



**Resilience in Housing Performance: An Investigation of Social Housing in the  
UK**

**Melis Tekin**

A thesis submitted in partial fulfilment of the requirements for the degree of  
Doctor of Philosophy

The University of Sheffield  
Faculty of Social Sciences  
School of Architecture and Landscape

May 2025

## Acknowledgements

A great many people have played part in this research and this thesis would not have been possible without all the support from them.

Firstly, I would like to thank and express my gratitude to my supervisors Dr. Isaiah Durosaiye, Dr. Chengzhi Peng and Prof. Wen-Shao Chang. Thank you all for your support and expert guidance throughout my PhD study, especially during my writing-up period.

I would also like to express my sincere gratitude to Prof. Fionn Stevenson for the continuous support from the beginning of my PhD study. Thank you for all your wise words and providing me extra motivation in times that were difficult for me.

The contribution of the research participants (both inhabitants and design team) was highly valuable. I would like to thank you for all your time and support even if there was pandemic happening. I am also thankful for the Housing Association that willingly gave access to their scheme and the stakeholders that generously shared their expertise.

A heartfelt thank you for all my friends and colleagues, from all around the world, who kept me going with all your tremendous support and motivation.

Above all, I dedicate this thesis to my Mum and Dad, I am more than indebted to you both. Thank you so much for all your love, motivation and support throughout my whole life and my PhD journey, I couldn't have done it without you.

## Abstract

The social housing sector can play a significant role in reducing a nation's overall carbon dioxide emissions. While academic research has explored the energy performance of housing at the design stage, these studies have not considered the dynamic changes of inhabitants' practices from the perspective of *resilience*, how inhabitants learn from their experiences and adapt these experiences to their everyday lives, or how inhabitants' respond to changes adaptively.

This thesis proposes a practice-theoretical framework incorporating *robustness*, *adaptation* and *redundancy*, the three drivers of resilience, to better understand how people respond to extreme events, such as the pandemic and cost-of-living crisis, and how energy use in social housing is manifested through the practice of resilience. The thesis addresses the current knowledge gap regarding robustness, adaptation and redundancy, which have not been investigated systematically in post-occupancy housing studies. In particular, the connection between social housing performance and inhabitants' self-reported discussions about energy-related practices remains largely implicit. A better understanding of these discussions and how they can be articulated through robustness, redundancy and adaptation can provide a new source of knowledge for developing resilient social housing in the UK and beyond.

In this research, resilience in the home is examined through the practice theory lens in order to understand the relationships among design, practices and resilience. In order to achieve the aim and objectives of the research, a mixed method approach with a question-driven perspective is used. The research approach includes a literature review, case study, post-occupancy evaluation and data analysis. The four elements of practice theory help to structure the investigation via a resilience matrix. The matrix developed by the researcher was applied to map out the nexus between the four elements of practice theory and the resilience drivers.

Finally, this thesis highlights the implications for future-proofing social housing and recommends actions and policy changes to promote resilience in housing performance.

# Table of Contents

<b>ACKNOWLEDGEMENTS</b>	<b>I</b>
<b>ABSTRACT</b>	<b>II</b>
<b>TABLE OF CONTENTS</b>	<b>III</b>
<b>LIST OF FIGURES</b>	<b>VIII</b>
<b>LIST OF TABLES</b>	<b>X</b>
<b>LIST OF ABBREVIATIONS</b>	<b>XI</b>
<b>DECLARATION</b>	<b>XII</b>
<b>CHAPTER 1: INTRODUCTION</b>	<b>1</b>
1.1 BACKGROUND	1
1.2 HOUSING PROBLEM IN THE UK	2
1.3 SOCIAL HOUSING IN THE UK	3
1.4 RESEARCH GAP AND RESEARCH QUESTIONS	6
1.5 RESEARCH AIM AND OBJECTIVES	7
1.6 POSITIONALITY OF THE RESEARCHER	8
1.7 SCOPE AND LIMITATIONS	9
1.8 THESIS STRUCTURE	10
1.9 SUMMARY	12
<b>CHAPTER 2: RESILIENCE OF SOCIAL HOUSING: STATE-OF-THE-ART</b>	<b>13</b>
2.1 INTRODUCTION	13
2.2 DEFINITIONS OF RESILIENCE	13
2.2.1 RESILIENCE IN THE CONTEXT OF CLIMATE AND SOCIO-ECONOMIC CRISIS	13
2.2.2 FRAMING RESILIENCE IN HOUSING RESEARCH	14
2.2.3 CROSS-DISCIPLINARY UNDERSTANDINGS OF RESILIENCE	20
2.3 RESILIENCE AS A MULTIFACETED CONCEPT	22
2.3.1 SOCIAL CONTEXT	22
2.3.2 ENVIRONMENTAL CONTEXT	23
2.3.3 ECONOMIC CONTEXT	24
2.4 RESILIENCE DRIVERS IN SOCIAL HOUSING	25
2.4.1 ROBUSTNESS	25
2.4.2 ADAPTATION	26
2.4.3 REDUNDANCY	27
2.5 OPPORTUNITIES FOR AND BARRIERS TO DESIGNING RESILIENT SOCIAL HOUSING IN THE UK	29
2.5.1 OPPORTUNITIES	29
2.5.2 BARRIERS	31
2.6 RESILIENCE IN THE UK HOUSING POLICY CONTEXT	32

2.6.1 ENERGY EFFICIENCY LEVELS	32
2.6.2 HEATING AND VENTILATION STRATEGIES	33
2.6.3 HOME USER GUIDE	35
<b>2.7 SOCIAL DYNAMICS IN SOCIAL HOUSING</b>	<b>36</b>
<b>2.8 CRITICAL REFLECTION ON KEY FRAMEWORKS AND THEORIES</b>	<b>37</b>
<b>2.9 SUMMARY</b>	<b>40</b>
<b>CHAPTER 3: THE PRACTICE THEORY FRAMEWORK</b>	<b>42</b>
<hr/>	
<b>3.1 INTRODUCTION</b>	<b>42</b>
<b>3.2 RESEARCH APPROACH</b>	<b>42</b>
<b>3.3 THE ROOTS OF PRACTICE THEORY</b>	<b>44</b>
<b>3.4 ELEMENTS OF SOCIAL PRACTICES</b>	<b>46</b>
3.4.1 KNOW-HOW AND EMBODIED HABITS	47
3.4.2 INSTITUTIONALISED KNOWLEDGE AND RULES	48
3.4.3 ENGAGEMENTS	49
3.4.4 TECHNOLOGIES	50
<b>3.5 PRACTICE THEORY AND CHANGE</b>	<b>51</b>
<b>3.6 RESILIENCE AND INHABITANT PRACTICES WITHIN SOCIAL HOUSING</b>	<b>51</b>
3.6.1 ENERGY-RELATED INHABITANT PRACTICES AND POST-OCCUPANCY EVALUATION	51
3.6.2 EVALUATING RESILIENCE	53
<b>3.7 SUMMARY</b>	<b>54</b>
<b>CHAPTER 4: METHODOLOGY</b>	<b>55</b>
<hr/>	
<b>4.1 INTRODUCTION</b>	<b>55</b>
<b>4.2 METHODOLOGICAL APPROACH</b>	<b>55</b>
<b>4.3 CASE STUDY DESIGN</b>	<b>59</b>
4.3.1 CASE STUDY SELECTION STRATEGY	59
4.3.2 NEW-BUILD HOUSING ASSOCIATION HOMES	62
4.3.3 PRACTICAL AND ETHICAL CONSIDERATIONS OF THE CASE STUDY	62
<b>4.4 MIXED METHODS APPROACH</b>	<b>63</b>
4.4.1 LITERATURE REVIEW	64
4.4.2 DOCUMENT REVIEW	64
4.4.3 SEMI-STRUCTURED INTERVIEWS	65
4.4.3.1 Interviewee Selection	66
4.4.3.2 Interview Planning	70
4.4.3.3 Interview Format	70
4.4.4 USABILITY SURVEY	71
4.4.5 VISUAL RECORDING	73
<b>4.5 DATA ANALYSIS</b>	<b>73</b>
4.5.1 DATA MANAGEMENT AND TRANSCRIPTION	75
4.5.2 CODING	78
4.5.3 DATA ANALYSIS OF USABILITY SURVEY	78
4.5.4 CROSS-CASE SYNTHESIS	79
4.5.4.1 Thematic Analysis	79
4.5.4.2 Mapping	80
<b>4.6 RESEARCH VALIDITY</b>	<b>81</b>
<b>4.7 INTERPRETATION AND TRIANGULATION</b>	<b>81</b>
<b>4.8 SUMMARY</b>	<b>82</b>

---

**CHAPTER 5. HEATING PRACTICES IN THE SOCIAL HOUSING CASE STUDY** **83**

<b>5.1 INTRODUCTION</b>	<b>83</b>
<b>5.2 HEATING CONTROLS IN RELATION TO RESILIENCE AND SOCIAL CHANGE</b>	<b>83</b>
5.2.1 EXTREME FACTORS THAT AFFECT HEATING PRACTICES	84
5.2.2 INHABITANTS' UNDERSTANDING OF HEATING CONTROLS AND THEIR USE IN HEATING PRACTICES	87
5.2.3 IMPACT OF INSULATION LEVELS ON HEATING PRACTICES	90
5.2.4 ACCESSIBILITY TO ENERGY-RELATED SYSTEMS	93
<b>5.3 BOILER PRACTICES</b>	<b>95</b>
5.3.1 INHABITANTS' DISCUSSIONS ABOUT BOILER PRACTICES	95
5.3.2 USABILITY OF THE BOILER AND ALTERNATIVE OPTIONS	97
<b>5.4 ROOM THERMOSTAT PRACTICES</b>	<b>100</b>
5.4.1 INHABITANT DISCUSSIONS AND DECISION-MAKING	100
5.4.2 ROOM THERMOSTAT USAGE PATTERNS AND ROUTINES	103
5.4.3 USABILITY OF ROOM THERMOSTAT AND CHALLENGES WITH ITS FUNCTIONALITY	105
5.4.4 ALTERNATIVE HEATING EQUIPMENT FOR ROOM THERMOSTAT AND SAFETY CONCERNS	108
<b>5.5 PRACTICES ASSOCIATED WITH RADIATORS</b>	<b>111</b>
5.5.1 INHABITANT DISCUSSIONS AND HOUSEHOLD DYNAMICS RELATED TO RADIATOR USE	111
5.5.2 AWARENESS AND PERCEIVED USABILITY OF RADIATORS	112
<b>5.6 SUMMARY</b>	<b>114</b>

---

**CHAPTER 6. VENTILATION PRACTICES IN THE SOCIAL HOUSING CASE STUDY** **115**

<b>6.1 INTRODUCTION</b>	<b>115</b>
<b>6.2 VENTILATION PRACTICES IN RELATION TO RESILIENCE AND SOCIAL CHANGE</b>	<b>115</b>
6.2.1 CLIMATE CHANGE AND HOUSING RESILIENCE	115
6.2.2 BUILDING LIFETIME HOMES AND ADAPTABILITY	116
6.2.3 BREAKING INGRAINED HABITS AND INHABITANT ENGAGEMENT	117
6.2.4 VARIABILITY IN VENTILATION PRACTICES AND MAINTENANCE SUPPORT	119
<b>6.3 WINDOW USE PRACTICES</b>	<b>124</b>
6.3.1 SEASONAL FACTORS THAT INFLUENCE WINDOW USE	125
6.3.2 DISCUSSIONS AMONG INHABITANTS REGARDING WINDOW USE PRACTICES	127
6.3.3 UNDERSTANDING AND USAGE OF TRICKLE VENTS	130
6.3.4 DIFFERENCES BETWEEN DESIGN INTENTIONS AND WINDOW USE PRACTICES	131
6.3.5 USABILITY OF WINDOWS	132
6.3.6 ADDITIONAL EQUIPMENT RELATED TO WINDOWS	133
<b>6.4 DOOR USAGE PRACTICES</b>	<b>134</b>
6.4.1 HABITS OF THE INHABITANTS AND ADAPTABILITY	135
6.4.2 DEMOGRAPHIC-SPECIFIC NEEDS	136
<b>6.5 EXTRACT FAN USE PRACTICES</b>	<b>138</b>
6.5.1 INEFFICIENCY OF EXTRACT FANS AND RELIANCE ON WINDOWS	138
6.5.2 LIMITED ENGAGEMENT WITH EXTRACT FANS AND INSTITUTIONALISED KNOWLEDGE	140
6.5.3 FACTORS THAT INFLUENCE EXTRACT FAN USAGE PRACTICES	142
<b>6.6 SUMMARY</b>	<b>145</b>

---

**CHAPTER 7. DISCUSSION** **146**

<b>7.1 INTRODUCTION</b>	<b>146</b>
<b>7.2 RESILIENCE AND PRACTICE THEORY FRAMEWORK</b>	<b>146</b>
7.2.1 REFLECTION ON THE FRAMEWORK AND ITS RELATION TO THE FINDINGS	149

7.2.2 KNOW-HOW AND EMBODIED HABITS, AND THEIR NEXUS WITH ROBUSTNESS, ADAPTATION AND REDUNDANCY	152
7.2.3 INSTITUTIONALISED KNOWLEDGE AND RULES, AND THEIR NEXUS WITH ROBUSTNESS, ADAPTATION AND REDUNDANCY	155
7.2.4 ENGAGEMENTS AND THEIR NEXUS WITH ROBUSTNESS, ADAPTATION AND REDUNDANCY	157
7.2.5 TECHNOLOGIES AND THEIR NEXUS WITH ROBUSTNESS, ADAPTATION AND REDUNDANCY	159
<b>7.3 FUTURE-PROOFING SOCIAL HOUSING</b>	<b>162</b>
<b>7.4 SUMMARY</b>	<b>164</b>

---

**CHAPTER 8. CONCLUSION** **167**

<b>8.1 INTRODUCTION</b>	<b>167</b>
<b>8.2 KEY RESEARCH FINDINGS IN RELATION TO THE RESEARCH QUESTIONS</b>	<b>168</b>
8.2.1 RESEARCH QUESTION 1	168
8.2.2 RESEARCH QUESTION 2	170
8.2.3 RESEARCH QUESTION 3	172
8.2.4 RESEARCH QUESTION 4	173
<b>8.3 ORIGINAL CONTRIBUTION TO KNOWLEDGE</b>	<b>174</b>
8.3.1 CONTRIBUTION TO THEORY	175
8.3.2 CONTRIBUTION TO PRACTICE	176
8.3.3 CONTRIBUTION TO POLICY	176
<b>8.4 RECOMMENDATIONS</b>	<b>177</b>
8.4.1 POLICY RECOMMENDATIONS	177
8.4.2 PRACTICE RECOMMENDATIONS	178
<b>8.5 LIMITATIONS</b>	<b>179</b>
<b>8.6 FURTHER RESEARCH</b>	<b>180</b>
<b>8.7 CONCLUDING REMARKS</b>	<b>181</b>

---

**CONFERENCE PAPER ARISING FROM THESIS WORK** **183**

---

**REFERENCES** **184**

---

**APPENDICES** **208**

APPENDIX 1: MAPPING DIAGRAM ILLUSTRATING UNDERLYING FACTORS OF RESILIENCE, DEVELOPED BY THE RESEARCHER (CONTINUED NEXT PAGE)	208
APPENDIX 2: USABILITY SURVEY DATA ANALYSIS USING SPSS	210
APPENDIX 3: ANONYMISED PARTICIPANT INVITATION LETTER	211
APPENDIX 4: ANONYMISED PARTICIPANT INFORMATION SHEET	212
APPENDIX 5: PARTICIPANT CONSENT FORM	216
APPENDIX 6: ETHICAL APPROVAL	217
APPENDIX 7: USABILITY SURVEY FOR THE INHABITANTS	218
APPENDIX 8: INTERVIEW QUESTIONS TO THE PROJECT DIRECTOR AND PROJECT COORDINATOR	221
APPENDIX 9: INTERVIEW QUESTIONS TO THE ARCHITECT	224
APPENDIX 10: INTERVIEW QUESTIONS TO INHABITANTS	228
APPENDIX 11: ANONYMISED SEMI-STRUCTURED INTERVIEW TRANSCRIPTION OF PROJECT DIRECTOR	232
APPENDIX 12: ANONYMISED SEMI-STRUCTURED INTERVIEW TRANSCRIPTION OF PROJECT COORDINATOR	241
APPENDIX 13: ANONYMISED SEMI-STRUCTURED INTERVIEW TRANSCRIPTION OF ARCHITECT	249
APPENDIX 14: ANONYMISED SEMI-STRUCTURED INTERVIEW TRANSCRIPT OF INHABITANT: R1	257

APPENDIX 15: ANONYMISED SEMI-STRUCTURED INTERVIEW TRANSCRIPT OF INHABITANT: R2	263
APPENDIX 16: ANONYMISED SEMI-STRUCTURED INTERVIEW TRANSCRIPT OF INHABITANT: R3	267
APPENDIX 17: HOME USER GUIDE FROM THE HOUSING ASSOCIATION	273

## List of Figures

Figure 1.1 Average number of years in current home by tenure type from 2011 to 2022 (adapted from the Department for Levelling Up, Housing and Communities, 2022).....	5
Figure 1.2 Research onion (adapted from Saunders, Lewis and Thornhill, 2009) .....	10
Figure 2.1 Number of scientific articles about ‘resilience’ in Scopus, Web of Science and Science Direct databases from 2012 to 2022 .....	15
Figure 2.2 Number of scientific articles about ‘resilience and housing’ in Scopus, Web of Science and Science Direct databases from 2012 to 2022 .....	16
Figure 2.3 Energy cultures framework diagram (Stephenson <i>et al.</i> , 2015) .....	38
Figure 2.4 Combined resilience and practice theory framework diagram (adapted from Stephenson <i>et al.</i> , 2015) .....	40
Figure 4.1 Research design of this thesis .....	57
Figure 4.2 An example of data mapping that the researcher prepared during first cycle of coding (n = 11) .....	76
Figure 4.3 Example of the second cycle of coding of the inhabitants’ responses using the mapping method (prepared by the researcher) .....	77
Figure 4.4 Example of the second cycle of coding of the design team’s responses using the mapping method (prepared by the researcher) .....	78
Figure 5.1 Parts of the heating system in the social housing: (a) a gas combi boiler; (b) a room thermostat.....	84
Figure 5.2 The percentage of inhabitants who do or do not have the home user guide .....	89
Figure 5.3 Inhabitants’ rating of user guide’s usability for operating equipment in their home .....	89
Figure 5.4 The older inhabitants’ response for the mean rating of their ability to use their energy-related technical equipment.....	90
Figure 5.5 Inhabitants’ responses to the question; does the boiler show any response to your actions? .....	99
Figure 5.6 The percentage of inhabitants who discuss with each other when they need to use the room thermostat .....	100

Figure 5.7 The percentage of inhabitants who take charge of using the room thermostat based on the inhabitants who are at home most of the time, in the evenings or other times.....	102
Figure 5.8 The percentage of inhabitants who take charge of the room thermostat based on gender .....	103
Figure 5.9 Pie diagram showing the inhabitants’ understanding of operating the room thermostat .....	106
Figure 5.10 Inhabitants’ responses about whether the heating programmer shows a response when they turn it on and off .....	108
Figure 6.1 A section of the social housing case study and the ventilation system in the homes, where each floor is for a different flat. This figure is adapted from the documents provided by housing association.....	120
Figure 6.2 A section of the selected social housing case study, showing the ventilation system in the homes. This figure is adapted from the documents provided by the housing association .....	121
Figure 6.3 The mean rating of the ventilation controls in relation to inhabitants’ presence at home and floor location.....	122
Figure 6.4 Pie diagram showing inhabitants’ awareness of ventilation control maintenance procedures .....	124
Figure 6.5 Ventilation controls in the social housing: (a) the double-glazing windows in one of the homes; (b) the trickle vents on top of the window in one of the homes .....	125
Figure 6.6 The percentage of inhabitants who discuss within their households when using windows .....	128
Figure 6.7 The percentage of inhabitants who take charge of using the windows in relation to their presence at home.....	129
Figure 6.8 The percentage of inhabitants who discuss with other household members when they need to use the extract fans .....	141
Figure 6.9 The percentage of inhabitants who take charge of the extract fans in relation to their presence at home.....	141
Figure 7.1 Resilience and practice theory framework diagram (adapted from Figure 2.4)...	151

## List of Tables

Table 1.1 Thesis structure .....	11
Table 2.1 Search strategy string by combinations of keywords .....	17
Table 2.2 Key representative studies about resilience in UK housing over the last 10 years ..	17
Table 2.3 Resilience definitions in different fields .....	20
Table 3.1 Different epistemologies in social sciences .....	43
Table 3.2 Key elements in the understanding of social practices .....	47
Table 4.1 Research structure .....	58
Table 4.2 Case study characteristics .....	60
Table 4.3 Requested case study documents .....	65
Table 4.4 Overview of the semi-structured interviews with inhabitants and design team .....	67
Table 4.5 Design team participant characteristics .....	68
Table 4.6 Inhabitant Characteristics .....	69
Table 4.7 Resilience matrix in relation to practice theory, prepared by the researcher as an analytical tool .....	74
Table 7.1 Resilience matrix with the key findings after data analysis .....	148

## List of Abbreviations

BEIS: Department for Business, Energy and Industrial Strategy

BPE: Building Performance Evaluation

BRE: British Research Establishment

BS: British Standard

CO<sub>2</sub>: Carbon dioxide

EPC: Energy Performance Certificate

IPCC: Intergovernmental Panel on Climate Change

LILAC: Low Impact Living Affordable Community

MEV: Mechanical Extract Ventilation

POE: Post-occupancy Evaluation

RIBA: Royal Institute of British Architects

SAP: Standard Assessment Procedure

UKGBC: The UK Green Building Council

## Declaration

I, Melis Tekin, confirm that the Thesis is my own work. I am aware of the University's Guidance on the Use of Unfair Means ([www.sheffield.ac.uk/ssid/unfair-means](http://www.sheffield.ac.uk/ssid/unfair-means)). This work has not previously been presented for an award at this, or any other, university.

# CHAPTER 1: INTRODUCTION

## 1.1 Background

The global surface temperature increase is projected to exceed 1.5°C over the 21<sup>st</sup> century, leading to more frequent and prolonged heatwaves, as well as more intense precipitation in many regions (Intergovernmental Panel on Climate Change, 2021). According to the *Climate Change Act 2008*, to maintain climate change within tolerable levels, carbon dioxide (CO<sub>2</sub>) emissions must be reduced to net zero in the UK by 2050. However, many climate experts argue that achieving net zero carbon in the UK is more urgent and the target should be brought forward to 2030 (RIBA, 2019; The UK Green Building Council, 2019).

Energy-efficient housing with reduced energy demand is considered critical for reducing CO<sub>2</sub> emissions and addressing the impacts of climate change (Luo *et al.*, 2019). While much attention is paid to increasing the energy performance of housing at the design stage, Grandclément, Karvonen and Guy (2015) indicate that the occupation stage is the key to achieving greater energy efficiency. Gill *et al.* (2010) and Stevenson (2019) also argue that comprehensive building performance evaluations through additional post-occupancy evaluation (POE) methods provide a better understanding of the monitored building performance in relation to how humans actually inhabit their homes and how they use their appliances. According to the Office for National Statistics (2023a) report, 17.0% of all carbon emissions in the UK were caused by the residential sector in 2022, placing this sector in a critical position for reducing carbon emissions by improving building performance (Intergovernmental Panel on Climate Change, 2023). Additionally, the English Housing Survey noted that 35% of the households who live in social housing in the UK struggled with paying their energy bills due to the increased energy prices throughout 2021 (Department for Levelling Up, Housing & Communities, 2021). Consequently, a better understanding of inhabitants' energy-related practices within social housing is necessary to understand the underlying factors of resilience in these households. The scale of social housing provided by housing associations and the specific opportunities for and challenges of providing adequate heating and ventilation in low-income households make this an appropriate sector for research.

This thesis addresses the current knowledge gap by exploring robustness, adaptation and redundancy in terms of inhabitants' practices and home energy use, because these three drivers of resilience have not been systematically investigated in post-occupancy housing studies. Further details about how these three key drivers were identified are provided in Section 2.2. In this research, *adaptation* refers to the adjustments made to reduce the impacts of social changes, and has been developed through social science to include the capacity of individuals and groups to affect resilience, either intentionally or unintentionally (Walker *et al.*, 2004). *Robustness*, another driver of resilience, is defined as the ability to maintain the preferred housing performance despite social changes and the ability to withstand shocks (Buso *et al.*, 2015). In this context, one social definition of *redundancy* is 'the extra capacities available to a housing community, compared with a single individual, to help them adapt and keep control of their home environments in a more resilient way' (Stevenson, Baborska-Narozny and Chatterton, 2016, p. 790). The following sections explore the research gap by focusing on the housing problem in the UK, and present the research aim and objectives.

## 1.2 Housing Problem in the UK

According to Palmer *et al.* (2016), the UK housing stock emits two or three times more carbon than is calculated through design modelling. The Intergovernmental Panel on Climate Change (2023) identified that improvements to housing are critical in order to reduce carbon emissions and adapt to climate change. The updated UK Climate Change Act of 2019 mandates a 100% reduction of CO<sub>2</sub> emissions by 2050 (*Climate Change Act 2008*). A POE study from Baborska-Narozny, Stevenson and Grudzińska (2017) shows that overheating in newly built homes has increased during the summer in the UK due to climate change and its effects. While there are adaptation strategies for concerns about ventilation, heating and cooling in housing, no POE studies have yet demonstrated how to future-proof homes such that they are fully resilient to physical and social changes, revealing a research gap in this area (Stevenson, 2019).

Gill *et al.* (2010) argue that inhabitants' behaviours, due to their poor understanding of the equipment in their homes and the complexity of the design, reduce housing performance.

Despite significant attention being paid to energy performance of housing at the design stage, Grandclément, Karvonen and Guy (2015) further develop the argument of Gill *et al.* (2010), indicating that understanding the occupation stage is key to achieving energy efficiency. This stage is not usually considered at the building design and implementation stages, creating an energy performance gap. Grandclément, Karvonen and Guy (2015) develop their argument by demonstrating the need for designing flexible housing to accommodate diverse inhabitants with different demographics, profiles and practices. However, no studies explore whether homes can carry on performing resiliently despite shocks and social changes. This raises the question about the extent to which housing developments are sensitive to inhabitants' discussions about energy-related practices and how these interface with the key drivers of resilience: robustness, adaptation and redundancy.

The terms 'house' and 'home' have different meanings, but are often used interchangeably in housing studies. Research on the 'house' mainly examines physical elements such as heating and cooling systems, building materials and appliances (Ellsworth-Krebs, Reid and Hunter, 2015). However, studies of the house generally do not pay attention to how inhabitants use energy, assuming that the house users are passive, rather than understanding the role of inhabitants (Shove and Walker, 2014; Ellsworth-Krebs, Reid and Hunter, 2015). 'Home' is an active noun, continuously changing in relation to the inhabitants' physical and social lives, and social and cultural expectations (Mallett, 2004; Ellsworth-Krebs, Reid and Hunter, 2015). Studies about the home explore how inhabitants' routines and practices shape performance, how they manage their home, and how they use technology (Gupta and Chandiwala, 2010; Shove, Pantzar and Watson, 2012). Therefore, in this research the term 'home' is used within the societal 'housing' context to better understand inhabitants' energy-related practices in terms of social robustness, adaptation and redundancy.

### 1.3 Social Housing in the UK

In the late 19<sup>th</sup> century, social housing was primarily for working-class households, providing affordable and high-quality homes (Pearce and Vine, 2014). As home ownership became more accessible and a good investment for households, social housing became a viable

option for those who could not afford to access the private rental housing market (Pearce and Vine, 2014). Boomsma *et al.* (2017) refer to social housing as affordable housing that provides homes for people who cannot afford to buy their own homes. Social housing can also be defined as secure and decent homes for people who cannot afford private housing market prices in the UK (Tabatabaei Sameni *et al.*, 2015). In the UK, the social housing sector is characterised by the institutional arrangements like state ownership and management, mainly serving low-income households (Stephens, Burns and MacKay, 2003). During the 1950s, the social housing sector in the UK began to focus on selecting residents, usually prioritising those with urgent housing needs (Blackwell and Bengtsson, 2023).

The private housing market in the UK does not adequately meet the demand for housing, leading groups, such as housing associations and local authorities, to take the initiative for social housing (Karakusevic, 2018). The social housing market can be seen as a direct provider of housing and is a growing industry with an increasing number of management bodies, like housing associations, adapting to political and economic changes (Reeves, 2006). In the UK, housing associations act as developers and managers of properties, while local authorities (such as councils) provide cash grants to housing associations to plan and build social housing developments (Reeves, 2006).

According to the Department for Levelling Up, Housing & Communities (2022), social housing represents 15.7% of the UK's building stock, with this percentage increasing to 17% in the Yorkshire region. In 2022, 60% of social housing tenants rented their homes from a housing association, and the rest from local authorities (Department for Levelling Up, Housing & Communities, 2022). Figure 1.1 shows that social housing renters tend to stay in their homes longer than private renters. While owner-occupiers tend to live in their homes the longest, it is clear that social housing renters also have long tenures, averaging at least 10 years, benefiting from the decent standard provided.

This research focuses on social housing, where financial limitations (such as lower rents and tighter budgets) are a dominant factor in decision-making (e.g., during the planning stage). However, unlike the private rental sector, which may involve individual landlords making more fragmented decisions, social housing developments are managed by professional landlords such as housing associations or local authorities (Sunikka-Blank *et al.*, 2012). These

organisations have more resources and a more formal decision-making structure, making it easier to implement decisions and policies (such as improving energy efficiency or retrofitting homes) within social housing compared to private landlords who may lack these capabilities (Sunikka-Blank *et al.*, 2012).

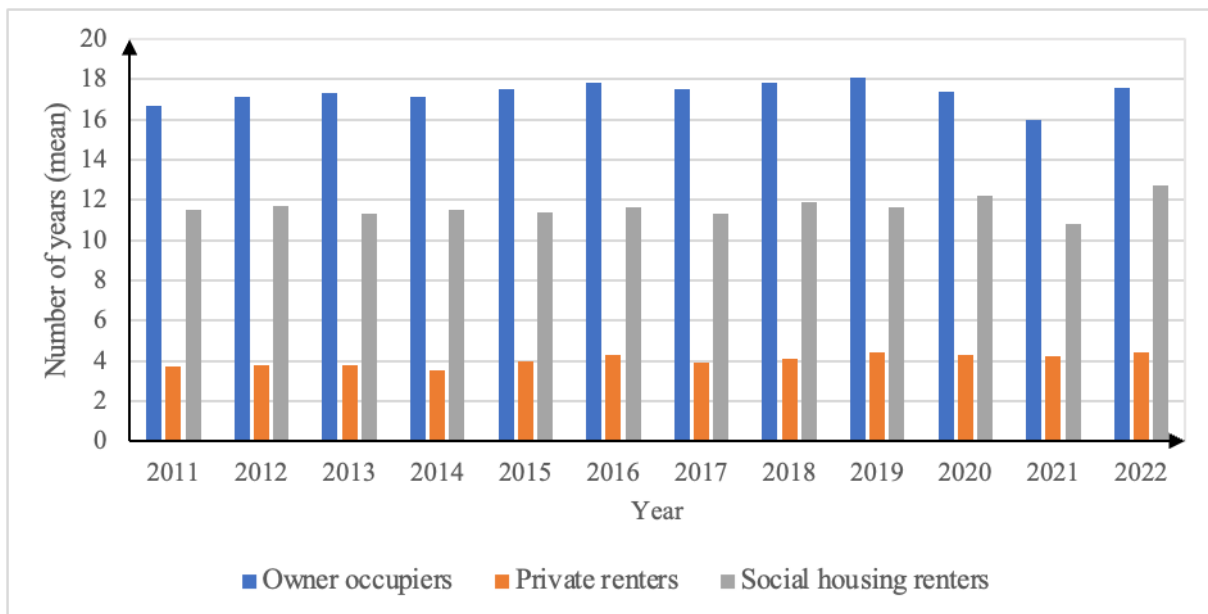


Figure 1.1 Average number of years in current home by tenure type from 2011 to 2022 (adapted from the Department for Levelling Up, Housing and Communities, 2022)

According to the National Housing Federation (2022) report, social housing renters have to spend 15.5% of their income on heating, equivalent to nearly two months’ worth of their annual income. Upgrading social housing to the net zero energy efficiency standard by 2030 could save inhabitants more than £700 million a year in heating costs, an average saving of £567 per household per year (National Housing Federation, 2022). Since the energy crisis and the increases in energy bills, having an energy-efficient home has become a significant and urgent need, particularly for low-income households living in social housing. Therefore, the social housing sector is a key subject to study to achieve the 2030 net zero energy target.

According to Sheffield City Council’s (2013) housing strategy report, the social housing stock is of higher quality than private sector housing, following the investment and improvement strategy in the city. Sheffield’s sustainable investment strategy includes maintaining decent standards in the long term. Additionally, the low-income households in social housing

developments need to have energy-efficient homes to reduce heating costs, as mentioned in the National Housing Federation report (2022). Thus, the researcher chose Sheffield as the case study site to explore and understand the inhabitants' behaviours and activities within social housing, and to understand if these social housing developments perform as designed. Additionally, Sheffield City Council (2024) has an ambition to reduce housing carbon emissions to net zero by 2030. However, 30% of Sheffield's carbon emissions currently come from domestic energy use, and to achieve this ambition, the amount of energy from domestic use needs to be reduced. Thus, doing research in Sheffield will help to explain how inhabitants use the energy-related equipment within their homes and increase understanding of how to reduce domestic energy use and achieve the 2030 net zero energy target.

Achieving the net zero energy target is vital for reducing carbon emissions; however, there is still a need to understand the gap between the energy performance targets set during the design stage of new-build housing and their achievement in practice (Liang *et al.*, 2018). This energy performance gap can be attributed to factors including inhabitants' behaviour, the efficiency of systems in homes, and the thermal performance of the building materials (Gupta and Kotopouleas, 2018). Inhabitants' behaviour, lifestyle and socio-economic status significantly impact energy use through their choices about using the heating and cooling systems, hot water and electricity (Yohanis *et al.*, 2008; Steemers and Yun, 2009; Fuentes, Arce and Salom, 2018). Thus, this thesis aims to understand the inhabitants' energy-related practices within households and how these practices reflect resilience to have a better understanding of this energy performance gap.

#### **1.4 Research Gap and Research Questions**

Previous studies of inhabitants' practices have not focused on robustness, adaptation and redundancy together, nor have they explored the connection between these resilience drivers to understand if social housing is sensitive to inhabitants' discussions about their energy-related practices. Consequently, there is a need for a deeper understanding of inhabitants' discussions about energy-related practices and how these are interrelated with robustness, redundancy and adaptation as an opportunity for developing resilient social housing in the UK.

This research studies how inhabitants discuss their social rules in the household by examining energy-related practices to determine how robust, adaptable, and redundant the social housing is in terms of accommodating social changes related to energy use. These changes include shifts in inhabitants' habits and knowledge, institutional knowledge and rules, the way inhabitants use their homes, and changing technologies.

The above leads to the main research question and four sub-questions:

**Main research question:** How can social housing performance be future-proofed through a better understanding of inhabitants' discussions in the home, in terms of robustness, redundancy and adaptation within resilience over time?

**Sub-question 1:** What are the main opportunities for and barriers to designing robust, adaptable and redundant social housing in the UK?

**Sub-question 2:** What are the underlying factors of robustness, adaptation and redundancy in social housing developments?

**Sub-question 3:** How do inhabitants discuss their energy-related practices in the household and how do these discussions interface with robustness, adaptation and redundancy in social housing design?

**Sub-question 4:** How can social housing be future-proofed to become more robust, adaptable and redundant over time?

## 1.5 Research Aim and Objectives

The overall aim of this research is to explore and understand robustness, adaptation and redundancy in relation to inhabitants' energy-related practices in the household. To achieve this aim, the research has been structured around four specific objectives:

**Objective 1:** Understand the state of the art of the discourse about robustness, adaptation and redundancy of social housing in the UK.

**Objective 2:** Develop an understanding of underlying robustness, redundancy and adaptation in a selected social housing case study.

**Objective 3:** Explore and explain robustness, adaptation and redundancy of the selected social housing design and inhabitants' discussions about energy-related practices.

**Objective 4:** Identify key insights for a new understanding of social housing robustness, adaptation and redundancy in relation to inhabitants' energy-related practices in the household to help future-proof homes.

## 1.6 Positionality of the Researcher

Positionality refers to a researcher's worldview, standpoint and social context when conducting research (Coghlan and Brydon-Miller, 2014). As an architect from Turkey, my view on the resilience of social housing in the UK is shaped by my cultural background, professional training, and personal experiences in both the Turkish and international architectural contexts. I approached this research with the understanding that resilience is not just a technical challenge but a social, governmental and cultural issue. In considering resilience in social housing, I draw on the idea that architecture is both a reflection of and a response to the social landscape, which includes the lived realities of communities and the institutional structures that shape them. Therefore, I see resilience through a lens that respects not only physical durability in the face of climate change, but also social adaptability.

My standpoint as an architect is that the inhabitants' activities and behaviours will influence housing performance. In Turkey, social housing developments have been both a solution and a challenge; in my study during my master's research and in other works, I witnessed the complexities of providing affordable housing in rapidly urbanising regions such as Istanbul (Özen and Aksoy, 2021). My professional background emphasises the importance of resilience in housing design and the UK's social housing context presents a different meaning of resilience compared to Turkey, where social housing is more subjected to policy debates around sustainability, funding cuts and community resilience (Karakusevic, 2018). My own experiences as a researcher, knowledge as a carrier of practices, and the time of data collection (which coincided with Covid-19) are considered mindfully throughout and made visible where appropriate.

As a researcher and an architect, my worldview is to understand the meaning behind human behaviour and how this leads to people's actions and the socially constructed nature of 'reality'. I believe that reality is not objective; it is shaped by human interactions and shared understandings. Thus, I embraced the interpretivist philosophical stance to emphasise the role of meaning and interactions in knowledge production, and to understand human and social reality (Crotty, 1998, p. 67; William, 2024). What the researcher observes is only a partial view of an individual's reality in a specific timeframe, and interpreting data such as interviews (explained in Section 4.7) is always open to the researcher's own experience and knowledge (May and Perry, 2017). An entirely objective interpretation of data is not realistic, meaning that interpretive research is susceptible to misinterpretation or bias. This risk can be reduced by adopting a reflexive approach, which involves critically examining the researcher's own assumptions and exploring potential alternative interpretations (May and Perry, 2017). In this research, I applied Scholte's ideal of reflexivity: 'there is, or should be, a discontinuity between experience and reality, and between the investigator and the object investigated' (Scholte, 1974, p. 435), and accepted the power dynamics between myself as the researcher and participants that require 'careful consideration of the consequences of the interactions with those being investigated' (England, 1994, p. 82).

## 1.7 Scope and Limitations

This study was carried out in new-build social housing, as these homes are required to be 'good-quality' homes that are energy efficient, compliant with building standards and have improved air quality (Balaban and Puppim de Oliveira, 2017; Martiskainen and Kivimaa, 2019). This study purposefully focused on social housing association homes, as this sector has been at the forefront of developing and managing good-quality and affordable homes and remains a major developer of new homes in the UK. This research was confined to a particular social housing association in Sheffield that adheres to UK building regulations, thereby eliminating the influence of policies from other countries. The selected social housing comprises low-rent homes, as these are typically occupied and rented by households with low incomes, potentially influencing their heating and ventilation practices. Research participants included inhabitants and design team members (project developer, project coordinator and architect) to enable consideration of both design intentions and the actual practices of inhabitants. In the present study, the majority of research participants

are over 50, mirroring the demographic profile of social renters in the UK. However, households with children are in the minority in this study, because the selected housing association primarily accommodates older people; therefore, this group represents a research gap for further research.

## 1.8 Thesis Structure

The overall research approach is illustrated in Figure 1.2, adapted from the research onion diagram by Saunders, Lewis and Thornhill (2009), and sets out an exploratory study of the research topic. A practice theory approach is adopted, taking Gram-Hanssen's (2010) definition as the basis, using both inductive and abductive reasoning. The methodology adopted is mixed methods, using a case study approach. The case study design employs semi-structured interviews, usability survey, document study methods, and mapping, within one time period. The case study is selected using an 'information-oriented' approach to provide the 'maximum variation' of characteristics relevant to the research topic as defined in Section 4.3.1. Table 1.1 outlines the scope of each chapter and sets out the thesis structure.

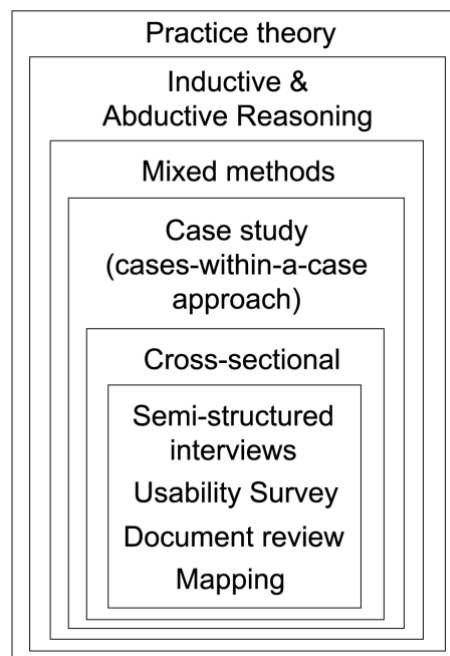


Figure 1.2 Research onion (adapted from Saunders, Lewis and Thornhill, 2009)

Table 1.1 Thesis structure

Thesis Chapter		Chapter Content
1	<b>Introduction</b>	<p>Context of climate change, housing problem in the UK, social housing in the UK</p> <p>Knowledge gap and research questions</p> <p>Research aim and objectives</p> <p>Scope of the study and limitations</p> <p>Thesis structure</p> <p><i>The following chapter locates the research topic in a wider context and the gap in the knowledge is evidenced.</i></p>
2	<b>Resilience of Social Housing: State-of-the-art</b>	<p>Critical review of literature, including existing research and government documents, related to social housing and heating and ventilation systems</p> <p>Research gap is explored and evidenced</p> <p><i>In the next chapter, the theoretical framework is explained with the reasons for the approach selected.</i></p>
3	<b>The Practice Theory Framework</b>	<p>Presenting the research approach and the reason for choosing practice theory</p> <p>The roots, development and continuing evaluation of practice theory</p> <p>Gram-Hanssen's definition of practice theory and elements of social practices as an analytical tool</p> <p><i>The following chapter explains the methodology adopted for this research and methods for investigating the gap in the knowledge, using the theoretical framework adopted.</i></p>
4	<b>Methodology</b>	<p>Methodological approach and rationale, data collection methods, data analysis methods</p> <p><i>The following chapter sets out the findings and analysis of the collected data that are related to the heating practices.</i></p>
5	<b>Heating Practices in the Social Housing Case Study</b>	<p>Analysis of heating practices in the selected case study, in terms of the framework described in Chapter 3, by looking at both the inhabitants' and design team's perspective</p> <p><i>The following chapter sets out the findings and analysis of the collected data that are related to the ventilation practices.</i></p>
6	<b>Ventilation Practices in the</b>	<p>Analysis of ventilation practices in the selected case study in terms of using the framework described in Chapter 3, by</p>

	<b>Social Housing Case Study</b>	looking at both the inhabitants' and design team's perspective  <i>In the next chapter, the analysis of heating and ventilation practices of the inhabitants of social housing based on Chapters 5 and 6, are discussed.</i>
<b>7</b>	<b>Discussion</b>	Resilience matrix developed by the researcher is defined and discussed by using the analysis on the energy-related practices described in Chapters 5 and 6  The interrelationship between the inhabitants and design team is discussed in terms of future-proofing policies for social housing  <i>In the final chapter, the research questions are answered by drawing on the findings, analysis and discussions. The contributions and limitations of the research are explained and directions for future work are suggested.</i>
<b>8</b>	<b>Conclusion</b>	Aim and context of the research are summarised Key research findings and contributions to theory, knowledge, policy and practices are explained with reference to the literature and the themes in Chapter 7 Recommendations for policy and practice Limitations and further research

## 1.9 Summary

This chapter has presented an overview of the research background. The housing problem in the UK was explained by highlighting the importance of home energy use and inhabitants' energy-related practices within the home. Social housing in the UK was discussed to explain why the social housing provided by housing associations was the appropriate sector for this research. The research gap and research questions were identified. The research aim and objectives were presented, followed by the scope and limitations of the research. The overall research approach and thesis structure were illustrated in Section 1.6. The following chapter provides a critical review of the literature and evidences the knowledge gap.

## CHAPTER 2: RESILIENCE OF SOCIAL HOUSING: STATE-OF-THE-ART

### 2.1 Introduction

The broader context for this research is the resilience of social housing and its relation to inhabitants' practices and social change. This chapter sets out to review current knowledge and policies in order to identify the gap in the literature. The theoretical underpinning of this research is then presented in Chapter 3.

### 2.2 Definitions of Resilience

#### 2.2.1 Resilience in the Context of Climate and Socio-Economic Crisis

Resilience is the capacity to resist or absorb the social, economic and environmental impacts of disruption and to recover from these impacts by maintaining stability and adapting flexibly to a new state or system (Walker *et al.*, 2004; Tyler and Moench, 2012; van Zandt *et al.*, 2012). The concept of resilience has been expanding and developing since the 1970s, when Holling (1973) defined it as the ability of systems to absorb disturbances while maintaining their functions. Resilience has also been described as the opposite of vulnerability, requiring flexibility, change and learning in urban, ecological and socio-ecological systems (Tyler and Moench, 2012; Intergovernmental Panel on Climate Change, 2022a). Biggs *et al.* (2012) further discuss resilience processes in socio-ecological systems and describe how communities interact with their environment and governance by exchanging information necessary to function and recover after disturbances.

'Social resilience' can be considered as an umbrella term encompassing the behaviours, experiences and demands of people facing adversity (Ungar and Liebenberg, 2011). It can be enhanced by identifying underlying qualities and issues, and helping people cope with minor stressors and disturbances and serious environmental events more effectively (Fletcher and Sarkar, 2013; Grant and Kinman, 2014). Governments worldwide have recognised the need to empower communities and individuals, particularly in developing countries, to reduce the impact of floods, severe storms, pandemics and so on (Boon, Cottrell and King, 2016). This is crucial, as developing countries have fewer resources and lower budgets for recovery.

### 2.2.2 Framing Resilience in Housing Research

The global surface temperature is projected to increase by 1.5°C over the 21<sup>st</sup> century (Intergovernmental Panel on Climate Change, 2022b). According to the Intergovernmental Panel on Climate Change (2021), heatwaves are likely to occur more often and last longer, and in many regions extreme events like storms and flooding will occur more intensely. The UK Climate Change Committee (2023) states that long-term plans to reduce the impacts of climate change include adapting buildings to have cooling and insulation measures. In addition, the global financial crisis of 2007/08 and the Covid-19 crisis that started at the end of 2019 both affected UK housing production and created space pressures for occupants in households (Earley, 2021).

Ever since the oil crisis of the early 1970s, significant attention has been paid to increasing the energy performance of housing at the design stage, as noted by Painter (2014). However, many studies indicate that the occupation stage and how people actually use their homes are key to understanding how to achieve greater energy efficiency (Gill *et al.*, 2010; Grandclément, Karvonen and Guy, 2015; Stevenson, 2019). Recently, the increasing focus on climate change has driven efforts to understand whether buildings and communities are resilient enough for the unpredictable events that might occur in the future.

Having outlined key aspects of resilience in this section, it is next necessary to explore the state of the art in relation to the development of resilience in the context of housing. A literature review was undertaken to find all the relevant studies in relation to this field, synthesise the findings and identify research gaps (Jesson, Matheson and Lacey, 2011). This literature review first explored the latest developments and research in relation to the field of inquiry (Bettany-Saltikov and McSherry, 2016) and included:

- Conducting a comprehensive search using all available information sources;
- Creating a matrix of resilience drivers, including robustness, adaptation, and redundancy;
- Listing the opportunities and barriers according to the literature review;

- Identifying key existing and potential social shocks and stresses related to occupancy change according to the literature review.

The review included selected databases: Scopus, Web of Science and Science Direct. First, the keyword ‘resilience’ was searched in these databases between 2012 and 2022 (see Figure 2.1). Over the past decade, the number of papers published about resilience has increased significantly. The keywords ‘resilience AND housing’ were then searched in the same databases and timeframe (see Figure 2.2). Figure 2.2 shows that the number of scientific papers published on ‘resilience and housing’ has been increasing over the last 10 years. Despite a slight decrease in the number of published papers on ‘resilience’ in the Web of Science database between 2021 and 2022, there was still an increase for ‘resilience and housing’ in the same database during that period (see Figure 2.1 and Figure 2.2).

