re-imagine their relationships with energy rather than seeking to effect specific instrumental changes in behaviour.

The theme of 'control' over heating is also picked up in Johnson's (2016) article on the Pimlico District Heating Undertaking (PDHU), a district heating system built in the 1950s to supply the landmark social housing project, Churchill Gardens. Johnson (2016) outlines how district heating – where heat is generated remotely and transmitted via steam or hot water to a group of buildings – was pioneered in the late nineteenth century in the US, and by the 1930s was rising in popularity for municipal governments across Western Europe and the Soviet bloc. In social democracies across Northern Europe district heating is a widespread form of heating infrastructure. The rationale for Pimlico district heating set out in the 1940s was twofold: first, for the state to take on responsibility for producing a warm home; and second, to free up citizens (particularly women) from the labour of heat production. The Pimlico system was designed to supply heat from 5:00 am to 11:00 pm, and the amount of heat to supply to each room was established by modelling the thermal characteristics of the buildings and the external air temperature. As the weather got colder, the PDHU team could adjust the temperature of the water feeding the radiators in each room. In more recent years, PDHU has been able to apply for a government grant to invest in its own generating capacity. In 2015, it generated a surplus of £250,000 which allowed it to subsidise the rates it charges to people as well as to produce less carbon-intense heat. When people living on the estate were prompted about the heating as part of this study, there was a general acceptance of how the system performed. However, an interview with a housing provider revealed some of its drawbacks, including for new residents to the estate who find it difficult to understand why they have to pay heating charges through the summer when the service is not running, as well as the lack of 24-hour heating. Despite these few complaints, he has never received a request to leave the system, simply because, he believed, it is cheaper.

Identity and social groups

Hards (2013) examines how energy practice is bound up with status and stigma. Drawing on qualitative interviews with sixteen participants who considered themselves to be doing something to tackle climate change, Hards (2013) found that energy-conserving practices were commonly seen as status-enhancing within ethical-environmental lifestyles. This included installing solar panels and stoves, comparing

carbon footprints with friends, inviting others to see a newly renovated home, or buying renewable energy and making sure others knew about it. Practices that may be considered as “scrimping” – or carry a risk of stigma and embarrassment for some – were carried out with pride by this participant group (environmentalists with a mostly middle-class background). A particular energy practice may thus have a different meaning in different contexts and for different social groups. This also leads on to the question about the extent to which home heating is a product of individual belief or collective practice. Empirical research exploring the winter actions and beliefs of a diverse sample of older people in the UK found respondents largely felt disengaged from their wider generation and broader generational conventions of achieving winter warmth at home (Hitchings and Day, 2011). As a wider lesson for energy policy, Hitchings and Day (2011) assert, “people do not always feel inclined to do the same as their peers in terms of domestic energy use, and they may have very good reasons for this” (pp. 2464). Targeting older people in terms of promoting shifts to alternative heating systems, then, will have little effect unless sensitive to the diversity of the group. They argue that this does not mean dispensing with the idea of targeting older people altogether, but that it should be done in appropriately sensitive ways.

Older people’s experiences and processes of the ‘thermal landscape’ are focused on by Tweed et al. (2015) who explore motivation behind, and impact and manifestation of thermal changes in the home. Older people demonstrated an expansive understanding of their environment and heat, incorporating the impact of weather, seasonal changes, times of day and locations in the house into their thermal decision making. Tweed et al. (2015) found that this knowledge was used to influence heating conditions in the house and older people’s use of the home accordingly. Older people were found to be especially sensitive to loss of or lack of heat and so were more motivated by being able to achieve sufficient levels of heat rather than environmental concerns. Tweed et al. (2015) consequently argue that low-carbon transitions may be better targeted at this population in terms of their potential to open up areas of the home previously abandoned due to lack of suitable heat retention and production sources. In contrast, a study in India, where older people had access to a variety of thermal control systems for cooling, found that older people were conscious of their energy use. They used energy intensive systems only in the extremes of the weather (Shahzad et al., 2020).

Groves et al. (2017), in a biographical approach, explore the evolving entanglements of practices, technologies and identities in relation to the desirability and viability of different forms of energy transition. They found that people’s emotional investments in everyday energy-consuming practices which help to constitute their identities can act as a barrier and make energy transition difficult. In their empirical research with householders, they reveal the importance of energy consumption as articulated by participants in two ways. First, different ways of consuming energy are necessary for taking care of certain attachments, in this instance, keeping rooms warm as a way of taking care of older family members. It is also important as being a ‘good carer’ was central to the participants’ sense of self. In terms of energy justice, Groves et al.’s (2017) contribution is a vital and - within the wider literature – unique one. As the authors argue, distributive justice is often tackled as an issue to be solved through better allocation of resources or the management of change. The problem, as they argue, is that there is no universal user as such as some users may have a greater need of energy and others less:

“In order to be genuinely equitable, definitions of what forms of energy consumption are genuinely needed have to be responsive to how people themselves understand the difference between necessary and non-necessary uses of energy” (pp. 79).

Similarly, in a study focusing on homes with children, Shirani et al. (2013) found that the immediate needs of childcare outweighed considerations for sustainable futures and made changes to energy consumption within the household inherently difficult. Furthermore, as Xu et al. (2012) argue, children are considered as vulnerable towards extremes of the weather.