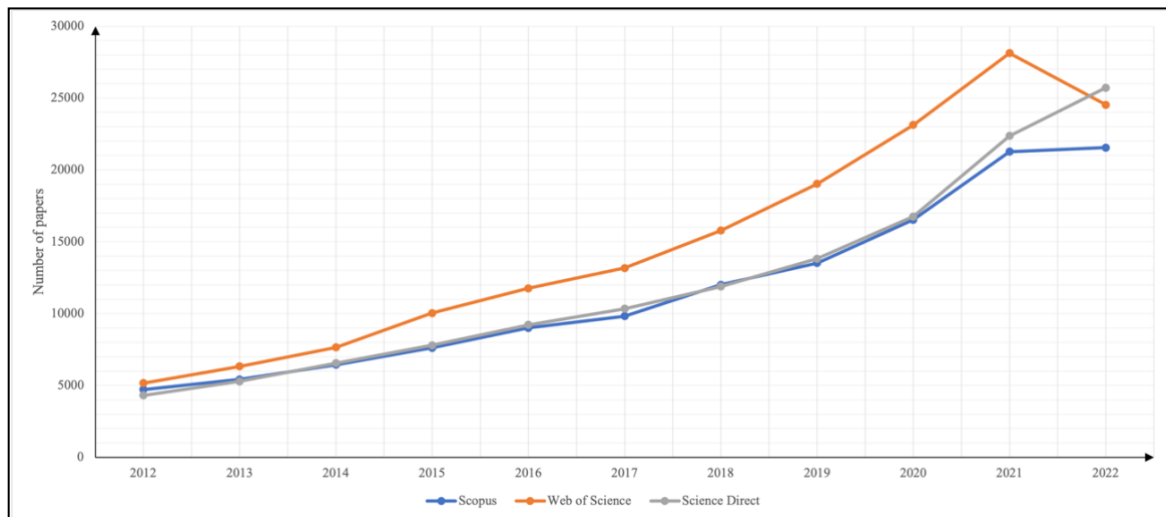


Figure 2.1 Number of scientific articles about ‘resilience’ in Scopus, Web of Science and Science Direct databases from 2012 to 2022

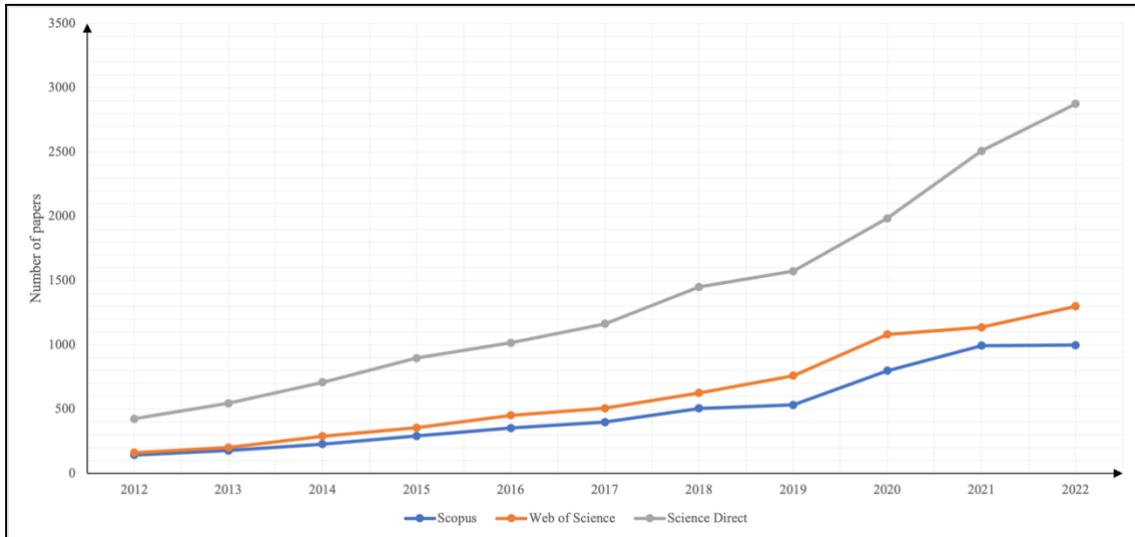


Figure 2.2 Number of scientific articles about 'resilience and housing' in Scopus, Web of Science and Science Direct databases from 2012 to 2022

The next stage of the literature review was to combine the key research terms with the actors and location (see Table 2.1). In order to reach more in-depth literature around the research aim, different combinations of key research terms were used, as shown in Table 2.1. When the in-depth detailed hits were found, to exclude non-relevant articles, all titles and abstracts were read. After excluding non-relevant articles, the remaining articles were grouped to identify which areas of resilience had been covered, revealing the research gaps. Three key drivers of resilience were identified: robustness, redundancy and adaptation. These drivers were reviewed separately, and none of the studies covered all three drivers together in relation to resilience and social housing. Some key articles on resilience in UK housing from the last 10 years are presented in Table 2.2. These papers were selected because they are representative of resilience research in UK housing.

Table 2.1 Search strategy string by combinations of keywords

Terms	Actors	Location
1- Resilience	6- Inhabitant	13- UK
2- Hous*	7- Occupant	
3- Energy-use	8- User	
4- Behaviour	9- Resident	
	10- Dweller	
	11- Household	
5- Combine 1-4 using 'AND'	12- Combine 5 with 6-11 using 'AND'	14- Combine 5 - 12 - 13 using 'AND'

Table 2.2 Key representative studies about resilience in UK housing over the last 10 years

Author	Representative Articles	Key Themes
Gupta and Kapsali (2016)	Empirical assessment of indoor air quality and overheating in low-carbon social housing dwellings in England, UK	Resilience in terms of adaptation
Behar (2016)	A socio-technical perspective of ventilation practices in UK social housing with whole house ventilation systems; design, everyday life and change	Resilience in terms of adaptation
Gupta and Gregg (2018a)	Assessing energy use and overheating risk in net zero energy dwellings in UK	Resilience in terms of robustness and adaptation
Baborska-Narozny and Stevenson (2015)	Continuous mechanical ventilation in housing – understanding the gap between intended and actual performance and use	Resilience in terms of redundancy and adaptation
Stevenson, Baborska-Narozny and Chatterton (2016)	Resilience, redundancy and low-carbon living: co-producing individual and community learning	Resilience in terms of redundancy

---

Jones et al. (2013)	Assessing vulnerability, resilience and adaptive capacity of a UK Social Landlord	Resilience in terms of robustness and adaptation
Jones and Tanner (2017)	‘Subjective resilience’: using perceptions to quantify household resilience to climate extremes and disasters	Resilience in terms of robustness and adaptation
Brierley (2021)	Fresh air and low-carbon: a practice approach to maintaining home ventilation	Resilience in terms of robustness

---

Gupta and Kapsali (2016) analysed qualitative and quantitative data related to energy performance, occupant feedback, environmental conditions and adaptation. Their findings reveal that indoor environmental conditions in dwellings are determined not only by the building systems and fabric, but also by the interactions of inhabitants with these systems. They note a lack of adjustability in the systems, such as usable home user guides or usable controls for energy systems in the home, hindering adaptation. They argue that the disparity between design intentions and inhabitants’ understanding is a key reason for the performance gap in terms of energy and environment. However, they do not cover the robustness and redundancy aspects of resilience.

Behar (2016) also focuses on the adaptation and social practice theory in her thesis on the ventilation practices within low-energy social housing in the UK. Her key finding is that inhabitants do not always follow the design intentions. While some of the inhabitants’ ventilation practices slowly adapt to changes in ventilation systems, others are unpredictable in adapting to these changes. Behar’s thesis emphasises domestic ventilation practices of inhabitants and their adaptability to design intentions, but does not address robustness and redundancy. She mentions that it would be beneficial to look at inhabitants’ practices by using alternative qualitative methods to find out more about their daily lifestyles.

Similarly, Gupta and Gregg (2018a) explore energy use and overheating risks in net zero energy housing using the adaptive comfort methodology. They conducted climate change simulations and analysed the energy end use for different climate projections to improve

next-generation housing despite extreme conditions. Their study focuses on the adaptive measures of technologies in the home and physical robustness to improve housing as the climate warms. However, they do not cover redundancy aspects or other energy-related practices beyond overheating.

Baborska-Narozny and Stevenson (2015) conducted a building performance evaluation study, particularly focusing on mechanical ventilation in two UK low-carbon housing developments, by using practice theory related to adaptation and redundancy. They found that, despite the adjustments to the ventilation systems, most inhabitants still rely on hybrid ventilation as a backup. To increase the success of interactions with mechanical ventilation systems in homes, the usability of the system controls should align with users' expectations. Their study does not cover robustness or energy-related practices besides ventilation. Similarly, the study of Stevenson, Baborska-Narozny and Chatterton (2016) introduces the concept of redundancy in low-carbon cohousing practice and makes recommendations for various stakeholders to future-proof housing developments.

A recent study on reducing carbon emissions in response to climate change was conducted through Brierley's (2021) thesis, which addresses this issue by examining the long-term maintenance of ventilation systems in low-energy housing association homes in England. She adopted a practice theory approach to comprehend the complexity of maintenance practices and the various ways they are shaped, bundled and constrained within low-energy homes. Her work provides a new perspective on ventilation practices and the challenges to effective maintenance in these homes. While this study focuses on existing ventilation maintenance practices, Brierley's research does not cover how these practices evolve in response to changing inhabitant behaviour, policy shifts or emerging technologies.

In summary, these papers focus on inhabitants' practices related to different aspects of resilience, but do not link these resilience drivers together in relation to social housing. To future-proof homes, the nexus between robustness, redundancy and adaptation in terms of inhabitants' energy-related practices needs to be revealed.

### 2.2.3 Cross-Disciplinary Understandings of Resilience

A number of scholars from a diverse range of disciplines, including ecology, engineering, social sciences and economics, have reviewed the concept of resilience (see Table 2.3). In terms of engineering, resilience is the ability of a material or a system to withstand change and continue to function (Porter, Steele and Stone, 2018). In ecological studies, resilience is the ability to function even if there is a change and disturbance to the ecosystem (Holling, 1973). The ecological perspective of resilience differs from the engineering perspective because ecological resilience measures the extent of disturbance before there is a change in the ecosystem (Cretney, 2014). Adger (2000) and Shaw (2012) describe resilience as the ability to change, evolve and learn, rather than continuing to do the same thing. Porter, Steele and Stone (2018) define resilience from a housing studies perspective, suggesting that adaptation is a critical indicator of resilience that explains how well a system can withstand disturbances. This argument is crucial because extreme events, such as Covid-19, affect both the housing system and the inhabitants living in it.

Table 2.3 Resilience definitions in different fields

<b>Author</b>	<b>Research Area</b>	<b>Definition</b>
Holling (1973)	Ecological studies	Stability and the ability to function even if there is a change and disturbance to the ecosystem
Adger (2000)	Social and ecological studies	The ability of individuals and social groups to withstand external shocks and stresses
Hollnagel (2010)	Engineering studies	The ability to respond to events by estimating possible threats and opportunities
Duval, Elmeskov and Vogel (2011)	Economics studies	The ability to pursue output close to potential after a shock

<b>Author</b>	<b>Research Area</b>	<b>Definition</b>
Hassler and Kohler (2014)	Housing studies	A bridge between the implementation of sustainability targets and adaptation to shocks and stresses
Schwarz (2018)	Psychological studies	The responsibility of an individual to behave in a way that influences his or her life course while avoiding threats

Hassler and Kohler (2014) and Moffatt (2014) indicate that sustainability and resilience are concepts that change according to differences in scale, such as building, neighbourhood or city scale, allowing the long-term development of the built environment, innovation in timing, and approaches such as planning and design to adapt to changing conditions. According to Berkes, Johan and Folke (2003), the concept of resilience can also be viewed as an analytical tool that can be used to retain sustainability despite change. Hassler and Kohler (2014) similarly identified resilience as a bridge between the implementation of sustainability targets and adaptation to shocks and stresses. Despite the stresses and problems, a resilient community is one that reacts to these stresses in a positive way (Garrefa *et al.*, 2021).

The ongoing development of resilience as a concept within built environment research is supported by the ongoing sustainability debate, climate change research, and the awareness of increased risks (Hassler and Kohler, 2014). Resilience has become a positive indicator for communities where various factors, such as social and physical changes, harm the well-being of the occupants (Stollmann, 2016). According to Tyler and Moench (2012), increasing the resilience of urban environments involves reducing the fragility of the systems (e.g., water and food supply, power networks, transportation, communication) by adapting them, enhancing the capacities of social agents to develop adaptive responses, and determining the institutional factors (e.g., social injustices) that prevent effective responses. Resilience can also integrate the ability of housing to respond to change and crisis through housing policy discourse (Pablo, Littleton and London, 2024).

Given these definitions of resilience in different fields, the role of resilience in shaping housing developments becomes increasingly critical. Social housing, in particular, is at the intersection of socio-economic constraints and policy-driven interventions (Blackwell and Bengtsson, 2023). Understanding how resilience affects social housing is essential for evaluating the lived experiences of inhabitants and the effectiveness of housing policies. The following section explores resilience as a concept that addresses social, environmental and economic contexts within social housing.

## 2.3 Resilience as a Multifaceted Concept

Resilience is a multifaceted concept that is viewed through social, environmental and economic lenses (McCarthy *et al.*, 2011). These dimensions help explain resilience in a holistic way, particularly in relation to housing, by emphasising social integration, affordability and improvements in energy efficiency (Tsenkova, 2021). This section explains what resilience means in different domains and how these contexts interact within social housing. By examining these contexts, this thesis aims to contribute to a more comprehensive understanding of resilience, emphasising energy practices within housing research.

### 2.3.1 Social Context

The social impact of resilience is predominantly explored in social-ecological studies. Folke *et al.* (2003) highlights key social features that are essential for the resilience of social-ecological systems, such as monitoring and responding to environmental feedback, enabling legislation and social networks. However, it is unclear whether these social features play a similarly significant role in the resilience of housing systems. Social aspects of resilience are very useful when there is a need for more understanding of the capacities of individuals and communities to cope with change (Brown and Westaway, 2011); however, Brown (2014) notes that social factors, particularly power dynamics and social differences, lack adequate recognition in social science disciplines. Maclean *et al.* (2017) describe resilience as a process rather than an outcome, highlighting social impacts such as flexibility, adaptive capacity and durability. Baldwin and King (2018) look at the social impacts of resilience using a different approach, stating that it involves 'people' and focusing on how people communicate with and behave towards each other, and their everyday behaviours.

Conducting research and experiments on social housing sites can be a strategic way to increase quality and efficiency, set new standards, and aid recovery from a crisis such as Covid-19 (Brai, Mangialardi and Scarpelli, 2022). According to a United Nations Human Rights report, housing became ‘the front-line defence against coronavirus’, emphasising the importance of access to adequate and resilient housing (United Nations Human Rights, 2020). The Covid-19 pandemic caused significant changes to the ‘state’ of the housing system: households improvised to enable their homes to function as places to work and study (for example, by creating home offices), and cooking and eating at home increased (Pablo, Littleton and London, 2024). These diverse perspectives indicate that resilience in housing should be viewed as extending beyond physical infrastructure and should instead be examined through the lived experiences and social dynamics of its inhabitants.

This study primarily focuses on the social impacts of resilience in social housing due to the need for greater understanding of the social aspects in housing and energy studies. However, this study also touches on the environmental and economic aspects that affect housing and participants where relevant.

### 2.3.2 Environmental Context

This section discusses the key environmental impacts that affect social housing. Climate change and extreme weather events, such as heatwaves and flooding, necessitate high-quality homes with adequate space and equipment, and without negative externalities, specifically in the social housing sector, where residents are more vulnerable to these extreme events (UN-Habitat, 2009; Climate Change Committee, 2023). Different regions experience natural hazards at different levels, influenced by climate change and the severity of their impact can depend on local housing management plans (Moghim and Garna, 2019). Moghim and Garna (2019) state that the environmental context of resilience includes the impacts of disasters such as flooding, earthquakes, extreme temperatures, and landslides, and the ability to recover from these impacts. Vulnerable communities are more susceptible to the negative effects of these extreme events due to improper management policies (Huq *et al.*, 2007; Baker, 2012).

Housing is one of the main sectors that suffers the consequences of global warming, but it also has great potential to reduce these impacts (United Nations Environment Programme,

2022). Webster and Bogunovich (2021) state that planning, designing and using housing effectively will determine energy consumption and greenhouse gas emissions, meaning there is a need for housing that is not only affordable, but also resilient to the consequences of climate change. Research indicates that energy is invisible to the households who have little or no awareness of how the energy is generated, thus they are not aware of and do not consider the increased energy consumption of their homes (Sherriff *et al.*, 2019; Ambrose, 2020).

This thesis explores the environmental context concerning the negative effects of climate change on social housing and how this impacts the energy-related practices of its inhabitants.

### 2.3.3 Economic Context

The Covid-19 pandemic and the energy crisis following the war in Ukraine have put the UK's energy system under pressure, resulting in high energy prices with increased vulnerability of the population (International Energy Agency, 2022b; Burlinson *et al.*, 2024). For instance, Guan *et al.* (2023) state that low-income households and vulnerable groups like pensioners face a difficult choice between paying for energy and other necessities, thus it is necessary to mitigate the increased energy costs (Deller, Turner and Waddams Price, 2021). Additionally, the rising costs of both owner-occupier and rental housing is an area of concern for vulnerable populations, as they are likely to suffer from a lack of access to quality and affordable housing (Rowley *et al.*, 2023). According to Burlinson *et al.* (2024), one of the economic impacts related to the energy crisis is the affordability of household bills, which directly affects inhabitants' quality of life and well-being.

Improving the resilience of housing infrastructure across its lifespan whilst considering different household demographics is essential for designing more liveable housing for the future, as it might be difficult for some households, such as pensioners, to pay for costly renovations (Kraatz, 2018). However, policy interventions that protect consumers from price shocks and the availability of unconditional financial support might lead some households (particularly those who can afford to pay for the energy prices) to not adjust their consumption behaviours (Burlinson *et al.*, 2024).

This study focuses on the economic impacts related to increased energy bills due to Covid-19 and the energy crisis, examining how these factors affect inhabitants' energy-related practices. To summarise, this thesis highlights the critical need to understand the social context of resilience within social housing, particularly in housing and energy studies. While the main focus is on social resilience, this thesis also acknowledges the interconnected nature of resilience by considering environmental and economic contexts where relevant. The following section highlights the importance of resilience drivers in shaping how social housing and its inhabitants respond to external disruptions.

## 2.4 Resilience Drivers in Social Housing

Adger (2000) emphasises resilience as an important factor for adapting to environmental change. A similar approach is proposed by Maguire and Cartwright (2008), who examine resilience across three dimensions: stability, recovery and transformation. These dimensions show that, when subjected to environmental changes, a community can either withstand minor disruptions, recover from more severe ones, or fail to be resilient. However, these dimensions often overlook the dynamic change of communities through transformational resilience, where people learn from their experiences and adapt these experiences to their everyday lives, thus responding to change adaptively. Therefore, a deeper understanding of robustness, adaptation and redundancy is needed to understand how people respond to extreme events, and how this relates to home energy use. This section explains how the multifaceted concept of resilience is actively maintained and strengthened through its key drivers.

### 2.4.1 Robustness

According to Anderies *et al.* (2013), robustness is typically associated with consistency or precision in the designed systems or algorithms, such as robust control systems or robust decision algorithms. In these computational contexts, robustness captures the idea that some computational methods work well even if the information about the system is incomplete. Applied to the housing context, robustness can be defined as reduced sensitivity to shocks and stresses (Anderies *et al.*, 2013).

Robustness is a driver of resilience that aims to maintain a building's performance over its lifespan (Anderies, 2014; Kotireddy, Hoes and Hensen, 2018). It is further defined as the ability to sustain a building's energy performance at the preferred level despite extreme conditions, and the ability to withstand shocks, such as heatwaves (Buso *et al.*, 2015). Kotireddy, Hoes and Hensen (2018) support this principle by defining robustness as the building's capability of performing at the preferred level in the face of social changes and different uncertainties occurring during the building's operation. Tuohy (2009) defines robustness in the building performance context as the ability to withstand uncertainties and this study addresses the gaps in sustainability frameworks by considering inhabitants' behaviour and climate change. Similarly, Loonen *et al.* (2017) evaluate robustness of buildings' elements in terms of inhabitants' behaviour and changing weather conditions. Robustness is also highlighted in the building performance gap studies of Fawcett *et al.* (2012) and de Wilde (2014), who define robustness as reducing the performance gap between the predicted and actual energy performance by ensuring the predicted performance over the building's lifespan. Rouleau, Gosselin and Blanchet (2019) investigate robustness from a different perspective and define a non-robust building as one that performs differently than predicted, often due to not taking into account occupants' behaviour when measuring the energy performance of buildings.

For the purposes of this study, robustness is defined as 'the ability to maintain the preferred housing performance despite social changes over time'. In this thesis, a study of this type of robustness is needed to understand whether energy systems in the home (e.g., heating and ventilation systems) can withstand sudden shocks and social changes.

#### 2.4.2 Adaptation

Adaptation focuses on measuring function in relation to crisis and dynamic possibilities (Porter, Steele and Stone, 2018). Traditionally, adaptation refers to adjustments in a system's behaviour and characteristics that increase its ability to overcome external shocks and stresses (Brooks, 2003). The term adaptation has also been developed further through social sciences to include the capacity of individuals and groups acting to affect resilience, either intentionally or unintentionally (Walker *et al.*, 2004). According to Adger, Arnell and Tompkins (2005), adaptation can also protect economic well-being or improve safety to

benefit the individual or the community. These authors explain that a successful adaptation strategy, however, depends on how the action meets the objectives and the ability of achieving the adaptation goal in response to social changes. Gupta and Gregg (2018a) describe adaptation as an adjustment to reduce the impacts of physical and social changes. Garrefa *et al.* (2021) also argue that sustainability should be an objective that guides the actions of adaptation towards resilience. Brooks (2003) and Maguire and Cartwright (2008) suggest that adaptation should allow actions to reduce vulnerabilities, and Chatterton (2015) describes how 'collective learning' plays a major role in terms of developing housing performance.

For the purpose of this study, adaptation is defined as 'the ability for long-term learning to overcome the effects of social shocks and stresses'. This thesis considers social adaptability to understand how adaptable the home is in relation to social changes, involving a three-way relationship among inhabitants, discussions and homes. For example, an individual is in the habit of keeping the boiler on during the night and off during the day, and he also discusses the boiler with his partner. However, something happens to change his habit and he starts to keep the boiler on all day, increasing the energy usage in the home. The social adaptability considered here depends on how changes in the inhabitants' habits affect the ability of the home to adapt.

#### 2.4.3 Redundancy

In the context of resilience, the term 'redundancy' is most commonly used in ecological resilience studies. In an ecosystem, if one species goes extinct, other species with similar roles can continue to function and maintain the stability of the ecosystem; this is called functional redundancy (Walker, 1992; Morelli and Tryjanowski, 2016). Functional redundancy is also used in housing studies, where housing can be seen as an ecosystem that has different organisms within it that take on different functions. In housing, different pieces of equipment can perform similar functions; for example, shading, windows, doors, photovoltaic lighting, blinds, etc., can provide similar functions of ventilation, heating, cooling, etc., that can take over if a piece of equipment fails. For instance, mechanical ventilation and windows are different types of equipment in the home, but they perform the

same function of ventilation. If the mechanical ventilation fails, windows can continue to provide ventilation in order to maintain the performance of home.

The role of redundancy is critical for housing communities and low-carbon living due to the poor resilience of housing generally (Maguire and Cartwright, 2008; Stevenson, Baborska-Narozny and Chatterton, 2016). One definition of redundancy is 'the extra capacities available to a housing community, compared with a single individual, to help them adapt and keep control of their home environments in a more resilient way' (Stevenson, Baborska-Narozny and Chatterton, 2016, p. 790). Middlemiss and Parrish (2010) highlight that increasing the use of redundancy effectively depends on the occupants' personal and social experiences. Petcou and Petrescu (2015) argue that the residents themselves can propose alternative solutions and test their self-management and self-production of a project. These 'alternatives' are a means of establishing the degree of functional redundancy present in the home and within a community, for example, by using solar energy generation, rainwater collection and compost-powered heating as 'alternatives' for heating, water-use and energy consumption. Stevenson, Baborska-Narozny and Chatterton (2016) also argue that social diversity is another major aspect of redundancy in the community-based Low Impact Living Affordable Community (LILAC) field study. In this study, the housing development has developed a considerable amount of physical and social redundancy to enable its occupants to achieve the goal of low-impact living (Biggs *et al.*, 2012). While social, economic and physical aspects of redundancy are crucial for future housing developments, 'over-redundancy' must be avoided to prevent unnecessary costs, energy loss and occupant confusion (Stevenson, Baborska-Narozny and Chatterton, 2016).

For the purpose of this study, redundancy is defined as 'having alternative options available that have similar functions, in order to maintain housing performance (if one of the alternatives fails) for future proofing, and for its inhabitants to maintain a low-impact lifestyle'.

Examining resilience in social housing through robustness, adaptation and redundancy is essential, as these key drivers determine the effectiveness of housing energy systems and their inhabitants' responses to external disruptions. Inhabitants of social housing often face heightened vulnerabilities due to having financial constraints and being an ageing

population that is more susceptible to external shocks such as climate change and energy crises (Stephens, Burns and MacKay, 2003; Boomsma *et al.*, 2017). By analysing the energy-related practices of inhabitants and their social housing in relation to these key drivers of resilience, this study contributes to a deeper understanding of inhabitants' long-term learning adaptability (adaptation), the ability of energy systems to withstand disruptions and social changes (robustness), and the ability to maintain housing functionality and inhabitants' practices by having alternative options (redundancy).

While identifying the key drivers of resilience enhances our understanding of inhabitants' practices within social housing, as discussed in this section, it is also essential to examine the key opportunities and barriers that influence the design of resilient social housing in the UK. Consequently, the following section examines the main opportunities for and barriers to designing robust, adaptable and redundant social housing in the UK.

## 2.5 Opportunities for and Barriers to Designing Resilient Social Housing in the UK

Designing resilient social housing in the UK necessitates a comprehensive understanding of both the opportunities that enable resilience and the barriers that prevent its implementation (Blackwell and Bengtsson, 2023). By identifying these factors, effective strategies can be developed to enhance the robustness, adaptability and redundancy of social housing for its inhabitants.

### 2.5.1 Opportunities

The residential sector accounts for approximately 17% of all CO<sub>2</sub> emissions in the UK, contributing around 56.4 million tonnes of greenhouse gases in 2022 (National Statistics, 2023). Thus, the Intergovernmental Panel on Climate Change (2023) highlights the need for improved building performance in the residential sector as a critical approach in terms of reducing carbon emissions and mitigating the effects of climate change. According to Stevenson (2019), there are two primary types of energy sources for homes, renewable and non-renewable, and it is crucial to determine how to provide the level of energy needed by homes without increasing carbon emissions or exceeding the limits of our planetary resources. Homes need to be adapted to cope with the negative effects of extreme events caused by the changing climate, and the degree to which homes are future-proof against

climate change is yet to be established (Stevenson, 2019). Additionally, homes that have robust construction offer the opportunity to study how buildings will cope with conditions under future changes to our climate (Nik *et al.*, 2016; Stevenson, 2019). Another key resilience driver is redundancy, as mentioned in Section 2.4.3, and moving towards smarter homes poses a barrier to traditional redundancy since the failure of one part of a centralised mechanical system can lead to a total failure. Therefore, as a resilience driver, having alternatives in social housing provides additional means and knowledge for inhabitants that become an opportunity for building their capacities (Stevenson, 2019).

One opportunity that enables resilience in social housing is a robust housing design that continues performing even if there are disruptions, such as the environmental impacts of climate change (Balaban and Puppim de Oliveira, 2017; Martiskainen and Kivimaa, 2019). For example, developing social housing with sufficient ventilation and improved indoor air quality can provide the opportunity to withstand the heatwaves that occur more often due to climate change (Zahiri and Gupta, 2023). This is a potential health benefit for the social housing sector, as by 2039, it is projected that over 70% of households will include at least one person aged 60 or older (Chenari, Dias Carrilho and Gameiro da Silva, 2016; Copeman and Beech, 2022).

Another opportunity is a 'good quality' housing design that is guided by the importance of environmental values and impact, comfort, and lower energy costs (Martiskainen and Kivimaa, 2019). Another example of a resilient energy system within the home is the smart meter, which can provide near-real-time information about energy use to inhabitants (Office for National Statistics, 2023b). According to the 2021 to 2022 English Housing Survey report (2022), social renters were more likely to have a smart meter in their homes (48%) than private renters (36%). This offers an opportunity for resilient energy systems in social housing, providing inhabitants are willing to use these systems. It is also important to note that these smart energy systems can help to improve the energy efficiency and the indoor air quality of the home when these measures are installed correctly and when the inhabitants know how to use them (Martiskainen and Kivimaa, 2019). Particularly in Sheffield in the UK, using resilient energy systems can be an opportunity to achieve the 2030 net zero energy target by reducing domestic energy use in social housing (National Housing Federation, 2022).

### 2.5.2 Barriers

According to the Department for Business, Energy and Industrial Strategy (2023) report, using low-energy options such as air source heat pumps or solar panels for heating homes can reduce household greenhouse gas emissions. However, the same report identifies that inhabitants face significant barriers to switching to low-energy heating systems, such as concern about cost, lack of knowledge about the new low-energy technology, and uncertainty about the possibility of installing this system in their home. Several studies note that the incorrect use of these new technologies can cause problems such as overheating (Gupta and Gregg, 2012; Shrubsole *et al.*, 2014). This also raises questions about the inhabitants' ability to use their conventional energy systems adequately, and whether they are using these systems as effectively as they could. This aspect is one of the key focuses of this thesis.

Another barrier to designing resilient social housing is financing, because, according to the Social Housing Sector report, the sector has difficulties in managing increased operational costs (e.g., increased energy prices) and lower income (e.g., funding) (House of Commons Levelling Up, Housing and Communities Committee, 2024). The same report mentions that the social housing sector faces financial pressure due to requirements to meet decarbonisation goals, repair costs that were delayed due to Covid-19, and costs related to supporting inhabitants of social housing. Financial constraints are another key focus of this thesis, particularly in terms of understanding the challenges that the social housing association had during the design and implementation phase, and their effects on the inhabitants of the social housing in this case study.

The final barrier to designing resilient social housing is linked with the large number of policy instruments in the UK that create a 'policy mix', and these rapidly changing policies need to be acknowledged by actors such as architects in order for these policies to be effective (Kern, Kivimaa and Martiskainen, 2017). The building regulations are not always complied with, and there are concerns about the sufficient implementation of minimum energy standards (Evans, Roshchanka and Graham, 2017; Kivimaa, Kangas and Lazarevic, 2017). Evans, Roshchanka and Graham (2017) also mention how policymakers are now focusing on the importance of good implementation by enforcing the current standards rather than

setting stricter requirements. According to Stevenson (2019), building regulations need to anticipate future climate change conditions and their effects on new-build or retrofitted homes. After outlining the policy requirements, the next section highlights resilience in social housing and the policy context related to energy systems in the home.

## 2.6 Resilience in the UK Housing Policy Context

### 2.6.1 Energy Efficiency Levels

From the perspective of housing studies, resilience can be used to describe social, technical, economic or environmental systems, as well as people, organisations and the housing sector as a whole (Carroll, 2012; Gibb, McNulty and McLaughlin, 2016). The UK government's energy efficiency policy aims for all fuel-poor homes to reach at least band C on the Energy Performance Certificate (EPC) scale (refer to Table 4.6) by 2030 and for the majority of homes to be at least band C by 2035 in the UK (Bolton, 2024). According to the 2021 English Housing Survey report, 35% of households living in social housing reported that they found it very difficult to pay their heating costs (Department for Levelling Up, Housing & Communities, 2021). The increases in energy prices since 2021 have made it increasingly difficult for those living in social housing to pay their energy bills (Department for Levelling Up, Housing & Communities, 2021). Additionally, according to the same English Housing Survey report, 59% of social housing households had someone self-isolating during the pandemic, so at least one person in the household was staying at home 24/7, leading to higher energy consumption (Department for Levelling Up, Housing & Communities, 2021).

In addition, Part 6 of the Building Regulations, which covers access to and use of dwellings, includes specific requirements for energy efficiency (HM Government, 2016b). According to the requirement, if the building is extended or renovated, the energy efficiency of the existing dwelling needs to be upgraded, addressing both adaptability and robustness aspects of resilience (HM Government, 2016b). The regulations also cover British Standards and the Standard Assessment Procedure (SAP), a tool developed by the British Research Establishment (BRE), to calculate the energy performance of buildings (BRE Group, 2024).

### 2.6.2 Heating and Ventilation Strategies

Housing insulation is crucial for resilience, as gaps in the insulation can lead to heat loss, mould and condensation, affecting inhabitants' health and well-being. According to the Approved Document L (HM Government, 2022), the continuity of insulation must be reviewed in the drawings (during the design phase) to ensure the insulation layer is robust, and this review should be followed by an on-site audit to confirm all the designed details have been constructed in line with the guidance. For heating, domestic hot water circuits should include both time and electronic temperature controls. Electric resistance space heating systems are assumed to be 100% efficient, so the regulations do not require any minimum efficiency to be set for this system (HM Government, 2022). On-site electricity generation and storage is another key factor in the Approved Document L (HM Government, 2022). When replacing the existing storage system, the newly installed system's generation capacity should not be less than the existing one unless a smaller system can be demonstrated to be more effective.

Building regulations aim to protect inhabitants according to different measures, such as safety, health and well-being, whilst also promoting sustainable development and energy efficiency (Vagtholm *et al.*, 2023). According to the Approved Document F, there are three key ventilation strategies for dwellings: extract ventilation from rooms where the pollutants are likely to be released, such as bathrooms and kitchens; whole dwelling ventilation, for pollutants not removed by extract ventilation; and purge ventilation to remove high concentrations of pollutants resulting from inhabitants' activities, such as paint fumes (HM Government, 2021b). This document states that extract ventilation is required in kitchens, utility rooms and bathrooms, and internal doors are required to have a 10mm gap from the floor to allow air to flow continuously within the home. According to the BS 5925 (British Standards Institution, 1991) and Approved Document F (HM Government, 2021b), purge ventilation can be delivered with single-sided ventilation, such as by opening windows or doors when there is a temperature difference of 3°C between the air inside and outside.

Background ventilators, such as trickle vents above windows, should be easy for inhabitants to reach and, according to the ventilation policy context (HM Government, 2021b), background ventilators should be left open. According to the Approved Document F (HM

Government, 2021b), intermittent extractor fans should be placed in all wet rooms (e.g., kitchens, bathrooms, utility rooms) and if the wet room does not have any external walls, the extract fan has to meet to purge ventilation standards by extracting four air changes per hour. If the wet room does not have an openable window, the intermittent extract fan should have settings that enable it to continue operating for at least 15 minutes after the room is vacated (HM Government, 2021b). According to the National Institute for Health and Care Excellence (2020), ensuring effective ventilation is critical to reduce damp and condensation in homes, and inhabitants' health and well-being can be affected by indoor air pollutants. According to the Approved Document F (HM Government, 2021b), all rooms with external walls should have background ventilators, and if the home has more than one exposed façade, the background ventilators should be in a similar area on each façade to allow cross-ventilation. This document also states that homes with combined kitchens and living rooms need at least three background ventilators.

The latest policy on the ventilation of housing focuses on energy efficiency measures in terms of the building work (e.g., roof and window insulation, replacement of windows and doors, draught-proofing) and assessment of the newly built and existing ventilation measures (HM Government, 2021b). Resilience in terms of robustness is addressed in the Approved Document F: 'Ventilation' (HM Government, 2021b); the regulation indicates that if the existing windows do not have background ventilation, they need to be replaced, and it must be ensured that ventilation is not worsened in the process.

Building Regulations Requirement O1 'Overheating mitigation' aims to reduce the occurrence of high indoor temperatures, which can lead to overheating (HM Government, 2021a). According to the Secretary of State's view (HM Government, 2021a), this requirement is achieved by limiting unwanted solar gains in summer and providing adequate solutions (e.g., via dynamic thermal modelling) to remove excess heat, thereby protecting the health and well-being of inhabitants.

Ways of assessing the overheating risk in new-build housing, as outlined in the Approved Document O (HM Government, 2021a), include categorising residential buildings by location as 'moderate risk' or 'high risk' and determining whether they have cross-ventilation. Solutions to limit solar gains include shading devices for glazed areas, external shutters with

a means of ventilation, and shading provided by nearby buildings or structures. Internal blinds and curtains can also provide some reduction in solar gains; however, they are not taken into account when assessing whether Requirement O1 has been met (HM Government, 2021a). According to Approved Document O, the housing should be built to meet Requirement O1 by using passive means of ventilation (e.g., opening windows) to remove the excess heat, before using any mechanical cooling systems, such as air conditioning. The Approved Document O also states that information about the overheating mitigation strategy (e.g., limiting solar heating) and its maintenance requirements must be clearly communicated to the owners of the housing. The same document also mentions that the home user guide should contain a section called 'Staying cool in hot weather' which provides non-technical advice for inhabitants (HM Government, 2021a).

### 2.6.3 Home User Guide

According to the Approved Document L, Volume 1: 'Dwellings', Section 9, a home user guide should be provided for new-build housing (HM Government, 2022). This guide should include sections for each energy-related system (for example, ventilation, heating and hot water), offering non-technical advice on the relevant system to help inhabitants understand, operate and maintain these systems. In terms of having redundancy within the homes, regulation 25A within the Approved Document L: 'Conservation of fuel and power', which came into effect on July 2013, requires consideration of alternative systems for new buildings (HM Government, 2022). According to this regulation, before construction of the new building, the technical, environmental and economic feasibility of using high-efficiency alternative systems (e.g., heat pumps, decentralised energy supply systems based on renewable sources, collective heating and cooling systems based on renewable sources) must be analysed. This analysis should be carried out during the design phase of the project and applied to all housing units connected to the system in the area, whether they are individual housing, groups of similar housing, or similar housing typologies in the same area (HM Government, 2022).

Overall, in terms of resilience, UK housing policies and regulations focus primarily on where and how energy-related controls should be placed and used to address discrepancies between design intentions and inhabitants' actual use and maintain the energy performance

of the housing through tools like SAP. However, these regulations and policies do not deeply explore the social aspects or how social changes and inhabitants' understandings might impact these controls, nor do they assess whether UK homes are resilient to these changes or the differing understandings and practices of inhabitants.

## 2.7 Social Dynamics in Social Housing

Social interactions among inhabitants are primarily observed in cohousing, where each household has a private home and can also gather at shared facilities, such as communal kitchens and dining areas (Scanlon and Arrigoitia, 2015). An example of this is the LILAC field study in Leeds (see also Section 2.4.3) where inhabitants engage in self-managed activities, including maintenance, and use shared facilities, like laundry rooms, to promote a low-impact lifestyle (Chatterton, 2015). Collaborative practices occur as these communities actively participate in management of energy-related systems, knowledge distribution and decision-making (Jarvis, 2011; Hammond, 2018). Collaboration in practices can be achieved through engagements and social relations among inhabitants, which are also significant for the development of routines (Gram-Hanssen, 2008; Bartiaux *et al.*, 2014). Such collaborative practices can also be described as settings where people gather to learn new techniques from one another (Bartiaux *et al.*, 2014). However, these collaborative practices have not been studied in the context of social housing to determine whether inhabitants in these homes engage with other members of their households when making energy-related decisions, nor how external factors influence their practices, highlighting a significant research gap.

According to Steemers and Yun (2009), the use of heating and cooling systems and their control are decisions of the inhabitants, and they see this as a behavioural factor. Thus, in this thesis, inhabitants' discussions about using the energy-related systems are seen as behavioural factors involving decisions made among the inhabitants. Inhabitants' discussions can be explained as the social interactions among inhabitants aimed at proceeding to actions (Finch, 2003). For example, consider a discussion about opening windows: in a home with two inhabitants, one frequently prefers to have the windows open (inhabitant 1), while the other gets cold easily and often prefers to have the windows closed (inhabitant 2). If they discuss whether to open the windows, inhabitant 2 may win, resulting in the windows

remaining shut. However, when inhabitant 2 is not at home, inhabitant 1 opens the windows until inhabitant 2 comes home, affecting energy use in the home. These social interactions can be also addressed as collective agency where inhabitants bond to make sense of what they are doing and decide their energy-related practices (Melucci, 1996; Welch and Yates, 2018).

Previous housing studies have not addressed whether social housing is sensitive to inhabitants' discussions about their energy-related practices, or the nexus with resilience drivers.

## 2.8 Critical Reflection on Key Frameworks and Theories

The aim of this thesis is to capture not only what inhabitants do, but also how their practices continue, adapt or break down in response to different conditions, particularly disruptions. Several key relevant theories and frameworks were considered in the development of this study, such as actor-network theory, the energy cultures framework and socio-technical theory.

Actor-network theory recognises that material culture (e.g., objects and technologies) plays a crucial role in shaping behaviour through dynamic interactions (Latour and Porter, 1993; Law *et al.*, 1999; Stephenson *et al.*, 2010). It is employed in numerous studies focusing on domestic energy consumption and models an agent-based framework that includes interactions between policies, housing stock and households (Keirstead, 2006). Barr and Gilg (2007) also use actor-network theory to examine environmental behaviour and the gap between intentions and actions. This theory seeks to understand how both human and non-human actors form networks to achieve specific goals and gives equal value to technologies (objects) and society when investigating a social phenomenon (Law, 1992, p. 383). Actor-network theory defines actors as entities (e.g., human, material or technological) that gain agency through their relations with others, while practice theory focuses on the dynamics of human actions within a social context (Latour, 2005; Gram-Hanssen, 2010). While actor-network theory could highlight how technologies influence practices, it does not offer a framework for understanding how inhabitants' practices persist or change in the face of social changes or disruptions, making resilience a more relevant choice.

The energy cultures framework draws on actor-network theory to explore the factors shaping energy consumption behaviours while identifying opportunities for change (Stephenson *et al.*, 2010). At its core, the framework conceptualises energy behaviour as the interplay among cognitive norms (e.g., beliefs), material culture (e.g., building form) and energy practices (e.g., activities) (Stephenson *et al.*, 2015). These elements interact dynamically: cognitive norms shape behaviours and technology choices; material culture influences cognitive norms and practice possibilities; and energy practices, in turn, reinforce or shift norms. Each element is itself a system that collectively shapes energy consumption and behavioural outcomes (Stephenson *et al.*, 2010). The energy cultures framework (see Figure 2.3) is useful for categorising energy behaviours into material culture, cognitive norms and practice-based elements, helping to map energy-use patterns.

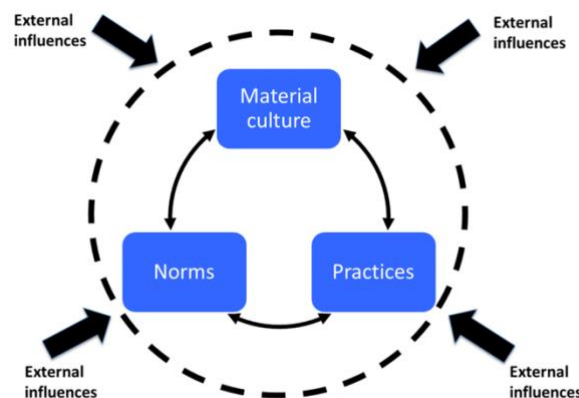


Figure 2.3 Energy cultures framework diagram (Stephenson *et al.*, 2015)

While this framework is useful for understanding energy consumption patterns, it does not directly account for how inhabitants' practices adapt in response to changes or disruption. Since this thesis focuses not only on energy-related practices, but also on how inhabitants' practices persist or evolve in response to external factors, the resilience lens is a better fit.

Socio-technical theory is another approach to understanding energy efficiency studies and the relationship between people and technology. This approach, as described by Pasmore *et al.* (1982), views organisations (in this thesis, it is housing) as interconnected systems where

social and technological components influence each other and their broader environment. Socio-technical theory acknowledges the importance of social factors in system design and implementation, so can be applied to bridge the gap between social and technical aspects of energy use (Guy, 2004, p. 691; Bauer and Herder, 2009). The energy cultures framework challenges the notion that social factors alone can explain socio-technical phenomena, as cultures and values themselves are shaped by networks of social and material entities (Stephenson *et al.*, 2010). Socio-technical theory provides a valuable perspective on the co-evolution of technology and society, highlighting interactions between technological systems, policies and user behaviour (Abbas and Michael, 2023). However, this approach does not explain the adaptability of inhabitants' practices in response to external changes, such as the energy crisis or social change. This thesis, therefore, benefits from a resilience lens, which explicitly addresses the persistence and transformation of practices over time.

Through engagement with these alternative frameworks, it became clear that while each offers insights into different aspects of inhabitants' practices, they do not fully capture their durability, changes and capacity to respond to stressors. Practice theory, particularly Gram-Hanssen's (2010) approach, provides a strong foundation for analysing everyday habits, embodied know-how, engagements, technologies and institutionalised rules, as explained in the following chapter (see Section 3.4). Using resilience and practice theory frameworks in combination offers a way to examine not only what inhabitants do, but also how their practices endure or transform in dynamic conditions. This combined approach is particularly useful in understanding inhabitants' practices within dynamic environments, where external influences (e.g., technological changes, policy changes, energy crisis, Covid-19) shape everyday actions. Figure 2.4 illustrates this integrated approach, demonstrating that the resilience of homes can be studied by examining the interrelationships between resilience drivers (robustness, adaptation, redundancy), energy-related practices (heating and ventilation practices), and stakeholders' perspectives (design team and inhabitants), and how these, in turn, are influenced by external factors (social change, climate change, the energy crisis, Covid-19). Incorporating resilience within practice theory as a framework provides a means to analyse practices not just as socially and materially embedded routines, but as practices with varying degrees of flexibility to change. This combined approach also

fills a gap in practice-based approaches by introducing a resilience dimension that is overlooked in practice theory and socio-technical studies.

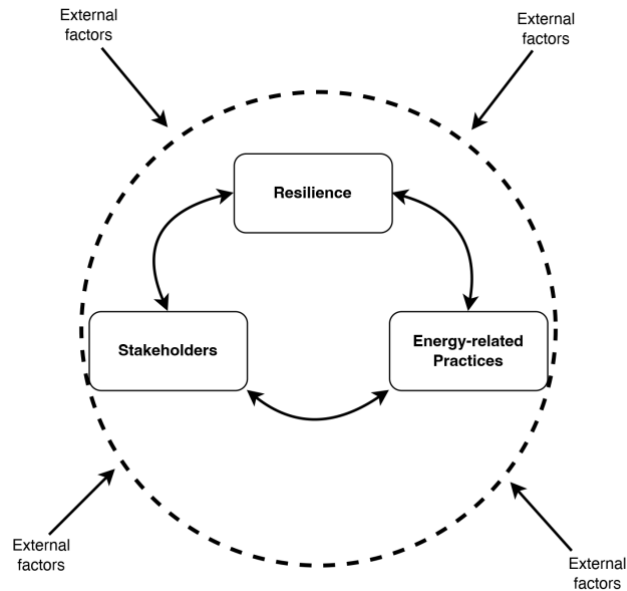


Figure 2.4 Combined resilience and practice theory framework diagram (adapted from Stephenson *et al.*, 2015)

## 2.9 Summary

In this chapter, an overview of the definitions of resilience across various fields and a literature review have been presented. This chapter discussed the impacts of resilience on social housing within the context of three pillars of sustainability: social, environmental and economic. This study's main focus on the social impacts of resilience was highlighted, alongside environmental and economic aspects that directly affect the social context.

The research gap was identified by reviewing previous studies on inhabitants' practices. It was identified that previous studies have not concurrently focused on robustness, adaptation and redundancy, nor have they explored the connection among these resilience drivers to understand if social housing is sensitive to inhabitants' discussions about energy-related practices. Consequently, there is a need for a better understanding of inhabitants' discussions on energy-related practices and how these are interrelated with robustness,

redundancy and adaptation to determine opportunities for developing resilient social housing in the UK.

Objective 1 was achieved in Section 2.5 by discussing the opportunities for and barriers to resilient social housing in the UK, supported by relevant literature to understand the latest developments and research regarding the discourse. This chapter reflected on the policy context of resilience in UK housing through relevant literature and building regulations, followed by the social dynamics in social housing. The chapter concluded by reflecting on key theories and frameworks. The following chapter explains the research approach of this thesis.

## CHAPTER 3: THE PRACTICE THEORY FRAMEWORK

### 3.1 Introduction

Following the introduction to the thesis in Chapter 1 and a review of the state-of-the-art regarding the resilience of social housing and inhabitants' practices, evidencing the knowledge gap, in Chapter 2, this chapter sets out the research approach and introduces the theoretical framework adopted. In this chapter, the rationale for a practice-based approach is explained, as are the roots of practice theory. The methodology is then set out in Chapter 4, which is designed to investigate the research gap using the practice theory approach outlined in this chapter.

### 3.2 Research Approach

There are different ways of understanding reality, including realism, constructivism, positivism and interpretivism (see Table 3.1) (Crotty, 1998). Practice theory is used as a methodological lens in this research because it combines various relevant individual human and non-human aspects that other epistemologies focus on (e.g., things, engagement, actions, habits, behaviours), and reveals how they act together in the moment and how they are all brought together through practices as a nexus. Therefore, resilience in the home is examined through the practice theory lens in order to understand the relationships among design, practices and resilience. In order to achieve the aim and objectives of the research, a mixed method approach with a question-driven perspective is used (O'Leary, 2021). The research approach includes a literature review, case study, post-occupancy evaluation (POE), and analysis.

Table 3.1 Different epistemologies in social sciences

<b>Primary Theorists</b>	<b>Epistemology</b>	<b>Ontology</b>	<b>Key Audience</b>	<b>Preferred Methods</b>
Auguste Comte Wittgenstein Heisenberg and Bohr	Positivism and Post-Positivism	Objects in the world have meanings before, objectivist (Crotty, 1998)	Empirical scientists	Quantitative methods : experiments, surveys, modelling, among others
Heidegger	Constructivism	Reality is contingent upon human practices when they engage with the object (Crotty, 1998; Simons, 2009)	Qualitative researchers, participants	Qualitative methods: interviews, direct observations, among others
Max Weber and Thomas Schwandt	Interpretivism	Looks at human and social reality in terms of cultural and historical interpretations (Crotty, 1998; Simons, 2009)	Social science community	Qualitative methods: interviews, direct observations, among others
Guba and Lincoln	Realism	Reality exists outside of the mind, objectivist. Tries to answer 'how things really are and how they really work' (Crotty, 1998; Simons, 2009)	Human and social scientists	Qualitative and quantitative methods: experiments, observations, among others
Schatzki, Gram Hanssen	Practice Theory	Practice theory brings all these epistemologies together by looking at things, behaviours, culture, rules and technologies together by using mixed-methods (Schatzki, Knorr-Cetina and Savigny, 2001; Gram-Hanssen, 2010)	Social science community, participants	Action-oriented, mixed methods: interviews, direct observations, visual ethnographic methods, document analysis, surveys, among others

### 3.3 The Roots of Practice Theory

Latour (2005), as a sociologist, argues that the key means for improving energy use is to design a 'hybrid' form of housing that combines human and material elements that mutually constitute each other. Gill *et al.* (2010) state that, from a psychological perspective, behavioural assessments should be included in POE methods to gain a better understanding of building performance in relation to how humans actually inhabit their homes, what their behaviours are, why these behaviours have developed, what their impacts are, and how these behaviours can be changed. In contrast, Shove (2018), another sociologist, argues from a different theoretical perspective, stating that people use energy when performing social practices at home, at work and when moving around. This theoretical concept of 'practice' is discussed next.

Giddens (1984) developed the theory of structuration, which concerns human activity and how these activities are shaped by the social structure. He questioned the functions of society and how effectively people coordinate, develop and change. For Giddens, social practices are held together within space and time by the 'duality of structure', which is defined as the synthesis of social structures (e.g., educational, political, religious institutions) and agency, and this social structure exists when people act in accordance with their reproduced understandings. These shared understandings are formed as 'rules' in people's memories (Galvin and Sunikka-Blank, 2016). Bourdieu (1990) argued further that people's actions are motivated by these rules. His understanding of rule-following is based on the notion of 'habitus' and 'interactions', through which people learn practical know-how and social skills from other people around them and absorb these skills as habits. For Bourdieu, habitus is 'constituted in practice and is always oriented towards practical functions' (Bourdieu, 1990, p. 277).

Schatzki (1997) critiqued this view by stating that rules alone cannot explain the nature of human action and formed a schema for social theorising based on practical understandings, explicit rules and teleoaffectivity (interactions, expectations and desires). Schatzki's schema further explains how people coordinate with each other within a particular activity and how society influences particular habituated practical actions. For Schatzki, Knorr-Cetina and Savigny (2001), practices are defined as arrays of human activity shaped around shared skills

or understandings and they further developed the argument and explained the practice as a nexus of doings and sayings, which means certain elements/things hold the practice together. Reckwitz critiqued Schatzki's schema by explaining that practical actions are strongly involved with materiality and revised the key elements of practices as know-how, meaning, and material (Reckwitz, 2002a, 2002b). Reckwitz further defined 'practice' as a routinised type of behaviour including several elements, such as body, mind, things, knowledge, structure, and agent. He argued that while practice is social, it is also a type of behaviour and understanding that is happening at different points of time and is carried out by different bodies and minds. According to his perspective of practice theory, 'body' means intellectual activities and movements of the body, and 'mind' consists of mental routines, certain bodily activities and knowing how to do something. For Reckwitz, 'things' are as important as people and social practices represent how people deal with the 'things'. 'Knowledge' means the way of understanding the world, objects and humans. 'Structure/process' consists of routinisation of body movements and using things, and 'the agent' is the carrier of the practice (Reckwitz, 2002a).

Practice theory, therefore, defines the position of human beings and things in a social world and opens up new possibilities of self-understanding. Shove (2010) also challenged the psychological account of social change that depends on attitudes (A), behaviour (B) and choices (C), known as the ABC model. Shove argued that to understand social change, understanding how practices capture, progress and lose the inhabitant is crucial. Shove, Pantzar and Watson (2012, p. 7) further defined the individuals who carry out the practice as 'the carriers or hosts of a practice'. Shove (2010) developed her practice theory approach by taking into account Reckwitz's understanding of the relation between forms of bodily activities, mental routines, dealing with things, know-how and knowledge. Shove then used these ideas to understand the circulation of practices and categorised them as materiality (things and technologies), meaning (ideas and aspirations) and competence (skills and know-how) (Shove, Pantzar and Watson, 2012). After categorising the practices, Shove integrated these definitions by looking at the relation between time, space and practice because all of these practices are happening somewhere (where) at some time (when) (Shove, Pantzar and Watson, 2012).

### 3.4 Elements of Social Practices

Before Gram-Hanssen's (2010) work, practice theory was not commonly used in energy studies about the home; it was mostly used in consumer studies like those of Warde (2005) and Shove and Pantzar (2005). The main difference between the approaches of Shove and Pantzar (2005) and Gram-Hanssen (2010) is that Gram-Hanssen's approach follows that of Schatzki (1997), while Shove and Pantzar's model comprises two components: (1) know-how and habits; and (2) institutionalised knowledge and explicit rules (Bartiaux *et al.*, 2014).

Gram-Hanssen (2010) builds on all these perspectives by taking a very specific approach related to her seminal study of standby energy consumption behaviour in households. She highlights how practice theory can provide a new understanding of how people learn new knowledge related to their behaviour and even change it. The aim of Gram-Hanssen's approach to practice theory is to understand the contribution of routines and technologies to energy consumption studies, and how institutionalised knowledge and behaviours impact practices (Gram-Hanssen, 2010). She refined four elements, which are distinctly different from Shove's (2010) three elements of materiality, meaning and competence, and more appropriate for understanding energy use in buildings:

- Know-how and embodied habits (behaviour),
- Institutionalised knowledge (culture and rules),
- Engagements (interaction),
- Technologies (things).

These four elements can be used as an analytic tool to understand how individuals learn new knowledge and hold an energy-related practice together. Gram-Hanssen's (2010) study reveals that when the knowledge and motivation of the occupants' change, established habits also change accordingly with rearranging the technology. She argues that practice theory can be used to understand how practices change over time. In this research, the nexus between Gram-Hanssen's practice theory elements and social resilience indicators will reveal whether housing in the UK is socially resilient in relation to social changes over time.

A comparison of the four approaches to practice theory is shown in Table 3.2.

Table 3.2 Key elements in the understanding of social practices

<b>Schatzki (1997)</b>	<b>Reckwitz (2002b)</b>	<b>Shove (2010)</b>	<b>Gram-Hanssen (2010)</b>
<b>Practical understandings</b> Know-how Habits Includes tacit or implicit rules	<b>Know-how</b> Body Mind The agent	<b>Competence</b> Skills Know-how	<b>Know-how and embodied habits</b> Understandings Routines Habits
<b>Explicit rules</b> Expectations	<i>Rules are not included as an element of practices</i>	<i>Rules are not included as an element of practices</i>	<b>Institutionalised knowledge</b> Rules Language
<b>Teleoaffectivity</b> Desires	<b>Meanings</b> Discourse/language	<b>Meanings</b> Ideas Aspirations	<b>Engagements</b> Meaning Purposes Beliefs
Things and technologies are co-produced with practices by forming 'material configurations' but they are not part of an element of practices	<b>Materials</b> Things	<b>Materiality</b> Things Technologies	<b>Technologies</b> Things Products

The four elements of practice theory described by Gram-Hanssen help to structure this research by forming the basis of a resilience matrix. This matrix will help to explain the nexus between the four elements of practice theory and the resilience indicators. The resilience matrix is explained in Chapter 4.

#### 3.4.1 Know-how and Embodied Habits

This element of practice theory refers to the actual and often unconscious way of using equipment. For example, when the inhabitants use appliances as they were designed to be used, their routines become embodied with their daily use (Gram-Hanssen, 2010). Know-how and embodied habits include the skills that the inhabitants already have, and they are an important element of what constitutes a practice. These know-hows represent the routines and the things that the inhabitants do without conscious reflection, which is key to understanding if a practice may be conceptualised as such (Bartiaux *et al.*, 2014).

Giddens (1984) sees routines as practical consciousness and explains how the repetition and recognition of routines can create safety for actors (in this thesis, the inhabitants), to reduce ontological insecurity (Warde, 2005). According to Gram-Hanssen (2008), routines are significant for household energy consumption and can change or develop with different everyday technologies. To give an example of how embodied habits and routines change, a study involving women born in the 1920s and 1930s described how having a fridge for the first time did not immediately change their habits. It was the combination of having a fridge, having fewer shopping options due to moving from the city centre to the suburbs, and having fewer food delivery options that made the women adapt their routines to these changing conditions (Gram-Hanssen, 2008). Embodied habits are the routinised practices of inhabitants that are performed in everyday life, often performed unconsciously (Gram-Hanssen, 2014). Yi, Knudsen and Becker (2016) view routines as a target of change and argue that the stability of routines limits adaptation. Shove, Watson and Spurling (2015) and Heidenstrøm and Kvarnlöf (2018) explain know-how as having the necessary skills to help practices evolve, and embodied habits as the knowledge that may lie dormant for years without prompting action. Practice theory critiques the individualistic models of action and instead highlights habitual and routinised behaviour (Hansen, Gram-Hanssen and Knudsen, 2018). Social practices are the routines of people, which they consider 'normal', and they use energy as part of carrying out social practices at home (Shove, 2018). Know-how is something that inhabitants learn when they are exposed to and then perform these practices themselves, becoming the carriers of practices (Larsen and Gram-Hanssen, 2020).

In this thesis, the know-how and embodied habits of inhabitants are looked at in terms of how much their embodied habits involving energy use change depending on social change, how these changing habits affect inhabitants' ability to continue using the same equipment, and how changes in inhabitants' habits affect the ability to adapt.

#### 3.4.2 Institutionalised Knowledge and Rules

Schatzki (2001) considers explicit rules as an element of practices, describing them as the expectations of the inhabitants. In contrast, institutionalised knowledge and rules are not included by Reckwitz (2002b) or Shove and Pantzar (2005) when they describe the elements of practices. Gram-Hanssen (2010) takes a more detailed approach, explaining this element

through language, tacit rules and knowledge. Additionally, institutionalised knowledge and rules are directly influenced through policies such as government regulations (Bartiaux *et al.*, 2014).

In this thesis, institutionalised knowledge and rules are looked at in terms of language, regulations and policies. The questions addressed include: how might changes in institutionalised rules and knowledge affect the functioning of the home, how might this affect redundancy in the home, and how might this affect the ability to adapt? These questions are analysed from both the inhabitants' and design team's perspectives to understand whether or not the design team translated and communicated knowledge to the wider audience, such as households.

### 3.4.3 Engagements

Schatzki (1997) views this element of practice as teleoaffectivity, which consists of desires, purposes, emotions and moods, while Reckwitz (2002b) and Shove (2005) refer to it as meanings. Gram-Hanssen (2010) brings together all these definitions in engagements, and this element emerges out of social relationships, interactions and beliefs. Collaboration in practices can also be achieved by the correlative role of elements, such as engagements (Bartiaux *et al.*, 2014).

Engagement is referred to in terms of ideas, aspirations and participation, and this element of practice theory is used to understand how inhabitants attach their ideas and meanings in order to make sense of their practices (Shove, Pantzar and Watson, 2012; Wethal, 2020). In addition, engagement implies that there is a reason that guides a practice, meaning something to the inhabitants who perform that practice (Gram-Hanssen, 2014). In this thesis, engagement refers to inhabitants' discussions about their heating and ventilation practices, as well as their engagement with the energy-related controls. Engagements are also explained as practices consisting of doing and saying, such as regulating thermostats and discussing the temperature of the thermostat (Gram-Hanssen *et al.*, 2017).

In this thesis, engagements are looked at in terms of inhabitants' engagements and discussions about energy-related practices whilst addressing questions like: how do inhabitants discuss the use of equipment with the household, do these discussions and

engagements affect the redundancy in the home, and does anyone take charge of the equipment?

#### 3.4.4 Technologies

Technologies are one of the elements of practice to be 'practised', incorporating certain know-how or habits about how to use these technologies within the practice, relating to the physical features of the home and its materials (Bartiaux *et al.*, 2014; Hansen, Gram-Hanssen and Knudsen, 2018). Gram-Hanssen (2010) refers to technologies as products that hold the practice together. Reckwitz (2002a) refers to technologies as material understandings that are able to act as resources in practices. According to practice theory, materials are handled in specific ways within practices, with 'know-how about using these things (Reckwitz, 2002a). However, as Warde (2014) states, it is crucial to focus on social structures and social differences when understanding inhabitants' practices related to energy and climate issues. Households rely on technologies, which involve things and products within practice theory, to perform their daily routines, and such technologies may define or change their practices (Wethal, 2020).

According to Gram-Hanssen (2008), new technologies in homes go through phases where households initially resist and are unsure of the advantages, or they become interested with less resistance. It is more challenging to encourage inhabitants to adopt new technologies that directly interfere with well-established practices associated with strong cultural norms, such as washing machines in the 1920s and 1930s, and smart meters in the 2010s (Gram-Hanssen, 2008; Martin and Larsen, 2024).

In this thesis, technologies are analysed in terms of whether the heating and ventilation systems in the homes are able to withstand shocks and social changes, whether social housing has redundancy, and how changing technologies affect households' ability to adapt.

Understanding inhabitants' energy-related practices requires including all four of these elements of practice theory simultaneously as an analytical approach, recognising that practices include these four elements together and are not solely based on individual norms and attitudes (Gram-Hanssen, 2014).

### 3.5 Practice Theory and Change

The changing nature of heating and ventilation practices through robustness, redundancy and adaptation to new circumstances in everyday life makes practice theory particularly substantial as the framework for this study. Learning is a part of changing practices, occurring over time as a process where the old practices coexist with newly learned practices (Kemmis, 2022; Tellarini and Gram-Hanssen, 2024). Sometimes changes occur due to extreme events; for example, the work by Wethal (2020) examines how power outages affect household experiences and how this disruption forces households to find new meanings in order to continue their daily life in rural Norwegian households.

In the context of social change, practice theory offers a unique perspective. For instance, in the study of Gram-Hanssen (2010) about standby energy consumption in households, participants were encouraged to change their daily habits. Households that changed their daily habits did so either because of a change in their knowledge or a change of motivation following a technological rearrangement. Households that did not change their habits faced inertia in their routines and challenges in increasing their motivation levels. In terms of social change, the social differentiations of the ways in which people engage in practices connect with the sociological themes of collective identity (Warde, Welch and Paddock, 2017). Collective identity can be defined as the need for people to bond in order to make sense of what they are doing (Melucci, 1996). In addition, according to Welch and Yates (2018), addressing the relationship between collective agency and everyday practices is necessary, as it produces patterns of consumption. In this thesis, collective agency is examined in terms of understanding inhabitants' discussions, as explained in Section 2.8, and how inhabitants' discussions interface with resilience in social housing, which is explained in the following section.

### 3.6 Resilience and Inhabitant Practices within Social Housing

#### 3.6.1 Energy-related Inhabitant Practices and Post-Occupancy Evaluation

In 2022/2023, Europe and the UK faced increased energy prices and threats of power cuts due to the consequences of the energy crisis, significantly impacting households (Bolton, 2024; Brauer *et al.*, 2024). Thus, it is crucial to understand the effects of the energy crisis on households by focusing on energy-related practices within the home. As Gram-Hanssen

(2014) notes, energy consumption itself is not a 'practice'; instead, the inhabitants' activities that consume energy, such as cooking, washing, and showering, are considered practices.

The energy consumed within the residential sector is related to inhabitants' use of appliances, behaviours, activities and lifestyles (Verhallen and van Raaij, 1981). Studies on energy consumption and sustainability emphasise the importance of constructing daily household practices and managing peak energy demand by using practice theory (Gram-Hanssen, 2010; Strengers and Maller, 2011). Within the field of energy consumption and housing studies, inhabitants and their behaviour are crucial for understanding energy use within homes (van den Brom *et al.*, 2019). Several studies indicate that housing energy use depends on behavioural patterns, which in turn depend on the characteristics of the inhabitants (e.g., age, occupancy level) (Yohanis *et al.*, 2008; Steemers and Yun, 2009). A Danish study by Hansen, Gram-Hanssen and Knudsen (2018) finds that inhabitants reconfigure their practical understandings and their energy-related habits when they live in energy-efficient homes. These authors also suggest that material arrangements (e.g., building characteristics and technologies) significantly influence inhabitants' practices and energy demand according to Shove and Walker's (2014) practical understandings.

According to the study by Hansen, Gram-Hanssen and Knudsen (2018), practice theory effectively explains energy-use behaviour by focusing on 'how' the energy is used to carry out social practices. Energy cannot be separated from these practices because it is involved in the bundles of social practices (Shove and Walker, 2014). Practice theory contributes to energy-use studies in terms of how energy is used and changed by looking at routines, social norms and the roles of technologies within the household (Pullinger, Lovell and Webb, 2014). Another study that focuses on inhabitants' energy-related practices is that of Martin and Larsen (2024), which addresses how incorporating smart infrastructure in household energy management can be increased by considering inhabitants' practical knowledge and everyday experiences of their social practices. They also highlight that the energy sector prioritises technological interventions, economic advantages, and forms of institutionalised knowledge, but often neglects to implement practical knowledge in practices.

The user experience of and satisfaction in new-build homes in the UK is mostly assessed using POE, which aims to understand the building's performance after construction,

including whether it meets the expectations of its users (Federal Facilities Council, 2001; Maslova and Burgess, 2023). POE originated in the US, and it was introduced to appraise building performance after it has been handed over and occupied (Bordass, 2003; Palmer, Terry and Armitage, 2016). However, the evidence shows that POE is not implemented effectively. The practical research tends to be mostly quantitative and does not include in-depth qualitative research, which makes it difficult to find the reasons behind inhabitants' experiences of their homes (Bordass, 2003; Parn *et al.*, 2015; Palmer, Terry and Armitage, 2016). As explained in Section 3.3, behavioural assessments should be included in POE methods to gain a more in-depth understanding of the inhabitants' behaviours and how they inhabit their homes (Gill *et al.*, 2010). Gathering real-time user data and feedback through POE informs designers and developers about evolving user needs (Maslova and Burgess, 2023).

Energy practices help to understand how energy is embedded in inhabitants' daily practices that meet their needs (Morley, 2018). Thus, practice theory can be used to understand inhabitants' activities and behaviours through know-how, rules, engagements and things (Brauer *et al.*, 2024). These elements are linked together to configure the practice. For example, daily showering is dependent on 'things' such as showers and domestic water systems, 'know-how' on how to wash oneself, 'rules' on maintaining good hygiene, and 'engagements' in turning the shower on and off. Practice theory thus demonstrates how these four elements come together and co-evolve by creating norms of comfort and usability in the process (Shove and Trentmann, 2018).

### 3.6.2 Evaluating Resilience

The concepts of robustness, adaptation and redundancy each address problems at particular scales, but none covers the full range of energy-related practices in social housing resilience. This study aims to clarify the relationships between robustness, adaptation and redundancy as drivers of resilience and use them together as a resilience framework linked with the elements of practice theory to suggest policy recommendations for future-proofing social housing. This section outlines the evaluations needed in order to understand resilience in relation to energy-related practices in UK social housing using document analysis and NVivo

coding. Inhabitants' practices are evaluated using semi-structured interviews and a usability questionnaire, which are thematically analysed using NVivo.

In this research, robustness is defined as the ability of systems (heating and ventilation) in the home to carry on performing despite shocks and social changes. Social change here refers to inhabitants' discussions about practices, occupancy changes and different household demographics. The discussion between the inhabitants is explored and analysed by asking the inhabitants how they discuss their energy-related practices in the home (e.g., opening windows). To understand how adaptable the home is in terms of social change, different household compositions and inhabitants' discussions of practices are analysed in the semi-structured interviews and usability surveys. Redundancy is explored by examining occupancy changes and the availability of multiple means of carrying out the same energy-related function. For instance, if more inhabitants live in the home, additional alternatives (e.g., a heater in each inhabitant's room if the heating system fails) ensure functionality even if one system fails.

### 3.7 Summary

Gram-Hanssen's (2010) approach to practice theory provides a suitable framework to explore and understand resilience in relation to energy-related practices and social change. This theoretical approach, which focuses on how people act, carry out and shape practices in the real world, offers key elements that can be used as an analytical tool for achieving a deep understanding of the research topic. The methodological choices made throughout this research (see Chapter 4) seek to maximise the potential of the practice theory approach. Therefore, this thesis examines resilience in social housing through the four elements of practice theory: know-how and embodied habits, institutionalised knowledge and rules, engagements, and technologies. As set out in this chapter, using the practice theory approach to investigate inhabitants' discussions about their energy-related practices offers the potential for uncovering hidden practices that influence the resilience of homes and identifying the underlying issues. The next chapter explores the methodology of this thesis.

## CHAPTER 4: METHODOLOGY

### 4.1 Introduction

This chapter sets out the methodological approach used to investigate the research gap identified in Chapter 2 using practice theory as detailed in Chapter 3. The research uses a mixed methods approach to understand social housing resilience in terms of social change by looking at energy-related practices in households, focusing on the everyday practices of inhabitants and the design intentions of the design team. A case study approach is adopted within a large housing development, using multiple data collection methods. Data analysis is carried out in two cycles of coding, followed by a thematic analysis and mapping, moving from inductive to abductive reasoning.

In this chapter, the methodological approach (Section 4.2) and case study design (Section 4.3) are presented first. Then the data collection methods using the mixed methods approach are explained (Section 4.4), followed by the data analysis methods (Section 4.5). The positionality of the researcher and reliability are discussed (Section 4.6). An interpretation and triangulation (Section 4.7) and a chapter summary (Section 4.8) are then presented.

### 4.2 Methodological Approach

Resilience in social housing is examined through the lens of practice theory in order to understand the relation between design, practices and resilience. A mixed methods approach allows researchers to address complicated research questions and collect richer data than any single method (Yin, 2018, p. 63). Thus, to achieve the aim and objectives of the research, a mixed methods approach with a question-driven perspective is used (Schatzki, Knorr-Cetina and Savigny, 2001; Gram-Hanssen, 2010; O’Leary, 2021). This study seeks to answer ‘how’ and ‘why’ questions within the inhabitants’ energy-related practices and provide an extensive and in-depth description of resilience in social housing, thus using case study research is appropriate (Yin, 2018, chap. 1). A cases-within-a-case approach is used in this study to develop a detailed understanding of the issues described above by examining specific examples with different characteristics (Flyvbjerg, 2006; Yin, 2018, chap. 2).

Figure 4.1 illustrates the research design of this thesis, explaining the whole research process from beginning to end by linking the research questions and objectives to each method. The mixed methods approach includes a literature review, which guides the development of the research questions, aim and objectives, followed by a document review and a POE using both qualitative (semi-structured interviews) and quantitative (usability questionnaire) methods using a cases-within-a-case approach to gain in-depth knowledge of inhabitants' energy-related practices in relation to resilience in social housing. The POE data were collected based on the questions related to robustness, adaptation and redundancy in terms of inhabitants' energy-related practices. The interview questions were based on a matrix prepared by the researcher, linking resilience drivers with Gram-Hanssen's (2010) practice theory elements as an analytical tool. After collecting data, the data analysis was conducted using NVivo coding and cross-case synthesis with thematic analysis and mapping to identify themes and patterns. The role of the mixed methods approach with a cases-within-a-case approach is to understand 'how' and 'why' (Yin, 2018), and the final part of this analysis, interpretation and triangulation, seeks to understand 'why' in order to identify key insights for future-proofing social housing, and so provide policy and practice recommendations.

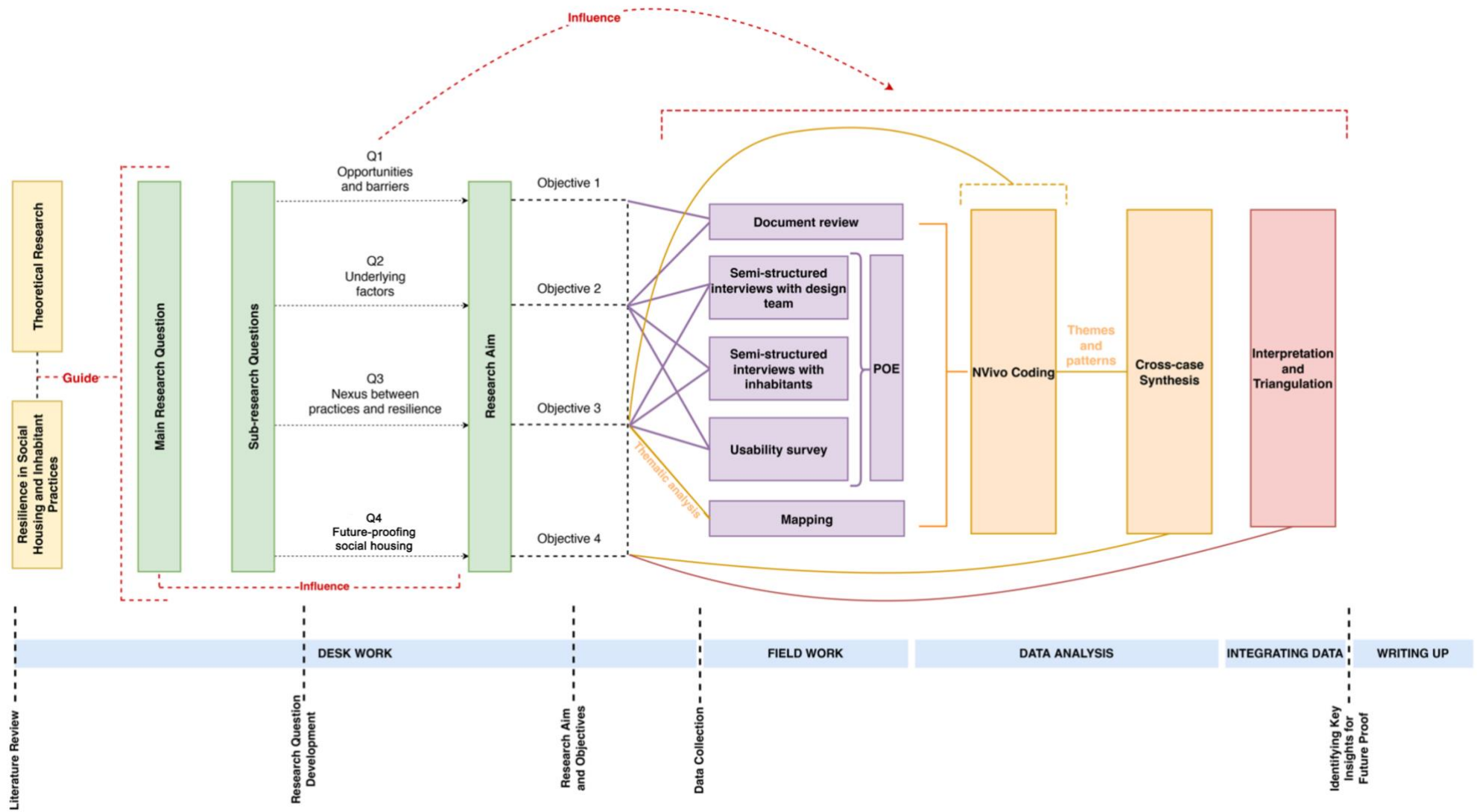


Figure 4.1 Research design of this thesis

Table 4.1 summarises the research questions, objectives and methods, and how they interlink. The research questions and related objectives are shown in the first and second rows, respectively. Each column shows the related question and objectives (e.g., Question 1 is answered by Objective 1 shown in the first column). The methods are shown in the third row, and the specific methods used to address each related research question and the objectives are shown in each column (e.g., to answer Question 1, the literature review and document review are used as methods). The last row summarises each method used to answer the relevant research question.

Table 4.1 Research structure

<b>Research Questions, Objectives and Methods</b>				
<b>Research Question</b>	Question 1 What are the main opportunities for and barriers to designing robust, adaptable and redundant social housing in the UK?	Question 2 What are the underlying factors of robustness, adaptation and redundancy in social housing developments?	Question 3 How do inhabitants discuss their energy-related practices in the household and how does this interface with the robustness, adaptation and redundancy in social housing design?	Question 4 How can social housing be future-proofed to become more robust, adaptable and redundant over time?
<b>Objectives Related to Each Question</b>	Objective 1 Understand the state-of-the-art of the discourse about robustness, adaptation and redundancy of social housing in the UK	Objective 2 Develop an understanding of underlying robustness, redundancy and adaptation in a selected social housing case study	Objective 3 Explore and explain robustness, adaptation and redundancy of the selected social housing design and inhabitants' discussions regarding energy-related practices	Objective 4 Identify key insights for a new understanding of resilient social housing in relation to inhabitants' energy-related practices in the household to help future-proof homes
<b>Methods</b>	Literature review (Chapter 3) Document review (4.4.2)	Document review (4.4.2) Case-study interviews (4.4.3) Usability survey (4.4.4)	Data analysis (4.5) Thematic analysis (4.5.4.1) and mapping (4.5.4.2)	Data analysis (4.5) Interpretation and triangulation (4.7)

		Visual recording (4.4.5) Data analysis (4.5)		
<b>Summary of Method</b>	Literature review of academic papers, regulations, government and product websites  Review of selected case study documents including project brief, drawings (plans, sections, elevations) and specifications	Cases-within-a-case: A large social housing development  Semi-structured interviews with design team: Project coordinator, project developer and architect  Semi-structured interviews and usability survey with inhabitants  Recording the photos of inhabitants' heating and ventilation controls within their homes	Two coding cycles using NVivo  Cross-case synthesis through thematic analysis using practice theory	Thematic analysis  Interpretation and triangulation of analysed data

### 4.3 Case Study Design

#### 4.3.1 Case Study Selection Strategy

A case study can be defined as ‘a detailed exploration and assessment of a particular situation embedded in the real world for the purpose of seeking evidence, constructing generalisations and insights to get the best possible answers to the research questions’ (Gillham, 2000, p. 1). A case study answers exploratory questions like ‘how’ and ‘why’ and focuses on generating in-depth knowledge within a real-world context (Yin, 2018, p. 13). In this research, a cases-within-a-case approach and cross-case analysis help to explain the link between the cases (Yin, 2018). A cases-within-a-case approach is the in-depth exploration and understanding of a single case as a stand-alone entity (Mills, Durepos and Wiebe, 2010). This approach is used in this thesis to identify the case’s unique attributes and patterns by examining the homes within the single large social housing development, and then conducting a cross-case comparison to identify what households have in common as well as what attributes of each household are unique (Mills, Durepos and Wiebe, 2010; Yin, 2018).

The strategy used to select the case study was based on maximising the usability and significance of the information gathered from the case, with the intention of understanding

resilience in social housing (Flyvbjerg, 2001). Thus, in this research, an ‘information-oriented selection’ with the ‘maximum variation’ type of case study was used to enhance the value of information for the case study process and its outcome (Flyvbjerg, 2006).

This case study design involved 16 homes within a single large social housing association and analysis was performed at numerous levels, both within and between selected homes (Yin, 2018). In this thesis, environmental conditions serve as a control group to ensure that variations in inhabitants’ practices can be more clearly examined. The study focuses on a single large housing development in Sheffield, in a single climate zone, where all homes have similar physical attributes (heating and ventilation systems, as outlined in Table 4.2). This approach mitigates confounding variables related to environmental differences and enables a more focused exploration of socio-demographic influences on inhabitants’ practices.

While this approach facilitates a more focused investigation into social and behavioural factors, it is acknowledged that future climate uncertainties could influence resilience in ways not fully captured within the scope of this thesis. This limitation is acknowledged, and its impact on resilience and housing research is elaborated upon in the further research section.

Table 4.2 Case study characteristics

<b>Tenure Type</b>	Social housing
<b>Typology</b>	One-bed flat Two-bed flat Three-bed semi-detached house
<b>Project Completion Date</b>	Newly built in 2016
<b>Location</b>	Sheffield, UK
<b>Energy Level</b>	EPC rating score range 81-86 (Energy Rating B) Code for Sustainable Homes Level 3
<b>Heating System</b>	Gas central heating with gas combi boilers Radiators with thermostatic valves Room thermostat Digital heating programmer
<b>Ventilation System</b>	Mechanical extract ventilation (MEV) Extractor fans Double-glazed windows

	Trickle vents Doors (10mm gap from the floor)
--	--

The majority of social housing in Sheffield comprises houses (46%) or flats (40%) that have one to three bedrooms (Sheffield City Council, 2017). The selected housing typologies of one-bed flats, two-bed flats and three-bed semi-detached houses were chosen in this study because they reflect a broad range of typical social housing types in Sheffield. These housing types are among the most common in social housing stock and thus serve the broader housing market for low-income households (Sheffield City Council, 2017). Each housing typology presents distinct challenges and opportunities regarding energy efficiency and heating and ventilation systems, making them ideal for exploring the diversity of energy-related practices.

The selection of 16 homes was designed to include a variety of household compositions to represent a range of social contexts. A mixture of household types, including single people, couples and families, were chosen to capture a broad range of energy usage behaviours and practices. This variation allowed the study to explore how household size and demographic factors influence energy consumption and energy practices.

The case study of these 16 homes resulted in a total of 18 semi-structured interviews with inhabitants, 26 usability survey with inhabitants, and three semi-structured interviews with the design team, namely the project coordinator, project developer and architect. Of the 16 homes, 12 homes had at least two inhabitants, and four homes had one inhabitant each. The 12 homes with at least two inhabitants provided data about inhabitants' discussions. The four homes with one inhabitant were included to understand their habits and how they use their heating and ventilation equipment.

The concept of saturation is widely used in qualitative studies as 'data saturation' or 'thematic saturation', indicating that the collected data have captured the depth, diversity and content of the issues being studied (Francis *et al.*, 2010; Hennink, Kaiser and Marconi, 2017). According to Lincoln and Guba (1985), the sample size can be determined by seeing when no new information is gathered when more units are sampled. This research took the approach of Francis *et al.* (2010) to reach thematic saturation, which involves two main principles: the researcher specifies an initial analysis sample (e.g., 10 interviews) for the first

round of analysis, and a stopping criterion, that is a number of interviews (e.g., three interviews) for further analysis that are conducted until no new themes emerge. In this research, the sample size was 21 semi-structured interviews and 26 usability questionnaires. The researcher started the first round of analysis with 11 semi-structured interviews, and analysed seven more interviews in the second round, which was sufficient to reach thematic saturation. After the total of 18 semi-structured interviews, no new themes related to the energy-related practices in the social housing emerged. Three more interviews were analysed after the second cycle of analysis to confirm data saturation.

#### 4.3.2 New-build Housing Association Homes

As the need for emission reduction and energy-efficient new-build homes continues to rise, there is a growing demand for new social rental homes. Additionally, with the UK's ageing population, there needs to be more housing suitable for the elderly (Goddard, 2022). It is important to understand how new-build homes respond to the housing problem in the UK (see Section 1.2). Housing associations play a significant role in the UK's house-building programme and low-energy housing construction, making new-build housing association developments appropriate as a case study for this research.

The case study selection aimed for a mixture of typologies of new-build social housing (see Table 4.2 for case study characteristics). This ensured maximum variation in typologies and socio-demographic data of inhabitants (presented in

Table 4.6). The initial approach was made by email to key contacts from various housing associations in 2021 during the Covid-19 period. The researcher explained the aims and research scope and provided a research proposal and case study brief, which included case study characteristics (see Table 4.2). The housing association was selected based on its willingness to participate and compatibility with the case study brief.

#### 4.3.3 Practical and Ethical Considerations of the Case Study

Ethical issues like informed consent, confidentiality, anonymity, and privacy had to be carefully considered throughout the research process (Byrne, 2017). Therefore, this study was conducted according to the ethical policy of the University of Sheffield. After gaining ethical approval (see Appendix 6) in 2022, all the participants were contacted by the housing

association via an email that the researcher had prepared, which included a participant invitation letter. Owing to the limited number of participants that were willing to be involved in the research, the invitation letters were also sent by post to each household within the large housing development. In order to increase participation rates, the researcher conducted site visits with one of the housing association's neighbourhood officers to explain the research to each household face-to-face. Information sheets were given to the inhabitants who expressed interest in participating the research. The project coordinator and project developer were first contacted through the housing association, and once the researcher had their details, the researcher contacted them by email. The architect was contacted by the researcher through the architectural company, of which the architect is a partner. Information sheets and the consent forms were sent to the design team by email after they agreed to participate in the research.

The planning and data collection stage of this research were directly affected by the Covid-19 pandemic. It took longer to recruit participants willing to engage in the research, and because of Covid-19, the majority of the inhabitants preferred to participate over the phone rather than face-to-face, impacting the researcher's ability to observe the inhabitants during the interviews. Additionally, some interviews had to be rescheduled due to participants contracting Covid.

#### **4.4 Mixed Methods Approach**

Combining quantitative and qualitative methods provides a good opportunity to 'ground' practice analysis in the POE studies. This approach provides a baseline for evaluating the outcome of inhabitant practices within the physical context of social housing (Leaman, Stevenson and Bordass, 2010; Foulds, Powell and Seyfan, 2013). According to RIBA (2020), POE is defined as the process of gathering feedback on the building's performance after occupancy, including collecting information on the building, its energy use, and user satisfaction. Thus, in this research, to better understand the inhabitants' energy-related practices within the home, POE was conducted through document review (see Section 4.4.2), semi-structured interviews (see Section 4.4.3), and usability surveys (see Section 4.4.4). The following sections provide a detailed description of how this research used the mixed methods approach by explaining how each method was used and why it was chosen.

Table 4.1 illustrates the methodological approach of this thesis, showing how various research methods relate to each other and to the research objectives.

#### 4.4.1 Literature Review

Literature reviews play a key role in reducing a broad range of literature and a rigorous review of the references in order to refine the knowledge gap and research questions (Groat and Wang, 2013; Hart, 2018). A literature review was conducted to identify all the relevant studies, synthesise the findings and understand what these articles included and excluded to reveal the research gap (Jesson, Matheson and Lacey, 2011). A detailed explanation of the literature review method was provided in Section 2.2, which included the search strategy in the selected databases (Scopus, Web of Science and Science Direct), the results of the search and how the research gap was revealed. Given the objectives of the literature review for this study, which are to understand energy-related practices and the requirements in the subject area, grey literature, such as building regulations, heating and ventilation system product websites and government websites, were accessed by internet search.

#### 4.4.2 Document Review

Documents are defined as written texts that can be published or unpublished, or printed, photographed or recorded material that can be used to present information or processes (Nock and Scott, 1991; Dolowitz, Buckler and Sweeney, 2008). In this research, the document review was used as part of the auditing process of POE in order to understand the process of the project over time, its construction strategy, and the actions taken during the design and delivery of the project (Stevenson, 2019, p. 83). A careful and comprehensive document review was conducted to: understand the case study scheme; determine what within the case study accounts for robustness, redundancy and adaptation, or creates barriers in relation to inhabitants' energy-related practices and discussions (Objective 1); and test the reality of things (technologies and design) against the interviews in order to understand more deeply the underlying robustness, redundancy and adaptation in the case study (Objective 2). Key documents for analysis included the brief (design intentions), plans, sections, elevations and specifications for the development. A checklist of case study documents (see Table 4.3) was requested from the housing association prior to the interviews with the design team and inhabitants. Additional documents were studied to

understand what the inhabitants were doing in relation to their home energy management, which helped to shape interview questions (see Appendix 8 to Appendix 10) and observations, including induction and maintenance documents (see Table 4.3). The document review of the case study informed the interviewing and enabled comparison of the design intentions with the actual practice.

Table 4.3 Requested case study documents

<b>Corporate</b>	Housing association’s vision and values Development strategy Corporate policies and strategies related to sustainability, energy efficiency, building standards
<b>Housing Development</b>	Key project participants: housing association’s project director, architect, project developer Project timeline and phasing Site layout plan Housing layout plans, sections and elevations Scheme specification including the standards specified for energy efficiency Mechanical information documents: heating and ventilation layout plans and technical specifications Construction types, including window/door details Heating and ventilation equipment product information, instruction manuals, user instructions, maintenance instructions Energy Performance Certificate
<b>Housing Development Handover</b>	Home user guides (see Appendix 17) Maintenance handbook

#### 4.4.3 Semi-structured Interviews

The difference between quantitative and qualitative research is that quantitative methods look at ‘what’ residents do while qualitative approaches seek to understand ‘how’ and ‘why’ the residents do things (e.g., interactions, engagements, habits and reflections)’ (Baker and Edwards, 2012). Interviews can be very useful for explaining the ‘how’ and ‘why’ of key events, reflecting participants’ perspectives (Yin, 2018). There is a significant difference between structured and semi-structured interviews. Structured interviews have a limited set of response categories because the interviewer asks highly structured questions; in

contrast, in addition to the structured questions, semi-structured interviews allow new perspectives and issues to be brought up by the respondents (Fontana and Frey, 1994; Yin, 2018).

The validation of the semi-structured interviews is important to demonstrate the credibility of the data and findings. One way to ensure validation is triangulation, where the researcher finds a nexus from different sources of information in order to form themes and categories by eliminating overlapping areas of research data (Creswell and Miller, 2000). This is usually done using multiple approaches, such as observations, document reviews and interviews, amongst others, in different combinations for achieving broader results (Denzin and Lincoln, 2013).

#### 4.4.3.1 Interviewee Selection

The main reason for conducting a cases-within-a-case approach in this research was to build an understanding of the issues in rich detail through the specific examples with different characteristics in a variety of contexts (Yin, 2018). Thus, an 'information-oriented selection' of the case study was made, and the interviewees were selected using 'snowballing' as sampling strategy, reflecting the aim of this research and providing a basis for analysis within and between the households (Flyvbjerg, 2006; Flick, 2018). The invitation letters prepared by the researcher were sent to participants by the housing association; however, to increase the number of participants, the case study site was visited by the researcher with one of the neighbourhood officers.

Using the snowballing strategy for sampling helped to increase the number of participants, as the interviewees provided the researcher's information to other potential interviewees within the housing development (Flick, 2018). As a result, the overall sampling strategy changed dramatically through snowballing, as more participants were formally interviewed. The snowballing approach that was used to recruit participants resulted in participants being quite similar in terms of their world view and social characteristics. In this case, snowball sampling resulted in a sample dominated by older individuals, skewing the participant profile in favour of those over the age of 50 (see Table 4.6). This homogeneity aligns with patterns observed in UK social housing, where the largest age group among social housing renters is 45 to 64 years old (Ministry of Housing, Communities and Local Government,

2024). However, this homogeneity also underscores the limitations of the snowballing method in achieving broader diversity (Parker, Scott and Geddes, 2019). Reflecting on the implications of using the snowballing approach, this study focused on a population associated with the social housing context and the sampling naturally drew from a population which reflects the demographic pattern of this housing context in the UK.

The research includes one household with two adults and children under 18, one household with three adults, 10 households with two adults (the majority of them are older couples). The presence of children in a household has a crucial influence on household energy dynamics, as they significantly shape energy consumption patterns and household routines (Fell and Chiu, 2014). However, in the context of present study, they are not fully captured due to the selected social housing case study primarily accommodating older people. This research focuses on older inhabitants due to their specific energy challenges, such as heating needs, vulnerability to fuel poverty, or limited mobility, which makes them more dependent on consistent and affordable energy. As a result, this study does not fully capture the diverse dynamics found in family households with children, which is acknowledged as a limitation and discussed in the limitations and further research sections. (see Sections 1.7, 8.5 and 8.6).

Initially, a total of three semi-structured interviews with the design team were conducted (see Appendix 11 to Appendix 13) in order to gain a better understanding of energy-related design intentions (see Table 4.4). After the design team interviews, a total of 18 semi-structured interviews with inhabitants were conducted. These aimed to understand how the inhabitants use the heating and ventilation equipment in the households, how social changes affect their energy-related practices, and how they discuss their energy-related practices with one another within the household (see Table 4.4).

Table 4.4 Overview of the semi-structured interviews with inhabitants and design team

<b>Type of Participant</b>	<b>Number</b>	<b>Comment</b>
Inhabitant	5	Semi-structured face-to-face interview, recorded and transcribed
	13	Semi-structured phone interview, recorded and transcribed
Project director	1	Semi-structured Google Meet interview, recorded and

		transcribed
Project coordinator	1	Semi-structured Google Meet interview, recorded and transcribed
Architect	1	Semi-structured Zoom interview, recorded and transcribed
<b>Total</b>	<b>21</b>	

Key design team members (see Table 4.5) were identified at the planning stage and contacted through the housing association. The key design team participants were selected based on their detailed knowledge about the housing development and its stages throughout the whole design and build process. The design team participants were also selected based on their involvement in the different stages (RIBA plan of work stages) of the housing development.

Table 4.5 Design team participant characteristics

<b>Participant Number</b>	<b>Role</b>	<b>Region</b>	<b>Organisation Type</b>
D1	Project director	South Yorkshire	Housing association
D2	Project coordinator	South Yorkshire	Housing association
D3	Architect	UK-wide	Architectural firm

Across the single large social housing case study, the selection of inhabitants was designed to examine the experiences and practices of a wide range of households, varying in the number of adults in the household, gender, age, and housing typology (see Table 4.6). The aim was to explore what impact these social factors may have on energy-related practices. The cases within the large housing development vary in size and typology as ‘maximum variation’ type (Yin, 2018) and include ground-floor and first-floor one-bed and two-bed flats, and a three-bed semi-detached house.

All inhabitants in the case study scheme were contacted by a letter (see Appendix 3) that had been drafted by the researcher and sent via the housing association’s email and by post, inviting volunteers to participate in the study. However, due to limited responses the researcher contacted the housing association and arranged a meeting with a neighbourhood officer working in the case study scheme. The researcher visited the case study scheme to invite participants face-to-face with the neighbourhood officer, which increased the number of participants who were willing to engage in the study. Not all inhabitants of each

household participated in the interviews, but all the inhabitants in the household filled in the usability questionnaire (see Appendix 7), which was important to understand the inhabitants' discussions and to capture their engagement with the heating and ventilation equipment in the household. Some inhabitants were excluded from the invitation based on the housing association's opinion, where personal circumstances such as a history of violence or serious health conditions could affect the interviewing process.

Table 4.6 Inhabitant Characteristics

<b>Participant Number</b>	<b>Household Number</b>	<b>Number of Adults in the Household</b>	<b>Gender</b> (male: M, female: F, other: O)	<b>Age</b> (under 30, 30-50, 51-70, over 70)	<b>Employment Status</b>	<b>Housing Typology</b>	<b>EPC Rating Score</b> A(best):92+ B:81-91, C:69-80, D:55-68, E:39-54, F:21-38, G(Worst):1-20
R1	H1	2	F	51 – 70	Unemployed	Ground floor	85 (B)
R2			M	51 – 70	Employed		
R3	H2	2	F	51 – 70	Employed	Ground floor	84 (B)
R4	H3	2	F	Over 70	Retired	Ground floor	84 (B)
R5			M	Over 70	Retired		
R6	H4	1	F	51 – 70	Employed	First floor	84 (B)
R7	H5	2	M	51 – 70	Employed	First floor	84 (B)
R8			F	30 – 50	Unemployed		
R9	H6	3	M	51 – 70	Employed	First floor	86 (B)
R10			F	51 – 70	Retired		
R11	H7	2	M	51 – 70	Employed	Ground floor	84 (B)
R12			F	51 – 70	Employed		
R13	H8	1	F	51 – 70	Retired	First floor	85 (B)
R14	H9	2	M	51 – 70	Retired	Ground floor	84 (B)
R15	H10	2	F	30 – 50	Employed	First floor	84 (B)
R16			M	51 – 70	Employed		
R17	H11	1	F	Over 70	Retired	Ground floor	84 (B)

R18	H12	2	F	51 – 70	Retired	First floor	84 (B)
R19			M	51 – 70	Employed		
R20	H13	2	F	51 – 70	Unemployed	First floor	84 (B)
R21			M	51 – 70	Retired		
R22	H14	1	F	Over 70	Retired	Ground floor	85 (B)
R23	H15	2	M	51 – 70	Employed	Ground floor	81 (B)
R24			F	51 – 70	Unemployed		
R25	H16	2	F	30 – 50	Employed	Semi-detached	83 (B)
R26			M	30 – 50	Employed		

#### 4.4.3.2 Interview Planning

The interview appointments with the design team were scheduled by email, and any missing documents were requested at this stage. Owing to Covid-19, several interviews with the design team and inhabitants had to be rescheduled. All the interviews with the inhabitants were conducted around the same season (between September and February) to understand how social changes affect the inhabitants' energy-related practices within the same season and location. Interview appointment times were agreed with inhabitants and confirmed by phone, text or email. Two households that initially agreed to participate later informed the researcher that they were unwilling to participate due to the heating problems in their homes.

The researcher showed photo identification on arrival for the face-to-face interviews with the inhabitants to ensure their safety. Owing to Covid-19, the majority of the inhabitants preferred phone interviews rather than face-to-face, and the researcher sent the usability questionnaire by post prior to the interviews. Safety arrangements were implemented for the researcher; a friend of the researcher was present when the interviews were taking place in the inhabitants' homes and the researcher sent the meeting times and addresses to supervisors by creating a Google meeting. Once the interviews were finished, the researcher deleted the Google meeting invite to notify the supervisors that the interview had finished.

#### 4.4.3.3 Interview Format

The case study interviews were semi-structured, incorporating both structured and unstructured sections to allow new perspectives to emerge from the research participants in

a more conversational way (Galletta, 2016). All design team interviews took place online with using Google Meet and Zoom, and they each lasted 30–40 minutes (Stevenson, 2019). The information sheet and consent forms were provided to the design team before the interviews. Interviews with the inhabitants were conducted at mutually convenient times. Five inhabitants were interviewed face-to-face; one interview was conducted in a café and the other four took place in the inhabitants' homes. Thirteen inhabitant interviews were done by phone, owing to the inhabitants' preference due to Covid-19 at the time of data collection. The information sheet (see Appendix 4) and consent form (see Appendix 5) were provided to the inhabitants prior to interviews, and they were given the opportunity to raise questions before signing the consent form. The inhabitant interviews lasted about 20–50 minutes each, and the researcher took hand-written notes from the face-to-face interviews in order to gain knowledge beyond what was verbalised. During the interviews, the researcher noted the inhabitants' responses, and if an inhabitant did not respond clearly, the question was asked again in a different way with examples.

All the interviews were recorded on a voice recording device. The research participants had been informed that they would be recorded when they signed the consent form, and the researcher reminded them of this before starting the interview.