Other literature has explored heating transitions and practices for particular social groups, recognising the need to take into account a range of social differences when planning and delivering interventions. As stated by Ivanova and Middlemiss (2021), “it is important to understand the differences in what people are able to consume when considering how to address a transition to a more sustainable future” (pp. 1188). Research with older households, for instance, has found ventilation habits (sleeping with the window open, including during winter nights) stemming from generational beliefs about the healthiness of cold air, which were carried out as a way of ‘disciplining the body and home’ against decline (Day and Hitchings, 2011). Elsewhere, others have noted the preoccupation with fresh air, space and light may stem from unsanitary conditions in overcrowded industrial towns from the late nineteenth/early twentieth centuries (Rudge, 2012). Of relevance to understanding heating transitions, this research highlights the importance of viewing the home space not simply as a material structure, but a space imbued with meaning and symbolic function, within which people actively construct routines and practices as they see fit, and have good reasons for the choices they make (Day and Hitchings, 2011).

The review identified an emerging body of work on gender and energy practices, arguing that further understanding this area will help to explore (and rectify) gender (dis)parity in current energy transitions. These studies see the household as a ‘heavily gendered sociomaterial network’, and as such, consider how heating/energy technology and gender are configured during heating transitions and adoption of new technologies. This includes studies on decision-making related to renewable energy technologies in households in the Netherlands (de Wilde, 2021). Combining participant observation in consultations, technical audits, and energy fairs, focus group interviews with technicians, and document analysis of marketing materials, de Wilde (2021) analysed how technicians mobilise gendered affection, knowledge and action in households to effectuate adoption of renewable energy technologies. When selling these technologies, technicians relied on gendered constructs around a ‘male love of technology’ and asserted that women took more convincing to ‘come on board’. During fieldwork, de Wilde (2021) observed that technicians were more likely to sell the technical rationale of renewable energy technologies to men, affecting a form of homosocial bonding over technical rationality. When engaging women, on the other hand, technicians emphasised the sensory qualities of the technology (thermal comfort, aesthetics and noise). During the installation of renewable energy technologies, installers assumed it would be the woman in the household who would be responsible for the domestic routines to maintain performance, including cleaning its components, thus enacting a traditional gendered division of labour. Thermal comfort, and the difference between heat pumps and gas central heating in regulating it, was assumed to be a female concern. Nevertheless, through engaging women via the practices of ensuring thermal comfort, technicians re-defined renewable energy technology from high-tech to comfort-enhancing equipment. The specifics of these negotiations appear to differ depending on the study. In Denmark, for instance, Tjorring (2016) found that while energy advisors took a different approach when speaking to women and men, they also found that women tended to defer decisions to their (male) partners and were much less interested in energy renovations than men who considered house maintenance the man’s domain.

Taking a similar approach, Offenberger and Nentwich (2009) explore gender as a symbolic binary through the market distribution of heating energy technologies for private households. Whether a heating system was gendered as masculine or

feminine was dependent on its intended positioning, or 'gendered spatial order' in the house; whether in the living room or the cellar:

"Home heating is either constructed as technology and machine dominated "facility management" taking place in the cellar or as a comfortable lifestyle and people focused "home making", centred around living area of the house" (pp. 85).

This serves to contribute to naturalised assumptions of technology as a masculine sphere and comfort and well-being as a feminine one.

Anshelm and Hultman (2014) trace the history of energy and environmental politics alongside shifts in hegemonic masculinity. At the beginning of the nineties, they argue, a shift occurred in hegemonic masculinity from a masculinity of industrial modernity to an ecomodern masculinity in which toughness, determination and hardness was mixed with appropriate moments of compassion and care. This ecomodern masculinity demonstrates care and responsibility for the environment while at the same time promotes economic growth and technological expansion. Seen through this lens, heating and energy transitions are intricately entwined with gender politics and the hegemonic framing of masculinity; that any move away from industrial rationality may be a threat to this version of masculinity itself.

A similar framing is evident in Cupples et al. (2007) in relation to hitherto unsuccessful behaviour change campaigns in Christchurch (New Zealand) which sought to shift householders from using coal and wood burners to cleaner forms of heating in an attempt to tackle high air pollution levels in the city. Environment Canterbury aimed to convert up to 60,000 fuel-burning households in Christchurch to alternative forms of heating, including electrically powered heating options and high-efficiency solid-fuel burners. While Cupples et al. (2007) acknowledge that barriers to making this shift are to some extent economic in nature given the high cost of cleaner forms of heating, they also insist that cultural dimensions are at play, an angle often dismissed by conventional studies of air pollution. They argue that culturally embedded discourses of the pioneer heritages and expressions of both national identity and masculinity within New Zealand "creates a collective and individual identity which regulates home-heating choices in specific ways and leads to a reluctance to change these practices" (pp. 2887). While they acknowledge that such discourses are shifting and, equally, negotiated and contested by actual men (and women), they appear as a dominant feature in the cultural landscape of New Zealand. These discourses revolve around a denial of pain and discomfort, a hark back to male pioneers and their association with endurance of physical hardship. Log burners and open fires, and the use of firewood, to heat homes are particularly symbolic of these constructions of gender and national identity and allow particular (colonial) relations to be enacted inside the home. Cupples et al. (2007) conclude then, that any health and social benefits that might come from cleaner air might not outweigh the impacts on masculine national identities, and that any campaigns around air pollution (or shifts to new, cleaner forms of heating for that matter) must contend with deeply ingrained discourses (in this case around national identity and masculinity).

Masculinity and national identity are also applied as concepts in reference to the reliance on coal in Poland. Allen (2022) argues that historically and culturally embedded gendered subjectivities have been overlooked as explanations as to why efforts to change behaviour around a reliance on coal for heating in Silesia, Poland have largely failed. Civil society movement, Polish Smog Alert, and policymakers have both attempted to 'fix' the air pollution crisis by focusing on raising awareness of the issue to instigate rational technical and behavioural changes, incentivised by social pressure, (limited) public subsidies, and bans on, and fines for, use of lowest quality coal types. Yet, as Allen (2022) argues, such strategies often do not take account of embedded social and cultural patterns that shape identities and everyday practices,

such as heating, in Poland, and Silesia particularly, where coal-mining life remains a socio-cultural norm, and asserts a sense of masculine pride and prestige:

“With increasingly fearful reflexivity in response to encroaching post-traditional and ecological norms in contexts of economic precarity, the clinging on to industrial breadwinning petro-masculinities works to re-entrench their dominance, generating friction against ecologically just futures” (pp. 214).

Likewise, Kuchler and Bridge (2018) examine the mobilisation of a powerful socio-technical imaginary by policymakers that fuses the mining and burning of coal with national development. The origins of this narrative are traced back to Polish independence but it was further reinforced during the communist era that forged the symbol of ‘black gold’ as a bedrock of the country’s place in the world, as well as its role in rebuilding the country post-WWII. Following declining outputs and inefficiencies in the post-communist period, successive governments have attempted to shore up a national socio-technical imaginary that ground the country’s future in the further mobilisation of domestic coal resources by expanding production through new mines and modernising coal’s production through technological innovation. Looked at more broadly, it is possible to see how the current and future role of fuels in a national energy mix is shaped by widely held socio-technical imaginaries.

Emotion and memory

It has been argued that human emotions have been given less prominence in sustainability transitions literature than issues such as the agency and behaviour of actors and institutions and the examination of processes and outcomes (Martiskainen and Sovacool, 2021), though this review highlights an emerging body of work beginning to address this gap.

Sahakian and Bertho (2018) show how a focus on emotions can help to reveal tensions in discourse and practice and present windows of opportunity for either de-stabilising or reinforcing existing practices around energy use in the home. Their mixed-method research project involved mainly ethnographic approaches to understanding energy-using practices among households, followed by a quantitative survey representative of the population in Western Switzerland. They found that people’s practices – including those around energy usage – are intricately bound up with emotions. In prioritising, justifying and negotiating different practices, participants drew from different organising principles in relation to cleanliness, health and safety. Expectations from family members and different standards of cleaning or cooking, in the same home or between generations, might lead to forms of justification. Health and security issues were also significant in relation to normative practices, in addition to “comfort, cleanliness and convenience” and more so than environmental registers. The implications for changing energy use – or governing transitions – were less clear. Strategies for managing these tensions could either lead to decreased or increased energy use.

In another study focused on emotion, oral history accounts from the village of Ynysbwl in South Wales – a region once dominated by coal extraction – revealed more than just emotions about energy at play but a variety of atmospheres and affects engendered by the energy system and arising in different spaces within it (Rohse et al., 2020). Of relevance for current and future changes in energy systems, their research suggests that it is more than just feelings of loss of livelihood and landscape change (although these are factors too) but major changes in sense of place, in affectual bonds “as bodies become choreographed in quite other ways” (pp. 144), and atmospheres of everyday life. It was also important to note that changes were interpreted differently by different parties (in this case, between ex-miners and women’s accounts), and that change also threw up more positive emotions such as

wonder, relief and hope for the future. The authors conclude that recognising and engaging with emotions is crucial in managing energy systems change, and by doing so, fruitful avenues can be opened for collectively working through once negative emotions and harnessing more positive ones, “we should engage people in how best to create infrastructural assemblages that induce positive affect, to better facilitate their acceptance” (pp. 144).

Ransan-Cooper et al. (2020) found mixed emotional responses to new household solar-battery systems in Australia, encompassing frustration, confusion and excitement. Complementing social practice approaches that tend to focus on ‘thinking and doing’, this study adds to the emerging body of work on emotion in relation to energy technologies, “further[ing] understanding of the messiness and complexity of trade-offs that households negotiate as they purchase, install and use smart energy technologies” (pp. 2). Their in-depth empirical research explored how emotions in response to battery storage installation changed over time (a three-year period), from pre-installation to just after installation and a year later. Negative emotions, such as confusion and frustration, stemmed from householders feeling the link to accountable actors who could explain and interpret the operation of their system was unclear or unavailable. This finding demonstrates the need to involve householders in the early design and planning stages for new energy technologies. Positive emotions were also evident, however, such as enthusiasm about the sustainability values of the new system, its ability to provide backup power, and potential to save money on bills. These mixed emotional responses are deemed likely to reflect how new household energy technologies will be met across different locations and households.

In a systematic review of the extant literature on how emotions have been reported or examined in energy transitions, Martiskainen and Sovacool (2021) propose a new research agenda for low-carbon transitions that takes into account people’s emotions. Their results are presented as an ‘inventory of emotions’, including: ‘object properties emotions (desire/alarm)’, either desire for new appliances or negative emotions towards them; ‘future appraisal emotions (hope/fear)’, hoping for a certain outcome through energy projects and practices or fearing the impacts of transitions or new energy developments; ‘event related emotions (joy/anger/grief)’, relating to the joy certain energy systems bring, or the anger and grief surrounding the losses brought about by transitions around sensory experience, jobs and livelihoods or ways of life; ‘self-appraisal emotions’, including pride about involvement in energy projects or negative social emotions connected with various behaviours in terms of energy use; ‘attached emotions (love/hate)’, including strong emotions such as love or hate being attached to particular entities, objects, people or ideas; and ‘other emotions’, or those that did not fit neatly into the above categories such as a positive sense of wellbeing related to technologies, positive emotional attachments to technologies or practices such as sitting around coal fires or hearth, feeling connected to places and communities such as coal mining towns, as well as resistance towards new energy projects, and fatigue related to excessive commitments required for successful energy projects. Their review revealed that most emotions contained on this spectrum are not static but change over time, whether over a person’s lifetime or across different temporal phases. Some emotions, however, were found to persist, such as nostalgia for practices learnt in childhood, or how people cope with changing circumstances like the death of an industry. Based on these findings, the review makes the case for greater emotional literacy from policymakers or those who design, develop and decide on energy systems – and for both policy and research, a recognition that emotions are an inherent part of the success, or unsuccess, of sustainability transitions.