#### 4.4.4 Usability Survey

The usability survey aimed to identify any gaps between design intentions and the actual use of specific technologies in the home (Baborska-Narožny and Stevenson, 2019). Inhabitant diversity is often underestimated, and architects assume that inhabitants know how equipment in homes is used based on their own understandings and experiences (Stevenson, 2019). In this research, the usability survey helped to fill the gaps between the design intentions and the actual usage of the 'things' (Gram-Hanssen, 2010). Usability studies do not always explain the inhabitants' inappropriate use of controls, because inhabitants may lack the knowledge to use them (Baborska-Narožny and Stevenson, 2019). Therefore, semi-structured interviews were also conducted to understand the reasons 'why' inhabitants use or cannot use the heating and ventilation controls. The survey (see Appendix 7) took 10–15 minutes to complete and provided a detailed evaluation of the selected controls in the home, assessing how usable the heating and ventilation controls were in

order to understand how robust the inhabitants found them, and to understand how much redundancy there was. The researcher prepared the usability survey based on the usability and engagement tool of Baborska-Narožny and Stevenson (2019), and adapted this tool based on the research questions and objectives of this thesis. The usability survey was expert-led because inhabitants were sometimes unclear about the control interfaces, and they needed reminding about how to operate them (Baborska-Narožny and Stevenson, 2019). The survey did not include the additional heating and ventilation equipment introduced by the inhabitants, such as portable air conditioning units or personal dehumidifiers.

The usability survey covered the connection between inhabitants and the controls in their homes (Stevenson, 2019). This survey was very useful when combined with the document review and inhabitant interviews, revealing underlying usability issues in the home and engagement with ‘things’ in practice, including all the heating and ventilation control touch points affecting resilience. The researcher was present while the inhabitants filled out the survey to help them complete it.

In total, 26 usability surveys were completed by the participating inhabitants in the households. In each household, at least one member was interviewed; however, in some households, the second household member chose not to participate in the interviews. To address the limitation of not gathering enough information about household discussions from both members, the researcher included questions about these discussions in the usability survey. These questions explored whether energy-related decisions are discussed collaboratively or made by a single household member. The particular questions about the discussions were asked for each specific heating and ventilation system control in the usability survey, and these questions were as follows: *‘Do you discuss with your household member when you need to use this control?’* and *‘Do you take charge of using this heating/ventilation equipment?’* This approach ensured that, even in households where only one interview was conducted, the perspectives of both members could still be captured through the completion of two usability surveys.

#### 4.4.5 Visual Recording

During the face-to-face interviews with the inhabitants, relevant features of the home, including the heating and ventilation system equipment, were photographed using the researcher's phone camera, after getting informed consent from the inhabitants.

### 4.5 Data Analysis

This section outlines the evaluations needed to understand robustness, adaptation and redundancy concerning energy-related practices in UK social housing using NVivo coding. Inhabitants' practices were evaluated using semi-structured interviews and usability questionnaires, and thematically analysed using NVivo and SPSS.

Matrixes are based on cross-classification of two or more variables, or concepts relevant to a topic, reflecting the relationships among the data (Lofland, Snow and Anderson, 2006). Thus, a matrix was prepared by the researcher by linking robustness, adaptation and redundancy within resilience with Gram-Hanssen's (2010) practice theory elements to understand the energy-related practices within the households (see Table 4.7). The matrix was prepared before the data collection stage to help with developing the interview questions effectively for the inhabitants and design team. This matrix was also used in the data analysis stage as an analytical framework to understand the nexus between practice theory elements and resilience drivers. The discussion and conclusions in Chapters 7 and 8 were also framed according to this resilience matrix, helping the researcher to connect the resilience indicators, inhabitants' practices and new-build social housing design (see Section 8.2).

Table 4.7 Resilience matrix in relation to practice theory, prepared by the researcher as an analytical tool

<b>Resilience Indicators / Practice Theory Elements</b>	<b>Robustness</b> <i>(The ability of the home to carry on performing despite social changes)</i>	<b>Redundancy</b> <i>(The ability of different things to satisfy the same function)</i>	<b>Adaptation</b> <i>(Adjustment to reduce the impacts of social changes)</i>	<b>Physical Factors That Need to Be Considered in Social Housing</b>
<b>Know-how and Embodied Habits</b>	<ul style="list-style-type: none"> <li>How much can people's habits and knowledge change while the home carries on performing?</li> </ul>	<ul style="list-style-type: none"> <li>How do changing habits and knowledge affect the ability of different things to perform the same function?</li> <li>How do inhabitants change their ways of using the home in relation to the different things that cause more or less redundancy?</li> </ul>	<ul style="list-style-type: none"> <li>How do know-how and habits differ depending on different household demographics and occupancy level?</li> <li>How do changes in people's habits affect the ability of the home to adapt?</li> </ul>	<ul style="list-style-type: none"> <li>Size of the home</li> <li>Systems in the home: heating and ventilation</li> </ul>
<b>Institutionalised Knowledge and Rules</b>	<ul style="list-style-type: none"> <li>How able is the social housing to continue functioning despite changes to institutional knowledge and rules?</li> </ul>	<ul style="list-style-type: none"> <li>How might the change in rules affect redundancy in the home?</li> <li>Occupancy level and household demographics (age, gender, employment status, etc.)</li> </ul>	<ul style="list-style-type: none"> <li>How do changes in the institutionalised knowledge and rules affect the ability of home to adapt?</li> </ul>	
<b>Engagements</b>	<ul style="list-style-type: none"> <li>How able is the home to cope with changes in engagement?</li> <li>How do inhabitants discuss using things in the home?</li> </ul>	<ul style="list-style-type: none"> <li>How do changes in the way inhabitants engage with technology and which technologies they engage with affect the redundancy of the home?</li> </ul>	<ul style="list-style-type: none"> <li>How do changes in inhabitants' engagements and discussions affect the ability of home to adapt?</li> </ul>	
<b>Technologies</b>	<ul style="list-style-type: none"> <li>How do changing technologies affect the ability of the home to carry on?</li> <li>Can systems in the home able to withstand shocks and social changes? An increase in occupancy level can increase the usage of systems in the home</li> </ul>	<ul style="list-style-type: none"> <li>How many things are available to carry out the same function in the social housing?</li> </ul>	<ul style="list-style-type: none"> <li>How do changing technologies affect the ability of home to adapt?</li> </ul>	<ul style="list-style-type: none"> <li>MEV</li> <li>Windows</li> <li>Boiler</li> <li>Heat pumps</li> <li>Glazing</li> <li>PV systems</li> <li>Solar controls</li> </ul>

#### 4.5.1 Data Management and Transcription

Once the data collection phase was finished, all audio files from the inhabitant and design team interviews were grouped and labelled. The design team interviews were transcribed first to understand the design intentions of the selected case study, and then the inhabitant interviews were transcribed.

Semi-structured interviews were transcribed using NVivo's transcription service, but the interviews were also manually listened to again and checked by the researcher because the transcription software was not always accurate. As the data analysis focused on the in-depth responses from both the inhabitants and design team, all of the discussions during the interviews were transcribed to text in a Microsoft Word document (McLellan, MacQueen and Neidig, 2003).

NVivo 14 for Mac software was used for coding and data analysis. For data analysis, the researcher also used Microsoft Excel and draw.io software, which helped the thematic analysis and mapping of the analysed data. All the participants were anonymised by using pseudonyms, such as D1 for the design team members and R1 for the inhabitants (see Table 4.5 and Table 4.6).

#### 4.5.2 Coding

NVivo is analytical software used for linking ideas, finding patterns between gathered data and integrating reflections, and this was used to organise themes in order to reflect on the research questions (Richards, 1999; Auerbach and Silverstein, 2003). In terms of pre-coding, NVivo was used to work from practice theory to data (Saldaña, 2013). Thematic analysis based on pre-coding was used to analyse the semi-structured interviews and usability questionnaires about inhabitants' energy-related practices, and it showed the underlying patterns and themes related to inhabitants' practices (Saldaña, 2013). The coding process for both cycles of coding was based on the pre-codes that had already been found in the literature review, focusing on the key three resilience drivers: robustness, redundancy and adaptation. The other pre-codes were Gram-Hanssen's (2010) practice theory elements – know-how and embodied habits, institutionalised knowledge and rules, engagements, and

technology – which were used in the second cycle of coding to identify patterns and find links between aspects of practice theory and the collected data. Additionally, in this research, counting the ‘frequency’ of the codes in order to find patterns was measured by the ‘presence’ of codes related to each theme, rather than the ‘number’ of times these codes appeared in the data.

In the first cycle of coding (n = 11), the transcribed interview data were coded by the line of inquiry based on the research gap. The first cycle of coding was carried out by using an inductive approach to analysis to capture the frequency of the codes and the relevant codes related to the lines of inquiry (Klix, 2001). The semi-structured interview questions were based on the following lines of inquiry: resilience of the home, robustness, adaptation, and redundancy. The first cycle of coding also included the frequency of the codes that appeared in the interviews in general. The mapping method was used to find links between the design team’s and inhabitants’ perspectives to understand the underlying factors of resilience to answer Research Question 2. For example, the researcher developed Figure 4.2 to understand the underlying factors of resilience by analysing the differences and similarities between the design team’s and inhabitants’ perspectives during the first cycle of coding. This mapping was further developed by the researcher after the second cycle of coding and during the thematic analysis (see Appendix 1).

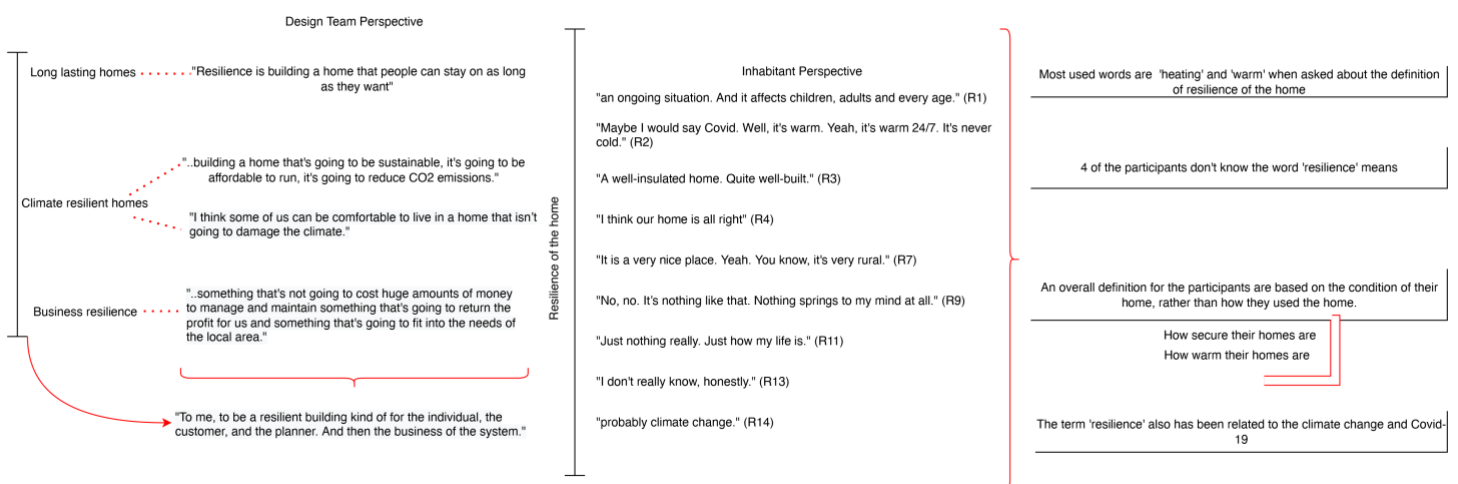


Figure 4.2 An example of data mapping that the researcher prepared during first cycle of coding (n = 11)

The second cycle of coding (n = 18) was the detailed coding where the researcher did the coding word-by-word for each participant. In this cycle, the theoretical aspect of the study was linked with the first cycle of coding, helping to identify patterns between the cases. Both inductive and abductive approaches were used to understand the data and find patterns (Klix, 2001; Saldaña, 2013). After 18 interviews, similar codes were appearing, and no new codes or themes were emerging from the data (Saunders *et al.*, 2018), so data saturation was reached with 18 interviews, and then the remaining three interviews were coded. Figure 4.3 and Figure 4.4 were developed by the researcher using the mapping method, showing the design team’s and inhabitants’ data coding and the patterns from the first cycle of coding (in the blue circles) and the extra themes from the second cycle of coding (in red triangles) related to aspects of Gram-Hanssen’s (2010) practice theory.

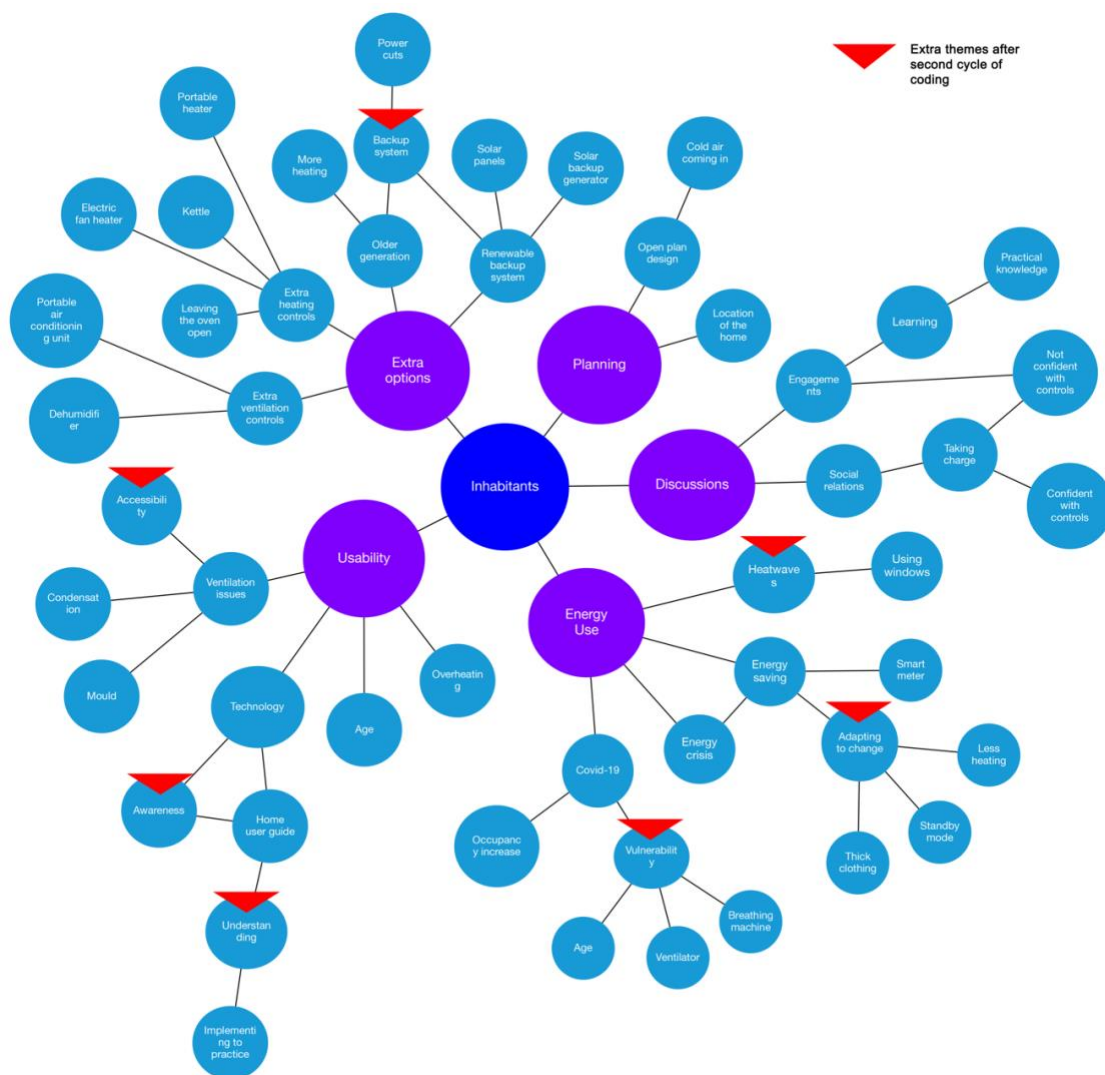


Figure 4.3 Example of the second cycle of coding of the inhabitants’ responses using the mapping method (prepared by the researcher)

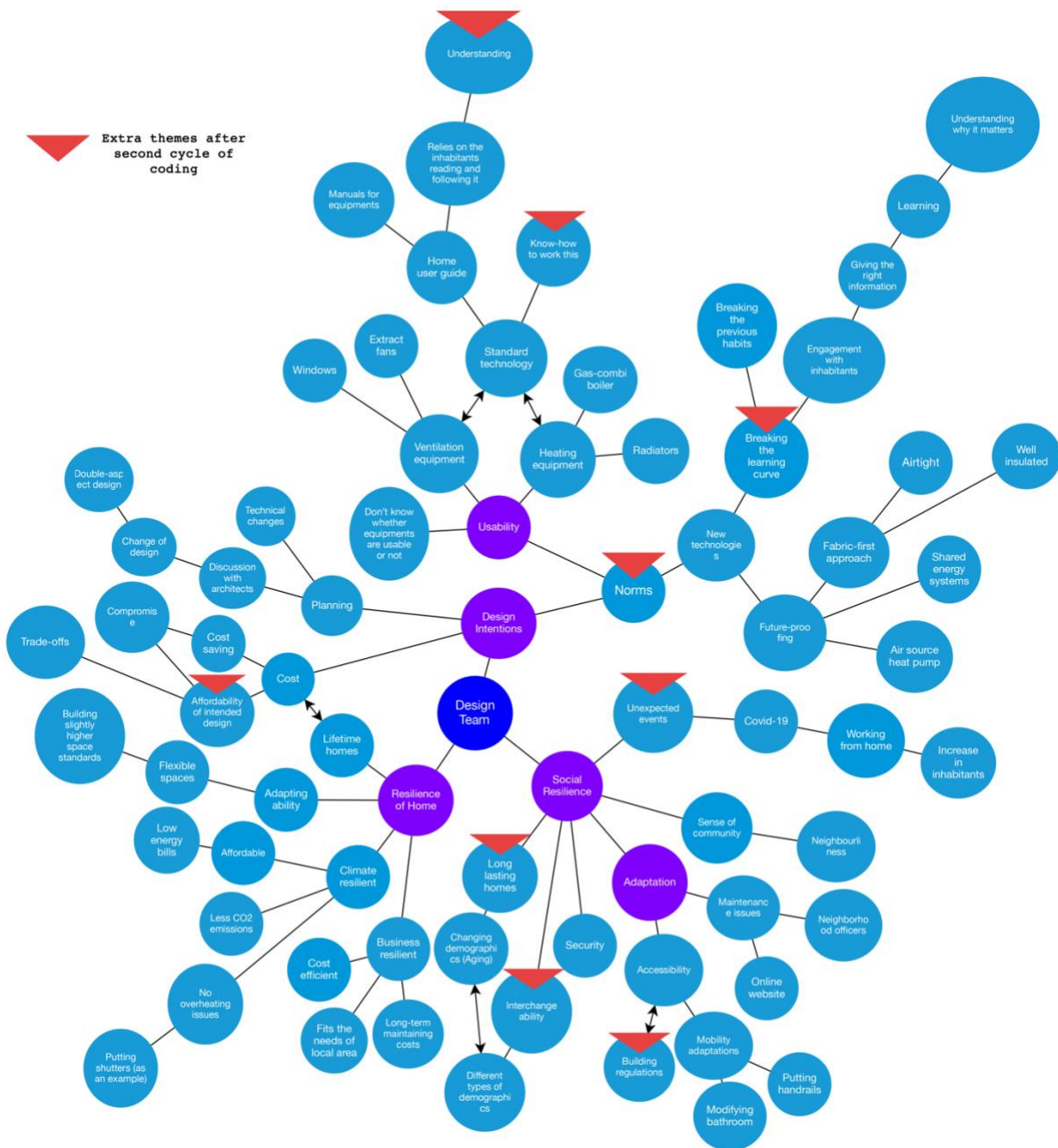


Figure 4.4 Example of the second cycle of coding of the design team's responses using the mapping method (prepared by the researcher)

4.5.3 Data Analysis of Usability Survey

The usability survey was designed such that its findings could be cross-related with the findings from the other POE methods (Leaman, Stevenson and Bordass, 2010). Inductive reasoning was used to analyse the usability survey data, which helped to explain the inhabitants' energy-related practices described in the semi-structured interviews in more depth (Klix, 2001). Thus, the usability survey findings were cross-related with those of the

semi-structured interviews in the thematic analysis stage to understand how easy the inhabitants found the heating and ventilation controls to use and to compare the inhabitants' use of energy-related controls and their heating and ventilation practices (see Section 4.5.4.1). After the data collection process, the collected data were organised by the researcher in Microsoft Excel and then imported to IBM SPSS Statistics software for data analysis (see Appendix 2). All the data (n = 26) were coded based on the SPSS standards; for example, binary variables were coded as 1 or 2, and category variables were coded as 1, 2, 3, or 4 with the highest being the most positive value and the lowest being the most negative value (Kent, 2015, p. 41). For the purposes of this research, the collected usability survey data were coded with nominal variables as 1 = *Yes*, 2 = *No*, 3 = *I don't know*, and the scale variables coded as 1 to 7, with 1 being *very poor* and 7 being *excellent*. After coding all the data, the researcher prepared graphs and diagrams by looking at different socio-demographic data (e.g., age, gender, time spent at home, etc.) and reflecting on the research questions. All these graphs and diagrams were then used in the cross-case synthesis described in the following section.

#### 4.5.4 Cross-case Synthesis

Cross-case synthesis was done by conducting thematic analysis and using the mapping method (Yin, 2018). During the thematic analysis stage, all the findings were compared using the mapping method. The cross-case synthesis stage was used to identify the within-case patterns across the individual households in this research and to understand why each housing typology performs as it does, thereby identifying key insights for future housing and policy recommendations (Yaneva, 2016).

##### 4.5.4.1 Thematic Analysis

As described by Braun and Clarke (2006), thematic analysis is a method for identifying, analysing and finding patterns in the data. They also note that themes do not emerge from the data; rather the researcher plays an active role in identifying the patterns through abductive reasoning. Therefore, the interactions among the researcher, the theory, the data and the literature were critical at the final analysis stage in order to answer Research Question 3.

The researcher used Microsoft Excel in the thematic analysis stage. After the second cycle of coding, all the important codes from both the resident and design team interviews were moved to the Excel document. The usability survey data analysis was done using SPSS, as explained in Section 4.5.3, and the survey data supported the interview data in the thematic analysis stage. During the thematic analysis, the researcher also prepared relevant graphs in SPSS from the data collected from the usability questionnaire, which helped the researcher to strengthen the analysis of the interviews. In this stage, themes derived from the coding were linked with the theoretical aspects of the study. During thematic analysis, the resilience matrix (see Section 4.5.1) that the researcher developed was also used as an analytical tool to find and understand the nexus of practice theory and aspects of resilience. Thematic analysis in this research aimed to identify the cross-case patterns and connections among the analysed data and aspects of practice theory using abductive reasoning. Hewitt-Taylor (2001) highlight that a simple counting of the frequency of codes could weaken the essence of qualitative data and its in-depth meanings. Thus, in this research, the presence of the codes related to each theme was considered, as mentioned in Section 4.5.2. The patterns and connections of the analysed data were cross-referenced with the characteristics of the inhabitants to better understand the nature of these patterns and their significance.

#### 4.5.4.2 Mapping

Mapping is a powerful technique that involves linking different ideas and is an effective way to visualise patterns of significant impacts on outcomes and to gain new insights (Bourne and Walker, 2005; Buzan and Buzan, 2010, p. 161). The mapping method was used during the coding process and thematic analysis stage, helping the researcher to highlight connections and differences between different households, as well as reflect on inhabitants' practices and their relation to resilience (see Appendix 1). Mapping was also used in the coding process to gain a better understanding of the underlying issues of resilience in social housing by comparing the design team and inhabitant responses (see Figures 4.3 and 4.4). During the coding process, mapping was used to link the key themes that appeared after analysing the interviews. The analysed data were visualised using connection lines between the key themes to summarise the large amount of data.

## 4.6 Research Validity

Recognising the researcher as the primary instrument throughout the entire study emphasised the importance of increasing the credibility and validity of the study. To achieve this, several steps were taken. First, the mixed methods approach was used to collect a richer and stronger array of evidence and data that could not be achieved by a single method alone (Yin, 2018). Quantitative research examines 'what residents do', whereas qualitative research delves into 'how and why residents do things'. By integrating these approaches, the strengths of both methods are enhanced and their limitations are reduced (Baker and Edwards, 2012). Thus, using the mixed methods approach helped the researcher to collect richer data to understand 'what the inhabitants do with the specific energy-related controls within the home' using a quantitative approach, and 'how and why the inhabitants do things within the home' using a qualitative approach. The second step involved 'peer debriefing' with two PhD supervisors who were not directly involved in the data collection, but were part of the research development. During peer debriefing, the researcher used the supervisors as a 'sounding board' to discuss emerging patterns in the data and critical questions that might help during the analysis (Corley and Gioia, 2004). The last step taken by the researcher was to triangulate the data as a way of addressing the validity issues. Validating the credibility of the semi-structured interviews was important to demonstrate the credibility of the resulting data and findings. One way to achieve this validation was by triangulation, where the researcher found a nexus from different sources of information to form themes and categories by eliminating overlapping areas of research data (Creswell and Miller, 2000). This is usually done using multiple methodological approaches, such as observations, document reviews and interviews, in different combinations to achieve broader results (Denzin and Lincoln, 2013).

## 4.7 Interpretation and Triangulation

In social science studies, to interpret is defined as 'to assign significance or coherent meaning' (Neuman, 2011, p. 177). In quantitative research, meaning comes from using numbers, while in qualitative research, meaning is derived from the discussions of the significance of ideas (Neuman, 2011). In this study, interpretation was done by giving meaning to data by cross-referencing them with the inhabitants' characteristics to develop

an understanding of the significance of and the reasons or motives for the inhabitant's practices. In social research, a more in-depth understanding of data can be obtained by observing from multiple perspectives rather than looking from a single perspective, which is known as triangulation (Neuman, 2011, p. 164). In this research, using a mixed methods approach helped triangulate the data to gain a deeper understanding of the inhabitants' practices within social housing by using both qualitative and quantitative methods as different perspectives. Triangulating data also offered a way of addressing validity issues. As Creswell (2013) explains, 'When qualitative researchers locate evidence to document a code or theme in different sources of data, they are triangulating information and providing validity to their findings' (p. 251).

#### 4.8 Summary

In this chapter, the research methodology was set out and the methodological approach of this research was justified as a cases-within-a-case mixed methods approach, as fitting for an investigation of energy-related practices in newly built social housing using practice theory. The key reason for selecting the case study was to maximise the amount of usable information collected from the case about resilience in social housing and inhabitants' energy-related practices using Flyvbjerg's (2006) approach.

The data collection methods were designed and implemented with reference to the research questions and objectives set out in Table 4.1 (see Section 4.2). Various methods were combined for the data collection process to ensure the validity of the outcomes and a complete understanding of resilience in social housing and inhabitants' energy-related practices. After the document review, a total of 21 semi-structured interviews and 26 usability questionnaires were analysed using two-cycles of coding, quantitative analysis using SPSS, thematic analysis, and cross-case synthesis. During these analysis stages, the researcher used the mapping method to illustrate the analysed data and to better understand the links and patterns between the themes.

Next, Chapters 5 and 6 present the key findings and analysis that align with Objectives 2, 3 and 4 of the thesis, while Chapter 7 discusses these findings and analyses them in relation to practice theory.

## CHAPTER 5. HEATING PRACTICES in the SOCIAL HOUSING CASE STUDY

### 5.1 Introduction

This chapter presents the analysis and findings of the semi-structured interview and usability survey data about inhabitants' heating practices and explores how the inhabitants discuss their heating practices in terms of resilience. This study examines the heating practices from two different perspectives: those of the inhabitants and the design team. Inhabitants' heating practices are critically analysed in terms of the key resilience drivers and Gram-Hanssen's (2010) practice theory elements (see Table 4.7). This is a step towards achieving Objectives 2, 3 and 4 of this thesis in relation to understanding the underlying resilience and inhabitants' heating practices in the case study, as well as identifying key insights for resilient social housing.

### 5.2 Heating Controls in Relation to Resilience and Social Change

This section focuses on heating controls (see Figure 5.1) in relation to the resilience of social housing in the face of social change, first with a focus on the general central heating controls and then on specific heating controls. The first key theme to emerge from the analysis relates to the extreme factors that affect heating practices, such as Covid-19 and the energy crisis. The next key theme is about the inhabitants' understanding of their heating systems, based on the data gained by the usability survey, and how they implement their understanding in their heating practices. The next theme found from the analysis is about the insulation in the social housing, and how this impacts the inhabitants' heating practices. The last key theme from the analysis is about how the housing typologies and accessibility support or hinder inhabitants in the face of social change.

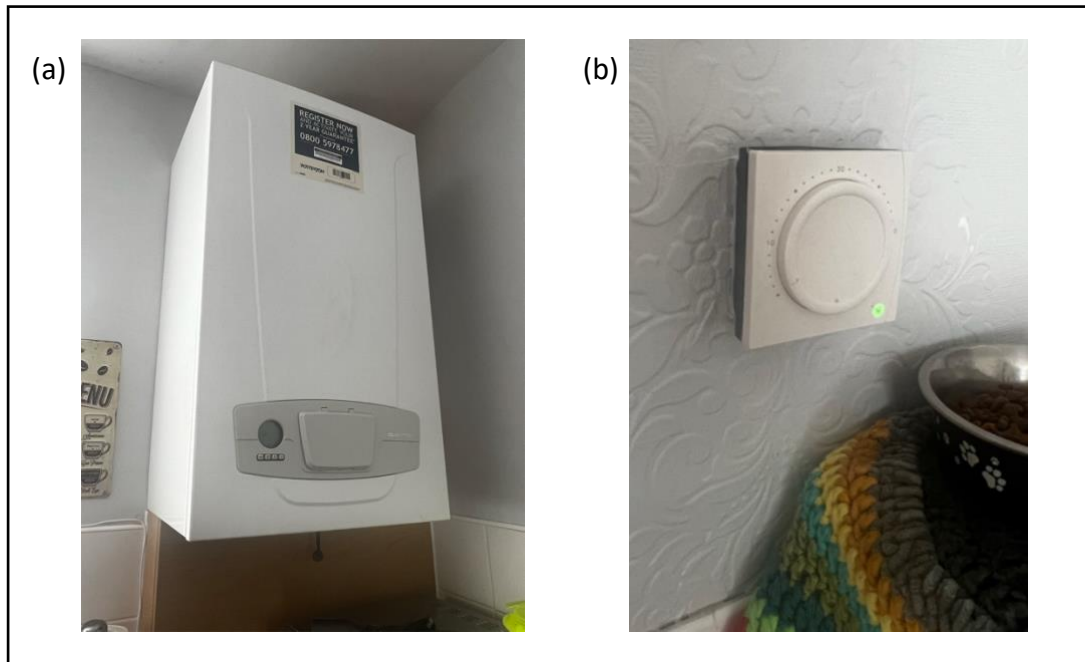


Figure 5.1 Parts of the heating system in the social housing: (a) a gas combi boiler; (b) a room thermostat

### 5.2.1 Extreme Factors that Affect Heating Practices

One of the extreme factors that occurred during the data collection period of this study is Covid-19, which affected the time that inhabitants spent in their home, directly impacting the energy use in the household. Some inhabitants who had previously worked outside the home started to work from home during the pandemic, for example:

*“Well, I used to go out to visit the clients that I supported before the pandemic. And after Covid, I do an awful lot of work from home.” (R7, age 51-70, male, lives on the first floor)*

This highlights how Covid-19 led to a social change as inhabitants were confined to their homes, particularly older inhabitants who are likely to spend more time indoors. Another study also found that the Covid-19 pandemic caused these changes to inhabitants’ lifestyles, which affected how electricity was consumed (Kawka and Cetin, 2021). This social change raised energy bills, as R7 noted:

*“So, uh, so certainly, you know, the electricity bills rate up a little bit from working from home, but then I spent an awful less on petrol. So overall, my energy expenditure is going down.” (R7, age 51-70, male, lives on the first floor)*

Another key highlight from the analysis is that some inhabitants over 50 who had Covid-19 became more vulnerable, for example, by having to use breathing machines or becoming more sensitive to cold weather:

*“My breathing machine affected the energy-use, and we use the washing machine a lot more regularly. Other than that, no [when asked if any social or environmental changes that have affected their energy use].” (R1, age 51-70, female, lives on the ground floor)*

R1, who lives with R2, mentioned that using a breathing machine affected their energy use. Similarly, R15 mentioned that they needed to use the heating more after Covid-19, which increased their energy usage:

*“The only thing was my husband [R16, age 51-70] got Covid and he was on a ventilator. And since then, he feels the cold more. So, we have to have the heating on more. But now, obviously with the price, and we are thinking more about it. We are wearing more thick tops and things like that to keep warm.” (R15, age 30-50, female, lives on the first floor)*

Consequently, R15’s household adapted to this changing situation by keeping the heating on longer. In these two households, the inhabitants over 50 who became more vulnerable to the temperature inside their homes due to contracting Covid-19 changed how they used energy in their homes.

Another extreme factor happened during the data collection period was the energy crisis, which commenced in 2021 in the UK. Owing to this crisis, inhabitants had to consider the increase in energy bills:

*“I mean in summer, we do not use the central heating. Which most people do not. And at the moment I have been very careful because of the cost of living rises. I know*

*it because like everybody, when you are a pensioner you have got to be really careful.” (R13, age 51-70, female, lives on the first floor)*

R13 mentioned that the pensioners living in this social housing need to be careful about using the central heating, as there has been an increase in the energy bills due to energy crisis. In this research, eight out of 16 households rely on their pensions, so these households need to be cautious with their use of heating and electrical appliances that affect their energy use. Apart from the pensioners, some of the inhabitants (see above for R15’s quote) also try to reduce their use of heating by wearing thicker clothes to keep warm. As a result, the inhabitants adapted their heating practices when there was an extreme situation, such as the energy crisis, when they needed to think about their financial situation.

Martiskainen and Kivimaa (2019) find that using smart systems is beneficial to reduce energy usage when inhabitants understand how to use them and are willing to use them. Interestingly, only one household (H15) mentioned that they had installed smart meters within their household:

*“It is like I said, we have the meters [smart meters]. We are better off [with smart meters] because there are a lot of people, friends that we know say that how their bills have gone up. You know, because they are on these set things or whatever they do. We decided, years ago that the best thing for us was to get something like this [smart meter] and then you pay what you use.” (R23, age 51-70, male, lives on the ground floor)*

As R3 explained, having access to near real-time data by using smart meters allowed them to see how much energy they were using, making energy consumption more understandable. When energy use is visible, it becomes easier for users to identify high energy consumption behaviours and adjust accordingly (e.g., increase in energy use during certain times of day or while using specific energy-related controls) (Office for National Statistics, 2023b). Therefore, smart meters act as a form of monitoring daily routines and making energy use visible to the inhabitant, supporting more informed and energy-conscious decisions.

In terms of the resilience of social housing, the design team stated that cost is a very important factor. The term 'cost' also appeared as a significant pattern in design intentions. Cost efficiency for the design team is seen as building sustainable homes that do not cost huge amounts of money for management and return a profit to the housing association. Cost is also a very important factor in the planning process, in relation to both the initial cost of using sustainable materials and equipment in the design and the long-term maintenance costs. The design team also looked at cost from the inhabitants' perspective, as D2 noted:

*"I think with everything, you know, we kind of consider [cost] from a few angles, obviously we will look at the impact of the cost, both in terms of the kind of initial cost of putting it, and in the long-term cost of maintaining it. And also cost to customers of running it. And we would also look at sustainability implications. So, you know, is this going to make the house more comfortable, cheaper to run, warmer in the winter?" (D2, project coordinator)*

D2 mentioned that the design team consider cost factors from a few angles, while also considering the inhabitants and how the designs could make an impact on the inhabitants' energy use.

#### 5.2.2 Inhabitants' Understanding of Heating Controls and Their Use in Heating Practices

The housing association provides a home user guide to the inhabitants when they move into their homes, and each home has a specific guide depending on the controls in that home. The home user guide includes the property information sheet, general guidance, heating and ventilation system controls and how to use them, instruction manuals and general energy and water saving tips, as D2 noted:

*"When people move into property, we make what is called a home user guide. And it is just kind of general information about the property, also includes details on all of the systems within that property. So, you know, the use manuals of the boiler, the ventilation or anything like that will be included in that." (D2, project coordinator)*

According to the design team, the social housing association provides very comprehensive user manuals for the inhabitants:

*“Now whether this is quite patchy across the industry, so some of us are very good at this and they have, you know, very comprehensive user manuals for their new houses. And depending on complexity then they can get quite interesting how you do that [providing user manuals]. Whether [the housing association] did that, I am sure they did it, whether they did it to the degree that the residents feel inadequate or not, is something I just do not know. And it would be interesting to find that out.” (D3, architect)*

However, architect D3 stated that after providing the home user guides, the design team do not know if the inhabitants find them useful or not. This highlights the design team’s lack of understanding of inhabitants’ ability to understand and use the energy-related controls during the occupancy stage. This is also highlighted by D1:

*“In terms of how people use different systems in the house. So, the home user guide has all of that in it, but it relies on people reading it obviously and following it. We have done some sort of energy doctor work, you know, where we go in and say to people, you could save fuel if you did this, this and this. But in general, I do not think we do a lot of that moment.” (D1, project director)*

D1’s statement develops D3’s argument that they rely on the inhabitants to read, understand and follow home user guides provided. She also mentioned that the housing association previously went to the homes to explain how the inhabitants could save energy. However, as D3 mentioned, the housing association is not aware of the inhabitants’ ability to understand their energy-related controls.

As shown in Figure 5.2, most of the inhabitants said that they have the home user guide. Additionally, the majority of inhabitants who said that they have the home user guide rated its usability for operating equipment in their home as above average or excellent (see Figure 5.3). However, even if the inhabitants have the home user guide, the important thing is that the inhabitants understand how to use the controls and understand why it matters, as D1 noted:

*“It is really very important people know how to use them. It does not mean that you are telling them you mean they do. So, it is how do you engage people to do, you*

know, to do the right things and how to give people the information and they actually do it.” (D1, project director)

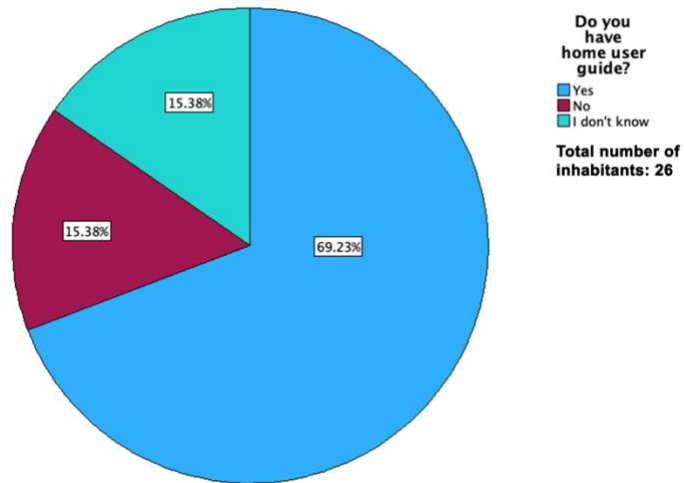


Figure 5.2 The percentage of inhabitants who do or do not have the home user guide

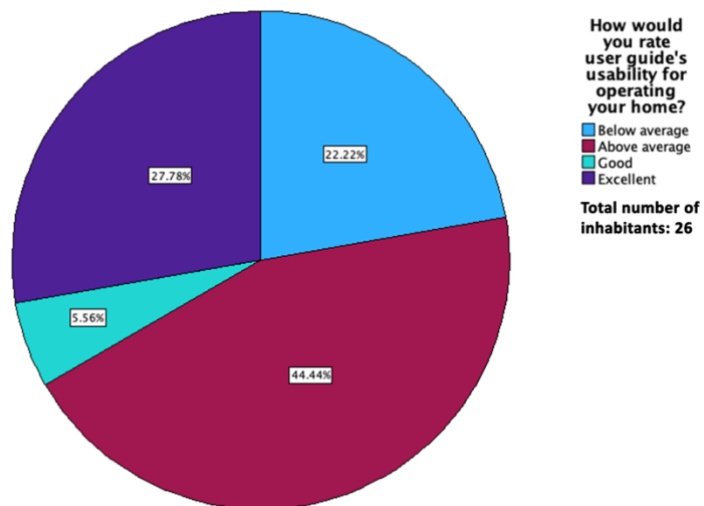


Figure 5.3 Inhabitants' rating of user guide's usability for operating equipment in their home

To further develop D1’s statement, Figure 5.4 shows the inhabitants’ mean rating of their ability to use the technical equipment in their homes. It shows that the inhabitants who are over 70 gave a mean rating of their ability to use the technical equipment as below average, in contrast with the inhabitants aged 51–70, who gave a mean rating of above average. As a result, Figure 5.4 indicates that the inhabitants over 70 struggle with using energy-related technical equipment more than those under 70. This argument is also supported by R22:

*“Well, you can control it [central heating] with [a] thermostat. Which I do because the timer around the boiler does not work, it never has done and apparently, they are all the same. So, if it gets a bit chilly, you know, I just manually turn the thermostat up so that the heating will come on.” (R22, age over 70, female, lives on the ground floor)*

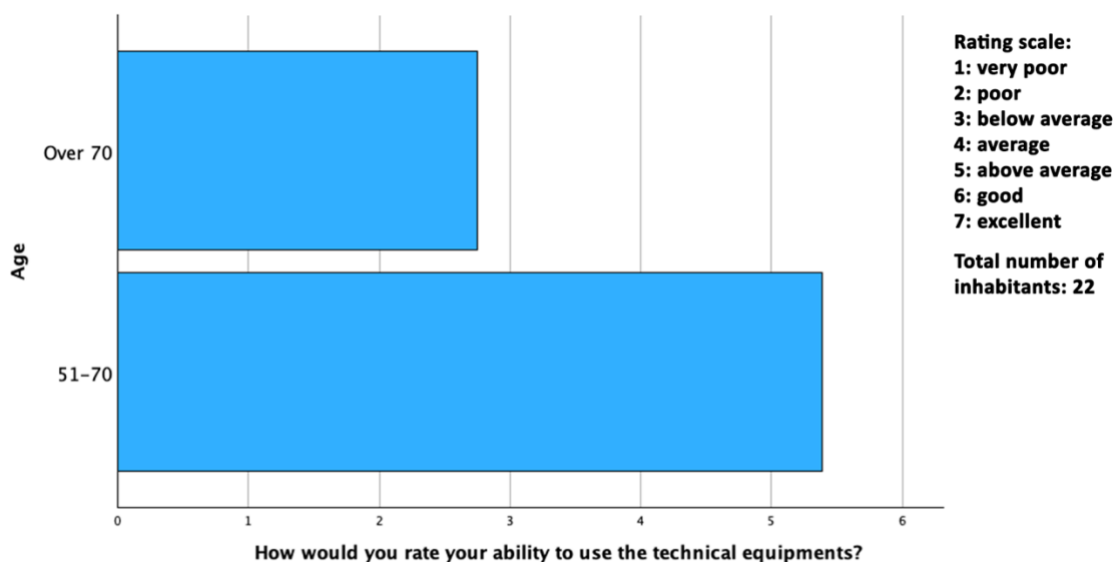


Figure 5.4 The older inhabitants’ response for the mean rating of their ability to use their energy-related technical equipment

### 5.2.3 Impact of Insulation Levels on Heating Practices

One of the key highlights from the design team is the level of insulation in this case study. This is particularly important because the energy performance of homes depends on several factors, including wall insulation and the energy performance of appliances (e.g., boilers),

and these factors are assessed through the EPC scores (Office for National Statistics, 2023c). Architect D3 described the insulation of the homes within this case study:

*“They are quite well insulated because the houses have blown insulation into the walls. So, all the cavities are completely full. I think from an insulation point of view, they probably exceeded the building regulations. So, I think they are quite well insulated homes with double glazing and, you know, within certain rooms.” (D3, architect)*

Regarding insulation, D3 mentioned that the homes exceeded the building regulations. When the homes were built in 2016, the building regulations for the wall insulation U-value was limited to 0.30 W/(m<sup>2</sup>·K) and, according to the document review, the selected social housing development was designed to exceed the requirements of the building regulations (HM Government, 2016a, p. 15). This is also supported by the EPC rating scores of B (see Table 4.6) for all the homes in this case study, indicating the homes must have a ‘very good’ rating of wall insulation to achieve an EPC level C or above (Office for National Statistics, 2023c). When we compare the architect’s remark about the insulation levels exceeding the building regulations with the inhabitants’ perspective on their general heating practices, we find the majority of them (16 out of 18 inhabitants) stated that their homes are comfortable and warm most of the time during cold weather:

*“Oh, I do not, I do not use my heating. I mean I have got somebody above, somebody below, somebody at both sides of me. So, it is a very, very warm flat without heating on, so it is not very often I do have the heating on. But when I do, I am not going to sit here cold, I do have my heating on, yes.” (R22, age over 70, female, lives on the ground floor)*

R22 explained that the location of her flat ensured her home remains very warm, so she does not often use the heating. This argument is further supported by D3’s statement about these homes having a very good level of insulation that helps to keep them warm. Out of 18 interviews, only two inhabitants (R4 and R20) stated that their homes are extremely cold in winter:

*“In winter it is freezing, the bedroom and the bathroom. Because we never get any sun in here on [the] bedroom and bathroom. So, in winter we are freezing, even [when] the heating is on.” (R4, age over 70, female, lives on the ground floor)*

*“I was in for the summer and this house [is] extremely hot and really hot and, in the winter it really is ridiculously cold. And most of the people, you know, the neighbours have said it is actually the same. I do not think there is any cavity wall in them and it is ridiculously cold, especially we live in the upstairs and when you get to the staircase to go to the front door, it is never ever warm. The radiators make no difference there and it is freezing cold.” (R20, age 51-70, female, lives on the first floor)*

The similarity between these two households is that, even when they use their heating systems; their homes still remain very cold in winter. The reason for this could be that the inhabitants are not using the heating controls properly, or the heating system may be faulty:

*“When the flat gets into a certain temperature, it [room thermostat] switches off for so long and then it will switch on. You know what I mean? It is not me. I do not like it at all because you know, you just get warm, and then it will switch off. I suppose it seems to do something with it, but I do not know.” (R4, age over 70, female, lives on the ground floor)*

R4 and R20 described that the room thermostat turns off automatically when the temperature reaches 20°C and their home is not warm enough for them even if their radiators are switched on. In contrast, the remaining 16 out of 18 inhabitants stated that they do not need to turn on the heating for long because their flats are warm, even without the heating being on; for example:

*“It [heating] is on when it is wintertime, where we put it in probably 40 minutes, you know. Which is sufficient, because the housing has carpets, and we only need it [for] about 40 minutes.” (R9, age 51-70, male, lives on the first floor)*

To further develop this argument, a good level of insulation is one of the key factors that keeps the inhabitants' homes warm:

*“If it gets a bit chilly you know, I just manually turn the thermostat up so that the heating will come on. And then once it is heated up, I turn it down a little bit. But then, you know, it just stays nice and warm, like I said it is well insulated. So, a lot of times, once it is warmed up I turn it off and it is fine for absolutely ages.” (R22, age over 70, female, lives on the ground floor)*

This statement by R22 is consistent with the architect’s (D3) statement about the insulation levels of the homes in this case study, and these good insulation levels reduce the use of the heating for most of the inhabitants (16 out of 18 inhabitants).

#### 5.2.4 Accessibility to Energy-related Systems

The main aim for the housing association is to provide long-term stability for inhabitants who have or might have mobility issues in the future, including families looking after an elderly relative who is living with them. When the design team were asked whether they considered social changes that affect inhabitants within their designs, the architect D3 responded that they always think about Building Regulations Part M: ‘Access to and use of buildings’, particularly the categories M4(2): ‘Accessible and adaptable dwellings’ and M4(3): ‘Wheelchair user dwellings’ in their scheme:

*“I suppose you have got to think carefully about if we spend quite similar amounts of money making all of our housing resilient [to the standards of] M4(2) and M4(3), is that the right thing to do? Or is it better to assign that money to do more adaptable and resilient housing [that] is specifically designed for need, and I think that is the debate that is out there, really.” (D3, architect)*

Regarding the type of social change brought about by Covid-19, D1 noted:

*“I mean, the only thing we have done is [that] we have certainly started to plan on house types [for] more homeworking, because that was not really factored in before. So little incidental spaces where you could put a desk or some kind of, you know, be able to find sort of a space, either [for] homework, schooling or homeworking. [...] we try and get as much daylight in as possible, try and get natural ventilation. So, we are trying to kind of make the houses sort of work for them by themselves and that makes sense.” (D1, project director)*

D1 explained that, specifically after Covid-19, the housing association started to plan housing typologies that are adaptable to more homeworking and that have spaces within the home that are more flexible, in case of social changes. The design team aim for homes that work for themselves by getting as much as daylight and natural ventilation as possible. In line with the comments of D1, the project coordinator D2 also noted that they have been thinking about social changes:

*“It [a social change affecting inhabitants over time] is something that we have been thinking about a lot more recently. [...] So, obviously there are many more people who are kind of working from home now, but also I suppose more, much more worth you know, what happens if there is pandemic again? So, that is kind of one of the really key things we have been doing is assessing, trying to increase that in all in all of our new-build homes.” (D2, project coordinator)*

Similarly, the majority of the inhabitants (13 out of 18 interviewees) think that their home is robust and mentioned that their home could cope with a social change like a sudden disability in the household. For example:

*“Well, we live on the first floor. We are not a ground floor flat. So it would be coming up the stairs. But those stairs are just over a straight flight of stairs. So, uh, we probably have to maybe put some kind of stair lifting, or something like that. [...] Those would be relatively easy changes to make in the house.” (R7, age 51-70, male, lives on the first floor)*

The inhabitants also mentioned that they could continue their everyday energy-related practices and the social housing association would adapt the appliances if there were any accessibility issues:

*“Well, it [adapting the appliances] is very difficult at the moment with the bathroom. But everything else, all the doors are wide, you know, will fit the wheelchair. Kitchen appliances are quite okay. And generally moving around is pretty good. It is just all the things are okay apart from the bathroom. Which is built for the younger generation, but we are mostly older generation here, mostly over 50s.” (R14, age 51-70, male, lives on the ground floor)*

R14 mentioned that if they experienced a social change, they could use their energy-related appliances in the same way, but it would be difficult for them to use the bathroom in terms of accessibility. The inhabitants' perspective also links with design team's approach to the adaptability of the housing appliances if there were to be a sudden social change in these homes.