In another study, Sovacool et al. (2021) focus on individual experiences of smart meters, illustrating how the technology confers seven different types of phenomenological uses comprising parental care, pain alleviation, fresh air, personal care, social signalling, structuralism and zoophilism (care of plants and animals).

These aspects of heating use are under-acknowledged in research and policy, and they caution that if this persists, the understanding of the reasoning and the ways people heat their homes will remain incomplete and attempts to allay climate change will be insufficient.

Most previous research on older generations in this field has tended to focus on their potential uptake of renewable energy technologies, suggesting that older adults may be less aware of and less likely to invest in them (Claudy et al. in Devine-Wright et al., 2014). As Devine-Wright et al. (2014) note, however, these studies overlook the childhood memories these generations are likely to hold surrounding the burning of solid fuels, particularly coal, in open fires for domestic heating. Devine-Wright et al. (2014) begin to address this gap by qualitatively exploring the values associated with domestic thermal experiences in a sample of older people, with particular interest in notions of 'the hearth', cosiness, glow and focal points of heat, and how such values and experiences may endure or not following the transition to low carbon thermal technologies. Their research involved interviews with a mix of participants aged 55 and above, in private households, extra-care housing schemes, and care homes. They identified six themes that captured how cosiness and glow were represented by participants, and how this shaped ways in which thermal comfort was managed on a day-to-day basis. Warmth was talked about as a visible entity, arising from the glow of a fireplace, and as such, dissatisfaction was expressed with thermal devices that failed to provide such visibility (underfloor heating and stove designs that did not reveal the burning wood inside). The glow of a fireplace was represented in emotional terms in the sense of feeling cheerful. Continuity in thermal experience was another theme to emerge from the study and was seen in how older participants took heating devices with them when they moved house and by the installation of coal-effect gas fires in care homes to enable a familiar experience of domestic heating. The provision of a visible, focal point of heat was important to participants in terms of sociability; fireplaces would often be used when guests or visitors came round. A hearth-like device was also associated with seasonal practices of homemaking, notably winter and Christmas. Overall, the study suggests that the production of domestic cosiness is variably achieved through the use of focal points of heat and lighting devices that produce a visible glow. In policy terms, simply providing information to householders on low carbon technologies, while overlooking pre-existing values, meanings and experiences, is not deemed to be sufficient. The challenge for policymakers, argue Devine-Wright et al. (2014), is to ensure that environmental values do not run counter to cultural values around the making of home.

In a similar vein, focusing on the likelihood of switching from wood to alternative heating, findings from Hine et al. (2007) suggest that educational interventions aimed at providing people with information about the health risks of wood smoke will not be sufficient on their own due to the positive affective associations with wood heating. More recent research by Karlsson et al. (2020) further explores the emotional motives of fireplace usage. Based on a questionnaire on the motives, emotions and behaviours around using a fireplace with participants in Sweden, Karlsson et al. (2020) found the two most common motives for using a fireplace were 'complementary heating' and 'cosy fire making'. The fire making process was seen to regulate emotions, effecting transitions from stress and anger to joy. This joyful experience was partly attributed to the 'warm, golden glow' from a fire as well as the social interaction associated with sitting around a fire. This data adds to the body of work that suggests sensory pleasure and emotions affect people's energy use and choices. The strength of attachment to wood burning as a form of domestic heating is also demonstrated by studies exploring resistance to its regulation. Research drawing on focus groups with households with and without wood heating in Armidale, Australia – where wood smoke levels regularly exceed national health advisory limits – shows that citizens draw upon a rich suite of justifications to present the activity as natural, traditional, and promoting comfort and cohesion. It was also associated with the 'rural' identity of the community and thus had

strong connections with sense of place (Reeve et al., 2013). Similar conclusions are reached in other studies which show how households actively choose wood-burning stoves not only for economic reasons but to accommodate their own needs and preferences regarding what they see as a sensuous experience of heating, in part formed by cultural expectations around what constitutes an 'ideal home' (Peterson, 2008). In Denmark, wood-burning stoves were found to be a subject of social interaction and cooperation between neighbours, colleagues and family, and through this interaction, norms for domestic wood combustion were negotiated and circulated (Peterson, 2008). Jalas and Rininen (2016) explore the temporal order of wood-based heating, finding that it creates rhythms in everyday life that are a source of joy and ease for people. Their study provides evidence that convenience and ease are not the only considerations citizens make when choosing a heating system, nor are they the only routes along which renewable energy technologies can proceed. This point is further supported in other studies which show how people can draw meaning from hard work and 'attendant inconvenience' (Roberts and Henwood, 2019).

Stojilovska et al. (2023) argue in their recent study that many European energy transition policies have disregarded the significance of fuelwood as a domestic energy source for numerous households across the continent. Drawing on the experiences of energy-vulnerable households in Portugal, Slovakia, Hungary, Austria, and North Macedonia, the study highlights how fuelwood serves as a central and versatile tool for coping with energy poverty. The researchers find that fuelwood is not only a vital cultural practice but also a critical means of addressing energy poverty. Thus, future EU policies should acknowledge the connection between fuelwood and energy poverty and provide a gradual and supportive phase-out of fuelwood that does not jeopardise the livelihoods of energy-vulnerable households while simultaneously advancing the Sustainable Development Goals.

Comfort

Another dominant framing concept in the articles reviewed is comfort. Some scholars have argued that standards, routines and expectations around comfort are socially constructed and heavily influenced by the beliefs, values and expectations of those who construct them (Shove, 2003; Cooper in Chappells & Shove, 2005: 33). As such, conventions around comfort (and what is defined and experienced as comfortable) change over time and are dependent on a range of socio-cultural factors.

The definition of thermal comfort has evolved through time from a straightforward idea of saving energy, as Olgay (1992) states "the point that minimum expenditure of energy is needed to adjust himself [*sic*] to his environment". Later, Fanger (1970) developed the idea of thermoneutrality and Hawkes (2002) considered it as the "intermediate point, when neither cold nor hot". Thermoneutrality is currently the basis of assessing thermal comfort, which is the seven-point scale, 'Thermal Sensation Vote' (TSV). The scale starts from cold on one end to hot at the other, while the neutral point in the middle represents the thermal comfort status (ASHRAE, 2009). Shahzad et al. (2019) argue that this method does not reflect the whole picture of thermal comfort, as many other factors are overlooked. This conflict is reflected in the most widely used definition of thermal comfort, as "that condition of mind that expresses satisfaction with the thermal environment" (ASHRAE, 2004). Hitchings (2009) argues that although the ASHRAE definition recognises the importance and significant impact of "that condition of mind", this is neither reflected in the TSV method nor the ASHRAE standard (2020). Only clothing and thermal factors are included in the ASHRAE standard. Many researchers found that this universally accepted standard that is expected to apply to a wide range of contexts does not guarantee thermal comfort of occupants (Humphreys and Nicol, 2002, Brager and de Dear, 2001). Thermal comfort standards represent a narrow band of thermal conditions and assume a uniform and continuous thermal environment to ensure the comfort of the occupant. Much energy is needed to

maintain this thermal environmental condition, which is practiced mainly in office buildings. However, there is a debate on the satisfaction level of the occupants (Shahzad et al., 2019).

The adaptive comfort theory, which was introduced by Nicol and Humphreys (1973), is based on the adaptive behaviour of the occupant: 'if a change occurs such as to produce discomfort, people react in ways which tend to restore their comfort'. In this approach, a much wider range of thermal conditions are acceptable, which directly affects the heating system and the energy use of the building. Shove (2003) argues that the constructions of comfort are central to energy usage and thus offer a key site to effect influence and change. While technology is essential to the transitions needed to address the climate emergency, alone it is unlikely going to be enough. Shove argues that standards of thermal comfort that we seek to achieve are, ultimately, too high: "while it is good to design more energy efficient heating and cooling technologies, the risk is that these inadvertently sustain what are ultimately unsustainable concepts of comfort" (2003: 203). Perhaps providing nuance to this assertion, however, Day and Hitchings (2011) found that thermal experience among older people was determined by a combination of physical effects of age and chronic illness.

Chappells and Shove (2005) draw on the example of air-conditioning, tracing the shift from the 1990s when US campaigners argued that schoolchildren should study outdoors in the 'fresh air' to the contemporary demand for air-conditioning in cars and offices. Divergences between how different cultures manage, value and maintain different indoor conditions and interpretations of comfort also give weight to the argument that comfort is a socio-cultural achievement. Interviewing a selection of 13 architects, building services engineers, property developers, manufacturers and regulators, and 17 participants at a specially convened workshop, Chappells & Shove (2005) explore the way comfort is conceptualised and subsequently, just how negotiable the concept is. Their findings highlight the complexity around people's perceptions of comfort and how the concept cannot easily be reduced to variables surrounding temperature, humidity and air quality. Respondents saw comfort as going beyond that which can easily be measured to the physiological and psychological. Buildings are designed with these elusive concepts of comfort in mind, as well as other conventions around what buildings should contain, signifiers of quality and prestige. The authors conclude that "rather than figuring out more efficient ways of maintaining 21-23 degrees in the face of global warming, society should be embarking on a much more searching debate about the meaning of comfort and the ways of life associated with it" (pp.39).

Based on 17 oral history interviews with 25 residents in Lochiel Park, a nearly zero carbon housing estate in Australia, Goodchild et al. (2020) draw on comfort as a framework for understanding how residents have changed their heating and cooling practices over their life courses. They found that expectations around comfort had become more demanding over time; whereas the cooling practices undertaken in respondents' past parental homes were labour-intensive (sleeping out in hot weather, moving mattresses to cooler spots of the home, for instance), changes in lifestyle and changing cultural expectations made it more difficult to adapt to heat through these behavioural changes alone. Questions of equality are raised by the authors here, in terms of the gap between those who have the financial ability to purchase and use cooling technologies (and thus 'comfort') and those who do not.

Gram-Hanssen et al. (2010) empirically explore everyday practices of regulating domestic heat and ventilation through a practice theory framing of comfort. This study shows how different behaviour in identical houses results in diverging energy consumption. All interviewed households had different embodied habits with regards to how they interacted with heating devices and material components of the home to control the indoor climate and their level of comfort. Some of these habits were

associated with those learned elsewhere (in the workplace, campaigns or other types of knowledge) or from others in their past (their childhood experience of how their parents regulated indoor climate, for instance). The meaning and importance of the home also held a strong relevance to understanding these practices. Maintaining a high indoor temperature was seen as important in terms of creating a welcoming and cosy home.

Ellsworth-Krebbs et al. (2019) report that the majority of scholarship on comfort has tended to frame it only in terms of the physical (i.e. thermal comfort) when in fact, comfort is multidimensional. As the authors point out, there is more to the experience of home than ensuring human bodies are sufficiently warm or cool. Addressing this gap, Ellsworth-Krebbs et al. (2019) offer a broader framework of home comfort, drawing together literature on comfort, home comfort and home with an empirical study of 21 Scottish households on the meaning of home comfort. Their study revealed that while thermal comfort was still important to householders, other concerns were commonly significant to satisfaction in the home. These ranged from psychological attributes such as mental wellbeing, companionship and contributory comfort (contributing to the wellbeing of someone or a cause), as well as elements that were explained by participants as intersecting in both physical and psychological ways (relaxation, control, visual comfort, auditory comfort and familiarity). Energy policy would benefit from paying attention to these additional themes of home comfort in designing energy demand and heating transition interventions that go beyond a focus solely on thermal comfort. As Goodchild et al. (2017) argue, comfort also extends to ease of use, convenience and the provision of adequate, usable space.