To summarise this section, external factors like Covid-19 and the energy crisis significantly influenced household energy use and inhabitants' heating practices. The pandemic increased the time spent at home and made those over 50 particularly sensitive to indoor temperatures after recovering from the virus. The energy crisis prompted many inhabitants to adapt their heating habits due to financial pressures. Although home user guides are provided to inhabitants, the design team struggle to understand how effectively inhabitants use the energy-related controls, especially those over 70 who face difficulties with technical equipment. Nevertheless, effective insulation helped most inhabitants reduce their reliance on heating systems.

### 5.3 Boiler Practices

#### 5.3.1 Inhabitants' Discussions About Boiler Practices

All 18 of the inhabitants recognise the boiler as the primary source of heating within their homes. However, their interaction with the boiler is minimal, and their approach to its operation is largely passive. For example, R4 noted:

*“To be honest, we never took much notice about it [using the boiler]. But I know a few months ago, it is not much about me, it was from the energy supplier. And they were saying, turn your boiler down to a certain degree. [...] So, I turned the heating down to a certain degree. But apart from that, we never touch it.” (R4, age over 70, female, lives on the ground floor)*

Notably, some inhabitants, such as R4, mentioned that they never engaged with the boiler and were only made aware of its presence and function when asked by the researcher. Another example of minimal boiler interaction is from R6:

*“I will be honest with you. It [the gas combi boiler] frightens me a little bit. I do not touch the boiler at all because it was adjusted for everybody when you moved in, and someone [from the maintenance team] comes out regularly to check, to maintain the boiler. So, I prefer them to do that.” (R6, age 51-70, female, lives on the first floor)*

Similar to R4, R6 mentioned that she avoids operating the boiler and instead relies on maintenance personnel from the housing association to make any necessary adjustments. When R6 requires changes, she does not attempt to handle the boiler herself but waits for professional intervention. A common theme among the inhabitants is their reluctance to change the temperature settings on the boiler. Many leave them as they are, either out of satisfaction with the current state or due to a lack of understanding of their usage. For example, R7 stated:

*“No, we do not [discuss the boiler being on and off]. Primarily because we just do not need to have that conversation because you know the house is set so it is warming up. So, we have been very lucky enough that it works very well.” (R7, age 51-70, male, lives on the first floor)*

R7 stated above that he expresses contentment with the existing settings and highlighted that there is no need to discuss the boiler usage with other household members. Conversely, some inhabitants are dissatisfied with the temperature settings of the boiler but avoid making any changes due to difficulties in understanding the boiler’s instructions. For instance, R15 noted:

*“No, we do not [discuss the gas combi boiler being on and off], we sort of leave it [gas-combi boiler] as it is because it is so annoying and frustrating. And I do not understand it, about the instructions. I do not know how many times I tried and work something out and I cannot do it. So, that is why we just leave it on 16 [degrees].” (R15, age 30-50, female, lives on the first floor)*

From R15’s statement, it can be understood that, despite the household’s discomfort with the temperature within the home, they prefer to leave the boiler untouched rather than risk incorrect adjustments. The absence of interaction with the boiler results in a lack of discussion among the inhabitants regarding its use. According to the interviews with the

inhabitants, none of them take responsibility for altering the settings, nor do they discuss them within their households, reinforcing a passive approach to household heating practices.

Overall, the boiler remains a background element in the inhabitants' daily routines in this case study. While it provides essential heating, it is neither actively managed nor regularly discussed, reflecting a broader tendency toward non-intervention in the household's technological infrastructure.

### 5.3.2 Usability of the Boiler and Alternative Options

The findings from inhabitants R1, R2 and R14 indicate a persistent pressure problem with the boiler, revealing its lack of robustness in adapting to social changes. R1 stated:

*“But it [the gas combi boiler] has [had] a problem with competence for 4 years. The pressure is really low when we open the tap, so the shower does not work properly. We need to hire the service for maintenance.” (R1, age 51-70, female, lives on the ground floor)*

R1 explained that the boiler has a pressure problem that leads to failure when using the hot water, emphasising its inability to maintain performance to enable the inhabitants to continue their daily activities. The majority of inhabitants (14 out of 18 interviewees) mentioned that they rely on maintenance services when issues arise with the boiler. For example, R18 noted:

*“No, we have to phone SHD [Social Housing Development] and they will inform somebody else, and they had to come out. It has broken down about twice, so.” (R18, age 51-70, female, lives on the first floor)*

R18's statement highlights that usability is critical, and she explained that their boiler had maintenance issues before, so they contacted the social housing association to fix the boiler issue. Similarly, and as R15 highlighted in Section 5.3.1, difficulties in understanding the boiler instructions contributed to a passive approach to its usage. Without sufficient knowledge, inhabitants are less likely to engage with fixing the problem, reinforcing a cycle of dependence on external maintenance. Additionally, the majority of households (14 out of

16 households) do not have an alternative for the boiler, beyond using a kettle to heat water. This reliance on external maintenance highlights a passive interaction with the boiler, where inhabitants do not actively engage with the boiler to fix the issue.

Furthermore, R14 explained that hot water is essential for daily activities, such as washing dishes and showering:

*“About every day, [using the gas combi boiler], like washing pots and all that. And having a shower. You know, the problem with the shower is, the water pressure does not seem to be very high. When you have been to somebody else’s house and see their shower and it is like the pressure is very powerful and you get back home and you think, oh, this is not what it was supposed to be.” (R14, age 51-70, male, lives on the ground floor)*

As R14 described, the expectation of seamless functionality underscores the boiler’s role in everyday life, meaning it remains largely unnoticed until it fails. However, its limitations become particularly apparent during periods of social change, such as an increase in household occupancy during the Covid-19 pandemic. This inability to scale with social and environmental changes challenges its resilience. A more resilient infrastructure would be able to adapt to changes without disrupting inhabitants’ daily routines.

Additionally, there is a clear need for an alternative option in case of boiler failure. Research by Stevenson, Baborska-Narozny and Chatterton (2016) highlights the importance of backup systems to maintain household functionality when the primary heating system fails. However, findings from this study indicate that 14 out of 16 households do not have an alternative for the boiler. Instead of preparing for potential breakdowns, the majority of the inhabitants prefer to wait for the maintenance team. R7 is one of the inhabitants who does not own a backup option:

*“Oh, well, I think going forward you are going to have to be aware of what is going to happen in terms of where, you know, when the boiler breaks. But that is more of an issue for [...] Housing Association. You know with the boiler reach the end of its life, we would have some kind of a consultation with [...] Housing Association.” (R7, age 51-70, male, lives on the first floor)*

As R7 noted, inhabitants rely on the housing association to resolve issues when the boiler reaches the end of its life, rather than considering backup solutions. This lack of alternatives is further emphasised by R1, as she noted:

*“We are using the kettle, but it is really difficult. I have been here for six years now and it is still not fixed.” (R1, age 51-70, female, lives on the ground floor)*

R1 stated that using a kettle as a temporary solution is inconvenient, yet they have had no alternative for six years. Furthermore, Figure 5.5 indicates that many inhabitants either do not perceive their gas combi boiler as responsive to their actions or lack the knowledge to operate it effectively. This reinforces the idea that the boiler remains a passive part of the inhabitants’ practices, only gaining attention when it fails.

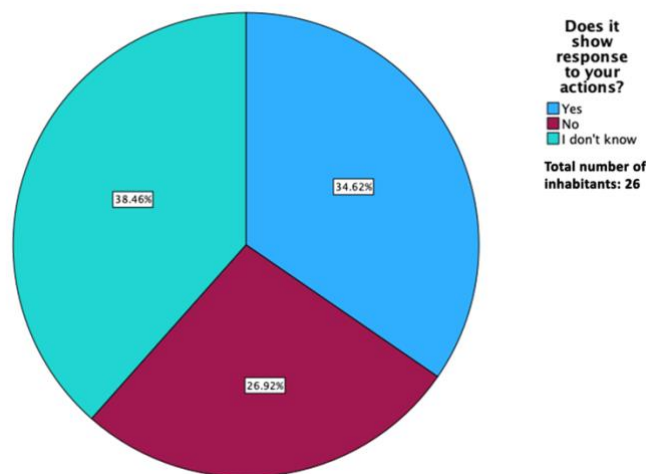


Figure 5.5 Inhabitants’ responses to the question; does the boiler show any response to your actions?

In contrast, R6 who does not own an alternative option for the boiler mentioned:

*“Well, I do not have any alternative [for the gas combi boiler]. And to be honest, it is never broken down. I think with the regular checks, you know, it is safe.” (R6, age 51-70, female, lives on the first floor)*

R6 expressed a sense of security due to regular maintenance checks, implying trust in the social housing association rather than a personal understanding and knowledge of managing

the boiler. However, this approach does resolve situations when maintenance services are delayed or unavailable, further underscoring the need for an alternative for the boiler.

To summarise, the boiler’s failure to integrate into evolving domestic conditions, the absence of alternative options and its reliance on external maintenance highlight its lack of resilience. This analysis exemplifies how technological systems must be both reliable and adaptable to ensure continued functionality in response to shifting household needs. A resilient heating system would not only function reliably under varying conditions (e.g., Covid-19, increase in occupancy) but also be designed in a way that encourages active user engagement and provides backup options, ensuring continuity in essential household practices.

## 5.4 Room Thermostat Practices

### 5.4.1 Inhabitant Discussions and Decision-Making

The analysis of room thermostat practices (see Figure 5.1 (b)) among inhabitants reveals a range of heating habits influenced by household dynamics and external factors such as the energy crisis. A key pattern observed in this thesis is that household members often discuss thermostat usage (see Figure 5.6) and one member typically takes charge of operating the control. This decision-making process varies depending on individual comfort levels, presence at home, and external constraints such as energy costs.

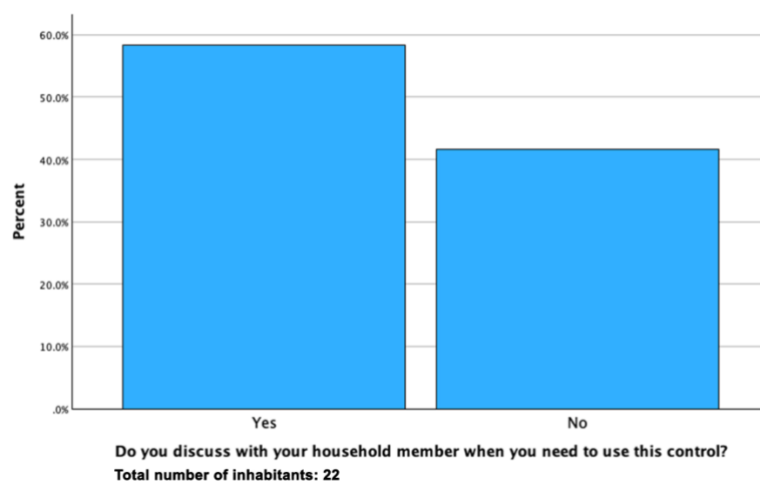


Figure 5.6 The percentage of inhabitants who discuss with each other when they need to use the room thermostat

In many households, the inhabitant who feels the cold more tends to make the decision to turn on the room thermostat, while another household member operates it. For example, R2 noted:

*“Do you discuss with your wife when you need to use heating in your home? Are there any difficulties that you faced when you were discussing?” (MT, researcher)*

*“Yeah. Yeah. My wife gets cold easily, so she needs heat. [...] So, sometimes I just leave it [room thermostat] on, if we go out somewhere and it is cold, you know, [we] come back and it is warm. We just leave it on.” (R2, age 51-70, male, lives on the ground floor)*

According to R2, R1 and R2 discuss their heating needs, and R1, who feels cold more easily, makes the final decision, while R2 physically controls the room thermostat. This aligns with broader findings that decision-making regarding room thermostat practices is often a collaborative process, yet one individual ultimately takes charge. Similarly, R18 mentioned the one who felt cold in the home takes charge of the room thermostat, but she also mentioned that her husband, R19, who works outdoors, is more accustomed to cold weather:

*“No, if he [R19] is cold he will operate it [room thermostat]. If I am cold, I go and open it [...] He [R19] is not getting cold, because he works outside. So, he does not get bothered with cold.” (R18, age 51-70, female, lives on the first floor)*

In contrast, R7 and R9 prefer to leave the room thermostat at a fixed temperature, only adjusting it seasonally. R9, for instance, maintains a constant setting of 25°C, avoiding unnecessary changes and reflecting a preference for stability and minimal intervention in thermostat control:

*“Oh, we use it [room thermostat]. We just leave it on in one setting, that is all. We do not really mess with it. We leave it on probably 25 [degrees], which is just like just above the ideal room temperature.” (R9, age 51-70, male, lives on the first floor)*

Another significant theme emerging from the analysis is ‘presence at home’, which means that one household member – often the one who stays in the home the most – takes charge of operating the room thermostat (see Figure 5.7). For example, R4 noted:

*“Well, yeah [discussion on using the room thermostat], because I am always at home more often than he [R5] is. He [R5] feels a lot more cold. Because I am always up doing something, you know. He [R5] gets colder than me, so. So, I usually open the heating, he tells me.” (R4, age over 70, female, lives on the ground floor)*

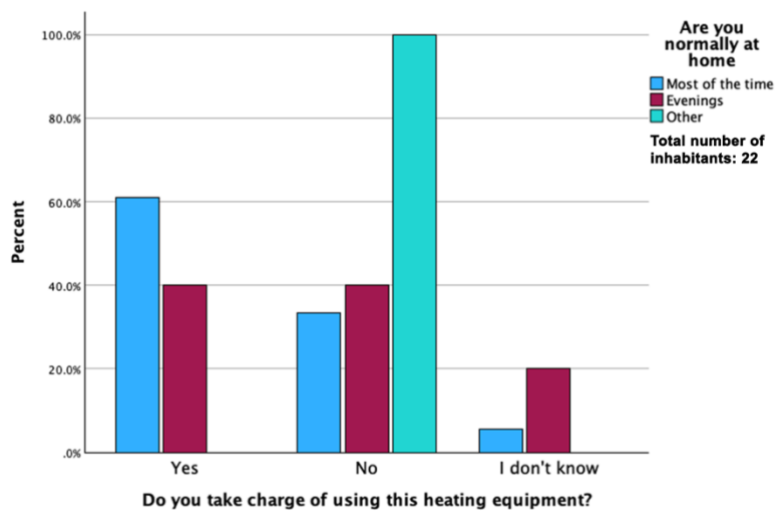


Figure 5.7 The percentage of inhabitants who take charge of using the room thermostat based on the inhabitants who are at home most of the time, in the evenings or other times

R4’s statement highlights that they discuss within their household when they need to use the room thermostat, and R4 is the one who takes charge of the heating. This decision-making process reflects a balance between comfort preferences and practical considerations of who interacts with the thermostat most frequently.

Another notable result of this thesis is the tendency for female inhabitants to take charge of the room thermostat (see Figure 5.8). For example, R3 noted:

*“It is mainly me [who takes charge of the room thermostat] because I am the one that was always in.” (R3, age 51-70, female, lives on the ground floor)*

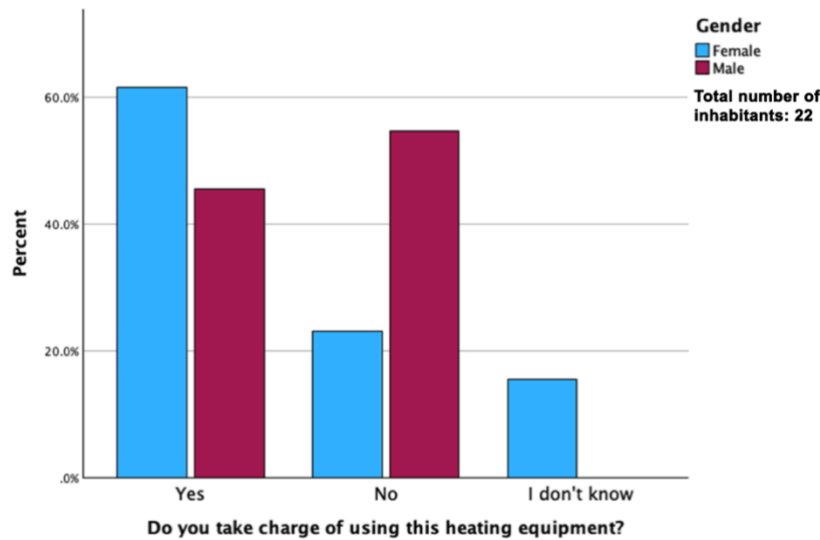


Figure 5.8 The percentage of inhabitants who take charge of the room thermostat based on gender

R3's statement highlights that she assumes responsibility for room thermostat control as she is home most of the time and familiar with the control's settings. R4's statement also supports this argument, because she mentioned that she takes charge of the thermostat as she is at home more often than her husband (R5). To interpret these findings, we can say that even in households where discussions occur, women often feel more comfortable operating the room thermostat. This finding suggests a gendered dimension in the household, highlighting that many female participants expressed greater confidence in using thermostat controls, often due to spending more time at home, as exemplified by R3 and R4.

#### 5.4.2 Room Thermostat Usage Patterns and Routines

The results also identify distinct room thermostat usage routines among the inhabitants. Some inhabitants, like R14 and R18, prefer to use the thermostat to turning the heating on for a limited period in the morning or evening and then switching it off. R14 noted:

*“Very rare [using the room thermostat]. I think first thing in the morning in the winter, put on 10 minutes and then turn it [room thermostat] off. That is it really.”  
(R14, age 51-70, male, lives on the ground floor)*

R15 follows a structured schedule, adjusting the thermostat to 20°C upon returning from work and lowering it to 16°C at bedtime:

*“We have it [room thermostat] on set to 16 [degrees], but that is quite cold. So, when we come home from work, I turn it [room thermostat] on up to 20 [degrees], to get it [home] warm for my husband [R16]. The moment when we go to bed, we turn it back down to 16 [degrees].” (R15, age 30-50, female, lives on the first floor)*

R15’s statement highlights that have a routine of using the room thermostat according to their personal preferences. Similarly, R17 maintains a daily routine, increasing the temperature to 20°C in the morning and reducing it to 18°C at night:

*“I turn it [room thermostat] down at night to 18 degrees because it has been really cold. And when I get up in the morning, I just turn it [room thermostat] up to 20 [degrees]. And because now it is cold, it keeps clicking the heating on and off, so it keeps it constantly low.” (R17, age over 70, female, lives on the ground floor)*

These variations suggest that room thermostat practices are deeply embedded in inhabitants’ personal routines and comfort preferences. Some inhabitants prioritise maintaining a consistent temperature, while others opt for more dynamic usage based on specific timeframes or comfort needs. Notably, this also highlights that many inhabitants are not in the habit of using the heating programmer, or ‘timer’, to control their heating. Instead, their habit (e.g., statements from R14, R15, R17) is to adjust the room thermostat manually when they feel cold. The usability of the heating programmer and its relation to room thermostats is explored in more detail in Section 5.4.3.

The ongoing energy crisis has influenced room thermostat practices, leading some inhabitants to change their heating practices to reduce energy consumption. For instance, R11 noted:

*“[We] do not leave anything on standby anymore and wear a jumper instead of putting the heating on [since the energy crisis].” (R11, age 51-70, male, lives on the ground floor)*

This statement highlights that, due to the energy crisis, R11 and their household have adapted their heating habits by wearing warmer clothing instead of turning on the room thermostat frequently. Similarly, R25 adopted time-based heating habits, using the room thermostat only during specific periods to manage energy costs effectively:

*“Well, normally we [R25 and R26] always say to the kids ‘turn all the lights off when you leave your room and do not leave their water running’ because these electric meters increase. You know earlier we used the room thermostat when it was cold and whenever the temperature drops to a certain temperature it just comes on. But now we do not do that anymore. We only use the heating [at] certain times of the day.” (R25, age 30-50, female, lives in a semi-detached home)*

The statement from R25 demonstrates that they have a similar approach to R11, and they mentioned the energy crisis as their main reason for changing their heating practices. These findings also align with Gram-Hanssen’s (2010) study, which highlights how household energy consumption can shift toward more sustainable practices, such as not leaving technological equipment on standby anymore.

#### 5.4.3 Usability of Room Thermostat and Challenges with Its Functionality

The usability of the room thermostat was assessed in terms of the inhabitants’ ability to continue using the equipment depending on age group, household type and gender. The thematic analysis of the interviews and usability surveys reveals that the vast majority of the inhabitants find it easy to control their room thermostat and understand how to use it effectively (see Figure 5.9). A key theme emerging from the analysis is ‘turning up and down’, which relates to the inhabitants’ habitual interactions with the thermostat. For example, R6 noted:

*“There is a thermostat on the wall in the hall and you can set it at a certain temperature so that it comes on automatically. If you feel like you would rather do*

*that, or you can just switch it on yourself and switch it off when you feel. It is very easy to manage.” (R6, age 51-70, female, lives on the first floor)*

The statement of R6 highlights that she understands how to use the room thermostat and how to change the temperature depending on her comfort level. This indicates that most inhabitants are confident in adjusting the room thermostat when needed, demonstrating intuitive and straightforward engagement with the heating control (also see Figure 5.9 below).

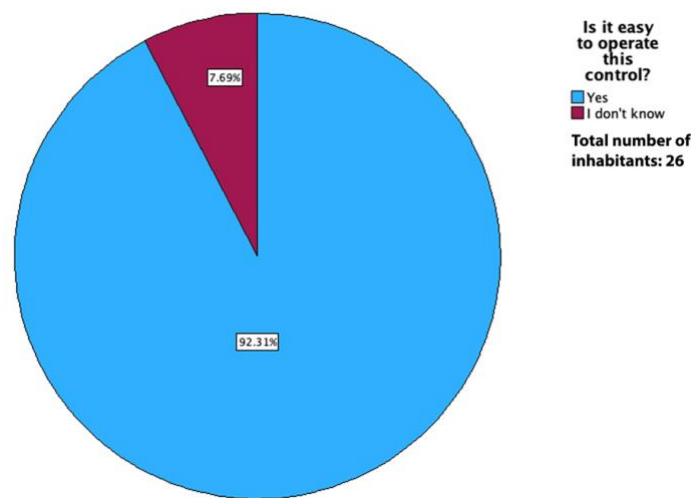


Figure 5.9 Pie diagram showing the inhabitants' understanding of operating the room thermostat

Despite general usability, some inhabitants reported issues with how the thermostat responds to temperature settings. For instance, R4 noted:

*“There is a thermostat on the wall. And you know, I just switch it on. Um, that is another thing I do not like because heating will not come on until you put it on a time set. When you put on a time, it switches on. So, if you select below 20 degrees, it switches off. So, it has to be 20 [degrees] or above.” (R4, age over 70, female, lives on the ground floor)*

R4's statement above explains that the room thermostat switches off at a certain temperature and does not switch on for extended periods, causing discomfort in colder seasons. Similarly, R22's statement in Section 5.2.2 highlighted that, she operates the room

thermostat manually to turn the heating on for short durations, taking advantage of the home's insulation to retain warmth. In this example, the heating programmer does not work as expected and, while the room thermostat switches off upon reaching the preferred temperature, it remains off for too long, causing discomfort. Another example came from R3:

*“There is a timer [heating programmer]. But I do not know how to work it out. I do not understand the instructions. You know, you can pre-set it at certain times. But I would not need it in general because it is not that cold, so I would not need it on whilst we were asleep or anything like that. So, I do not really need it programmed.”*  
(R3, age 51-70, female, lives on the ground floor)

R3 highlighted in her statement above that she does not understand the instructions for using the heating programmer. Despite the availability of manuals and home user guides, many (see Figure 5.10) find the instructions difficult to follow in their heating practices. Figure 5.10 further supports this argument by indicating that the heating programmer does not show a response to the majority of the inhabitants. This aligns with findings from Lomas *et al.* (2018), who reported that older inhabitants, particularly those over 60, often struggle with the programmable features of heating controls. The statements from the inhabitants reveal a recurring issue that inhabitants generally do not incorporate the heating programmer into their heating practices, and instead they prefer to use the room thermostat manually. This can be attributed to two main factors: difficulty in understanding the instructions and a perception that the heating programmer does not function properly. As a result, most inhabitants prefer the manual use of the room thermostat instead.

This pattern suggests a gap between the design intentions behind the heating controls and the actual user behaviour. Insights from the design team (see Section 5.2.2) indicate that, while the home user guide provides comprehensive instructions, its effectiveness ultimately depends on the inhabitants' understanding and ability to follow the instructions. This highlights the need for improved inhabitant and design team collaboration, more intuitive heating control interfaces, or potential design modifications to better align with inhabitants' practices.

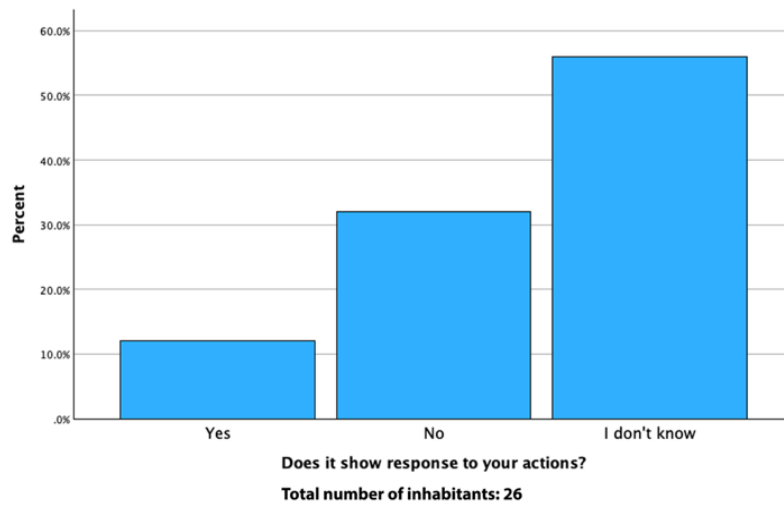


Figure 5.10 Inhabitants' responses about whether the heating programmer shows a response when they turn it on and off

Although room thermostats are generally considered easy to use by the inhabitants, several challenges remain, including thermostat malfunctions, economic constraints influencing heating habits, and reliance on alternative heating solutions, which will be explored in the following section.

#### 5.4.4 Alternative Heating Equipment for Room Thermostat and Safety Concerns

Half of the households (8 out of 16 households) have alternative heating solutions in case of room thermostat failures, demonstrating a form of redundancy in their heating practices. Portable electric heaters, fan heaters and electric fires are common backup options, with inhabitants purchasing this equipment themselves as a precautionary measure. For example, R18 noted:

*"I bought myself a little electric fire. If the heating does go off, I can just put the electric fire on." (R18, age 51-70, female, lives on the first floor)*

Similarly, R6 also mentioned she bought herself a portable air conditioning unit that she uses for both heating and cooling purposes:

*“I do have a small air conditioning unit [as an alternative for room thermostat], [a] very small one. A little unit which you can use for heating the room as well if necessary. But I have been there [social housing] since 2016 and so far nothing has ever broken down.” (R6, age 51-70, female, lives on the first floor)*

These interviews show how these households increased the redundancy in their homes by providing themselves alternative heating solutions in case the room thermostat fails. Only one household (R9) received temporary portable heaters from the social housing association when their central heating system malfunctioned for two days:

*“We have got some portable heaters, when the central heating was broken for about two days, the association gave us some small portable electric heaters for winter.” (R9, age 51-70, male, lives on the first floor)*

Reflecting on R9’s statement, his household did not have an alternative before their central heating system failed, which highlights that they relied only on the central heating system that was installed when they moved in. The malfunction of the heating system shows that there is a need for alternative equipment to increase the resilience of the social housing, even if the inhabitants trust the heating system. Sometimes the inhabitants, such as R2 (see Section 5.4.1) and R3, change their usual room thermostat practices even if there is no malfunction with their heating system. For example, R3 noted:

*“Well, they are [portable heater] just there as a backup in case the heating broke down. Or sometimes very, very rarely, if we have been on holiday, for example, in the wintertime, and we come in and it takes, say, 20 minutes for the heating to warm up. I would consider putting on the portable heater.” (R3, age 51-70, female, lives on the ground floor)*

This suggests that, when the temperature is very low in winter, inhabitants require an alternative way to achieve their desired thermal comfort more quickly than by heating their entire home.

A few inhabitants (R2 and R15) employ alternative heating methods based on personal thermal comfort and needs. For example, R2 mentioned:

*“We [H1] have [an] electric blanket and a fan heater. We use the electric blanket a lot in winter.” (R2, age 51-70, male, lives on the ground floor)*

Reflecting on R2’s statement, using electric blankets provides personal thermal comfort without the need for whole-house heating. Similarly, R15 noted:

*“Are you aware of other ways of heating your home like electric fan heater, portable gas heater, electric blanket? Are you aware of any other things? (MT, researcher)*

*“No, it is just purely the blankets and the heating.” (R15, age 30-50, female, lives on the first floor)*

R15 has a similar approach to R2 in that, as a household they rely on their heating system and use blankets for personal comfort. However, using electric blankets is not an alternative for heating their homes, as they will not be enough if their heating system fails.

One of the households, an extreme case, has adopted potentially hazardous heating practices when their central heating malfunctions or fails to provide adequate warmth. R17 noted:

*“Do you have any alternatives to [the] room thermostat?” (MT, Researcher)*

*“No, I have no other heating.” (R17, age over 70, female, lives on the ground floor)*

*“Do you think there is any other way [equipment] that you can use as an alternative to [the] room thermostat?” (MT)*

*“Oh, no. I will leave the oven open and that is it.” (R17)*

R17’s practice of leaving her gas oven open for heating purposes poses significant risks, including high energy consumption, increased humidity levels and potential carbon monoxide poisoning. These findings highlight the need for increased awareness regarding safe and efficient heating practices within social housing.

To summarise, alternative equipment for the room thermostat was not provided when the inhabitants first moved into their homes in this case study. The requirement for redundancy in social housing highlights the need for enhanced reliability of and access to heating

systems. The lack of usability of the heating programmers indicates a gap between the intended functionality and actual use, necessitating improved inhabitant understanding and knowledge, simplified control interfaces or adaptive heating technologies. Additionally, the alternatives (e.g., using an oven for heating) that pose health and safety risks to the inhabitants underscore the necessity for targeted interventions (e.g., via POE) to ensure both safety and energy efficiency in social housing.

## 5.5 Practices Associated with Radiators

### 5.5.1 Inhabitant Discussions and Household Dynamics Related to Radiator Use

In this case study, the radiators in the homes are equipped with thermostatic radiator valves, which allow inhabitants to control the temperature of individual radiators in different rooms. A long-term housing study conducted by Cholewa, Siuta-Olcha and Balaras (2017) indicates that thermostatic radiator valves contribute to energy-savings in households by reducing overall energy consumption. This highlights the importance of inhabitants' understanding of the radiator valves' function within their homes to achieve energy efficiency and thermal comfort.

Decisions regarding heating practices within the household, such as adjusting radiator valves, are frequently discussed within the household, much like the room thermostat practices explained in Section 5.4.1, as described in the interview with R11:

*“As a household, do you discuss using the radiator valves in the home?” (MT, researcher)*

*“Usually discuss it.” (R11, age 51-70, male, lives on the ground floor)*

*“Who decides to use that, like how does the discussion process go?” (MT)*

*“If it is cold, one of us will say, you know, put the heating on.” (R11)*

The 'presence at home' is also significant for the practices associated with radiators, as with room thermostat practices, meaning the radiator valves are often controlled by the inhabitant who spends most time at home. For example, R4 stated:

*“Do you discuss it with each other when you are using them [radiator valves]?” (MT, researcher)*

*“Yeah, we, we do sometimes. But I know, in [the] bedroom I think there is not any radiator valve in that one. There is, I think there is in living room and kitchen. And the spare bedroom they all have radiator valves. But it is not very often that we, you know, we put them on about number five [level], and just the spare bedroom we turn that [radiator valve] down to two or three.” (R4, age over 70, female, lives on the ground floor)*

R4’s statement above, along with her remarks in Section 5.4.1, highlights that their household discusses when to use the radiator valves and room thermostat. It is usually her husband, R5, who decides to turn on the heating, as he feels the cold more than R4. She also mentioned in Section 5.4.1 that she, R4, is often the one who turns on the heating, because she is the one who stays at home the most. Even when discussions do not occur within the households, the inhabitant who is at home the most tends to take charge of controlling the radiators, as noted in the interview with R3:

*“As a household, do you discuss using the radiator valves in the home?” (MT, researcher)*

*“I use it [radiator valves] myself, we do not discuss it. Because I am at home seven days a week.” (R3, age 51-70, female, lives on the ground floor)*

R3’s statement reported that she independently operates the radiator valves without discussion because she is at home seven days a week. This pattern mirrors room thermostat practices, as explored above and in Section 5.4.1, where the individual most present in the home typically manages the heating controls, indicating that the role of ‘presence at home’ influences heating practices.

#### 5.5.2 Awareness and Perceived Usability of Radiators

While the majority of the inhabitants (17 out of 18 interviewees) reported that they found radiator valves usable and easy to operate, there was an exception. The inhabitant who

explained that the radiator valves were not usable, R1, mentioned a lack of awareness of the radiator valves:

*“Do you have radiator valves?” (MT, researcher)*

*“No, we just have the radiators, we do not have radiator valves on them.” (R1, age 51-70, female, lives on the ground floor)*

R1 stated above that their radiators did not have thermostatic radiator valves, whereas R2, from the same household, confirmed that the radiator valves function properly and are easy to operate, according to the usability survey. This suggests that R1 was unaware of the presence of radiator valves, possibly due to R2 being primarily taking charge of the heating controls in the household (see Section 5.4.1 for R2 taking charge of the heating). R1 stated:

*“Sometimes we use [an] electric fan heater, if the weather is really, really bad. But we do not use them very much because we have radiators all around. We have the electric fan heater just in case, if the radiators are broken down. It is better than nothing.” (R1, age 51-70, female, lives on the ground floor)*

Reflecting on R1’s statement, their household purchased alternative heating equipment to maintain resilience in their homes and ensure continuing their heating practices as usual. This aligns with broader patterns observed in this study, where inhabitants (e.g., R3, R6, R9, R18) increased the redundancy of their homes by taking proactive measures to support or replace the central heating when they encounter inefficiencies or system failures (see Section 5.4.3).

To summarise this section, thermostatic radiator valves are widely used and understood by the majority of inhabitants. The findings show that the inhabitant who spends the most time at home typically takes responsibility for adjusting radiator valves, as with room thermostat practices. In cases where the radiator valves are perceived as unusable due to a lack of awareness or heating system failures, inhabitants provide themselves with alternative heating equipment to maintain household resilience. The tendency for some inhabitants to have alternative solutions suggests that reliability of and accessibility to heating controls remain critical factors in ensuring social housing resilience.

## 5.6 Summary

This chapter has analysed the heating practices of inhabitants and found that majority of the inhabitants within this social housing case study do discuss them with each other. There is a significant gap between the design team's understanding of how well the inhabitants can understand and use the heating equipment and the actual understanding of inhabitants. According to the findings, in this selected case study, the inhabitants who are over 70 still have hard time understanding their heating equipment, even though the design team think that these systems are the norm in the UK and everyone knows how to use them.

This chapter also highlighted the influence of external factors, like Covid-19 and the energy crisis, on inhabitants' heating practices in social housing. It has been observed that effective insulation reduces the dependence on the heating system. Although thermostatic radiator valves are commonly used and understood by the inhabitants, the responsibility for adjusting them often falls to the inhabitant who spends the most time at home. Failures in heating systems or a lack of understanding of their controls has led some inhabitants to seek alternative solutions, indicating a strong need for reliable and easy-to-use heating systems to maintain household resilience. These findings highlight the necessity for adaptable technologies, understandable heating controls, and enhanced inhabitant engagement to support the long-term resilience objectives of social housing.

## CHAPTER 6. VENTILATION PRACTICES in the SOCIAL HOUSING CASE STUDY

### 6.1 Introduction

This chapter presents the analysis and findings of the semi-structured interview and usability survey data about inhabitants' ventilation practices and explores how the inhabitants discuss their ventilation practices in terms of resilience. This study examines the ventilation practices from two different perspectives: those of the inhabitants and the design team. Inhabitants' ventilation practices are critically analysed in terms of the key resilience drivers and Gram-Hanssen's (2010) practice theory elements (see Table 4.7). This is a step towards achieving Objectives 2, 3 and 4 of this thesis in relation to understanding the underlying resilience and inhabitants' ventilation practices in the case study, as well as identifying key insights for resilient social housing.

### 6.2 Ventilation Practices in Relation to Resilience and Social Change

The design team's understanding of resilience is multifaceted, incorporating climate-resilient homes, lifetime homes, and homes that are adaptable in the face of social change. These aspects inform their approach to designing social housing that remains resilient over time.

#### 6.2.1 Climate Change and Housing Resilience

The design team prioritise climate-resilient homes that are affordable, produce lower CO<sub>2</sub> emissions, and can mitigate overheating (e.g., having cross-ventilation and removing excess heat according to HM Government (2021a)). For example, D1 noted:

*"How would you define resilience and how do you see that can be integrated into the building environment?" (MT, researcher)*

*"And you mean resilience to climate change?" (D1, project director)*

*"Yeah, more generally. Like what comes to your mind when we say resilience?" (MT)*

*"The first thing that would come into my mind would be climate change. So, I would think what standards we are hitting first time, in particular, in terms of fabric and*

*both the low energy bills and the overheating, you know, what are we allowing for.”*  
(D1)

As can be seen from D1’s statement, climate change is one of the first considerations that comes to mind when the design team are asked about the resilience of the home. The design team also mentioned that their priorities when building a resilient home are to lower energy bills and mitigate overheating. Another design team member said:

*“I think that kind of other aspects of resilience, aside from just the kind of person living in that property, it is climate resilience. So, you know, building a home that is going to be sustainable, it is going to be affordable to run, it is going to reduce CO<sub>2</sub> emissions. And I think that is incredibly important. I think some of us can be comfortable to live in a home that is not going to damage the climate.”* (D2, project coordinator)

Both D1 and D2 highlight the importance of climate change in the design team’s approach to resilient housing, emphasising energy efficiency and indoor thermal comfort as the core aspects of their design intentions. Their approach correlates with Sheffield City Council’s aim to reduce the heating costs and provide energy-efficient homes, particularly for low-income households in social housing, by 2030 (Sheffield City Council, 2024).

#### 6.2.2 Building Lifetime Homes and Adaptability

Another significant theme is the concept of lifetime homes – homes that remain suitable for inhabitants despite changes in their social circumstances – as the design team mentioned. For example, D2 noted:

*“How would you define resilience and how that can be integrated into the building environment?”* (MT, researcher)

*“I mean, I think for me, resilience is building a home that people can stay in for as long as they want. And, you know, being that, you know, having children in that home, getting older in that home, changing jobs in that home, and changing how you work in that home, you know, possibly having less health concerns, being able to [have] adapting ability.”* (D2, project coordinator)

The design team said that changing social circumstances include inhabitants ageing, families expanding, and work arrangements changing. In Section 5.2.4, D2 noted that the design team began to consider these social changes when the number of inhabitants working from home increased, particularly after Covid-19. As a result, these considerations highlight the significance of long-term usability and adaptability in their design intentions. However, although the design team are integrating adaptability into newer developments, the case study used in this thesis was built before the pandemic. Therefore, the original design decisions did not fully anticipate the effects of unforeseen social changes (e.g., an increase in time spent in the home), emphasising the challenge of designing resilient homes amid unpredictable disruptions (e.g., the Covid-19 pandemic). To give an example, when asked about the backup systems to maintain the performance of the home, D3 noted:

*“Well, I mean, [...] a lot of the other projects we are working on have much more advanced, sustainable and green credentials at the moment. We are building to passive house standards and every house has a battery in it, which is downloading electricity from the grid. But also from PV, which people can use within their own homes so they can get cheap electricity using them in their own homes. So, I suppose in some ways that is a sort of backup system to the house. But in this particular case, I mean, with the constraints of that site and the amount of substructure and retaining walls and also the fact that we were building housing with quite [a] large perimeter [and] the budget just was so low, just really difficult to [do]” (D3, architect)*

This example shows that the design team anticipate the effects of unforeseen social changes in their current projects. They are working on designing homes with backup systems that can help inhabitants who are older or have health concerns to continue their usual routines during a disruption. However, in this case study, due to the low budget of the housing association, these unpredictable social changes were not considered in the design.

### 6.2.3 Breaking Ingrained Habits and Inhabitant Engagement

In this study, adaptation is considered as the inhabitants’ ability to learn and adjust their practices to overcome the effects of social changes (see Section 2.4.2). Consequently, this raises the question of whether the design team’s intended design is accessible to the

inhabitants and whether they can understand and use the energy-related systems within their homes. The design team were asked about this question:

*“How easy is it for an occupant to meet a particular need using different functions relevant to the energy use of the design? For example, is it easy for occupants to use the equipment in the homes [...]?” (MT, researcher)*

*“So, I think at the moment it is. Because largely what we have in most of our homes is kind of a gas combi boiler system, which is kind of the norm in the UK and therefore people kind of understand how it works. [...] so, I do think that it is something for us to consider because these are kind of really ingrained ways of working within the UK and introducing a new way of doing it [would mean] that people do not understand it. It is just a learning curve and it is kind of breaking previous habits.” (D2, project coordinator)*

D2 said that it is easy for inhabitants to meet particular needs using different functions of the home related to energy use. They also noted that the inhabitants have ingrained practices in the UK, and when they introduce a new way of practice, they view it as ‘just a learning curve and it is kind of breaking previous habits’. This demonstrates that the design team acknowledge that heating and ventilation systems in this case study align with UK norms, implying a certain level of inhabitant familiarity. However, this assumption does not consider the inhabitants’ actual understanding and engagement with the heating and ventilation controls. For example, R15 noted:

*“Are you aware of the trickle vents, on top of the windows? The little gaps on top of your window.” (MT, researcher)*

*“Oh, right. Yeah, we have got them, but no, I never use them.” (R15, age 30-50, female, lives on the first floor)*

*“Is it because, it is not working well or do you prefer not to use it?” (MT)*

*“To be honest, I am not sure how to use it, you know, what to do, etc. So, I just do not bother.” (R15)*

As noted by R15, some inhabitants struggle with using the trickle vents and some of them (three out of 16 households) were not aware of their existence, as is mentioned in Section 6.3. Similarly, Section 5.4.2 stated that some inhabitants (e.g., R3 and R22) find it difficult to understand the heating programmer, despite the design team providing user guides and manuals on how to use these controls. Therefore, as indicated in the findings, some inhabitants find it difficult to understand and use energy-related controls, which contradicts the design team's statement on the norms. D2's statement that new practices require 'breaking previous habits' suggests an awareness of behavioural adaptation but fails to fully address the barriers that may prevent inhabitants from successfully adopting these new practices.

#### 6.2.4 Variability in Ventilation Practices and Maintenance Support

The findings highlight disparities in ventilation practices across different housing typologies within the social housing development. One key factor influencing these differences is the spatial design of the flats, particularly in relation to how cold air moves through their homes during winter. As noted by the architect, D3:

*“So we had to get quite inventive about the way the houses were planned. So, you will notice that when you go into the house, they do not really have an entrance hall that leads to a kitchen and then to a living room. In fact, you have to walk through your dining to get to your living room.” (D3, architect)*

The architectural rationale behind this open-plan layout of the homes was emphasised by D3's statement above, who noted the homes do not have an entrance hall that leads to the main living area. This design choice, while optimising space and creating an open and connected environment, inadvertently impacts thermal comfort and ventilation practices, particularly in winter. For instance, R4 noted:

*“You know, we have a door that leads to the hallway. And then you walk into the living room and kitchen, it is open planned, so we do not have any doors to, you know close. So it is, I find that especially in winter I mean, we have food delivered. In winter obviously you have to open the door, so that makes all the flat cold.” (R4, age over 70, female, lives on the ground floor)*

R4's statement highlights how the open-plan design of their home exacerbates heat loss by allowing cold air to enter when the front door is opened. In contrast, the first-floor flat entrances are located downstairs (see Figure 6.1), meaning that cold air is trapped below and so heat loss in the main living areas is reduced. The findings suggest that ventilation strategies must consider not only inhabitant behaviour, but also the spatial design of the homes, as certain typologies are inherently more vulnerable to cold air circulation than others.

In the selected social housing case study, the main ventilation system is a mechanical extract ventilation (MEV) system, which features trickle ventilators fitted in windows and continuously running mechanical extract fans in the kitchen and bathroom, areas considered to be 'wet rooms'. This system aims to remove moist air and odours in wet rooms by providing adequate ventilation and good air quality within the inhabitants' homes. Furthermore, all internal doors are designed with an undercut of 10mm above the final floor finish to allow air transfer between rooms. The ventilation system and its controls are illustrated in Figures 6.1 and 6.2, which show cross-ventilation within the flats and the extract fans in the wet rooms.

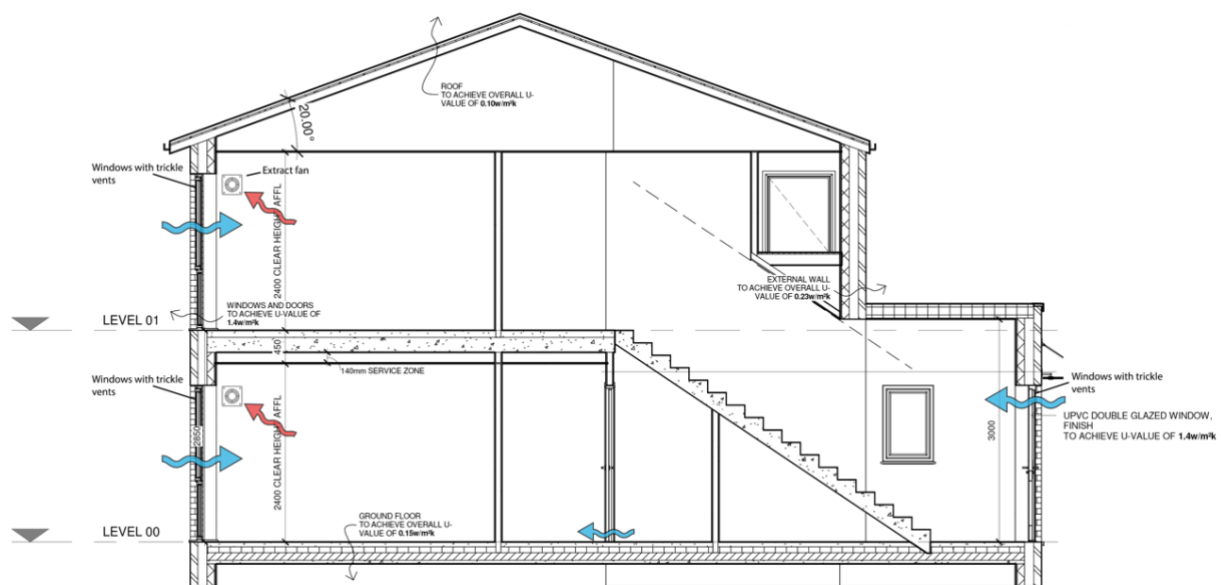


Figure 6.1 A section of the social housing case study and the ventilation system in the homes, where each floor is for a different flat. This figure is adapted from the documents provided by housing association

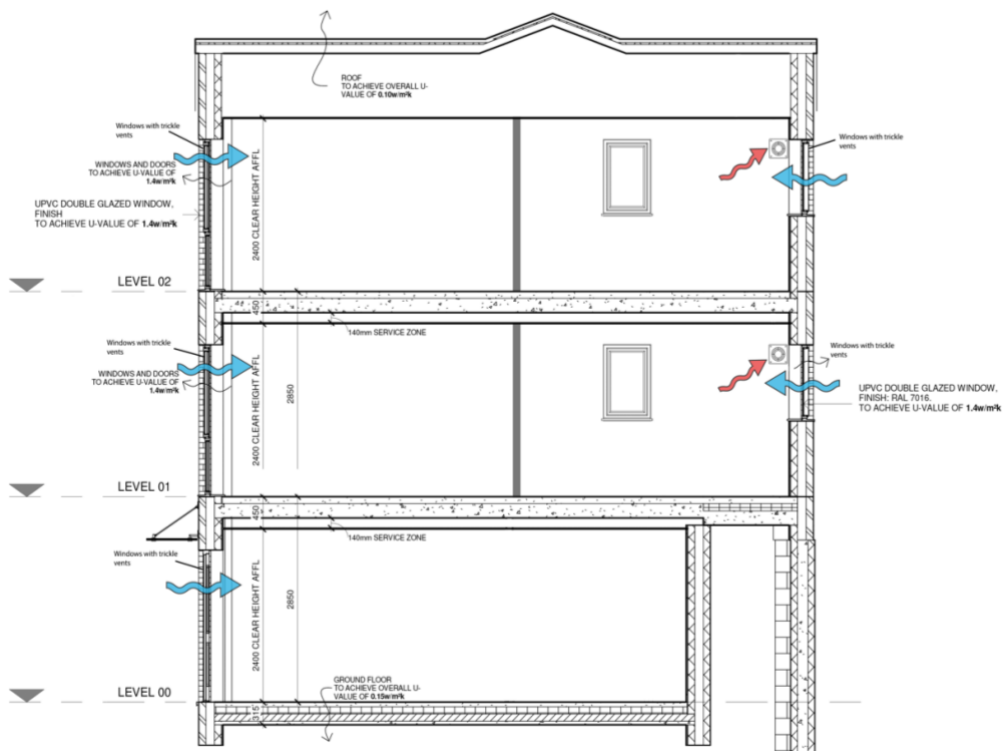


Figure 6.2 A section of the selected social housing case study, showing the ventilation system in the homes. This figure is adapted from the documents provided by the housing association

The findings also highlight that ground-floor inhabitants generally rate their ventilation control engagements as average, whereas first-floor inhabitants find them more usable (see Figure 6.3). For example, R11 noted:

*“Are you aware of the extract fans in your kitchen and bathroom?” (MT, researcher)*

*“We use those. Yes. Extractor fans in kitchen and bathroom.” (R11, age 51-70, male, lives on the ground floor)*

*“Do you think they work well?” (MT)*

*“No.” (R11)*

*“[...] In the bathroom, when you shower, do you open the windows?” (MT)*

*“We have no windows in bathroom. So, we have to use the extractor fan.” (R11)*

R11 highlighted that they have to rely on the extract fan due to the absence of windows in their bathroom. Even though they depend on the extract fans for ventilation, R11’s observation that the extract fans in the kitchen and bathroom do not function effectively is consistent with the results from the usability survey (see Figure 6.3). This indicates that design elements, such as airflow patterns and access to ventilation controls, may require further refinement.