Providing a slightly different perspective, Roberts and Henwood (2019) explore how households in old, hard-to-treat homes (solid-walled, off-grid) negotiate domestic thermal comfort practices. In this study, households adapted and changed their expectations of thermal comfort to suit their homes' needs, which often resulted in warming the body rather than the house. Narratives of stoicism and resilience were evident in households' accounts which the authors interpret as a potential way of protecting against being labelled as energy vulnerable. As evident in their analysis, networked energy is not the only form of energy that is utilised in carrying out everyday practices; human (bodily/mental) energy also played a part in households' achievement of thermal comfort.

Exploring how off-gridders in Canada heat their homes, Vannini and Taggart (2014) illustrate how off-grid use of renewable heating can be classified as 'hot'/high energy in terms of the corporeal involvement required to source, prepare, store and process energy. While off-grid living does not intrinsically involve living without sensory comforts such as heat, Vannini and Taggart (2014: 64) note that this does entail "a thorough reinvention and reassembling of the technologies and resources needed to generate and experience everyday bodily comforts". Thus, the authors use the concept of affective transformation to delineate on-grid energy as cold and off-grid as hot due to bodily involvement and provide insight into a more active, intensive dynamic between heat-beneficiaries and renewable energy.

5.2. Uptake of low carbon heating technologies

A number of studies have explored the drivers and barriers behind homeowners' decisions to switch from fossil fuel to renewable energy heating systems. Many of the transitions highlighted in the studies reviewed were connected to economic motivations and had government support (Sopha et al., 2010). For instance, Michelsen and Madlener (2016) draw on data from a 2010 survey among owners of existing single-family and duplex houses in Germany that had received a financial grant to install a residential heating system, particularly focusing on determinants of switching from fossil fuels to renewable heating systems. When receiving the grant, homeowners

could decide whether to stick with a fossil-fuel based system or to switch to a renewable one (i.e. heat pump or wood pellet-fired boiler). Results showed that homeowners with a preference for environmental protection and independence from fluctuating fuel prices and geopolitical crises that impact oil and gas supply had a high probability of converting to a renewable residential heating system. Further, those who had more knowledge about renewable systems were more likely to switch to them. Conversely, a high preference for comfort made homeowners more likely to stick with a fossil fuel-based system. It was also deduced that some homeowners are more likely to stick with a system they are familiar with and that did not require a change to their heating habits and routines. Specific barriers also related to each type of renewable heating system, such as the perceived difficulty of getting used to a heat pump and labour-intensity of the wood pellet-fired boiler. These motivations, perceptions and preferences regarding the heating system attributes were found to be more significant than socio-demographic characteristics and attributes of the home. Considering policy implications, the authors argue that the challenge is for policymakers and manufacturers to overcome existing habits and routines and to allay misperceptions about the suitability and convenience of renewable residential heating systems. Grants for replacement heating systems might be accompanied by targeted policy instruments around increasing information and awareness.

Similarly, Meles and Ryan (2022) focus on the adoption and uptake decisions of heat pumps for residential home heating in Ireland, finding that these decisions are complex processes that go beyond financial aspects to include psychological factors, social networks, and consumers' characteristics. In terms of implications for policy designed to effect heating transitions, and implement widespread low-carbon technologies, this research indicates that solutions will need to cater for a broad range of needs as a household's situation changes and which have a degree of flexibility to perform well in different contexts.

Mallet (2007) adds to debates around social acceptance of renewable energy innovations through research conducted in Mexico City from the perspective of those involved in solar water heaters (technicians, industry representatives, local government officials, community representatives/end users). They found a general lack of knowledge about this technology among potential users and little action on the part of the solar water heater companies and the government to increase awareness (especially compared to the advertising power of the state-run petroleum industry). Motives for switching to a solar water heater were also reduced by the fact that payback for the upfront large investment for the technology installation would not be seen for about five years. The final determinant revolved around a lack of communication – companies sharing little information with each other and programmes to promote and coordinate solar water heater take up being ineffective. The research concludes that technology cooperation in which active participants from various sectors interact continuously throughout the process is the most effective approach in eliciting social acceptance of renewable energy innovations.

In a place-based, people-centred approach, Frankowski and Herrero (2021) investigate the household-level impacts of a solid fuel stove replacement programme among Polish households. Amongst their findings were improved wellbeing in terms of additional free time (relating to the activities required to operate a solid fuel heating system) and improvements in indoor thermal comfort and air quality. This coincides with other studies which emphasise the positive effects of home energy improvements, although these were often focused on upgrades to existing energy systems rather than replacement with alternative ones (Gilbertson et al., 2006). In Frankowski and Herrero (2021), replacing stoves resulted in lower energy costs for some households but not all. The financial effect depended on how households responded to the substitute technology and the changes in expectations and routines in the way people used energy at home. In households where energy costs rose after the replacement, this

was attributed to a preference for additional thermal comfort and convenience. Five out of the 12 households who were spending more than 20 per cent of their income on energy after the intervention declared they were worried about their domestic budget and feared bills following the upgrade to their energy systems. There was also evidence that the new heating technologies were not unquestioningly adopted by all households. Some, for instance, kept (or hid) their old coal stoves not fully trusting the substitute technology or storing it for “difficult times”. This also highlighted the complexities in processes of socio-technical change and the historical and political significance of energy carriers and technologies. As the authors state, “in one of the collective imaginaries of today’s Poland, coal still represents predictability and security as the national fuel and ‘bedrock’ of the modern state” (pp. 10). The authors found a complex, fragmented energy landscape that challenges notions of a neat, one-way transition out of solid fuel heating.

Scott and Powells (2020) explore the material and sensory impact of domestic transitions to hydrogen, recognising the home as ‘one of the most intimate spaces of everyday life’. The study focussed especially on the invisibility of hydrogen flames: it found that 13 per cent believed that this would lead to a ‘significant’ or ‘complete’ change to their home heating practices and 42 per cent believed that this would not change their practices at all. Scott and Powells suggest that participants considered home heating through ‘boiler practices’ as an unconscious and invisible routine, nevertheless, they highlighted the sounds of the boiler and the ‘touch’ method of checking if the heating is on to participants’ experiences with their current heating systems (as opposed to sight, which relates to the significance – or lack thereof – of an invisible flame). They suggest a personal detachment from home heating, despite the recognition of the sensory (especially auditory) experiences associated with boilers. The boilers are also described as ‘materially’ backgrounded; they are in cupboards hidden away. The study concluded that the near-invisible flame of hydrogen would impact cooking but not heating. Still, their argument that ‘the human senses are crucial to how gaseous materialities are mediated’ is useful for thinking about heating transitions in other contexts and circumstances. Understanding how energy is sensed in the home across different usages practices is useful for understanding how transitions specifically effect routines related to heating systems.

In a global context, studies have shown that fuel and stove use continues even when electricity services are accessed, confirming the move from traditional energy sources to sole use of modern energy services is far from linear (van der Kroon et al., 2013). Highlighting the complexities and uncertainties associated with such shifts, Muhoza and Johnson (2018) explore users’ experience of connecting to and using electricity services from a solar mini-grid in Mpanta, a small rural fishing community in northern Zambia. They found poor expectation management and limited integration of local socioeconomic dynamics in the service design and an impact on affordability that led to only a slow and partial take-up of the mini-grids. One case study example focuses on a family who prior to mini-grid installation relied on kerosene and candles for lighting. While the mini-grid improved life in some ways – allowing them to spend more time in the house – the benefits were not fully felt by the wife and mother of the family who still had to collect firewood for cooking given Mpanta mini-grid was designed with a limited capacity of only 60 kW and to supply power for a limited number of hours and for ‘essential services’ only.

5.3. Personal histories of transition

Focusing on the personal stories of transition – how it is enacted, experienced and expressed in personal and local terms – often takes a backseat to macro policy tales of technological innovation and adoption in the energy policy literature (Darby, 2017). But, as Darby (2017) argues, personal stories can offer essential contributions to debate on the future of energy systems and should be viewed with equivalent

seriousness. Addressing this gap, Darby (2017) draws on a study conducted in 2000-2001 in a deprived area of lowland Scotland, in the West Lothian District, based on interviews with energy service advisors and observations of their work, and interviews with twelve of their clients who needed more in-depth support. In an initial scene-setting, Darby (2017) outlines the area's historical reliance on its coal reserves as both a source of energy and employment until the mid-1980s and the closure of British pits by the Conservative Government. At the beginning of the 21st century, Darby (2017) notes how the District contained pockets of severe deprivation. As part of a wider package of advice services to assist citizens with financial, legal, employment, and other difficulties, the West Lothian District Council set up the West Lothian Council Energy Advice Project in 1994 to offer free and impartial advice on fuel-related issues. Advisers were trained to negotiate with fuel suppliers and help arrange individual payment plans, to carry out home visits, and to give talks and training to community groups and organisations. The main issues that were driving citizens to ask for advice from the service included damp and cold dwellings, affordability and heating controls, as well as debt, disconnection and disputed bills. Similar to 'energy biographies' approaches, Darby's (2017) aim was to give voice to people who - often prompted by necessity and suffering - had asked for help with specific energy-related difficulties.

Writing first about the housing and fuel histories of the interviewees, Darby (2017) highlights how many had been through major changes in their energy systems, many of which accompanied life transitions. One female interviewee in her sixties, for instance, spent her upbringing in a mill in a steep-sided valley where they drew water from their own well, lit the house with paraffin lamps, and burned logs from trees that her father had chopped. Later in her childhood when her father became a shale miner, she moved to a miner's house 'equipped with a single electric plug' (pp. 123). After marriage she then moved with her husband to her first coal-fired house, and later to a council house with wall and loft insulation. The council offered her the choice between coal or gas-fired central heating, and her husband who had heart disease and disliked 'dry heating' had chosen coal. They contacted the energy advice service when her husband contracted lung cancer and they could no longer afford to pay their fuel bills, at which point the advice service helped her access government funding for a conversion to gas central heating. With ongoing help from the advice service around how to use the new heating system, she was satisfied with the new level of comfort she enjoyed and reduced fuel bills.

Subsequent examples of energy histories show similar transitions from relatively harsh living conditions to greater comfort, but also highlight the crucial role of the energy advisers in making these transitions possible and ensuring they run smoothly. Heating transitions, especially where householders had little control over them, often caused frustration and resignation. One interviewee spoke of when the council 'improved' her mother's heating by putting in a Rayburn fire. She spoke of missing the warmth of the coal fire and the free firewood they would collect and the dissatisfaction with the inefficiency and expense of the new fire. Other frustrations were caused by the lack of action on the part of the council to make energy performance improvements, such as replacing rotten window frames. Switches to different modes of heating also had social implications – while gas central heating meant more affordable comfort, a shift away from coal resulted in social losses as a trip to the coal shed was seen as an occasion to socialise with neighbours. A further difficulty of heating transitions for the interviewees arose from moving to less tangible forms of energy. If something went wrong with the less visible gas and electricity supplies, interviewees found it more difficult to understand what the problem was. What Darby's (2017) article shows, is that housing, climate, demographics and social networks play a significant role in how energy is captured and used and that "energy transition is more than a sequence of developments during which average people in average buildings meekly and unproblematically adopt new technologies and adapt to new infrastructures" (pp. 126). In easing these transitions, the advice and guidance of 'middle-actors' (energy

advisers) was essential, “offering material and social support to citizens whose experiences with housing and heating took new forms as new housing was built, old homes were retrofitted, and gas central heating became normalised” (pp. 126).