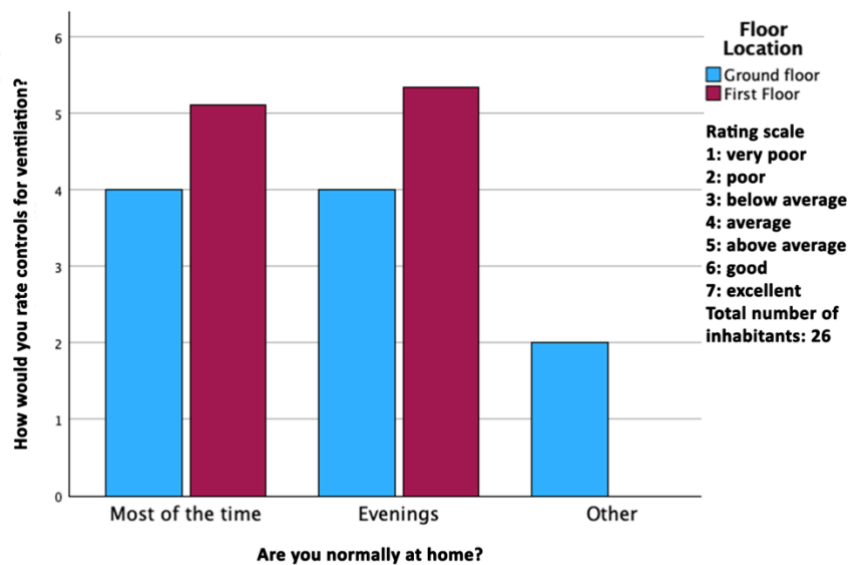


Figure 6.3 The mean rating of the ventilation controls in relation to inhabitants’ presence at home and floor location

A notable issue is the limited awareness among inhabitants regarding the maintenance of ventilation controls. According to the usability survey, illustrated in Figure 6.4, 42% of inhabitants are unaware of the need for ventilation control maintenance. Consequently, these inhabitants must rely on the social housing association for maintenance instead of attempting to resolve issues themselves. Alternatively, inhabitants may use alternative ventilation equipment to ensure their homes remain ventilated, as explained in the interview with R1:

*“Do you think there is any other way [equipment] that you can use as an alternative to windows other than air conditioning [as R1 mentioned before]?” (MT, researcher)*

*“No, just an air conditioner. So, when it is hot and it is really, really uncomfortable, the air conditioner is open all day and all night. I cannot stand when it is closed.” (R1, age 51-70, female, lives on the ground floor)*

Additionally, the design team mentioned they provide maintenance support through neighbourhood officers. D2 said:

*“We do have neighbourhood officers who are kind of our bridge, [who] may come, I suppose, [to] inform people what support is available. Also, you know, possibly do this bridging, kind of, come in and say, look, I found this person that [is] really struggling with X, Y, Z, what can you do to help them? So now we have, kind of, got those two mechanisms.” (D2, project coordinator)*

D2 explained that they have neighbourhood officers who communicate with the inhabitants and guide them if they have any problems. These neighbourhood officers are assigned to each housing development by the social housing association and they make regular visits to the households to see if they have any problems with their homes or community-related issues. Despite these neighbourhood officer visits, there are some households who do not get support for their maintenance issues from the housing association. For example, R24 noted:

*“I mean, when we first moved in, everybody has got a lot of problems with the boilers. And when we first stayed in, I phoned the housing association to get it going. I do not think they even know. They were trying to tell me over the phone how to do it when I am not messing about with the boiler. So, you best get someone here to get it sorted out. [...] And we ended up actually getting the people who made the boiler to come and sort it out. Because the housing association could not work it out. And every time they service it something goes wrong.” (R24, age 51-70, female, lives on the ground floor)*

The statements from R1 and R24 show that the inhabitants require assistance from the social housing association if the heating or ventilation controls encounter issues. If the housing association is unable to resolve these issues, the inhabitants need alternative equipment to continue their energy-related practices. Additionally, while the design team

provide maintenance support through neighbourhood officers, some inhabitants still require assistance and provide themselves alternatives just in case. This gap in support systems highlights the need for more effective engagement strategies to ensure all inhabitants can effectively use and maintain their energy-related systems.

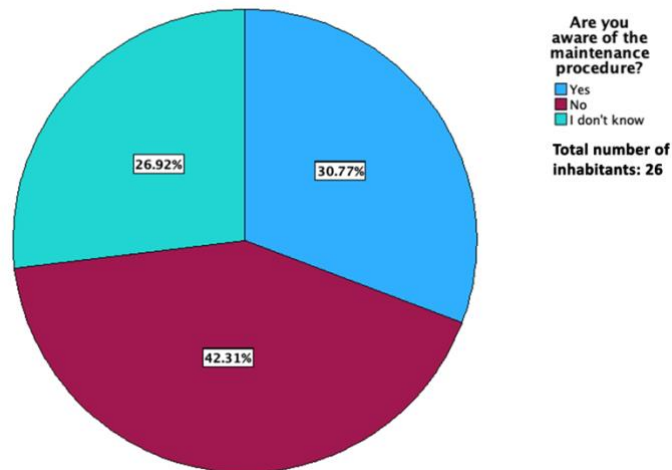


Figure 6.4 Pie diagram showing inhabitants' awareness of ventilation control maintenance procedures

To summarise, Section 6.2 highlights the design team's dedication to resilience, with their strong commitment to considering climate change, adaptability and long-term usability. Their emphasis on lifetime homes and responsiveness to social changes indicates a growing understanding of resilience in housing design. However, challenges remain, particularly in the areas of inhabitant engagement, maintenance accessibility and anticipation of future societal changes.

### 6.3 Window Use Practices

In this social housing case study, the window-use practices are examined in well-insulated homes that have double-glazing windows with trickle vents above each window (see Figure 6.5). The findings reveal diverse window-use practices that are influenced by seasonal factors, household dynamics, individual health needs and knowledge of the ventilation system.



Figure 6.5 Ventilation controls in the social housing: (a) the double-glazing windows in one of the homes; (b) the trickle vents on top of the window in one of the homes

### 6.3.1 Seasonal Factors That Influence Window Use

The majority of inhabitants reported a habitual practice of opening windows in the living room and bedroom in the morning to let the fresh air circulate. For example, R6 noted:

*“I always open my windows to let fresh air in. Even today I have left them on the latch to let some air in, because I think it is a sunny day and I think it is important to have some fresh air. I have got two cats, and I think it is important for them too.” (R6, age 51-70, female, lives on the first floor)*

During winter, this practice is often limited to a few hours to minimise exposure to cold air. The interview with R18 took place on a wet day, which affected her routine:

*“I just, I only open my bedroom window in winter. When I get up in the morning, I open the window for a couple of hours and then I shut it. But at this weather [rainy], no way. I do not open the windows.” (R18, age 51-70, female, lives on the first floor)*

R18 mentioned that she does not open the windows during wet weather, and only opens her bedroom window in the morning during winter. In contrast, during the summer,

particularly during heatwaves, some inhabitants said that they keep their windows open. For example, R15 noted:

*“How often are you opening your windows in summer?” (MT, researcher)*

*“Yeah, probably if we have got a heatwave, every day actually.” (R15, age 30-50, female, lives on the first floor)*

However, according to the UK Health Security Agency (2024), during a heatwave all windows must be closed in buildings, unless the outside temperature is cooler than the indoor temperature. As pointed out by Mavrogianni *et al.* (2015), owing the increased number of heatwaves affecting the UK and the high temperatures that might happen in the future because of climate change, combined strategies to reduce overheating risks and increase air quality in homes must be developed. Thus, keeping windows open all the time in summer may cause inhabitants' homes to overheat; therefore, inhabitants' window-use practices and their usual habits might affect both their home and health if they do not know about these effects.

For some inhabitants, health concerns require more regular use of windows. For instance, R1 noted:

*“In the autumn time, we try to keep the balance between the heater [heating] and ventilation. I have circulation problems on [in] my legs, so even in winter I get really hot. So even in winter we open the windows.” (R1, age 51-70, female, lives on the ground floor)*

R1's statement highlights that elderly inhabitants or those with specific health conditions require adequate air circulation in their homes; therefore, they open their windows more frequently, even during colder months. This correlates with a study on public housing in the USA by Tsoulou *et al.* (2023) that mentions that inhabitants' window opening practices depend on different factors, such as income, age and health.

### 6.3.2 Discussions Among Inhabitants Regarding Window Use Practices

The use of windows is predominantly an individual practice within households, with minimal discussion or engagement among inhabitants, as illustrated by Figure 6.6 from the usability survey. For example, R11 remarked:

*“As a household, do you discuss with your wife, when you need to use ventilation in your home?” (MT, researcher)*

*“If we need ventilation, and we need the windows open, we open them. We do not discuss it, if one person wants it open, they go and open it.” (R11, age 51-70, male, lives on the ground floor)*

According to these findings, half of the inhabitants (11 out of 22 inhabitants with at least two people in their household) do not discuss using windows within their household (see Figure 6.6). If one household member wants to use a window, they do it without having a discussion. Additionally, most of the inhabitants (nearly 60%) do not take charge of the windows and everybody does their own thing when they need to use them (see Figure 6.7). Inhabitants do take charge when one household member needs more air circulation within the home. For example, R23 noted:

*“Do you discuss with each other when you decide using the ventilation systems in your home, or does everybody do their own thing?” (MT, researcher)*

*“We do not discuss, but I do, I take charge. We have the bedroom window open all night and usually all day. Unless we go out, then we close them. But I cannot sleep. I cannot sleep unless there is a bit of air.” (R23, age 51-70, male, lives on the ground floor)*

The other situation where the inhabitants take charge of the windows was highlighted by R25:

*“Does anyone take charge of dealing with the ventilation controls?” (MT, researcher)*

*“Everyone is in charge of the ventilation controls. Well, my kids do not touch the ventilation. It is difficult for them to use if it is windy, so it is just grown-ups [who] use them.” (R25, age 30-50, female, lives in the semi-detached house)*

R25’s statement emphasises that the adults prevent children from using the windows because of the potential danger during windy weather. Different socio-demographic factors in households, such as the presence of children or older inhabitants, influence the window usage practices. Nevertheless, families with children need further examination, as this thesis includes only one family with children aged under 18, which is insufficient for drawing broader conclusions.

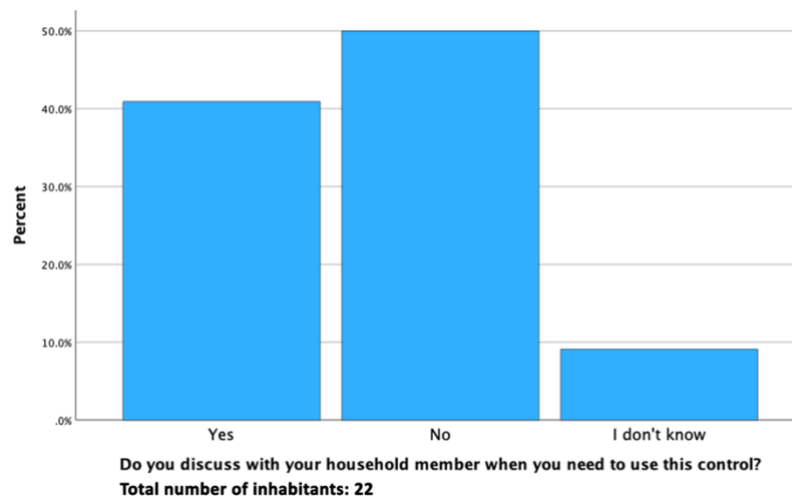


Figure 6.6 The percentage of inhabitants who discuss within their households when using windows

Examining Figure 6.7, it appears that the inhabitants responsible for the windows are primarily those who spend most of their time at home. This may be due to their increased use of the windows compared to others who are out during the day. For example:

*“Do you discuss with your household members when you need to use the ventilation controls in your home?” (MT, researcher)*

*“No, I do not discuss. Just before our interview, I was going to open up the windows. My husband is at work now, so he does not know about it. We just do our own thing.” (R25, age 30-50, female, lives in the semi-detached house)*

Thus, we can observe that the time spent in the home influences how inhabitants engage with their window usage, a point supported by Tsoulou *et al.* (2020), who suggest that both indoor air quality and window opening habits are shaped by the pattern of being at home.

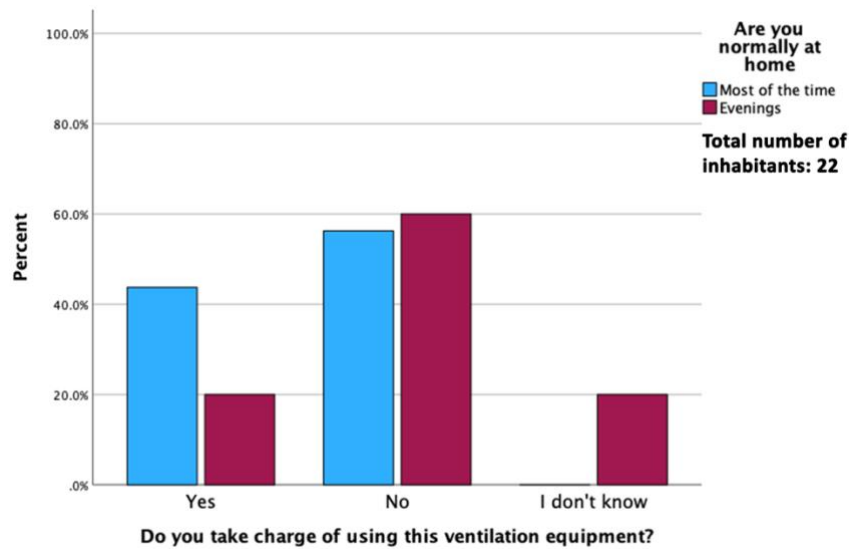


Figure 6.7 The percentage of inhabitants who take charge of using the windows in relation to their presence at home

The key point to highlight from this analysis is that window use practices are highly individualistic and influenced by individual needs rather than collective decision-making within households. This indicates that air circulation within the household is regarded as a matter of personal, immediate concern, not requiring discussion or coordination with others. The absence of discussion or engagement about window usage may also reflect an implicit understanding among household members that each individual will manage their own comfort independently. However, there are situations where consideration of another inhabitant's sensitivity to the indoor temperature or specific air circulation needs takes precedence over this individualistic approach. This indicates a dynamic where inhabitants' energy-related practices are driven by both individual preferences and occasional responsiveness to the needs of more vulnerable inhabitants in the household.

### 6.3.3 Understanding and Usage of Trickle Vents

The windows in the homes have trickle vents (see Figure 6.5(b)), which contribute to continuous ventilation if they are open. One of the key findings from the analysis in relation to trickle vents is that some inhabitants keep them open throughout the day, particularly in summer. For example, R17 noted:

*“Are you aware of the trickle vents on top of your windows?” (MT, researcher)*

*“Yes, the trickle vents on all the windows.” (R17, age over 70, female, lives on the ground floor)*

*“Do you also use them?” (MT)*

*“Yes. In summer I leave the trickle vents open all the time day and night when it is warm to let the fresh air in.” (R17)*

By leaving the trickle vents open, households benefit from continuous air circulation throughout the day. Additionally, the inhabitants who are aware of the trickle vents use them in winter, particularly when avoiding opening the windows. For instance, R7 mentioned:

*“I mean, in winter, we close the windows and we just have little ventilation strips [trickle vents] on top of windows, so we just pop that open to get some fresh air into the property, rather than just totally rely upon on sealing all the air in. [...] So we always use that. We always have a little bit of ventilation.” (R7, age 51-70, male, lives on the first floor)*

A significant outcome of this finding is that being aware of and properly using trickle vents significantly contribute to maintaining indoor air quality and comfort, especially during winter, without opening the windows. Inhabitants who effectively understand and use these vents benefit from continuous ventilation, which balances air circulation while minimising exposure to outdoor conditions such as cold air.

However, some of the inhabitants are unaware of the trickle vents. While the home user guide includes information about their usage, some inhabitants either do not read it or struggle to understand it. For example, R4 noted:

*“There is one extract fan in bathroom. But we do not use them. Because we have [the] window open.” (R4, age over 70, female, lives on the ground floor)*

*“Does your bathroom have the window with trickle vents?” (MT, researcher)*

*“No, it does not.” (R4)*

R4’s statement highlights that she uses the window in the bathroom and is not aware of the trickle vent and its function to help the air flow in the room. In Section 6.2.3, R15 said that despite being aware of the trickle vent, she does not use it due to a lack of understanding. This is aligned with what D1 from the design team mentioned in her interview (see Section 5.2.2): the home user guide has all the information, but the most important aspect is for the inhabitants to read, understand and then follow it. This underscores the importance of clear communication and guidance to ensure that inhabitants not only access but also implement such knowledge.

#### 6.3.4 Differences Between Design Intentions and Window Use Practices

A notable observation from the analysis is the difference between the design team member’s statement on window use habits and the inhabitants’ actual practices. For instance, D2 noted:

*“I mean, I suppose obviously there are instances by people using [heating and ventilation controls] differently. You know, sometimes we have come across properties that people have the windows open and the radiators on at the same time. But I think, in general, there is a pretty good understanding [of] how to use those more kind of standard bits of technology.” (D2, project coordinator)*

From D2's statement, we understand that the design team raised concerns regarding instances of simultaneous window openings and radiator usage, which they consider as inefficient. In contrast, most of the inhabitants in this case study mentioned that using both the windows and radiators at the same time is not sensible and would increase their energy bills. This is evidenced in the statement of R6:

*"When I open the windows, I do not switch the radiator on. Once I have closed the windows then I switch the radiators on. You know it is not really sensible to have them on at the same time because then the hot air will escape. So, I air the room, and then I switch the radiators on." (R6, age 51-70, female, lives on the first floor)*

A similar understanding was also highlighted by R25:

*"Do changes in your window usage affect your radiator usage in winter?" (MT, researcher)*

*"No. If we open the windows, I have to make sure the radiators are off." (R25, age 30-50, female, lives in the semi-detached house)*

These statements from R6 and R25 show that they are aware of the energy implications of their actions and so avoid opening the windows when the radiators are on. This indicates a potential contrast between the design team's assumptions and the actual behaviours of the inhabitants.

#### 6.3.5 Usability of Windows

The key point to highlight is that the majority of the households in this case study do not report usability problems with their windows, such as having difficulties in opening or closing a window because it is too stiff. However, one household mentioned that they have some usability issues that were related to maintenance issues. For example, R1 stated:

*"In the autumn time, we try to keep the balance between the heater and ventilation. I have circulation problems on [in] my legs, so even in winter I get really hot. So even in winter, we open the windows. But when it rains, the rain comes in, as I said, because*

*of the design. So, we put a pedal on it and we usually open the windows at the medium level.” (R1, age 51-70, female, lives on the ground floor)*

As well as making adaptations to stop rain entering when the windows are open, she had to adjust her usage practice by opening the windows to a medium level, due to a usability issue related to maintenance problems.

#### 6.3.6 Additional Equipment Related to Windows

One of the key findings from the analysis in relation to redundancy is that most inhabitants do not have a backup option or an alternative to windows for ventilation. For example, R15 remarked:

*“Do you think there is any other way [equipment] that you can use as an alternative to windows?” (MT, researcher)*

*“Well, only air conditioning, but I personally would not use it.” (R15, age 30-50, female, lives on the first floor)*

As R15 stated, she is aware of an alternative option but prefers not to purchase and use it. In contrast, three households reported having additional equipment, such as portable air conditioning units, which they purchased themselves. For example, R11 noted:

*“Do you have any alternative to windows?” (MT, researcher)*

*“We have got an air conditioning unit that we bought.” (R11, age 51-70, male, lives on the ground floor)*

Another inhabitant (R6) also mentioned having a portable air conditioning unit:

*“I do have a small air conditioning unit, very small one. A little unit which you can use for heating the room as well if necessary. But I have been there since 2016 and such, nothing is ever broken down.” (R6, age 51-70, female, lives on the first floor)*

These statements from the inhabitants highlight that they use their portable air conditioning units for air circulation, and one household mentioned she is also using it for heating her home. R6 also noted:

*“As it seems to be with global warming, each summer will be getting hotter and that particular day when it reaches 40 degrees, it took about a week because I live upstairs. It took about a week for the flat to cool down. And I did really notice that. And for me, having come from Andalusia, where I was used to intense heat, I found that quite shocking. And I think it may be to do with the insulation in the loft, I am not sure, but I think maybe in future if we do have hotter summers like that, we would need maybe something fitting in a proper air conditioning feature.” (R6, age 51-70, female, lives on the first floor)*

The statement from R6 highlights that due to climate change and rising temperatures, their flats become very warm, necessitating additional equipment for ventilating their homes. Similarly, Gupta *et al.* (2021) note that by the 2080s the most effective solution for reducing indoor temperatures will be the use of air conditioning. However, the use of air conditioning also results in a high cooling load, emphasising the importance of balancing passive and active ventilation measures to minimise the cooling load. Given climate change and the increasing frequency of heatwaves in the UK, more effective strategies must be developed to enhance air circulation within homes during these extreme events (Wright and Venskunas, 2022). A key point to highlight here is that some inhabitants are adapting to the changing conditions by acquiring additional alternatives or backup options. Therefore, not having alternative equipment underscores a critical gap in redundancy for ventilation, particularly during extreme weather events like heatwaves.

To summarise this section, the findings highlight the complexity of window usage practices in social housing, which are shaped by individual habits, knowledge and usability barriers, seasonal influences, and a lack of redundancy in ventilation systems. These findings indicate the necessity for enhanced practical knowledge among inhabitants, better communication of design intentions, and improved maintenance support to align with the window usage practices of inhabitants.

#### 6.4 Door Usage Practices

The analysis of door usage practices in this case study reveals notable patterns regarding the simultaneous use of doors and windows, door usability, and the habits that influence inhabitants' door usage practices.

#### 6.4.1 Habits of the Inhabitants and Adaptability

A significant point found from the analysis is that ground floor households (eight out of 16 households) have a habit of using the entrance doors and windows simultaneously during summer to manage thermal discomfort. For example, R3 noted:

*“Do you discuss with each other when you need to use ventilation in your home?”  
(MT, researcher)*

*“And what do you mean by ventilation? Do you mean having the window open?” (R3,  
age 51-70, female, lives on the ground floor)*

*“Yeah. For example, windows, doors.” (MT)*

*“No, not really. We both have the bedroom window open. Sometimes in the summer,  
when it is very hot, we might have the door open.” (R3)*

As R3 mentioned, when the temperature is high, they use both windows and doors together for natural ventilation. Similar examples from other households (R17 and R22) are presented below. These highlight the need for additional ventilation control to improve air circulation within the homes, as they tend to get very warm. This was also noted in Section 6.3.6, where inhabitants described purchasing alternative equipment (e.g., portable air conditioning units) due to their homes becoming very warm. Additionally, this practice demonstrates a form of adaptability, where inhabitants use the available features of the home to maintain comfort despite inadequate ventilation systems. However, this reliance on using both doors and windows to increase the natural ventilation poses potential security risks, as R7 remarked:

*“Do you use your doors and windows together to increase the ventilation in your  
home?” (MT, researcher)*

*“No, we do not use the door. When we are in, the door is always shut because it is  
down at the bottom the stairs. So that is not something we [do] keep the door open  
to get ventilation.” (R7, age 51-70, male, lives on the first floor)*

R7's statement shows that they typically do not open the doors and windows simultaneously for cross-ventilation because the doors are located downstairs, raising security concerns. This underscores that spatial configurations significantly affect the capacity for long-term resilience, particularly in first-floor flats and semi-detached homes, as described by R25:

*"Do you use your doors and windows together to increase the ventilation in your home?" (MT, researcher)*

*"Okay. When I am cooking and the smell is overwhelming, I open the kitchen windows and doors just to let the smell out for a short period. But generally, no." (R25, age 30-50, female, lives in the semi-detached home)*

Thus, this reliance on opening the doors for a long period of time poses potential security risks that undermine the ability to continue these practices in the long term.

#### 6.4.2 Demographic-Specific Needs

A key finding from the analysis shows that inhabitants who consistently use trickle vents (24/7) also keep their windows and doors open during the day in the summer. The demographic data of these inhabitants reveal that they are all over 50 years old and spend most of their time at home. This is supported by the statement from R17:

*"Do you also use them [trickle vents]?" (MT, researcher)*

*"Yes. In summer I leave the trickle vents open all the time, day and night, when it is warm to let the fresh air in." (R17, age over 70, female, lives on the ground floor)*

*"Do you also use the doors and windows together?" (MT)*

*"Yes. Yes, I do. In summer." (R17)*

These inhabitants who spend most of their time at home adapt their indoor environments by maximising air circulation. Another example from R22 noted:

*"Do you use the doors and windows together to increase the ventilation in your home?" (MT, researcher)*

*“Yeah, yeah, I do. In summer I do, yeah.” (R22, age over 70, female, lives on the ground floor)*

*“Are you aware of the trickle vents, on top of the window?” (MT)*

*“Are the openings?” (R22)*

*“Yeah.” (MT)*

*“For the ventilation? Yeah, I have them open.” (R22)*

These behaviours highlight the need for adaptive ventilation systems that support demographic-specific needs that respond to temperature or air quality changes. Additionally, cooking and its relation to ventilation practices were often mentioned during the inhabitant interviews. The inhabitants’ cooking habits affect their door use practices. For example, in the interview with R24:

*“Do you use doors and windows together in summer when you cook, to increase the ventilation?” (MT, researcher)*

*“Kitchen window is open 24/7 in summer and that door is usually open. I do not use that fan [extract fan] in the kitchen, it is useless. I mean, we have got a visitor recently and I did some steaks, so I put the fan on. Smoke alarm went off. So, what is the point? There is no point in that. Absolutely useless.” (R24, age 51-70, female, lives on the ground floor)*

As noted by R24, when cooking, they open the windows, doors and trickle vents to enhance air circulation and eliminate cooking smells. This indicates redundancy in kitchen ventilation, as the inhabitants can use windows and trickle vents alongside doors. However, this redundancy also suggests a lack of effectiveness of existing ventilation systems, such as extract fans, that forces inhabitants to layer practices to achieve their wants.

To summarise this section, the analysis highlights how inhabitants adapt door usage practices to manage ventilation, how the location of their flats affects their door usage practices, older inhabitants’ door usage practices, and how having redundancy indicates inefficiency in the existing systems.

## 6.5 Extract Fan Use Practices

The analysis of extract fan usage in this case study uncovers significant aspects that emphasise both systemic and practical shortcomings in ventilation practices and infrastructure. This case study has MEV systems that serve as the primary ventilation system. The kitchen and bathroom are equipped with mechanical extract fans that run continuously. Additionally, there is a kitchen boost switch, a ventilation control device that allows the extract fan to operate for an extended duration, providing extra air circulation when needed, such as during and after cooking. Although extract fans are designed to help maintain indoor air quality, their reported inefficiencies raise significant concerns regarding design, implementation and user engagement.

### 6.5.1 Inefficiency of Extract Fans and Reliance on Windows

A key highlight from the analysis is that a majority of households (10 out of 16 households) perceive extract fans as inadequate for ventilation without using additional measures, such as opening windows. An example comes from the interview with R14:

*“Are you aware of the extract fans in your home?” (MT, researcher)*

*“Yeah. We use it, yeah. Especially when we are cooking, we use it. But it is not very good.” (R14, age 51-70, male, lives on the ground floor)*

*“[...] do you think they work well? For example, when you cook something, do you open windows?” (MT)*

*“Yeah, we open the windows. Because the extractor fan does not make any difference when you are cooking. So, it is just basically better to open the window and that is more effective than the extractor fan.” (R14)*

R14’s statement highlights that they use the extract fan; however, it does not make a significant difference, so they also use their windows for ventilation. Similarly, many other inhabitants expressed dissatisfaction with the performance of kitchen extract fans, particularly while cooking. For instance, in the interview with R3:

*“In the winter, for example, when you cook, is your extract fan enough for you to ventilate your home?” (MT, researcher)*

*“No, I would not think so. Not really. I would open a window if it is really smelly. Like if it was fish, for example.” (R3, age 51-70, female, lives on the ground floor)*

Since the extract fans are insufficient for the majority of the households, many inhabitants use their windows as an alternative to enhance the air circulation while cooking. Even in winter, they open their windows during cooking, despite most households (13 out of 16 households) reporting they did not often do so in winter. For instance:

*“Are you aware of the extract fans in your kitchen and bathroom?” (MT, researcher)*

*“Yes. I maybe of [have] used the one in the bathroom maybe once because I usually like to open the door and the windows to let the steam out. And the one in the kitchen I have used, because obviously for cooking and I open it. And I do love cooking in winter and I do open the windows in winter when I am cooking. But sometimes if it is something that really does smell then on that occasion, I have used it. Or if it is something burnt, I use it.” (R6, age 51-70, female, lives on the first floor)*

Some inhabitants also mentioned they have mould and damp in their homes. For example, R14 noted:

*“Ventilation is a bit hit and miss. We have a lot of mould on the windowsills, in the bedrooms and in the living room as well.” (R14)*

Inadequate ventilation raises CO<sub>2</sub> concentration levels and relative humidity, leading to mould and damp in homes (Fan *et al.*, 2023), as evidenced in R14’s statement. A similar issue is mentioned by R24:

*“We just got a bit of a problem with the damp. We have been here for six years. First two years we never had damp in our little bedroom, and all of a sudden it come. [...] These fans that were all up there [extract fans] and the one in [the] bathroom are a waste of time. So when we shower or bath, we open the bathroom window. We have got damp, you know in the ceiling and the bottom of [the] bathroom window, that*

*will not come off. I have got damp in the corners of kitchen windows; they will not come off.” (R24, age 51-70, female, lives on the ground floor)*

R24’s statement highlighted their reliance on kitchen windows to remove cooking odours and ventilate the room, due to the extract fan’s inefficiency. R14 and R24 explained that they often open windows to enhance air circulation in their homes; however, these adaptive practices are inadequate, resulting in the growth of mould and damp from poor ventilation. Similarly, R25 also remarked:

*“Do you have extractor fans in your home?” (MT, researcher)*

*“Yeah. We have an extractor fan in kitchen and bathroom. We also have a cooker hood with an extractor.” (R25, age 30-50, female, lives in the semi-detached home)*

*“Yeah. And do you think they work well?” (MT)*

*“No, I think they are useless. Even when the extract fans are on, I have to use the windows and door to get rid of the cooking smell. They [extract fans] do not do it much.” (R25)*

Despite having extract fans and cooker hood extractors, inhabitants like R25 reported that they still need to use windows for ventilation because the fans do not function efficiently. This practice occurs even during winter, as noted by R6 above, revealing that the extract fans do not adequately fulfil their ventilation needs. Although opening windows provides immediate airflow, this practice impacts energy efficiency, particularly in the colder months, as the inhabitants open windows despite concerns about heat loss. This behaviour highlights a gap between the intended functionality of ventilation systems and their actual usability.

#### 6.5.2 Limited Engagement with Extract Fans and Institutionalised Knowledge

None of the households reported discussions among the inhabitants about when to use the extract fans (see Figure 6.8), and most inhabitants indicated that they do not take charge of using them (see Figure 6.9). This lack of engagement within the households with the extract fans is because the extract fans are designed to operate both automatically and manually; however, the inhabitants lack confidence in their effectiveness. Many inhabitants stated (see

statements from R3, R6, R14, R24 and R25 above) that using extract fans does not make a noticeable difference, prompting them to rely on windows instead.

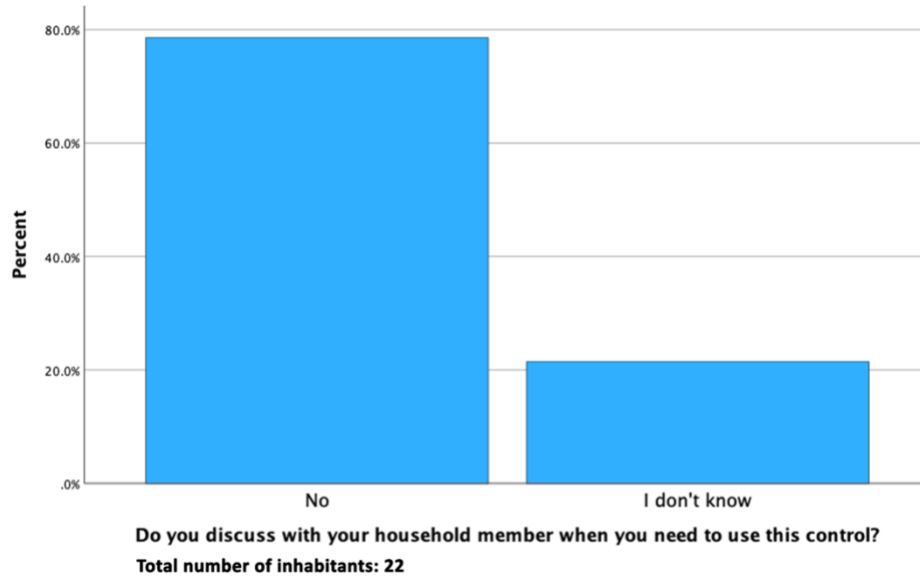


Figure 6.8 The percentage of inhabitants who discuss with other household members when they need to use the extract fans

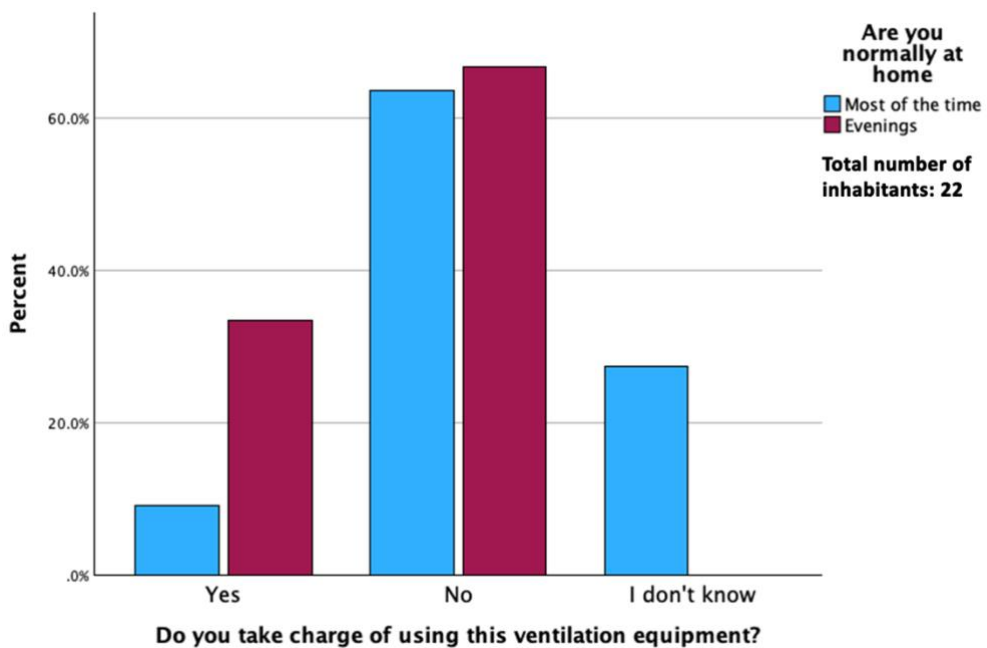


Figure 6.9 The percentage of inhabitants who take charge of the extract fans in relation to their presence at home

This limited engagement can also be linked to a broader lack of institutionalised knowledge regarding the benefits and proper usage of ventilation systems. Interaction with windows is highlighted as one of the ‘sophisticated behaviours’ that significantly influence building energy performance, and inhabitants prefer to manually control their windows (Park, An and Jeong, 2023). This suggests that the inhabitants use the windows instead of the extract fans because they feel more confident using the windows, as this knowledge is institutionalised for the majority of them. For instance, R15 noted:

*“There is the little extractor fan in the ceiling, the little square things. I try to remember turning them on, but I do not always remember.” (R15, age 30-50, female, lives on the first floor)*

*“And do you think the extract fans work well?” (MT, researcher)*

*“No, did not seem to do a lot.” (R15)*

R15’s statement emphasises her awareness of the extract fans, but she does not consistently remember to use them since this control has not yet become internalised enough to influence her ventilation practices. This preference for windows indicates a familiar reliance on manual solutions, suggesting that technological interventions have not successfully integrated into the habitual practices of the inhabitants.

### 6.5.3 Factors that Influence Extract Fan Usage Practices

Age, accessibility and ventilation levels are the factors that influence extract fan usage. Older inhabitants, particularly those over 70, feel the cold easily, as shown in this interview with R17:

*“When you open it [extract fan] do you think they work well?” (MT, researcher)*

*“Oh yes. Yeah. I mean I tried the extractor fan in the bathroom. And when I shower it led me to shiver, so that is why I do not use it and I prefer to open the window instead.” (R17, age over 70, female, lives on the ground floor)*

Similarly, R4 who is over 70 noted:

*“There is one extract fan in [the] bathroom. But we do not use them. Because we have [the] window open.” (R4, age over 70, female, lives on the ground floor)*

R4’s and R17’s statements highlighted that the inhabitants over 70 prefer using windows to extract fans to ventilate their bathrooms. This finding can also be related to the lack of institutionalised knowledge about extract fans and the more ingrained habit of window use, as discussed in Section 6.5.2. In contrast, inhabitants under 70 tend to use both extract fans and windows to let the steam out and bring fresh air into the bathroom. For instance, R9 stated:

*“For example, when you shower in the bathroom, do you need to open a window or is the extract fan enough?” (MT, researcher)*

*“Yeah, we got the extractor fan, but we also open the windows. You know, it is sufficient to keep the steam out.” (R9, age 51-70, male, lives on the first floor)*

R9, whose household is a family of three, reported using both extract fans and windows as a combined strategy to increase air circulation in their home. Similarly, R25, living in a family of four, opens windows when the extract fan is on during cooking to increase the airflow in the room (refer to Section 6.5.1 for R25’s statement). Therefore, inadequate ventilation in the homes influences inhabitants’ preferences regarding the use of additional ventilation controls (e.g., during cooking and showering).

In households with no windows in the bathrooms (e.g., those of R11 and R14), the only option for the inhabitants is using the extract fan, yet R14 reported severe issues with mould due to poor ventilation (refer to Section 6.5.1 for R14’s statement). For example, R14 mentioned he tried to fix this situation himself and noted:

*“We have a lot of mould on the windowsills, in the bedrooms and in the living room as well. When we first moved in, the builder said when you settle down, then it [mould] will go back to normal. But it never had. So, I bought two things on Amazon, dehumidifiers I think they are called. So, it sucks all the moist air to prevent mould. It works a bit, but helps reducing mould. It sucks the humid air.” (R14, age 51-70, male, lives on the ground floor)*

This raises significant concerns regarding the usability of extract fans in this case study and the lack of redundancy in the ventilation system, which impacts the inhabitants living in poorly ventilated homes. Issues like condensation, mould and poor air quality indicate systemic failures in housing design and maintenance that directly impact the physical health of inhabitants (Roh *et al.*, 2021). These problems have serious effects on inhabitants' health, and as many of the case study participants stay at home most of the time, they may be more affected by poor indoor air quality.

Accessibility is another factor that plays a crucial role in how inhabitants use extract fans. Many inhabitants, particularly older adults (over 50), find it challenging to use extract fans because of their placement or design. This often requires additional equipment, such as ladders, which can pose significant health risks, or relying on help from other household members. For example, R18 noted:

*“The only thing that is wrong with this place is, you know, the fans [extract fans] in the bathroom. You know, the extractor fan. It is seven-foot high. It is seven-foot high. It is right up near the roof. So, I have to get a chair to put it on. Or, I have to wait for my husband to turn it on. (R18, age 51–70, female, lives on the first floor)*

This underscores a gap between the physical design of ventilation systems and the actual usage of these controls. As a result, when the inhabitants find it difficult to use the extract fans, they adapt to this situation by using alternatives like windows (refer to statements of R4, R9, R17 and R24 about using windows). The reliance on alternative methods emphasises the critical need for improved and accessible ventilation systems in this case study.

To summarise Section 6.5, the analysis underscores a significant need for improvements in the design, maintenance and user integration of extract fans. The reliance on windows as a primary solution when the extract fans are not working efficiently reveals critical deficiencies in their functionality and accessibility. Additionally, the lack of inhabitant engagement indicates a disconnect between design intentions and the actual behaviours of inhabitants. The inhabitants' need for a combined approach to ventilation highlights the importance of redundancy to continue their ventilation practices, but also the insufficiency of current systems to meet these needs effectively.

## 6.6 Summary

As in the chapter about heating practices, this chapter examined ventilation practices from two different perspectives, those of the inhabitants and the design team. The ventilation practices were analysed based on the specific ventilation controls within the inhabitants' homes: windows (trickle vents were included in this section), doors, and extract fans. These specific ventilation practices of inhabitants were critically analysed in terms of the key themes that appeared during the analysis.

The findings show that the design team understand resilience as a multifaceted concept, focusing on climate-resilient homes, lifetime homes and adaptability to social changes. These priorities shape their design intentions for social housing, which needs to be functional and adaptable over time. However, challenges remain, especially in engaging inhabitants, enhancing maintenance accessibility, and anticipating societal shifts.

The findings about window use practices reveal that these practices are shaped by seasonal changes, household dynamics, individual health needs, and awareness of trickle vents. These challenges highlight the necessity for better communication of design intentions, enhanced inhabitant knowledge, and improved maintenance support to align with actual practices. Likewise, door usage practices reflect the adaptability of inhabitants, and are influenced by factors such as flat location, and age-specific strategies, while revealing inefficiencies in the existing ventilation system. The analysis of extract fan usage shows inefficiencies in performance and a reliance on windows as a means for inhabitants to maintain their practices. Additionally, limited inhabitant engagement indicates a gap between design intentions and user behaviours.

Overall, this chapter highlighted the necessity for a more integrated design approach that prioritises inhabitant engagement, practical usability, and additional alternatives to support resilient housing practices.

## CHAPTER 7. DISCUSSION

### 7.1 Introduction

In this chapter, the findings and analysis are discussed by linking the resilience indicators and practice theory elements together. The similarities and differences between data from the design team and the inhabitants are discussed by looking at two aspects of Gram Hanssen's (2010) practice theory: institutionalised knowledge and rules, and technologies. All four aspects of practice theory are discussed by linking with the inhabitants' data. This chapter aims to answer Research Question 4, to identify key insights to develop a new understanding of social housing resilience in relation to inhabitants' practices.

### 7.2 Resilience and Practice Theory Framework

In this research, practice theory is used to understand the inhabitants' energy-related practices and 'how' and 'why' their practices change/stay the same depending on social change. Practices are forms of doings and sayings that are held together across time and space by different elements such as habits, rules, meanings and understandings (Gram-Hanssen, 2010a, 2021). A practice is a pattern that needs regular 'performance', such as replacing windows during home renovation (Bartiaux *et al.*, 2014), which is a common practice even if done only once in a homeowner's lifetime. Researchers like Shove (2010) and Gram-Hanssen (2021) suggest that social practice theories are useful for raising policy issues and recommending new policies within the sustainability agenda (Bartiaux *et al.*, 2014). Thus, using the practice theory approach to understand 'how' and 'why' the inhabitants' energy-related practices change in terms of social resilience is a promising approach for raising new policy recommendations within the sustainability agenda.

In order to evaluate resilience within the social housing case study using a practice theory approach, a resilience matrix was designed by the researcher to help prepare the semi-structured interview questions. In this section, the discussion is framed according to this matrix (see Table 4.7), linking Gram-Hanssen's four practice theory elements developed as an analytical tool with robustness, adaptation and redundancy as resilience drivers. Table 7.1 presents the latest form of the resilience matrix, developed by the researcher after the data analysis, and highlights key findings from the data analysis.

<b>Resilience Indicators / Practice Theory Elements</b>	<b>Robustness</b> <i>(The ability of the home to carry on performing despite social changes)</i>	<b>Redundancy</b> <i>(The ability of different things to satisfy the same function)</i>	<b>Adaptation</b> <i>(Adjustment to reduce the impacts of social changes)</i>	<b>Physical Factors That Need to Be Considered in Social Housing</b>
<b>Know-how and Embodied Habits</b>	<ul style="list-style-type: none"> <li>▪ The importance of the heating and ventilation controls working sufficiently for inhabitants</li> <li>▪ Building lifetime homes where the inhabitants can live despite social changes</li> <li>▪ Usability problems related to age and accessibility</li> </ul>	<ul style="list-style-type: none"> <li>▪ Inhabitants have personal alternatives for heating system, rather than those provided by housing association</li> <li>▪ Inhabitants use windows and extract fans together when they are cooking</li> <li>▪ Inhabitants who are aware of trickle vents use them continuously</li> </ul>	<ul style="list-style-type: none"> <li>▪ Having flexible spaces and a standard form of adaptability</li> <li>▪ The importance of inhabitants having a practical understanding and implementing their understanding in their practices</li> </ul>	
<b>Institutionalised Knowledge and Rules</b>	<ul style="list-style-type: none"> <li>▪ Lack of awareness of the policy: Approved Document O: ‘Overheating’ (HM Government, 2021a)</li> <li>▪ Well-insulated homes aligning with the building regulations</li> <li>▪ Social housing association did not think about the social change in this case study, because this kind of extreme event (pandemic) had not happened before</li> <li>▪ Cost-efficiency considerations in social housing solutions</li> </ul>	<ul style="list-style-type: none"> <li>▪ The housing typologies with the bathrooms lacking windows need efficient extract fans</li> <li>▪ Not using the specific ventilation controls as intended (e.g., trickle vents) and inefficient controls (e.g., extract fans) lead to mould and condensation problems</li> </ul>	<ul style="list-style-type: none"> <li>▪ Inhabitants’ window use practices during heatwaves need to be adapted</li> <li>▪ Inhabitants must be aware of the overheating policy</li> <li>▪ Social housing associations need to inform inhabitants about the change in the home user guide</li> </ul>	<ul style="list-style-type: none"> <li>▪ Size of the home</li> <li>▪ Systems in the home: Heating and ventilation.</li> </ul>
<b>Engagements</b>	<ul style="list-style-type: none"> <li>▪ The inhabitants who take charge of the heating controls are the ones who feel confident using it and who have the practical knowledge</li> <li>▪ Discussions arise concerning the use of extract fans in the bathrooms, particularly for those with accessibility problems</li> </ul>	<ul style="list-style-type: none"> <li>▪ Heating system alternatives from inhabitants: electric fan heater, kettle, electric fire heater</li> <li>▪ Ventilation system alternatives from inhabitants: dehumidifier, portable air conditioning unit</li> </ul>	<ul style="list-style-type: none"> <li>▪ Inhabitants engage in discussions when they perceive their use of energy-related controls affects home energy consumption</li> <li>▪ Inhabitants do not discuss using windows and doors, unless for cross-ventilation</li> </ul>	
<b>Technologies</b>	<ul style="list-style-type: none"> <li>▪ The importance of the heating and ventilation controls working sufficiently and as intended in the design</li> <li>▪ Breaking the learning curve of new</li> </ul>	<ul style="list-style-type: none"> <li>▪ There is a need for redundancy in system failures, such as power failures, particularly renewable backup systems</li> </ul>	<ul style="list-style-type: none"> <li>▪ Inhabitants’ struggle with technology-related aspects of energy controls</li> <li>▪ Adapting to new technologies and</li> </ul>	<ul style="list-style-type: none"> <li>▪ MEV</li> <li>▪ Windows</li> <li>▪ Boiler</li> <li>▪ Heat pumps</li> </ul>

	<p>technologies could be difficult for inhabitants without any guidance</p> <ul style="list-style-type: none"> <li>▪ Usability problems related to the difficulties with technology and design intentions</li> </ul>	<ul style="list-style-type: none"> <li>▪ Cost-efficient sustainable materials and equipment within the design</li> </ul>	<p>introducing a new way of practice could be difficult without collaboration</p>	<ul style="list-style-type: none"> <li>▪ Glazing</li> <li>▪ PV systems</li> <li>▪ Solar controls</li> </ul>
--	--	--	---	---

Table 7.1 Resilience matrix with the key findings after data analysis

As defined in Section 2.4.1, robustness in this research is defined as the ability of home systems (heating and ventilation) to continue functioning despite shocks and social changes. Shocks in this research refer to extreme events, such as the Covid-19 pandemic and the energy crisis. Social change here refers to inhabitant discussions on practices, shifts in occupancy patterns, household demographics, and housing typologies. These were explored and analysed by asking the inhabitants how they discuss their energy-related practices in the home (e.g., opening windows). To further understand how adaptable the home is in terms of social changes, household compositions and inhabitants' discussions on practices were explored and analysed using semi-structured interviews and a usability questionnaire. Redundancy was explored and explained by analysing changing occupancy and the availability of multiple means of carrying out same energy-related function. These three drivers of resilience come together as a new definition of resilience in this thesis and highlighted as 'the ability of the home to carry on performing by using alternative options to maintain the preferred state and adjustments to reduce the impacts, even if there is social change over time.'

### 7.2.1 Reflection on the Framework and Its Relation to the Findings

Integrating resilience with practice theory has provided a comprehensive understanding of heating and ventilation practices. The framework highlighted inhabitants' embedded routines, the practices they have yet to internalise, and their ability to adapt in response to external factors. Practice theory helped uncover the energy-use habits, the role of technology (e.g., thermostatic radiator valves, heating programmers), social norms and engagements in shaping practices (Gram-Hanssen, 2021). Meanwhile, the aspects of resilience highlighted how these energy-related practices are adapted, maintained or disrupted in the face of shocks like Covid-19, the energy crisis or system failures. This combined approach was particularly useful in the social housing context, where external influences like social changes, policy shifts, economic challenges and global crises constantly alter daily routines. The resilience dimension highlighted how inhabitants adapt their heating and ventilation practices in response to these external influences – whether by adapting room thermostat use, exploring alternative heating options, or engaging with design initiatives such as home user guides. This framework provided a common language for the actors (e.g., design team and inhabitants), a structured representation of energy-related practices that can be examined individually or collectively through different research methods, and a model for integrating these findings cohesively.

Furthermore, this approach addressed a critical gap in practice-based research. While socio-technical studies and practice theory often examine how material infrastructures and social norms influence energy use, they tend to overlook the resilience dimension, specifically how systems and practices withstand, adapt or fail in response to external factors (Gram-Hanssen, 2021; Abbas and Michael, 2023). By integrating resilience thinking, this study underscored the necessity for heating and ventilation systems that are not only efficient and well-integrated into daily routines, but also adaptable, accessible and responsive to inhabitants. This insight is particularly important for informing the design of future energy systems in social housing, ensuring they support long-term housing resilience for the inhabitants.

By using this framework, this Sheffield-based study and findings can be extended to nationwide practices. For example, the resilience matrix can be used by social housing

associations in various regions to determine whether their inhabitants also have similar energy-related practices, or if their practices change depending on their locations. Furthermore, it would be interesting to explore how different housing associations are considering resilience in their designs. The questions from Table 4.7 can be used by social housing associations nationwide, potentially highlighting the similarities and differences in their understanding of resilient housing design. Additionally, understanding how inhabitants' practices evolve, progress and continue in different locations can be valuable for understanding the varying responses of housing associations to inhabitants' practices (Gram-Hanssen, 2010; Shove, Pantzar and Watson, 2012).

Figure 7.1 illustrates this integrated framework, demonstrating that the resilience of homes can be studied by examining the interconnections between resilience drivers (robustness, adaptation, redundancy), energy-related practices (heating and ventilation), and perspectives of key stakeholders (project director, project coordinator, architect). This framework also accounts for how external factors (e.g., Covid-19, the energy crisis, housing policies, extreme weather events, social changes and power outages) affect these interrelationships. This framework offers a way to analyse inhabitants' practices not just as socially and materially embedded routines, but as flexible and adaptive responses to changing conditions.

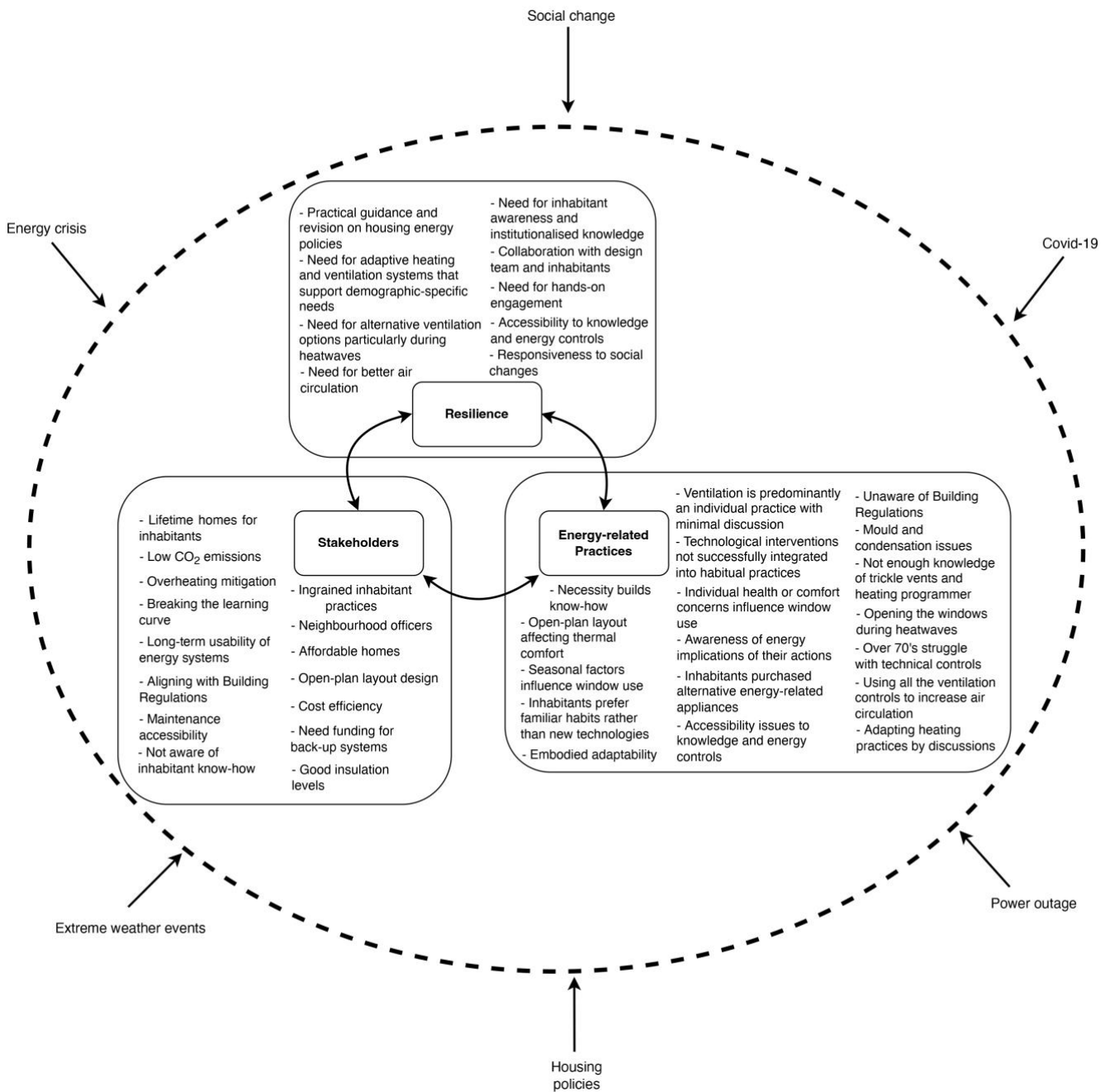


Figure 7.1 Resilience and practice theory framework diagram (adapted from Figure 2.4)

## 7.2.2 Know-how and Embodied Habits, and Their Nexus with Robustness, Adaptation and Redundancy

Schatzki's (1997) interpretation of the individual supports the fact that heating and ventilation practices are guided by something that makes sense to the individual. In the selected case study of social housing, the heating and ventilation systems are similar across households; while technology influences habits and routines for heating and ventilating the home, inhabitant (individual) interpretation also plays a significant role. Know-how and embodied habits are key elements of what constitutes a practice, including the skills inhabitants already have and the routines they undertake without conscious reflection (Gram-Hanssen, 2010; Bartiaux *et al.*, 2014).

The design team view climate change as a key factor in developing resilience strategies. Their emphasis on energy efficiency and indoor thermal comfort aligns with Sheffield City Council's goals for 2030, specifically their aim to reduce heating costs in social housing (Sheffield City Council, 2024). This approach underscores the design team's emphasis on climate adaptation; however, it primarily addresses resilience through an environmental lens rather than a holistic framework that also accounts for inhabitant behaviour. While the Building Regulations Part F does not require MEV systems in all new homes in the UK, they are a common and increasingly recommended solution alongside natural ventilation strategies (HM Government, 2021). However, their effectiveness is contingent on proper use and maintenance in areas where inhabitants may require more structured support.

Furthermore, the design team's goals are based on the assumption that inhabitants will use heating and ventilation controls as intended. These systems are deeply embedded in UK norms, yet the findings indicate that familiarity does not ensure active engagement. Looking from a practice theory perspective, the familiar energy systems and their institutionalised rules alone cannot explain inhabitants' actions without practical understandings and shared skills (Schatzki, Knorr-Cetina and Savigny, 2001). When the design team introduce a new practice or a new technology, they think of it as a 'learning curve' and in this way they make the inhabitants break their previous habits. Reflecting on practice theory, embodied habits are routinised practices of inhabitants; however, inhabitants need to know how to perform these practices by having the necessary skills (Gram-Hanssen, 2014; Shove, Watson and

Spurling, 2015). The design team assume that providing technical instructions will ensure correct usage, but actual usage relies on the inhabitants' understanding and engagement. This disconnect highlights a gap in knowledge between the inhabitants and the energy-related controls; while technical information is accessible, it does not integrate into inhabitants' practices. This is particularly evident among those over 70, who struggle to use the energy controls due to a lack of familiarity with digital interfaces. Thus, it is not easy for them to break their embodied habits, accept change, learn new technologies, and adapt their practices. Consequently, usability challenges prevent the integration of energy systems into inhabitants' daily routines, revealing a critical gap in resilience and know-how. The findings indicate a disconnect between inhabitants' ingrained habits and know-how and the design intentions, highlighting the need for a more user-centred approach to resilient housing.

The pandemic increased home occupancy, reinforcing embodied habits related to thermal comfort, especially among inhabitants over 50 who became more sensitive to indoor temperatures after recovering from the virus. Similarly, the energy crisis necessitated financial adjustments, leading to adaptations in heating behaviours, such as adopting time-based habits (refer to R25's statement in Section 5.4.2). In line with Gram-Hanssen's (2010) study about standby energy consumption, some of the inhabitants in this case study also mentioned that they reduce energy consumption in their homes by not leaving their energy-related controls on standby. In the UK, home energy use fell by 14% in 2022 and continued to decrease in 2023 due to new energy efficiency measures and households reducing their 'non-essential' energy use (Bolton, 2024). By comparison, the findings suggest that while reducing non-essential energy use, the inhabitants also reduced their essential spending on energy through reduced use of heating by wearing thicker clothes instead. The need to balance financial limitations with thermal comfort highlights how external pressures influence engagement with heating systems, revealing the interaction between resilience, know-how and socio-technical interactions.

Window usage practices further demonstrate the connection between know-how, engagement and resilience. Seasonal factors, household dynamics, and health needs affect ventilation habits, with inhabitants adapting their practices based on their implicit knowledge of thermal comfort. However, climate change is altering these embodied habits.

The UK Health Security Agency (2024) recommends closing windows during heatwaves, except when it is cooler outdoors. Effective window use, such as keeping the windows closed from 11am to 3pm during heatwaves, can affect indoor air quality and ventilation levels, contradicting ingrained habits of ventilation. In contrast, the findings reveal that inhabitants are largely unaware of the need to keep windows closed while the temperature is extremely high. This habit of opening windows during heatwaves, without being aware of potential risks, highlights the necessity for improved communication regarding ventilation practices. Reflecting on the practice theory perspective, a lack of awareness regarding the institutionalised knowledge about window opening prevents inhabitants from altering their habits during a heatwave (Gram-Hanssen, 2010). This, in turn, affects the indoor air quality, leaving the inhabitants unaware of the consequences of their actions. This underscores the need to convert expert guidance into accessible, actionable knowledge for inhabitants. This might also lead to a 'collective know-how' where the inhabitants perform their energy-related practices differently after they learn about the changing conditions or after being advised by another household member or the neighbourhood officer.

The responsibility for using windows and room thermostats often falls to the inhabitants who spend the most time at home. Rather than merely consulting instructions, they gain understanding by adjusting settings, feeling temperature changes, and adapting to external conditions. Over time, this repeated engagement leads to embodied habits, where actions become ingrained in practices. Gram-Hanssen (2008) highlights that household routines can change and shape the use of everyday technologies. Consequently, the use of windows and room thermostats becomes integrated into the routines of those who are home more, shaping their know-how over time. In contrast, those who are present less may not engage with or adapt to changes in temperature and airflow, limiting their exposure to these practices (Larsen and Gram-Hanssen, 2020). As a result, responsibility tends to consolidate among those with more experience and confidence within the household. This points out how necessity builds a form of know-how, builds confidence, and puts the inhabitant with the know-how in charge.

The next section focuses on institutionalised knowledge and rules, and discusses how policies might affect the home's functioning and how this relates to inhabitants' energy-related practices in relation to resilience.

### 7.2.3 Institutionalised Knowledge and Rules, and Their Nexus with Robustness, Adaptation and Redundancy

Examining the energy-related practices of inhabitants reveals that households who are aware of the trickle vents keep them open for fresh air, especially after cooking. This ventilation practice aligns with the current policy on ventilation, as explained in Section 2.7. The requirement that the inhabitants must follow is to keep the background ventilation (e.g., trickle vents) open for continuous ventilation within the home (HM Government, 2021b). Thus, we see that the inhabitants who are aware of the trickle vents follow this regulation, but those who are unaware of the trickle vents leave them closed, so they do not comply with this requirement. Therefore, it is challenging for some inhabitants to understand and follow the guidance according to this research. Reflecting on the practice theory perspective, know-how in performing energy-related practices is something that inhabitants learn (Larsen and Gram-Hanssen, 2020). Therefore, inhabitants who are aware of trickle vents and their role in ventilation are more likely to integrate their use into daily routines, especially after activities like cooking. Their practice aligns with policy expectations, demonstrating how institutionalised knowledge (e.g., building regulations) can translate into embodied practices. However, those unaware of trickle vents do not engage with them, so the vents remain closed and ventilation regulations are unknowingly disregarded. This significant point highlights that awareness and then know-how are prerequisites of effective utilisation and therefore of resilience.

During a heatwave, the UK Health Security Agency (2024) advises keeping windows closed unless the outdoor temperature is cooler than the indoor environment temperature. The building regulations set out by HM Government (2021a) state that home user guides should include a section that tells inhabitants how to stay cool in hot weather in a very clear and non-technical way (refer to Section 2.7). However, the document review conducted by the researcher found that the home user guide did not include this section because the housing development was built in 2016, which was before this section within the regulations came into effect in 2022. Consequently, inhabitants are unaware of this guidance and do not have this specific institutionalised knowledge. Therefore, rather than following the UK Health Security Agency's advice to keep windows closed during heatwaves, inhabitants continue their existing habit of opening windows to increase ventilation (refer to Section 7.2.2). This

reflects a broader theme in practice theory, where inhabitants do what is familiar and embodied, and they often perform these actions unconsciously (Gram-Hanssen, 2014). Therefore, if inhabitants are unaware of new overheating strategies (e.g., keeping windows closed during extreme heat), they are unlikely to change their practices without explicit intervention. This point highlights that inhabitants do not simply follow institutional rules automatically; rather, they must engage with new knowledge through practice, social interaction and technological experiences.

When comparing housing typologies, some of the homes do not have windows in their bathroom (e.g., H9) and the only options to ventilate this wet room are using extract fans or keeping doors open during and after using the shower. However, the data analysis in Section 6.3.1 reveals that most inhabitants find extract fans inefficient in increasing the air flow in their bathroom, making it challenging for homes without bathroom windows. Consequently, the housing typologies without windows in their bathrooms are not robust, as their bathroom ventilation systems do not perform as designed due to the lack of windows and inefficiency of extract fans. This problem is also related to the design team, and highlights their unawareness of the challenges that inhabitants face in terms of their ventilation controls. Therefore, the disconnect between maintenance practitioners and inhabitants hinders effective ventilation practices and, in turn, know-how (Brierley, 2021). If these options do not work well, they will affect the air quality of the room and inhabitants' health, according to National Institute for Health and Care Excellence (2020). In this regard, having an extract fan that works efficiently is crucial for the air quality of wet rooms without openable windows. This is supported by the policy context explained in Section 2.7, which states extract fans should continue to ventilate for at least 15 minutes after the room is vacated (HM Government, 2021b). Resilience in this context is about having a ventilation control that performs well enough to be integrated into inhabitants' routines, otherwise inhabitants have to adapt their practices by using alternative equipment.

The analysis in Section 6.5.2 highlights that some inhabitants face accessibility issues when they need to use the ventilation equipment, such as the extract fans, and they have to wait for another household member to operate them. Resilient social housing is housing that can respond to social changes and extreme disruptions (Pablo, Littleton and London, 2024). In this regard, having accessible heating and ventilation controls is crucial because, if there is a

sudden social change such as a disability or the need to accommodate an elderly family member, the social housing needs to be robust and continue performing its energy-related functions. This requirement is supported by the Building Regulations Approved Document F (HM Government, 2021b) and explained in Section 2.7, which states background ventilation controls such as extract fans should be accessible and easy to reach. Both the design team and the inhabitants in this case study are confident in the design's ability to cope with sudden social changes, such as a sudden disability in the household. The design team considered Building Regulation Part M: 'Access to and use of buildings' (HM Government, 2016b) in their designs and implemented these standards in some of the flats in the social housing case study, accommodating adaptations to social changes like mobility issues or elderly relatives moving in. In addition, during Covid, the presence at home increased as household members started working and studying at home more, highlighting the need to plan for more flexible housing typologies with more flexible places for work or study and design features that provide more natural ventilation, as noted by the design team in the analysis, see Section 6.2.

The next section focuses on the engagements and interactions within the household members and their engagements with the heating and ventilation controls.

#### 7.2.4 Engagements and Their Nexus with Robustness, Adaptation and Redundancy

This study examines engagements among household members (e.g., discussions) and inhabitants' engagements with their energy-related controls (e.g., technologies). These discussions are seen as a behavioural factor in inhabitants' decisions about using their heating and ventilation systems (Steemers and Yun, 2009). In this study, social relations are taken into account as 'discussions' between inhabitants when deciding on their heating and ventilation practices, and how these reflect resilience.

In this case study, most inhabitants discuss with each other when deciding to use the heating controls. However, they do not engage in discussions when using the boiler due to the lack of knowledge about how to change the temperature, or how to fix it if it breaks down. The lack of discussion regarding boiler use points a gap in competences where inhabitants do not have the knowledge required to adjust or fix the boiler, making it an

individual rather than a collective practice (Shove, Pantzar and Watson, 2012). This aligns with practice theory's emphasis on the role of competences in shaping actions.

In contrast, the use of the room thermostat is a shared decision in most of the households that is made through discussions with each other, as indicated in Section 5.4.1. Additionally, this increase in communication reflects social change, as the inhabitants started to discuss the thermostat more when they tried to be more careful due to the energy crisis and concerns over energy bills. Some households (e.g., H9, H12, H13) have established a habitual practice of using the room thermostat to turn the heating on for short periods, showing that their engagement with it is structured around balancing comfort with financial constraints. This shared decision between the inhabitants can also be described as collaboration in practices, where inhabitants actively participate in decision-making, which is significant for the development of routines (Gram-Hanssen, 2008; Hammond, 2018). This finding suggests that room thermostats are embedded in everyday inhabitant habits, and discussions enable collective decision-making. Additionally, the increased frequency of discussions about heating during Covid-19 and the energy crisis highlights how external disruptions can reshape energy-related practices, revealing their adaptability in response to changing socio-economic conditions.

The discussion of ventilation controls highlights a recurring theme, which is the gap between intended functionality and actual engagement. Most inhabitants do not discuss with each other when they need to use the windows, trickle vents or extract fans; each household member does their own thing. Extract fans, for instance, are designed to operate automatically or manually, yet inhabitants lack confidence in their effectiveness because they do not work efficiently and do not significantly improve air circulation. As a result, the inhabitants prefer to open the windows, relying on familiar routines as a practical consciousness that can provide safety and comfort (Warde, 2005). This interaction with windows is highlighted as a sophisticated behaviour that significantly influences building energy performance (Park, An and Jeong, 2023). Older inhabitants (those over 70) exemplify this issue, as they prefer using windows over extract fans due to embodied habits, highlighting that technological interventions have not been successfully integrated into their habitual practices. This suggests that when the technological interventions are not

understandable or do not work efficiently, inhabitants tend not to use them and they are not reflected in their practical consciousness.

Discussions about and taking charge of the heating and ventilation controls are important aspects in this research for understanding whether the inhabitants communicate with each other and whether they adapt their actions as a result of household discussions, reflecting resilience in relation to social change. The next section focuses on the relationship between technologies and inhabitants' energy-related practices, their understandings of the technologies, and how they implement or change their practices in relation to resilience.

#### 7.2.5 Technologies and Their Nexus with Robustness, Adaptation and Redundancy

In this study, technologies are considered as the products, things and controls, that often drive change and the emergence of new routines. As Gram-Hanssen (2008) argues, new technologies always demand changes in routines, and all of the technologies in our homes (such as washing machines, fridges, etc.) have gone through the phases of being new for the inhabitants before becoming embedded in daily life over time.

In this case study, the housing association employs neighbourhood officers who visit the homes multiple times a year to listen to the inhabitants' concerns or wants. This creates a form of a bridge between the inhabitants and the housing association. However, despite these visits, many inhabitants still struggle to use the energy-related controls, leading them to rely on established routines rather than adopting these systems. This reliance is particularly evident among older inhabitants (those over 70), who struggle with technical interfaces and instead continue their embodied habits, such as opening the windows rather than using extract fans. Similarly, those unfamiliar with the heating programmers prefer to use manual operation, which is an ingrained heating practice for the inhabitants. These ingrained habits can change or develop when inhabitants gain the necessary skills and are exposed to these practices (Heidenstrøm and Kvarnlöf, 2018; Larsen and Gram-Hanssen, 2020). From a practice theory perspective, these challenges underscore how know-how, technologies and embodied habits shape household energy practices (Gram-Hanssen, 2010). The unawareness of trickle vents, despite the availability of a home user guide, highlights that simply providing information is insufficient. Knowledge must be embedded into practice

through direct engagement and the acquired knowledge must be implemented through guidance. Thus, in this case study, more collaboration and engagement between the design team and the inhabitants is needed to improve the know-how and understanding of the technologies within the homes. This aligns with Andersen *et al.* (2022), who emphasise the importance of involving future users in new technological processes to ensure they can be incorporated successfully into household practices. Therefore, mere exposure to new technologies is insufficient; inhabitants need hands-on engagement and tailored guidance to understand and turn technical knowledge into practical know-how.

Alternative heating controls and their relation with know-how and embodied habits are significant when considering the number of 'things' (e.g., technologies) available for inhabitants' heating and ventilation practices if a specific control fails (Stevenson, Baborska-Narozny and Chatterton, 2016; Stevenson, 2019). Inhabitants adopt alternative methods to maintain comfort, particularly when systems fail or work inefficiently. This adaptive behaviour reflects a form of resilience, as inhabitants provide themselves solutions such as using kettles for hot water, portable heaters for space heating, dehumidifiers to remove excess moisture, or even leaving ovens open. Notably, the inhabitants who are under 70 tend to combine using both extract fans and windows to increase air circulation due to extract fans not working efficiently, demonstrating a more adaptive engagement with ventilation controls. The family with children also integrates multiple strategies to maintain air circulation and do not rely only on extract fans, reinforcing the notion that demographic factors influence how energy practices evolve.

The policy regarding overheating emphasises that before using any mechanical cooling system (e.g., portable air conditioning units), housing should meet the requirements through passive means of ventilation, such as windows and extract fans (HM Government, 2021a). However, the study highlights dissatisfaction with extract fans, leading some of the inhabitants to seek additional means of ventilation control to enhance air circulation, such as portable air conditioning units. Wright and Venskunas (2022) argue that using solar shading and natural ventilation systems will be required to reduce overheating considerably, as there will be a large increase in overheating by the 2080s due to climate change. The inhabitants' preference to not buy an air conditioning unit is often due to their economic

constraints and rising energy bills. In this regard, having effective alternative passive means of ventilation and properly working ventilation controls are crucial.

Additionally, redundancy is a key driver and a crucial factor for resilience (Stevenson, 2019). Some inhabitants expressed concerns about extreme situations like power failures during the energy crisis, particularly elderly inhabitants who rely on electricity for medical needs, or increased usage of energy-related systems due to increased occupancy levels. Given the increasing frequency of extreme events like the global energy crisis, pandemics and climate-change-related disruptions, the ability to maintain essential energy services is becoming crucial (International Energy Agency, 2022a). Stevenson, Baborska-Narozny and Chatterton (2016) emphasise that redundancy in housing design is essential to mitigate such risks. However, financial constraints often prevent housing associations from incorporating backup systems, as the design team mentioned, such as renewable energy generators. This highlights a conflict between economic limitations and the necessity for resilient housing design.

When the design team evaluated the estimated energy use of the housing, they did not estimate the potential energy consumption effects of extra equipment that the inhabitants might provide themselves if a system fails. According to National Energy Action (2023), supplementary heating equipment like fan heaters are among the highest electricity consuming appliances in the home. Thus, inhabitants using extra heating equipment will likely have a higher energy consumption than estimated by the design team. This links back to know-how and habits of inhabitants, because understanding how the energy-related systems work and implementing this learning process in their practices can impact energy use within their homes (Hansen, Gram-Hanssen and Knudsen, 2018). Proper knowledge could reduce the need for alternatives, but if issues are related to maintenance or power failure due to extreme events, institutional support is necessary to provide backup options.

The following section provides guidance on how to future-proof social housing based on the findings.

### 7.3 Future-proofing Social Housing

Future proofing in this context refers to ensuring that energy-related systems and social housing are robust, offer redundancy and are adaptable to allow maximum inhabitant engagement. As the study of Georgiadou, Hacking and Guthrie (2013) mentions, to minimise the need for future energy-saving actions, buildings should be ‘future-proofed’ by integrating durability, flexibility, technology-readiness and adaptability to changing inhabitant practices.

A crucial consideration when future-proofing social housing is how social and technological structures influence inhabitants’ daily practices and routines. It is also critical to understand how energy is used to carry out or change social practices (Pullinger, Lovell and Webb, 2014; Hansen, Gram-Hanssen and Knudsen, 2018). Social changes have reshaped heating and ventilation practices, with different age groups having varying energy-related practices, especially during extreme conditions such as the Covid-19 pandemic. Although this study was not initially designed to investigate extreme situations like Covid-19 and the concurrent energy crisis, these circumstances provided valuable insights into how future extreme situations might impact inhabitants’ energy practices.

Material arrangements, such as building characteristics and technologies, influence inhabitants to reconfigure their energy-related habits (Hansen, Gram-Hanssen and Knudsen, 2018; Shove, 2018). In this case study, various factors shape inhabitants’ habits, including housing typology and age. For instance, inhabitants over 70 who live on the ground floor tend to use their heating more frequently, as they often feel colder than those under 70 and because the ground-floor flats are generally colder than those on upper floors as cold air entering the doorway remains at lower levels and does not rise. Furthermore, those on the ground floor have different habits in their use of doors and heating systems compared with first-floor inhabitants. To improve resilience in future social housing developments, incorporating design features like foyers could help reduce heat loss when the entrance doors are opened.

Another future-proofing measure involves revising or recommending housing and energy policies. Bartiaux *et al.* (2014) argue that energy policy recommendations can be made by enriching the components of practices through linking doings (practical actions) and sayings

(understandings) while strengthening the engagement between these components. As climate change leads to more frequent heatwaves in the UK, developing combined strategies with the social housing association and inhabitants is essential (refer to Section 7.2.3). These combined strategies could include better guidance from the design team to inform and guide inhabitants on the impacts of opening windows during heatwaves. While guiding the inhabitants, the social housing association must also provide solutions that improve air quality in homes and reduce the risk of overheating. It is crucial for the inhabitants to understand the potential effects of heatwaves and follow the guidance by adapting their practices according to changes in their institutionalised knowledge. Given the rising temperatures in the UK (UK Health Security Agency, 2024), home user guides should be updated for homes built before 2022, and homeowners or housing associations should be informed of these changes.

Ventilation policies also need to be reconsidered in the light of climate change. According to Approved Document F and BS 5925, purge ventilation can be achieved with single-sided ventilation when there is a 3°C temperature difference between indoor and outdoor air (HM Government, 2021b). Given the changing climate and its effects, such as heatwaves, this policy needs to give inhabitants a clear understanding of when to open their windows. Policy recommendations are detailed in, Section 8.4.1.

Educating and communicating with both the design team and inhabitants is another strategy for future-proofing. Establishing educational programmes and training activities could integrate and improve both the professionals' and inhabitants' practical knowledge of the potential renewable heating and ventilation equipment. This is significant because it will inform designers about inhabitants' ability to understand the guidance provided (Maslova and Burgess, 2023), and offer inhabitants the opportunity for hands-on engagement with energy-related systems alongside professionals. Community learning projects supported by the social housing association or local authorities could also enrich this knowledge. Such initiatives could improve communication and collaboration between the design team and inhabitants, positively increasing inhabitants' knowledge and enhancing the implementation of their understanding, as mentioned in Section 7.2.4.

Regular POEs should also be conducted every few years to assess ongoing challenges related to heating and ventilation. POE includes inhabitants' experiences and their satisfaction with their homes, providing deeper insights into the problems they face, including those affecting air quality (Federal Facilities Council, 2001; Maslova and Burgess, 2023). Therefore, a strategy needs to be developed to ensure social housing associations collaborate more closely with households and conduct evaluations of heating and ventilation systems more frequently. These evaluations could also help address maintenance issues such as boiler malfunction and ineffective extract fans. As a result, inhabitants would not have to compensate for system failures, meaning any increase in energy bills would be due to national price increases rather than inefficient energy use.

Finally, incorporating redundancy into social housing design by integrating backup systems within homes is a critical future-proofing measure (Stevenson, 2019). In this case study, particularly concerning know-how and embodied habits, most inhabitants provide their own alternatives rather than rely on the housing association. Inhabitants often buy themselves alternative equipment as a backup and, even when there is no problem, they feel safer having extra equipment (e.g., portable heaters, portable air conditioning units, dehumidifiers) just in case the heating or ventilation system fails. This demonstrates how inhabitants enhance the redundancy of their homes to promote norms of comfort and usability (Shove and Trentmann, 2018). Ensuring that social housing includes built-in redundancy, particularly for vulnerable inhabitants, is crucial in the face of increasing extreme events like power cuts. Alternative systems, such as solar backup generators and solar panels, could enhance resilience. The architect from the design team noted that, although renewable-energy-powered backup generators were often integrated into newly built homes, they had been excluded from this case study due to budget constraints. Therefore, UK social housing associations should allocate additional funding for renewable-energy-powered backup systems to mitigate the impact of future extreme events.

#### 7.4 Summary

The diverse practices of inhabitants and the design team's intentions relating to heating and ventilation were analysed in Chapters 5 and 6 in terms of resilience. In this chapter, all these findings have been discussed with reference to practice theory and the resilience drivers,

from which the researcher developed the resilience and practice theory framework diagram (see Figure 7.1) as an analytical tool to synthesise the evidence from Chapters 5 and 6.

Some key points were highlighted in this discussion chapter. The first point discussed is *institutionalised knowledge and awareness*, which highlights how the inhabitants' lack of awareness of energy-related controls (e.g., trickle vents) or building regulations' guidance about not opening windows during heatwaves affects resilience in social housing (refer to Sections 7.2.2 and 7.2.3). This underscores that resilience can be achieved by awareness and, in turn, know-how.

Another point to highlight from the discussion chapter is about *breaking the learning curve and actual inhabitant understanding*. This highlights the inhabitants' understanding of the heating and ventilation controls that are seen as the norms in the UK by the design team, and how the design team assume inhabitants can easily break their existing habits by learning to use new technologies. This underscores a significant gap between the design team's assumptions of the inhabitants' know-how and their actual practices (refer to Section 7.2.2).

*Practical knowledge and implementation* is another key point highlighted in the discussion (refer to Section 7.2.2). Despite having neighbourhood officers and home user guides, inhabitants still find it challenging to use some of the energy controls (e.g., heating programmers, extract fans) due to lack of practical knowledge. Therefore, resilience can be achieved by offering hands-on engagement opportunities and guidance to help the inhabitants gain practical knowledge and implement this knowledge into their practices.

Another key point discussed in this section is how *necessity builds know-how*. Inhabitants who spend most of their time at home gain know-how by engaging with energy-related controls, which then becomes ingrained in their practices. This highlights how necessity builds a form of know-how and confidence that gives responsibility to the inhabitant who has this practical knowledge (refer to Section 7.2.2).

*Discussions as shared decisions* is another significant point discussed in this section (refer to Section 7.2.4). Inhabitants' discussions happen when they decide to use the room thermostat, and this shared decision is structured around indoor thermal comfort and

financial constraints due to the energy crisis. This significant finding reveals the inhabitants' ability to adapt to external disruptions via discussion.

The inhabitants tend to have *additional alternatives* when they think that the heating and ventilation systems do not meet their needs or if they want a backup option; however, these alternatives are not provided by the design team (refer to Section 7.2.5). This shows that designing redundancy into social housing is an opportunity to increase its resilience, so that it can continue performing even if the heating or ventilation system fails.

Lastly, Section 7.3 highlights insights on future-proofing social housing by suggesting actions that should be taken when designing resilient housing.

## CHAPTER 8. CONCLUSION

### 8.1 Introduction

The aim of this study was to explore and understand robustness, adaptation and redundancy in relation to inhabitants' energy-related practices in the household. Chapter 1 identified that housing and inhabitants' practices have not been systematically investigated in existing studies, and the nexus between social housing performance and inhabitants' discussions of energy-related practices remains largely implicit.

Chapter 2 reviewed the existing literature on resilience and post-occupancy housing studies, including previous research and government documents. This chapter highlighted the research gap, presented the search strategy in Table 2.1, and summarised key representative studies on resilience in the UK over the last 10 years in Table 2.2. It was noted that no existing study has simultaneously focused on robustness, adaptation and redundancy. This chapter also achieved Objective 1 by describing the opportunities for and barriers to resilient social housing in the UK.

Chapter 3 outlined the research approach and introduced the practice theory framework that is adopted in this research. The practice theory approach was chosen because it combines various individual human and non-human aspects that other epistemologies focus on and reveals how these aspects interact through practice as a nexus, as explained in Section 3.2. This chapter also explained how Gram-Hanssen's (2010) practice theory approach could identify underlying factors of resilience in social housing and uncover hidden inhabitant practices that influence the resilience of social housing in the UK.

Chapter 4 established the methodological basis for this study's approach. The research question guiding this study was: *How can social housing performance be future-proofed through a better understanding of inhabitants' discussions in the home, in terms of robustness, redundancy and adaptation within resilience over time?* The underlying sub-questions focus on understanding: (1) the main opportunities and barriers to resilient social housing in the UK; (2) the underlying factors of robustness, adaptation and redundancy in these housing developments; (3) how inhabitants discuss their energy-related practices within the household and how this interfaces with resilience; (4) how social housing can be

future-proofed to become more resilient over time. Given the emphasis on the inhabitants' energy-related practices in terms of accommodating social changes and how their energy-related practices change over time or in the face of extreme events, a case study approach was adopted to understand these processes within a particular setting.

Chapters 5 and 6 presented the study's findings and analysis regarding heating and ventilation systems, respectively. Objective 2 was achieved by exploring the underlying factors of resilience in terms of these systems from both the inhabitant and design team perspectives. These chapters also explored how inhabitants discuss and collaborate about their practices within their households (Objective 3).

Chapter 7 discussed these findings, and linked the three drivers of resilience (robustness, adaptation and redundancy) and practice theory elements together by using the resilience matrix developed by the researcher. This chapter achieved Objective 4 by identifying key insights for future-proofing social housing considering resilience and inhabitant practices.

This chapter summarises the outcomes of this study and goes into more detail to answer the research questions. The chapter then identifies the study's contribution to theory, knowledge, policy and practice. Finally, this chapter considers the study's limitations and opportunities for further research.

## 8.2 Key Research Findings in Relation to the Research Questions

### 8.2.1 Research Question 1

What are the main opportunities and barriers for designing robust, adaptable and redundant social housing in the UK?

To answer this research question, data were gathered by exploring the state of the art of the topic through an extensive literature review (Objective 1). The key research findings are summarised as follows:

**1- Robust housing design:** One of the opportunities provided by a resilient housing design is the ability to withstand environmental disruptions. A robust housing design is essential for energy-related systems to continue functioning despite external factors such as the energy crisis and heatwaves. The findings suggest that integrated passive design

strategies (e.g., cross-ventilation, improved ventilation systems, proper insulation) and future-proofing measures to maintain liveable conditions during external disruptions provide opportunities for resilient social housing.

- 2- Demographic considerations and health benefits:** Another opportunity for designing resilient social housing is adapting homes for social change. By 2039, over 70% of households will include at least one person aged 60 or older (Chenari *et al.*, 2016; Copeman and Beech, 2022). Therefore, resilient social housing that prioritises improved air quality and temperature regulation presents an opportunity for the ageing population in social housing.
- 3- Integration of smart and resilient energy systems:** Incorporating smart energy systems into social housing can provide real-time information on energy usage, enhancing energy efficiency (Office for National Statistics, 2023b). However, these smart energy systems present an opportunity only if they are usable and understandable for inhabitants. If these systems are not user-friendly, they may lead to issues within the home, such as inhabitants struggling to use the smart energy systems correctly. This could create a disparity between the intended design and the actual usage, highlighting a critical design challenge.
- 4- Lack of inhabitant knowledge about resilient energy systems:** One major barrier is the lack of inhabitant knowledge of and engagement with new energy technologies. This can lead to misuse, inefficiency and reduced effectiveness of energy-saving systems. This underscores the importance of inhabitant understanding in achieving the intended performance outcomes.
- 5- Financial constraints:** Social housing providers face pressure to manage rising operational costs, including higher energy prices, while dealing with reduced funding and financial challenges to meet decarbonisation goals (House of Commons Levelling Up, Housing and Communities Committee, 2024). Additional financial pressures, such as addressing delayed repair costs from the Covid-19 pandemic and supporting vulnerable inhabitants, hinder housing associations' ability to invest in resilient infrastructure, which presents another barrier to developing resilient social housing designs.

**6- Need for redundancy:** The encouragement to design resilient homes that use smart energy systems introduces new challenges for redundancy. The failure of one single component could result in a total system failure in smart energy systems, creating a significant barrier. This finding suggests that social housing design needs backup systems to ensure continued functionality in the event of mechanical failures, thereby enhancing resilience.

#### 8.2.2 Research Question 2

What are the underlying factors of robustness, adaptation and redundancy in social housing developments?

Answering this question relied on reviewing documents from the social housing association and analysing data collected from the design team and inhabitants (Objective 2). The data gathered from the design team and inhabitants were compared to understand the design intentions and the underlying factors of resilience within the case study. The key findings regarding the underlying factors of resilience drivers in social housing include:

- 1- Breaking the learning curve with new technologies:** This is one of the significant findings from the design team interviews. They stated that the heating and ventilation systems used in this case study are the norm in the UK, so they assumed that the inhabitants living in these homes would understand how these systems operate. Therefore, when new technologies are introduced in homes, they introduce a new way of practice, which the design team view as a learning curve by breaking the previous habits. However, this study also found that some inhabitants struggle to use the heating and ventilation controls because they do not understand them or they are unable to implement their understanding into their practices, contrary to the design team's characterisation of these controls as 'norms' in the UK.
- 2- Inhabitants' unawareness of institutionalised knowledge:** Inhabitants are unaware of the building regulations' advice on not opening windows during heatwaves, and some are also unaware of their windows' trickle vents. In contrast, those who are aware of trickle vents and their role in ventilation integrate their use into their practices, thus complying with the regulations. This significant finding emphasises that effective use of

energy-related controls, thus resilience, can be achieved through awareness and, in turn, know-how.

- 3- There is a gap between resilience and know-how:** The usability challenges that inhabitants face due to the lack of knowledge of the usage of energy-related controls prevent the integration of these controls into inhabitants' daily routines. This is particularly evident among older inhabitants, who are not familiar with technological interfaces. This disconnect between the inhabitants' understanding and the actual use of the energy controls makes it difficult for them to break their embodied habits and adapt their practices.
- 4- Mere exposure to technologies is insufficient:** Inhabitants find it challenging to use certain energy-related controls (e.g., heating programmers, extract fans), leading them to rely on their established routines instead of adapting to these systems (e.g., using windows rather than extract fans). In addition to having neighbourhood officers and home user guides, knowledge must be embedded into inhabitants' practices through direct engagement and guidance. This significant finding highlights that inhabitants' mere exposure to confusing energy-related controls is inadequate. Effective use of these controls, and therefore resilience, can be achieved through hands-on engagement and guidance to help inhabitants understand and implement technical knowledge into practical know-how.
- 5- Financial constraints hinder redundancy:** Inhabitants supply themselves with additional equipment when energy systems fail or work inefficiently. This behaviour is closely linked to the know-how and habits of inhabitants, as understanding how energy systems function and applying this knowledge into their practices can significantly influence energy use within the home. Although proper knowledge can reduce the need for alternatives, issues like maintenance or power failures due to extreme events, are beyond individual control. In such instances, institutional support is crucial to ensure access to backup options. However, the social housing association has a limited budget that restricts the availability of backup systems, such as renewable-energy-powered generators. Redundancy, and therefore resilience, can be achieved through both

individual and institutional support, as it depends on the knowledge and adaptability of inhabitants as well as institutional support.

### 8.2.3 Research Question 3

How do inhabitants discuss their energy-related practices in the household and how does this interface with the robustness, adaptation and redundancy in social housing design?

This research question was addressed by exploring the resilience drivers of social housing and inhabitants' practices, including their discussions within the household. These findings are based on analysing the data from the semi-structured interviews and usability survey using thematic analysis and mapping (Objective 3).

- 1- Necessity builds know-how:** It is found that the inhabitants who spend the most time at home take the responsibility for using windows and room thermostats. They gain know-how through repeated engagement with these controls, which becomes ingrained in their practices. In contrast, those who are present less often have limited exposure to these practices, and so the responsibility rests with those with more experience and confidence. This highlights how necessity builds a form of practical knowledge and confidence, placing the inhabitants with know-how in charge.
- 2- Room thermostat use as a shared decision:** The findings reveal that inhabitants discuss using the room thermostat, and this engagement is structured around balancing comfort with financial constraints due to the energy crisis. This shared decision-making process can be seen as collaboration among the inhabitants, who actively participate in determining their heating choices. This is significant for developing routines and highlights that room thermostats are embedded into the inhabitants' habits. This finding also indicates that external disruptions (e.g., the energy crisis) can reshape heating practices and influence the inhabitants' adaptability through discussion.
- 3- Gap between intended functionality and actual engagement:** Inhabitants express a lack of confidence in the effectiveness of extract fans, as they are either inefficient or do not function as intended. This leads inhabitants to use additional ventilation methods, such

as opening windows and doors, alongside extract fans to continue their ventilation practices. Additionally, older inhabitants (those over 70) prefer using windows over extract fans and rely on familiar habits that provide a sense of confidence and safety. These findings indicate that extract fans have not been successfully integrated into the practical consciousness of inhabitants, leading them to rely on embodied habits. The significant point here is that the inhabitants demonstrate embodied adaptability, either by adopting additional alternatives or by continuing with familiar practices that contribute to resilience in social housing.

#### 8.2.4 Research Question 4

How can social housing be future-proofed to become more robust, adaptable and redundant over time?

This research question was answered by identifying key insights and recommendations to enhance understanding of resilient social housing and inhabitants' energy-related practices, and thereby future-proof homes (Objective 4). The foundation for addressing this research question involved data analysis, interpretation and triangulation.

- 1- Design adaptations to support energy-related practices:** Social housing design should consider responsive design features regarding how energy-related practices change based on factors such as age, location within the building (e.g., ground or first floor), and personal comfort needs. Incorporating transitional spaces like foyers in newly built social housing can help minimise heat loss and prevent cold air entering the main living area when entrance doors are opened. Incorporating redundancy by implementing backup systems (e.g., solar backup generators, solar panels) can ensure that social housing remains liveable during heating or ventilation system failures. This is an increasingly critical need in terms of extreme disruptions like heatwaves or power outages.
  
- 2- Revision and recommendations on housing and energy policies, along with practical guidance:** Current ventilation policies (e.g., Approved Document F and BS 5925) indicate that purge ventilation should be implemented when there is a 3°C differential between indoor and outdoor conditions. However, this information is not known by the inhabitants, leading them to open their windows during heatwaves, unaware that this

impacts indoor air quality by increasing humidity levels. Therefore, updated guidance is necessary to help inhabitants understand when and how to ventilate their homes safely. There should be guidance about updating home user guides, particularly for social housing built before 2022 (when the policy on heatwaves was issued), to inform inhabitants about the policy changes and ensure that energy-related practices remain aligned with changing conditions.

**3- Institutionalised knowledge and energy-related practices change:** This study found that inhabitants struggle to understand and use the heating and ventilation controls (e.g., trickle vents, heating programmers, extract fans) that are considered norms in the UK. Therefore, collaborative strategies between design teams and inhabitants can help bridge this gap and enhance inhabitants' understanding and implementation of their energy-related practices. These collaborative strategies include conducting POEs every few years after inhabitants move in to identify any issues or challenges they face with the energy-related controls; and education and community learning projects that provide hands-on practical sessions and technical knowledge to improve mutual understanding between inhabitants and design teams. For example, developing mutual guidance (with the design team and inhabitants) on window usage during heatwaves strengthens shared responsibility for energy performance and comfort. During POE, inhabitants' feedback on their embodied habits and adaptive responses (e.g., purchasing additional equipment like dehumidifiers, portable fan heaters) should be integrated into evaluations to enhance resilience in social housing.

### 8.3 Original Contribution to Knowledge

This research makes original contribution to knowledge in three distinct areas: theoretical, practical, and policy contributions. It contributes to knowledge by redefining resilience in a way that is practice-based, rather than viewing resilience through conventional infrastructure-focused or energy-system efficiency definitions. This research proposes a new understanding of resilience as 'the ability of the home to carry on performing by using alternative options to maintain the preferred state and adjustments to reduce the impacts, even if there is social change over time' (see Section 7.2). This definition reframes resilience to incorporate inhabitants' embodied habits, know-how and adaptive capacities.

### 8.3.1 Contribution to Theory

This research makes an original theoretical contribution by integrating practice theory with resilience, providing a more comprehensive understanding of heating and ventilation practices. While practice theory has been widely used to understand how energy-related practices are shaped (Gram-Hanssen, 2010), it has not been used to explain how these practices respond to external disruptions such as climate change, energy crises or pandemics. This study addresses this gap by explaining how and why practices change, and how these practices withstand or adapt to external disruptions. Therefore, this research contributes to practice theory by incorporating resilience dimensions (robustness, adaptation and redundancy) into the analysis of energy-related practices. This allows for a dynamic understanding of how energy practices not only change over time, but also respond to shocks and failures.

The resilience practice theory framework (refer to Figure 7.1) developed as an analytical tool by the researcher, integrates the four elements of practice theory developed by Gram-Hanssen (2010) with resilience drivers (robustness, adaptation, redundancy). This framework provides a structure that connects practices with resilience, both collectively and individually, through different research methods. It offers a common language for the actors (design team and inhabitants), and a model that integrates these findings to examine the adaptive capacity of energy-related practices in social housing. This integration supports a deeper understanding of how routines are performed, how discussions among the inhabitants develop over time, and how inhabitants make use of alternative energy-related controls to maintain comfort and energy practices in their homes.

This study found that inhabitants' awareness of institutionalised knowledge (e.g., building regulations regarding the function of trickle vents) significantly influences the integration of this knowledge into their practices. This highlights that resilience and effective energy-related controls can be achieved through increasing awareness and, in turn, know-how.

This study contributes to understanding how frequent exposure to energy-related controls, such as spending more time at home, leads to increased engagement with these controls and, therefore, greater know-how. Responsibility for managing thermal comfort tends to lie

with those with greater experience, reinforcing the idea that necessity builds confidence and know-how in energy-related practices.

### 8.3.2 Contribution to Practice

This study contributes to practical knowledge by highlighting that engagement and direct support are essential for inhabitants to understand energy-related controls and implement them in their practices. Despite the availability of home user guides or neighbourhood officer support, many inhabitants rely on their embodied habits (e.g., using windows instead of extract fans) due to usability issues. This points to a need for embodied learning mechanisms in housing design and policy. This aspect also emphasises embodied adaptability in relation to usability limitations, offering new insights into how resilience is performed in daily life.

This research also identifies a significant gap between design assumptions and inhabitants' practices, even though this case study included heating and ventilation systems that are considered standard in the UK. While the design team perceive these systems as norms in the UK, many inhabitants (especially those over 70) struggle to understand and use them. This challenges the assumption that standardisation equals accessibility and understanding, highlighting the need for inclusive design approaches that account for varied levels of inhabitant knowledge and usability, thereby increasing resilience.

### 8.3.3 Contribution to Policy

Findings from the research confirm the critical importance of the underlying factors of resilience in social housing and the inhabitants' discussions about their energy-related practices to identify key insights to help future-proof homes. There are significant findings relevant to policy and practice in the UK:

- Inhabitants lack knowledge and awareness of the energy-related controls in their homes and this affects their energy-related practices during extreme events.
- There is a difference between the inhabitants' understanding of the energy-related controls and the design intentions.
- There is a need for additional alternatives within social housing.

- Combined strategies should be developed with the design team and inhabitants.

These strategic findings and contributions to practice and policy inform the detailed recommendations in the next section.

## 8.4 Recommendations

### 8.4.1 Policy Recommendations

Specific recommendations for policy, reflecting resilience in housing within the UK policy context detailed in Section 2.7, the heating and ventilation practices detailed in Chapters 5 and 6, and discussion in Chapter 7, are as follows:

- 1- The current review of Approved Document L: 'Conservation of fuel and power' should state that the programmer for the heating system should be understandable for inhabitants, so they can easily schedule their heating according to their preferences, which will help them reduce their energy bills.
- 2- The current Building Regulations Approved Document O: 'Overheating' should consider revising the section called 'Staying cool in hot weather' in the home user guide. This section came into effect in 2022, but in this case study, households did not receive this section in their home user guide. Adding this section to home user guides issued before 2022 and explaining it to households are essential to ensure that inhabitants know about this guidance and adapt their heating and ventilation practices accordingly, as explained in Section 2.6 and Section 7.3.
- 3- Policy and legislation on domestic heating and ventilation strategies should be reviewed by considering resilience and extreme events. Strategies for extreme events such as pandemic and energy crisis should be included.
- 4- In newly built social housing, on-site electricity generation and storage systems are required according to the Approved Document L (HM Government, 2022), as explained in Section 2.6. However, due to limited budgets, housing associations need to limit their planning and designs and prioritise their areas of focus carefully. Social housing associations within the UK should consider allocating budgets for planning and designing extra redundancy to future-proof social housing.