In their oral history study of home heating, Goodchild et al. (2017) also found respondents’ early memories of home often featured discomfort and hardship (cold, damp flats, power rationing and the focusing of resources to keep just one room warm). This was nuanced, however, by simultaneous memories of the one ‘warm room’ forming the nucleus of the home and thus causing the family to spend more time together in one space. In early childhood, the struggle for respondents’ families in heating their homes were of a more practical nature, such as the daily ritual of lighting a fire and keeping it burning or shovelling coal into coal stores. In later life, for some respondents who had moved into homes heated by gas central heating, these changed into financial struggles around paying heating bills. The study found that all respondents’ formative experiences had shaped and continued to shape their attitudes and practices concerning heating into adulthood. Those whose parents took a frugal approach to heating the family home also sought to be sparing in their use of heating even with modern systems. Others sought to emulate past experiences by investing in log burners. Having a heat source as a focal point was important to many of the respondents.

5.4. Summary

This chapter has looked at the myriad ways that heating and heating transitions play out in the domestic sphere, drawing out key themes and concepts from the literature around expectations and needs; the uptake of new heating technologies; and personal histories of transitions. The chapter has highlighted the complexity of factors at play in terms of what people want from their heating, how they use it and how they might manage any future transitions.

Conclusions

6

The main aim of this literature review was to identify the extent of existing literature – both academic and policy – on domestic heating transitions, and to explore the methods, theories and concepts applied. The review was based around the questions below, in terms of what the existing literature around heating transitions tells us about:

1. How past and present heating transitions (anywhere in the world, but particularly in Europe) and associated technological change have played out in the home and impacted the lives of citizens emotionally, materially, socially, economically, culturally and politically? How have these experiences varied according to place, time, gender and different social groups?
2. To what extent does the literature deal with these themes? If it doesn't, then what related themes does it engage with?
3. To what extent does the literature take a historic approach, looking to identify the origins of contemporary domestic energy challenges and learning lessons for the present?
4. What theoretical or conceptual frameworks are used in the studies identified? How do understandings of heating transitions vary across the literature according to the different frameworks used?
5. What methods have been used to study lived experiences of heating transitions? How have the methods used affected the depth of insight achieved? Who is represented in these studies?
6. The extent to which concepts of justice and fairness have been considered specifically in relation to home heating transitions. Where this is the case, which definitions of justice have been used and what conclusions have been reached?

Taking the above questions into account, this chapter draws out emerging key findings from the review that are of importance for present and future studies of heating transitions and policy intended to effect equitable transitions.

- The review takes as its starting point the UK Government's intention to phase out gas boilers effecting a transition to cleaner heating systems by 2035. The overt focus on behaviour change and helping people to 'make the right choices' about heating overlooks a multitude of complex considerations as this review has found.
- Switching to new heating systems firstly entails significant justice implications experienced unevenly across different social groups and identities. There was found to be an affordability issue across an international context, with many studies identifying high potential of already vulnerable groups being left further

behind through not being able to afford the up-front costs of transitioning as well as being faced with inflated costs from the gas industry. It is also the case that those with greater energy needs (e.g. disabled people) are one of the most at-risk groups in terms of affordability. Justice also extends to other social categories such as race and gender. Future transitions should be designed in a way that includes and benefits all, acknowledging how past transitions were built on colonial systems of racial abuse and exploitation.

- Historical case studies of previous key transitions to different fuel, energy and technology types, including coal and gas draw out lessons and challenges which may be of relevance to current and future shifts, acknowledging the need to take into account differences in socio-political contexts. Of key relevance in this literature is the acknowledgement that in past transitions, there were clear private benefits for consumers in switching to new energy sources and technologies, whereas the benefits are less obvious for low carbon energy sources and devices today. Presently, there is also no obvious UK organisation with the scope or authority to effect major changes at a system level, as there was in the days of nationalised energy industries.
- Bringing spatiality into studies as a key analytic lens may reveal hitherto neglected insights and questions which studies solely focused on the temporal may not have found. The scale at which transitions are analysed also matters as literature suggests distinct challenges for particular spaces (between rural and urban, for instance). It is also of critical importance to pay appropriate attention to the space in which transitions play out – that of the home – and to give weight to the complexity of conceptualisations of home as a physical, emotional and social space rather than simply the ‘bricks and mortar’ of the house.
- The goal of effectively replacing fossil-fuel-based systems with low carbon alternatives relies on a full understanding of habits, values and preferences for the experience of home heating systems, as well as their origins. Research has shown that householders often have a wider range of needs regarding heating than policies effecting transitions may appreciate.
- Preferences and needs regarding heating have also been shown to change over time, and with various lifecourse transitions. Whether lifecourse transitions offer critical junctures for change remains debated within the literature and is an area which requires further research.
- Heating is inextricably bound up with identity and as such, policies around transitions must recognise the need to take into account a range of social differences when planning and delivering interventions.
- An emerging area of literature also shows how heating and energy practices are deeply imbued with emotion and memory. Efforts to change these longstanding and emotionally-invested practices may require more than awareness-raising or educational campaigns; instead, policymakers and those responsible for future transitions require a greater degree of emotional literacy around heating practices to effect successful and fair transitions.

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