- 5- The current building regulations should incorporate guidelines on how heating and ventilation systems should be used by inhabitants. This is essential to ensure that the heating and ventilation systems provided in social housing work properly and that inhabitants use them correctly, as explained in the home user guide and manuals.

#### 8.4.2 Practice Recommendations

- 1- This research shows that some inhabitants struggle to understand how to use heating and ventilation controls (e.g., heating programmer), and some are unaware of specific systems (e.g., trickle vents). There is also evidence that inhabitants do not think some of the equipment, such as extract fans, are working properly, as explained in Section 6.5. Conducting a POE every few years within social housing association homes after inhabitants have moved in would benefit both inhabitants and the housing association. It would help the housing association understand the issues inhabitants face with energy-related systems and whether the inhabitants are using them correctly. This is essential for the social housing association to check if these heating and ventilation systems are working properly.
- 2- Within social housing associations, the job description of neighbourhood officers can be updated to allow them to act as a bridge between the design team and the inhabitants. They should be more active with the inhabitants to enhance their practical knowledge and address any problems with energy-related systems in their homes. As discussed in Section 7.2.2, some inhabitants need to acquire practical knowledge on how to use the heating and ventilation systems so they can implement this understanding in their energy-related practices. This could include a collective learning process that members of the design team can also be involved in. This collective learning process could include the design team providing practical sessions for the inhabitants, explaining the specific heating and ventilation systems that inhabitants struggle with (using information gathered by the neighbourhood officer prior to sessions) and how to use the new technologies within their homes. Practical knowledge on energy-saving methods could help future-proof homes and inhabitants' energy-related practices. This way, the inhabitants will gain more practical knowledge than they could from just reading the home user guide or

manuals, which leave them struggling to implement their knowledge in their practice.

- 3- Social housing associations in the UK should consider planning more flexible housing typologies, especially post-pandemic. This is essential because during Covid-19, the presence at home increased as household members started working and studying at home more, increasing the need for more flexible housing typologies. These housing typologies should include more flexible places to work or study, and design features that provide more natural ventilation, as discussed in Section 6.2.

## 8.5 Limitations

One limitation of the study is that the fieldwork was restricted to Sheffield. This practical decision was made early in the research planning, and it eliminated the need to consider policies and regulations from other countries. However, this prevents a comparison of how different national policies and regulations might affect the inhabitants' energy-related practices. As such, the findings about inhabitants' energy-related practices are only indicative for Sheffield; however, the theoretical contribution has wider implications.

Another limitation of the study is that the data collection process was conducted during the pandemic. The initial data collection phase of this research was planned to be face-to-face; however, when the pandemic hit during this planning phase, the researcher revised the approach to allow research participants to choose their interview preferences. Reaching out to inhabitants required permission from the social housing association and coordination with the neighbourhood officer to visit the case study site, due to the safety concerns and the pandemic. The pandemic also affected the interview schedules with both the design team and inhabitants, with some interviews being rescheduled due to participants contracting Covid-19.

Another limitation of this study relates to the sample. This sample is dominated by participants over 50 living as older couples and single-person households, and includes only one household with children under 18. Although using snowballing sampling in this social housing case study reflected the demographic patterns of UK social housing renters, this approach limited access to the diverse housing demographics including families with

children. To address the gap and ensure a broader understanding of household energy dynamics, future research could consider integrating more diverse housing demographics, including families with children.

## 8.6 Further Research

This research focused on new-build homes in the social housing association sector. The inhabitants' energy-related practices and the underlying factors of resilience in the social housing sector are significant for future-proofing homes to reduce the negative effects of extreme events caused by climate change. Thus, for further research, including other housing types would be of value and be relevant.

In this study, the environmental conditions are considered as a control group; therefore, future climate uncertainties are not fully captured in this thesis. Further research could include climate uncertainties and their impact on housing resilience could be elaborated using a different control group, for instance households with similar demographics but in different housing locations.

Additionally, this research was limited to new-build social housing in Sheffield. For further research, exploring different social housing associations within the UK and countries outside the UK, where different housing typologies, building regulations and policies affect heating and ventilation practices, would allow for comparison and learning from other practices.

The research participants in this research were mostly over 50, and families with children were a minority. To address this gap and to have a detailed understanding of families with children and their household energy dynamics, future research could consider focusing on families with children. This would provide a fuller picture of how varying household structures influence energy use and sustainability practices.

This study adopts a case study approach informed by practice theory to explore the energy-related practices of households. The main objective is to understand how social changes and external factors influence inhabitants' current heating and ventilation practices. Although this study does not focus on individual housing histories, it contributes to the housing field by contributing a resilience practice theory framework that outlines the dynamics of energy practices. Future research could expand on these insights by integrating longitudinal and

ethnographic approaches to analyse how past housing experiences inform present energy practices. However, within the scope of this thesis, the case study approach offers a focused analysis of inhabitants' current energy-related practices, aligning with the theoretical framework adopted.

During this research, the researcher developed a resilience matrix that helped to deepen the understanding of the nexus of inhabitants' practices with drivers of resilience. Further research is needed to explore whether this resilience matrix adds a useful dimension to the analysis of inhabitants' practices and resilience in other contexts and to gain a deeper understanding of the nexus between resilience and inhabitants' practices for future-proofing homes.

## 8.7 Concluding Remarks

Reducing carbon emissions in the housing sector is critical and plays a significant role in reducing the overall CO<sub>2</sub> emissions in the UK (The UK Green Building Council, 2019). However, there is a need for a more profound understanding of how the inhabitants live in their homes and how they use their energy-related appliances to gain deeper knowledge of the energy performance gap. This research proposed an integrated resilience and practice-theory framework to gain a deeper understanding of how inhabitants respond to extreme events in their homes, determining whether their homes remain resilient through these extreme events and continue performing as designed.

Academic research has explored housing energy performance at the design stage. However, these studies have not addressed the dynamic change of inhabitants' practices through the three drivers of resilience (robustness, adaptation and redundancy), which reveals a gap in the knowledge. The current focus in the housing sector is to use advanced smart technologies and design, which assumes that inhabitants can understand and use these technologies and adapt their habits as intended. However, this thesis evidences that, in this social housing case study, some of the inhabitants have difficulty understanding and using heating and ventilation controls that are considered 'norms' in the UK, according to the design team. This shows that inhabitants need practical knowledge and confidence to implement their understanding into their energy-related practices.

Additionally, the importance of extreme events (e.g., Covid-19, energy crisis, overheating) on the inhabitants' practices is revealed in the study, highlighting the need for future-proof social housing that takes resilience into account. The findings from this study highlight the three resilience drivers: inhabitants learn from their experiences by discussing, collectively learning and adapting their habits to changes; social housing associations can provide alternative systems so inhabitants can continue their practices despite the negative effects of extreme events; and, by considering inhabitant practices, housing and energy policies in the UK can be revised to ensure robust housing for the future.

This research, which reveals a deeper understanding of how inhabitants discuss their energy-related practices in their homes and how this can be interrelated with robustness, adaptation and redundancy for developing resilient social housing in the UK, is therefore both significant and timely.

## Conference Paper Arising from Thesis Work

One international peer reviewed conference paper will be published from the work of this thesis. The author gratefully acknowledges the helpful comments from the anonymous reviewers on the conference proceeding.

Tekin, M. (2025) 'Resilience in Social Housing: An Investigation of Heating Practices in the UK', paper will be presented at the Sustainable Built Environment Conference (SBE25) in ETH Zurich, Switzerland, 25 - 27 June 2025 and will be published at *IOP Conference Series: Earth and Environmental Science (EES)*.

## References

- Abbas, R. and Michael, K. (2023) 'Socio-Technical Theory', in Papagiannidis, S. (ed.) *TheoryHub Book*. Available at: Available at <https://open.ncl.ac.uk> / ISBN: 9781739604400 (Accessed: 10 February 2025)
- Adger, W. N. (2000) 'Social and ecological resilience: Are they related?', *Progress in Human Geography*, Thousand Oaks, CA: SAGE Publications, pp. 347–364. doi: <https://doi.org/10.1191/030913200701540465>.
- Adger, W. N., Arnell, N. W. and Tompkins, E. L. (2005) 'Successful adaptation to climate change across scales', *Global Environmental Change*, 15(2), pp. 77–86. doi: <https://doi.org/10.1016/j.gloenvcha.2004.12.005>.
- Ambrose, A. (2020) 'Walking with energy: Challenging energy invisibility and connecting citizens with energy futures through participatory research', *Futures: The Journal of Policy, Planning and Futures Studies*. doi: <https://doi.org/10.1016/j.futures.2020.102528>.
- Anderies, J. M. *et al.* (2013) 'Aligning key concepts for global change policy: Robustness, resilience, and sustainability', *Ecology and Society*, 18(2), pp. 8–8. doi: <https://doi.org/10.5751/ES-05178-180208>.
- Anderies, J. M. (2014) 'Embedding built environments in social-ecological systems: Resilience-based design principles', *Building Research and Information: The Journal of Research, Development and Demonstration*, 42(2), pp. 130-142. doi: <https://doi.org/10.1080/09613218.2013.857455>.
- Andersen, P. V. K. *et al.* (2022) 'Sociotechnical imaginaries of resident roles: Insights from future workshops with Danish district heating professionals', *Energy Research and Social Science*. doi: <https://doi.org/10.1016/j.erss.2021.102466>.
- Auerbach, C. and Silverstein, L.B. (2003) *Qualitative data: an introduction to coding and analysis*. 1st ed. New York: New York University Press. doi: <https://doi.org/10.5860/choice.41-4324>.
- Baborska-Narozny, M. and Stevenson, F. (2015) 'Continuous mechanical ventilation in housing - understanding the gap between intended and actual performance and use', *Energy Procedia*, 83, pp.167-176. doi: <https://doi.org/10.1016/j.egypro.2015.12.207>.
- Baborska-Narozny, M. and Stevenson, F. (2019) 'Service controls interfaces in housing: usability and engagement tool development', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 47(3), pp. 290-304. doi: <https://doi.org/10.1080/09613218.2018.1501535>.

Baborska-Narożny, M., Stevenson, F. and Grudzińska, M. (2017) 'Overheating in retrofitted flats: Occupant practices, learning and interventions', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 45(1–2), pp. 40-59. doi: <https://doi.org/10.1080/09613218.2016.1226671>.

Baker, J. L. (2012) 'Climate change, disaster risk and the urban poor: Cities building resilience for a changing world. Dar es Salaam case study overview.', Washington, DC: World Bank. doi: 10.1596/978-0-8213-8845-7.

Baker, S. E. and Edwards, R. (2012) 'How many qualitative interviews is enough?', *National Centre for Research Methods Review Paper* [Preprint]. doi: <https://doi.org/10.1177/1525822X05279903>.

Balaban, O. and Puppim de Oliveira, J. A. (2017) 'Sustainable buildings for healthier cities: Assessing the co-benefits of green buildings in Japan', *Journal of Cleaner Production*, 163, pp. S68-S78. doi: <https://doi.org/10.1016/j.jclepro.2016.01.086>.

Baldwin, C. and King, R. (2018) *Social sustainability, climate resilience and community-based urban development: What about the people?* Milton: Taylor & Francis Group. doi: <https://doi.org/10.4324/9781351103329>.

Barr, S. and Gilg, A. W. (2007) 'A conceptual framework for understanding and analyzing attitudes towards environmental behaviour,' *Geografiska Annaler, Series B, Human Geography*, 89(4), pp. 361-379. doi: <https://doi.org/10.1111/j.1468-0467.2007.00266.x>.

Bartiaux, F. *et al.* (2014) 'A practice-theory approach to homeowners' energy retrofits in four European areas', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 42(4), pp. 525-538. doi: <https://doi.org/10.1080/09613218.2014.900253>.

Bauer, J. M. and Herder, P. M. (2009) 'Designing socio-technical systems,' *Philosophy of Technology and Engineering Sciences*, pp. 601–630. doi: <https://doi.org/10.1016/B978-0-444-51667-1.50026-4>.

Behar, C. (2016) *A socio-technical perspective of ventilation practices in UK social housing with whole house ventilation systems; Design, everyday life and change*. PhD thesis. UCL Energy Institute.

Berkes, F., Johan, C. and Folke, C. (2003) *Navigating social-ecological systems: building resilience for complexity and change*. 1st ed. Cambridge; New York: Cambridge University Press.

Bettany-Saltikov, J. and McSherry, R. (2016) *How to do a systematic literature review in nursing: a step-by-step guide*. Second edition / Josette Bettany-Saltikov and Robert McSherry. London, England: McGraw-Hill Education/Open University Press.

Biggs, R. *et al.* (2012) 'Toward Principles for Enhancing the Resilience of Ecosystem Services', *Annual review of Environment and Resources*, 37(1), pp. 421–448. doi: <https://doi.org/10.1146/annurev-environ-051211-123836>

Blackwell, T. and Bengtsson, B. (2023) 'The resilience of social rental housing in the United Kingdom, Sweden and Denmark. How institutions matter', *Housing Studies*, 38(2), pp. 269–289. doi: <https://doi.org/10.1080/02673037.2021.1879996>.

Bolton, P. (2024) *Gas and electricity prices during the 'energy crisis' and beyond*. Available at: <https://commonslibrary.parliament.uk/research-briefings/cbp-9714/> (Accessed: 6 June 2024).

Boomsma, C. *et al.* (2017) "'Damp in bathroom. Damp in back room. It's very depressing!" exploring the relationship between perceived housing problems, energy affordability concerns, and health and well-being in UK social housing', *Energy Policy*, 106, pp. 382–393. doi: <https://doi.org/10.1016/j.enpol.2017.04.011>.

Boon, H. J., Cottrell, A. and King, D. (2016) *Disasters and social resilience [electronic resource]: a bioecological approach*. London: Routledge. doi: <https://doi.org/10.4324/9781315678726>.

Bordass, B. (2003) 'Learning more from our buildings - or just forgetting less?', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 31(5), pp. 406–411. doi: <https://doi.org/10.1080/0961321031000108825>.

Bourdieu, P. (1990) *The logic of practice*. Cambridge: Polity.

Bourne, L. and Walker, D. H. T. (2005) 'Visualising and mapping stakeholder influence', *Management Decision*, 43(5), pp. 649–660. doi: <https://doi.org/10.1108/00251740510597680>.

Brai, E., Mangialardi, G. and Scarpelli, D. (2022) 'Circular living. A resilient housing proposal', *TeMa*, 15(3), pp. 447–469. doi: <https://doi.org/10.6093/1970-9870/9068>.

Brauer, H. B. *et al.* (2024) 'Re-configuring practices in times of energy crisis – A case study of Swedish households', *Energy Research and Social Science*, 114, p. 103578. doi: <https://doi.org/10.1016/j.ERSS.2024.103578>.

Braun, V. and Clarke, V. (2006) 'Using thematic analysis in psychology', *Qualitative Research in Psychology*, 3(2), pp. 77–101. doi: <https://doi.org/10.1191/1478088706qp0630a>.

- BRE Group (2024) *RdSAP10 Specification*. Available at: <https://bregroup.com/expertise/energy/sap/sap10/> (Accessed: 6 May 2025)
- Brierley, J. M. (2021) *Fresh air and low-carbon: A practice approach to maintaining home ventilation*. PhD Thesis. University of Sheffield.
- British Standards Institution (1991) *BS 5925:1991: Code of Practice for Ventilation principles and designing for natural ventilation*. London: British Standards Publications
- Brooks, N. (2003) 'Vulnerability, risk and adaptation: A conceptual framework', *Tyndall Centre for Climate Change Research*, Working Paper No. 38.
- Brown, K. (2014) 'Global environmental change I: A social turn for resilience?', *Progress in Human Geography*, 38(1), pp. 107-117. doi: <https://doi.org/10.1177/0309132513498837>.
- Brown, K. and Westaway, E. (2011) 'Agency, capacity, and resilience to environmental change: Lessons from human development, well-being, and disasters', *Annual Review of Environment and Resources*, 36(1), pp. 321-342. doi: <https://doi.org/10.1146/annurev-environ-052610-092905>.
- Burlinson, A. *et al.* (2024) 'Household energy price resilience in the face of gas and electricity market crises', *Energy Economics*, 132. doi: <https://doi.org/10.1016/j.eneco.2024.107414>.
- Buso, T. *et al.* (2015) 'Occupant behaviour and robustness of building design', *Building and Environment*, 94, pp. 694-703. doi: <https://doi.org/10.1016/j.buildenv.2015.11.003>.
- Buzan, T. and Buzan, B. (2010) *The mind map book – Unlock your creativity, boost your memory, change your life*. New ed. Harlow: Pearson/BBC Active
- Byrne, D. (2017) 'Research Ethics', in *Research Project Planner*. London: SAGE Publications, Inc. doi: <https://doi.org/10.4135/9781526408556>.
- Carroll, M. (2012) 'Resilience: Why Things Bounce Back', *Booklist*. Chicago: American Library Association, p. 16.
- Chatterton, P. (2015) *Low impact living: A field guide to ecological, affordable community building*. London; New York: Routledge, Taylor & Francis Group.
- Chenari, B., Dias Carrilho, J. and Gameiro da Silva, M. (2016) 'Towards sustainable, energy-efficient and healthy ventilation strategies in buildings: A review', *Renewable and Sustainable Energy Reviews*, 59, pp. 1426-1447. doi: <https://doi.org/10.1016/j.rser.2016.01.074>.

Cholewa, T., Siuta-Olcha, A. and Balaras, C.A. (2017) 'Actual energy savings from the use of thermostatic radiator valves in residential buildings – Long term field evaluation', *Energy and Buildings*, 151, pp. 487-493. doi: <https://doi.org/10.1016/j.enbuild.2017.06.070>.

*Climate Change Act 2008, Section 27*. Available at: <https://www.legislation.gov.uk/ukpga/2008/27/notes/division/7/1/9/2> (Accessed: 3 May 2024).

Climate Change Committee (2023) *Progress in adapting to climate change - 2023 Report to Parliament*. Available at: <https://www.theccc.org.uk/publication/progress-in-adapting-to-climate-change-2023-report-to-parliament/> (Accessed: 6 May 2024)

Coghlan, D. and Brydon-Miller, M. (2014). 'Positionality', in Coghlan, D. and Brydon-Miller, M. (eds.) *The SAGE Encyclopedia of Action Research*. London: SAGE Publications Ltd, pp. 628 doi: <https://doi.org/10.4135/9781446294406>

Copeman, I. and Beech, L. (2022) *Housing our ageing population*. Local Government Association. Available at: <https://www.local.gov.uk/publications/housing-ageing-population#introduction> (Accessed: 4 June 2024).

Corley, K. G. and Gioia, D. A. (2004) 'Identity ambiguity and change in the wake of a corporate spin-off', *Administrative Science Quarterly*, 49(2), pp. 173-208. doi: <https://doi.org/10.2307/4131471>.

Creswell, J. W. (2013) *Qualitative inquiry and research design: Choosing among five approaches*. 3rd edn. Los Angeles: SAGE Publications.

Creswell, J. W. and Miller, D.L. (2000) 'Determining validity in qualitative inquiry', *Theory into Practice*, 39(3), pp. 124-130. doi: [https://doi.org/10.1207/s15430421tip3903\\_2](https://doi.org/10.1207/s15430421tip3903_2).

Cretney, R. (2014) 'Resilience for whom? Emerging critical geographies of socio-ecological resilience', *Geography Compass*, 8(9), pp. 627-640. doi: <https://doi.org/10.1111/gec3.12154>.

Crotty, M. (1998) *The foundations of social research: Meaning and perspective in the research process*. London; Thousand Oaks, Calif.: Sage Publications.

Deller, D., Turner, G. and Waddams Price, C. (2021) 'Energy poverty indicators: Inconsistencies, implications and where next?', *Energy Economics*, 103. doi: <https://doi.org/10.1016/j.eneco.2021.105551>.

Denzin, N.K. and Lincoln, Y.S. (2013) *The landscape of qualitative research*. 4th edn. Thousand Oaks, Calif.; London: SAGE.

Department for Business, Energy and Industrial Strategy (2023) *BEIS public attitudes tracker: Heat and energy in the home (Winter 2022, UK)*. Available at:

[https://assets.publishing.service.gov.uk/media/6407046e8fa8f527fb67cb77/BEIS PAT Winter 2022 Heat and Energy in the Home.pdf](https://assets.publishing.service.gov.uk/media/6407046e8fa8f527fb67cb77/BEIS_PAT_Winter_2022_Heat_and_Energy_in_the_Home.pdf) (Accessed: 6 May 2024)

Department for Levelling Up, Housing & Communities (2021): *Household resilience study, wave 3 April-May 2021 official statistics*. Available at: [https://assets.publishing.service.gov.uk/media/61657b1e8fa8f5298349484c/Household Resilience Study Wave 3 April-May 2021 Report.pdf](https://assets.publishing.service.gov.uk/media/61657b1e8fa8f5298349484c/Household_Resilience_Study_Wave_3_April-May_2021_Report.pdf) (Accessed: 10 April 2023)

Department for Levelling Up, Housing & Communities (2022) *English housing survey 2021 to 2022: Headline report*. Available at: <https://www.gov.uk/government/statistics/english-housing-survey-2021-to-2022-headline-report/english-housing-survey-2021-to-2022-headline-report> (Accessed: 8 May 2024).

De Wilde, P. (2014) 'The gap between predicted and measured energy performance of buildings: A framework for investigation', *Automation in Construction*, 41, pp. 40-49. doi: <https://doi.org/10.1016/j.autcon.2014.02.009>.

Dolowitz, D. P., Buckler, S. and Sweeney, F. (2008) *Researching online*. Houndmills, Basingstoke, Hampshire; New York: Palgrave Macmillan.

Duval, R., Elmeskov, J. and Vogel, L. (2011) 'Structural policies and economic resilience to shocks', *SSRN Electronic Journal* [Preprint]. doi: <https://doi.org/10.2139/ssrn.1002508>.

Earley, A. (2021) *Housing systems, their institutions and their resilience: Preliminary literature review*. Available at: <https://housingevidence.ac.uk/wp-content/uploads/2022/11/20210927-Housing-Systems-their-institutions-and-their-resilience.pdf> (Accessed: 6 May 2025)

Ellsworth-Krebs, K., Reid, L. and Hunter, C.J. (2015) 'Home -ing in on domestic energy research: "house," "home," and the importance of ontology', *Energy Research and Social Science*, 6. doi: <https://doi.org/10.1016/j.erss.2014.12.003>.

England, K. V. L. (1994) 'Getting personal: Reflexivity, positionality, and feminist research', *Professional Geographer*, 46(1). doi: <https://doi.org/10.1111/j.0033-0124.1994.00080.x>.

Evans, M., Roshchanka, V. and Graham, P. (2017) 'An international survey of building energy codes and their implementation', *Journal of Cleaner Production*, 158(C), pp. 382-389. doi: <https://doi.org/10.1016/j.jclepro.2017.01.007>.

Fan, X. *et al.* (2023) 'A single-blind field intervention study of whether increased bedroom ventilation improves sleep quality', *The Science of the Total Environment*, 884, pp. 163805-163805. doi: <https://doi.org/10.1016/j.scitotenv.2023.163805>.

Fawcett, W. *et al.* (2012) 'Flexible strategies for long-term sustainability under uncertainty', in *Building Research and Information: The International Journal of Research, Development and Demonstration*, 40(5), pp. 545-557. doi: <https://doi.org/10.1080/09613218.2012.702565>.

Federal Facilities Council (2001) *Learning from our buildings: A state-of-the-practice summary of post-occupancy evaluation*. Washington, D.C.: National Academy Press.

Fell, M. J. and Chiu, L. F. (2014) 'Children, parents and home energy use: Exploring motivations and limits to energy demand reduction', *Energy Policy*, 65, pp. 351–358. doi: <https://doi.org/10.1016/J.ENPOL.2013.10.003>.

Finch, J. (2003) *Negotiating Family Responsibilities*. London: Routledge.

Fletcher, D. and Sarkar, M. (2013) 'Psychological resilience: A review and critique of definitions, concepts, and theory', *European Psychologist*, 18(1), pp. 12-23. doi: <https://doi.org/10.1027/1016-9040/a000124>.

Flick, U. (2018) *An introduction to qualitative research*. 6th edn. Los Angeles: SAGE.

Flyvbjerg, B. (2001) 'The power of example', in *Making social science matter: Why social inquiry fails and how it can succeed again*. Cambridge: Cambridge University Press, pp. 66–87.

Flyvbjerg, B. (2006) 'Five misunderstandings about case-study research', *Qualitative Inquiry*, 12(2), pp. 219-245. doi: <https://doi.org/10.1177/1077800405284363>.

Folke, C. *et al.* (2003) 'Freshwater for resilience: A shift in thinking', *Philosophical Transactions of the Royal Society of London. Series B. Biological Sciences*, 358(1440), pp. 2027-2036. doi: <https://doi.org/10.1098/rstb.2003.1385>.

Fontana, A. and Frey, J. H. (1994) 'Interviewing: The Arts of Science', *Handbook of Qualitative Research*, pp. 361-376. Sage Publications, Inc.

Foulds, C., Powell, J. and Seyfan, G. (2013) 'Investigating the performance of everyday domestic practices using building monitoring', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 41(6), pp. 622-636. doi: <https://doi.org/10.1080/09613218.2013.823537>.

Francis, J. J. *et al.* (2010) 'What is an adequate sample size? Operationalising data saturation for theory-based interview studies', *Psychology and Health*, 25(10), pp. 1229-1245. doi: <https://doi.org/10.1080/08870440903194015>.

Fuentes, E., Arce, L. and Salom, J. (2018) 'A review of domestic hot water consumption profiles for application in systems and buildings energy performance analysis', *Renewable*

and *Sustainable Energy Reviews*, 81, pp. 1530-1547. doi:  
<https://doi.org/10.1016/j.rser.2017.05.229>.

Galletta, A. (2016) *Mastering the semi-structured interview and beyond: From research design to analysis and publication*. New York: New York University Press.

Galvin, R. and Sunikka-Blank, M. (2016) 'Schatzkian practice theory and energy consumption research: Time for some philosophical spring cleaning?', *Energy Research and Social Science*, 22, pp. 63-68. doi: <https://doi.org/10.1016/j.erss.2016.08.021>.

Garrefa, F. *et al.* (2021) 'Resilience in social housing developments through post-occupancy evaluation and co-production', *Ambiente Construído*, 21(2). doi:  
<https://doi.org/10.1590/s1678-86212021000200519>.

Georgiadou, M.C., Hacking, T. and Guthrie, P. (2013) 'Future-proofed energy design for dwellings: Case studies from England and application to the Code for Sustainable Homes', *Building Services Engineering Research and Technology*, 34(1), pp. 9-22. doi:  
<https://doi.org/10.1177/0143624412463016>.

Gibb, K., McNulty, D. and McLaughlin, T. (2016) 'Risk and resilience in the Scottish social housing sector: "We're all risk managers"', *International Journal of Housing Policy*, 16(4), pp. 435-457. doi: <https://doi.org/10.1080/14616718.2016.1198085>.

Giddens, A. (1984) *The constitution of society: Outline of the theory of structuration*. Cambridge: Polity.

Gill, Z. M. *et al.* (2010) 'Low-energy dwellings: The contribution of behaviours to actual performance', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 38(5), pp. 491-508. doi:  
<https://doi.org/10.1080/09613218.2010.505371>.

Gillham, B. (2000) *Case study research methods*. London; New York: Continuum.

Goddard, J. (2022) *Meeting housing demand: Built Environment Committee report*. Available at: <https://lordslibrary.parliament.uk/meeting-housing-demand-built-environment-committee-report/> (Accessed: 24 May 2024).

Gram-Hanssen, K. (2008) 'Consuming technologies - developing routines', *Journal of Cleaner Production*, 16(11), pp. 1181-1189. doi: <https://doi.org/10.1016/j.jclepro.2007.08.006>.

Gram-Hanssen, K. (2010) 'Standby consumption in households analyzed with a practice theory approach', *Journal of Industrial Ecology*, 14(1), pp. 150-165. doi:  
<https://doi.org/10.1111/j.1530-9290.2009.00194.x>.

Gram-Hanssen, K. (2014) 'New needs for better understanding of household's energy consumption - behaviour, lifestyle or practices?', *Architectural Engineering and Design Management*, 10(1–2), pp. 91-107. doi: <https://doi.org/10.1080/17452007.2013.837251>.

Gram-Hanssen, K. *et al.* (2017) 'Selling and installing heat pumps: influencing household practices', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 45(4), pp. 359-370. doi: <https://doi.org/10.1080/09613218.2016.1157420>.

Gram-Hanssen, K. (2021) 'Conceptualising ethical consumption within theories of practice', *Journal of Consumer Culture*, 21(3), pp. 432-449. doi: <https://doi.org/10.1177/14695405211013956>.

Grandclément, C., Karvonen, A. and Guy, S. (2015) 'Negotiating comfort in low energy housing: The politics of intermediation', *Energy Policy*, 84, pp. 213-222. doi: <https://doi.org/10.1016/j.enpol.2014.11.034>.

Grant, L. and Kinman, G. (2014) *Developing resilience for social work practice*. Basingstoke, Hampshire, England; New York, New York: Palgrave Macmillan.

Groat, L. N. and Wang, D. (2013) 'What's your question? Literature review and research design', in Wang, D. (ed.) *Architectural research methods*. 2nd edn. Hoboken, New Jersey: Wiley, 2013, pp. 141–171.

Guan, Y. *et al.* (2023) 'Burden of the global energy price crisis on households', *Nature Energy*, 8(3), pp. 304-316. doi: <https://doi.org/10.1038/s41560-023-01209-8>.

Gupta, R. *et al.* (2021) 'Monitoring and modelling the risk of summertime overheating and passive solutions to avoid active cooling in London care homes', *Energy and Buildings*, 252, p. 111418. doi: <https://doi.org/10.1016/j.enbuild.2021.111418>.

Gupta, R. and Chandiwala, S. (2010) 'Understanding occupants: Feedback techniques for large-scale low-carbon domestic refurbishments', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 38(5), pp. 530-548. doi: <https://doi.org/10.1080/09613218.2010.495216>.

Gupta, R. and Gregg, M. (2012) 'Using UK climate change projections to adapt existing English homes for a warming climate', *Building and Environment*, 55, pp. 20-42. doi: <https://doi.org/10.1016/j.buildenv.2012.01.014>.

Gupta, R. and Gregg, M. (2018) 'Assessing energy use and overheating risk in net zero energy dwellings in UK', *Energy and Buildings*, 158, pp. 897-905. doi: <https://doi.org/10.1016/j.enbuild.2017.10.061>.

Gupta, R. and Kapsali, M. (2016) 'Empirical assessment of indoor air quality and overheating in low-carbon social housing dwellings in England, UK', *Advances in Building Energy Research*, 10(1), pp. 46-68. doi: <https://doi.org/10.1080/17512549.2015.1014843>.

Gupta, R. and Kotopouleas, A. (2018) 'Magnitude and extent of building fabric thermal performance gap in UK low energy housing', *Applied Energy*, 222, pp. 673-686. doi: <https://doi.org/10.1016/j.apenergy.2018.03.096>.

Guy, S. (2004) 'Consumption, energy, and the environment,' *Encyclopedia of Energy*, pp. 687-696. doi: <https://doi.org/10.1016/B0-12-176480-X/00553-2>.

Hammond, M. (2018) 'Spatial agency: Creating new opportunities for sharing and collaboration in older people's cohousing', *Urban Science*, 2(3), p. 64. doi: <https://doi.org/10.3390/urbansci2030064>.

Hansen, A. R., Gram-Hanssen, K. and Knudsen, H. N. (2018) 'How building design and technologies influence heat-related habits', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 46(1), pp. 83-98. doi: <https://doi.org/10.1080/09613218.2017.1335477>.

Hart, C. (2018) *Doing a literature review: Releasing the social science research imagination*. 2nd edn. London: Sage Publications.

Hassler, U. and Kohler, N. (2014) 'Resilience in the built environment', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 42(2), pp. 119-129. doi: <https://doi.org/10.1080/09613218.2014.873593>.

Heidenstrøm, N. and Kvarnlöf, L. (2018) 'Coping with blackouts: A practice theory approach to household preparedness', *Journal of Contingencies and Crisis Management*, 26(2), pp. 272-282. doi: <https://doi.org/10.1111/1468-5973.12191>.

Hennink, M. M., Kaiser, B. N. and Marconi, V. C. (2017) 'Code Saturation Versus Meaning Saturation: How Many Interviews Are Enough?', *Qualitative Health Research*, 27(4), pp. 591-608. doi: <https://doi.org/10.1177/1049732316665344>.

Hewitt-Taylor, J. (2001) 'Use of constant comparative analysis in qualitative research', *Nursing Standard*, 15(42), pp. 39-42. doi: <https://doi.org/10.7748/ns2001.07.15.42.39.c3052>.

HM Government (2016a) *Approved Document L1A: conservation of fuel and power in new dwellings, 2013 edition with 2016 amendments*. Available at: <https://webarchive.nationalarchives.gov.uk/ukgwa/20190213060753/https://www.gov.uk/government/publications/conservation-of-fuel-and-power-approved-document-l> (Accessed: 31 May 2024).

HM Government (2016b) *Approved Document M: Access to and use of buildings*. Available at: <https://www.gov.uk/government/publications/access-to-and-use-of-buildings-approved-document-m> (Accessed: 5 May 2024).

HM Government (2021a) *The Building Regulations 2010 Approved Document O: Overheating - 2021 edition-for use in England*. Available at: <https://www.gov.uk/government/publications/overheating-approved-document-o> (Accessed: 7 May 2024).

HM Government (2021b) *The Building Regulations 2010 Ventilation Approved Document F Volume 1: Dwellings - Requirement F1: Means of Ventilation 2021 Edition*. Available at: <https://www.gov.uk/government/publications/ventilation-approved-document-f> (Accessed: 5 May 2024)

HM Government (2022) *The Buildings Regulations 2010. Approved document L, Conservation of fuel and power. Volume 1, Dwellings*. Available at: <https://www.gov.uk/government/publications/conservation-of-fuel-and-power-approved-document-l> (Accessed: 10 May 2024)

Holling, C.S. (1973) 'Resilience and Stability of Ecological Systems', *Annual Review of Ecology and Systematics*, 4 (1), pp. 1-23. doi: <https://doi.org/10.1146/annurev.es.04.110173.000245>.

Hollnagel, E. (2010) *Resilience engineering in practice: A guidebook*. Farnham, Surrey, England; Burlington, VT: Ashgate.

House of Commons Levelling Up, Housing and Communities Committee (2024) *The finances and sustainability of the social housing sector sixth report of session 2023-24 report*. Available at: <https://publications.parliament.uk/pa/cm5804/cmselect/cmcomloc/60/report.html> (Accessed: 15 March 2025).

Huq, S. *et al.* (2007) 'Editorial: Reducing risks to cities from disasters and climate change', *Environment and Urbanization*, 19(1), pp. 3-15. doi: <https://doi.org/10.1177/0956247807078058>.

Intergovernmental Panel on Climate Change (2021) *Climate Change 2021: The physical science basis. Contribution of working group I to the sixth assessment report of the Intergovernmental Panel on Climate Change*. [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge: Cambridge University Press. doi: <https://doi.org/10.1017/9781009157896>.

Intergovernmental Panel on Climate Change (2022a) *Climate change 2022 mitigation of climate change*. Available at: <https://www.ipcc.ch/report/ar6/wg3/>

Intergovernmental Panel on Climate Change (2022b) *IPCC sixth assessment report*. Available at: <https://www.ipcc.ch/assessment-report/ar6/>

Intergovernmental Panel on Climate Change (2023) *Climate change 2023: Synthesis report. Contribution of working Groups I, II and III to the sixth assessment report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]*. Edited by P. Arias *et al.* doi: <https://doi.org/10.59327/IPCC/AR6-9789291691647>.

International Energy Agency (2022a) *Global Energy Crisis – How the energy crisis started, how global energy markets are impacting our daily life, and what governments are doing about it*. Available at: <https://www.iea.org/topics/global-energy-crisis> (Accessed: 22 May 2024).

International Energy Agency (2022b) *World Energy Outlook 2022*. IEA, Paris. Available at: <https://www.iea.org/reports/world-energy-outlook-2022>

Jarvis, H. (2011) 'Saving space, sharing time: Integrated infrastructures of daily life in cohousing', *Environment and Planning A*, 43(3), pp. 560–577. doi: <https://doi.org/10.1068/A43296>.

Jesson, J., Matheson, L. and Lacey, F. M. (2011) *Doing your literature review: Traditional and systematic techniques*. London: SAGE.

Jones, K. *et al.* (2013) 'Assessing vulnerability, resilience and adaptive capacity of a UK social landlord', *International Journal of Disaster Resilience in the Built Environment*, 4(3), pp. 287–296. doi: <https://doi.org/10.1108/IJDRBE-03-2013-0004>.

Jones, L. and Tanner, T. (2017) "'Subjective resilience": using perceptions to quantify household resilience to climate extremes and disasters', *Regional Environmental Change*, 17(1), pp. 229–243. doi: <https://doi.org/10.1007/s10113-016-0995-2>.

Karakusevic, P. (2018) 'A new era of social housing: Architecture as the basis for change', *Architectural Design*, 88(4), pp. 48–55. doi: <https://doi.org/10.1002/ad.2320>.

Kawka, E. and Cetin, K. (2021) 'Impacts of COVID-19 on residential building energy use and performance', *Building and Environment*, 205, pp. 108200–108200. doi: <https://doi.org/10.1016/j.buildenv.2021.108200>.

Keirstead, J. (2006) 'Evaluating the applicability of integrated domestic energy consumption frameworks in the UK', *Energy Policy*, 34(17), pp. 3065–3077. doi: <https://doi.org/10.1016/j.enpol.2005.06.004>.

Kemmis, S. (2022) 'Addressing the climate emergency: A view from the theory of practice architectures', *The Journal of Environmental Education*, 53(1), pp. 42–53. doi: <https://doi.org/10.1080/00958964.2021.2017830>.

Kent, R.A. (2015) 'Data Preparation', in *Analysing quantitative data: Variable-based and case-based approaches to non-experimental datasets*. London: SAGE Publications Ltd, pp. 39–62. doi: <https://doi.org/10.4135/9781473917941>.

Kern, F., Kivimaa, P. and Martiskainen, M. (2017) 'Policy packaging or policy patching? The development of complex energy efficiency policy mixes', *Energy Research and Social Science*, 23. doi: <https://doi.org/10.1016/j.erss.2016.11.002>.

Kivimaa, P., Kangas, H. L. and Lazarevic, D. (2017) 'Client-oriented evaluation of "creative destruction" in policy mixes: Finnish policies on building energy efficiency transition', *Energy Research and Social Science*, 33. doi: <https://doi.org/10.1016/j.erss.2017.09.002>.

Klix, F. (2001) 'Problem Solving: Deduction, Induction, and Analogical Reasoning', in *International Encyclopedia of the Social & Behavioral Sciences*. doi: <https://doi.org/10.1016/b0-08-043076-7/00544-1>.

Kotireddy, R., Hoes, P. J. and Hensen, J. L. M. (2018) 'A methodology for performance robustness assessment of low-energy buildings using scenario analysis', *Applied Energy*, 212, pp. 428-442. doi: <https://doi.org/10.1016/j.apenergy.2017.12.066>.

Kraatz, J.A. (2018) 'Innovative approaches to building housing system resilience: a focus on the Australian social and affordable housing system', *Australian Planner*, 55(3–4), pp. 174-185. doi: <https://doi.org/10.1080/07293682.2019.1632361>.

Larsen, S.P.A.K. and Gram-Hanssen, K. (2020) 'When space heating becomes digitalized: Investigating competencies for controlling smart home technology in the energy-efficient home', *Sustainability (Switzerland)*, 12(15). doi: <https://doi.org/10.3390/su12156031>.

Latour, B. (2005) *Reassembling the social: an introduction to actor-network-theory, Introduction to actor-network-theory*. Edited by American Council of Learned Societies. Oxford: Oxford University Press.

Latour, B. and Porter, C. (1993) *We have never been modern*. Cambridge, Massachusetts: Harvard University Press.

Law, J. (1992) 'Notes on the theory of the actor-network: Ordering, strategy, and heterogeneity', *Systems Practice*, 5(4), pp. 379-393. doi: <https://doi.org/10.1007/BF01059830>.

Law et al. (1999) *Actor network theory and after*. Oxford: Blackwell/Sociological Review.

Leaman, A., Stevenson, F. and Bordass, B. (2010) 'Building evaluation: Practice and principles', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 38(5), pp. 564-577. doi: <https://doi.org/10.1080/09613218.2010.495217>.

- Liang, J. *et al.* (2018) 'Do energy retrofits work? Evidence from commercial and residential buildings in Phoenix', *Journal of Environmental Economics and Management*, 92. doi: <https://doi.org/10.1016/j.jeem.2017.09.001>.
- Lincoln, Y. S. and Guba, E. G. (1985) *Naturalistic inquiry*. Beverly Hills, Calif.; London: Sage.
- Lofland, J., Snow, D. and Anderson, L. (2006) *Analyzing social setting: A guide to qualitative observation and analysis*. 4th edn. Belmont, CA: Wadsworth Thomson.
- Lomas, K. J. *et al.* (2018) 'Do domestic heating controls save energy? A review of the evidence', *Renewable and Sustainable Energy Reviews*, 93, pp. 52-75. doi: <https://doi.org/10.1016/j.rser.2018.05.002>.
- Loonen, R. C. G. M. *et al.* (2017) 'Review of current status, requirements and opportunities for building performance simulation of adaptive facades', *Journal of Building Performance Simulation*, 10(2), pp. 205-223. doi: <https://doi.org/10.1080/19401493.2016.1152303>.
- Luo, T. *et al.* (2019) 'Mapping the knowledge roadmap of low carbon building: A scientometric analysis', *Energy and Buildings*, 194, pp. 163-176. doi: <https://doi.org/10.1016/j.enbuild.2019.03.050>.
- Maclean, K. *et al.* (2017) 'Converging disciplinary understandings of social aspects of resilience', *Journal of Environmental Planning and Management*, 60(3), pp. 519-537. doi: <https://doi.org/10.1080/09640568.2016.1162706>.
- Maguire, B. and Cartwright, S. (2008) 'Assessing a community's capacity to manage change: A resilience approach to social assessment', *Social Science Program – Bureau of Rural Sciences* [Preprint].
- Mallett, S. (2004) 'Understanding home: A critical review of the literature', *The Sociological Review (Keele)*, 52(1), pp. 62-89. doi: <https://doi.org/10.1111/j.1467-954x.2004.00442.x>.
- Martin, R. and Larsen, S. P. A. K. (2024) "'I never look at a temperature device, I just feel it": Practical knowledge, smart technologies, and heating and cooling practices between Denmark and Australia', *Energy Research and Social Science*, 108. doi: <https://doi.org/10.1016/j.erss.2023.103389>.
- Martiskainen, M. and Kivimaa, P. (2019) 'Role of knowledge and policies as drivers for low-energy housing: Case studies from the United Kingdom', *Journal of Cleaner Production*, 215, pp. 1402-1414. doi: <https://doi.org/10.1016/j.jclepro.2019.01.104>.
- Maslova, S. and Burgess, G. (2023) 'Delivering human-centred housing: understanding the role of post-occupancy evaluation and customer feedback in traditional and innovative social

housebuilding in England', *Construction Management and Economics*, 41(4), pp.277-292. doi: <https://doi.org/10.1080/01446193.2022.2111694>.

Mavrogianni, A. et al. (2015) 'Urban social housing resilience to excess summer heat', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 43(3), pp. 316-333. doi: <https://doi.org/10.1080/09613218.2015.991515>.

May, T. and Perry, B. (2017) *Reflexivity: The essential guide*. Los Angeles: SAGE.

McCarthy, D. D. P. et al. (2011) 'A critical systems approach to social learning: Building adaptive capacity in social, ecological, epistemological (SEE) systems', *Ecology and Society*, 16(3), pp. 18-18. doi: <https://doi.org/10.5751/ES-04255-160318>.

McLellan, E., MacQueen, K. M. and Neidig, J. L. (2003) 'Beyond the qualitative interview: Data preparation and transcription', *Field Methods*, 15(1), pp. 63-84. doi: <https://doi.org/10.1177/1525822X02239573>.

Melucci, A. (1996) *Challenging codes: Collective action in the information age*. Cambridge: Cambridge University Press.

Middlemiss, L. and Parrish, B. D. (2010) 'Building capacity for low-carbon communities: The role of grassroots initiatives', *Energy Policy*, 38(12), pp. 7559-7566. doi: <https://doi.org/10.1016/j.enpol.2009.07.003>.

Mills, A. J., Durepos, G. and Wiebe, E. (2010) 'Within-case analysis', *Encyclopedia of case study research*, pp. 971–972. doi: <https://doi.org/10.4135/9781412957397>

Ministry of Housing, Communities and Local Government (2024) *English housing survey 2022 to 2023: Rented sectors*. Available at: <https://www.gov.uk/government/statistics/english-housing-survey-2022-to-2023-rented-sectors/english-housing-survey-2022-to-2023-rented-sectors> (Accessed: 21 January 2025).

Moffatt, S. (2014) 'Resilience and competing temporalities in cities', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 42(2), pp. 202-220. doi: <https://doi.org/10.1080/09613218.2014.869894>.

Moghim, S. and Garna, R.K. (2019) 'Countries' classification by environmental resilience', *Journal of Environmental Management*, 230, pp. 345-354. doi: <https://doi.org/10.1016/j.jenvman.2018.09.090>.

Morelli, F. and Tryjanowski, P. (2016) 'The dark side of the "redundancy hypothesis" and ecosystem assessment', *Ecological Complexity*, 28, pp. 222-229. doi: <https://doi.org/10.1016/j.ecocom.2016.07.005>.

Morley, J. (2018) 'Rethinking energy services: The concept of "meta-service" and implications for demand reduction and servicizing policy', *Energy Policy*, 122, pp. 563-569. doi: <https://doi.org/10.1016/j.enpol.2018.07.056>.

National Energy Action (2023) *Home appliances that use the most electricity*. Available at: <https://www.nea.org.uk/get-help/resources/home-appliances-that-use-the-most-electricity/> (Accessed: 16 May 2024).

National Institute for Health and Care Excellence (2020) *Indoor air quality at home - NICE guideline*. Available at: [www.nice.org.uk/guidance/ng149](http://www.nice.org.uk/guidance/ng149) (Accessed: 21 May 2024).

National Housing Federation (2022) *How much would social housing residents save if their homes were made energy efficient?* Available at: <https://www.housing.org.uk/resources/housing-association-residents-energy-efficient-homes-savings/> (Accessed: 10 January 2025)

Neuman, W.L. (2011) *Social research methods: Qualitative and quantitative approaches*. 7th edn. Boston, [Mass.]; London: Pearson.

Nik, V. M. *et al.* (2016) 'Effective and robust energy retrofitting measures for future climatic conditions - Reduced heating demand of Swedish households', *Energy and Buildings*, 121, pp. 176-187. doi: <https://doi.org/10.1016/j.enbuild.2016.03.044>.

Nock, D.A. and Scott, J. (1991) 'A matter of record: Documentary sources in social research', *Canadian Journal of Sociology / Cahiers canadiens de sociologie*, 16(3), pp. 337-339. doi: <https://doi.org/10.2307/3340693>.

Office for National Statistics (2023a) *2022 UK greenhouse gas emissions: provisional figures - statistical release*. Available at: <https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/greenhousegasintensityprovisionalestimatesuk/provisionalestimates2022/previous/v1> (Accessed: 20 February 2024)

Office for National Statistics (2023b) *Climate change insights, families and households, UK - August 2023*. Available at: <https://www.ons.gov.uk/economy/environmentalaccounts/articles/climatechangeinsightsuk/august2023> (Accessed: 2 June 2024).

Office for National Statistics (2023c) *Insulation and energy efficiency of housing in England and Wales - Office for National Statistics*. Available at: <https://www.ons.gov.uk/peoplepopulationandcommunity/housing/articles/insulationandenergyefficiencyofhousinginenglandandwales/2022> (Accessed: 24 February 2025).

O'Leary, Z. (2021) *The essential guide to doing your research project*. 4th edn. Los Angeles: SAGE.

Özen, G. and Aksoy, M. (2021) 'User Participation in Social Housing Practices in Turkey', *Journal of Architectural Engineering*, 27(4). doi: [https://doi.org/10.1061/\(ASCE\)AE.1943-5568.0000469](https://doi.org/10.1061/(ASCE)AE.1943-5568.0000469).

Pablo, Z., Littleton, C. and London, K. (2024) 'Reconceptualising resilience in housing policy: an actor-network approach', *Regional studies, regional science*, 11(1), pp. 271–290. Available at: <https://doi.org/10.1080/21681376.2024.2325172>.

Painter, D. S. (2014) 'Oil and geopolitics: The oil crises of the 1970s and the Cold War', *Historical Social Research (Köln)*, 39(4 (150)), p. 186-208. doi: <https://doi.org/10.12759/hsr.39.2014.4>.

Palmer, J. *et al.* (2016) 'Building Performance Evaluation Programme: Findings from domestic projects - Making reality match design', *Innovate UK* [Preprint]. Available at: <https://www.ukri.org/wp-content/uploads/2021/12/IUK-061221-DomesticBuildingPerformanceSummary2016.pdf> (Accessed: 3 February 2023)

Palmer, J., Terry, N. and Armitage, P. (2016) 'Building Performance Evaluation Programme: Findings from non-domestic projects - Getting the best from buildings', *Innovate UK* [Preprint]. Available at: <https://www.ukri.org/wp-content/uploads/2021/12/IUK-061221-NonDomesticBuildingPerformanceFullReport2016.pdf> (Accessed: 5 February 2023)

Park, J. S., An, Y.-M. and Jeong, J.-W. (2023) 'Determinants of manual window control for natural ventilation in homes', *Building and Environment*, 244, p. 110741. doi: <https://doi.org/10.1016/j.buildenv.2023.110741>.

Parker, C., Scott, S. and Geddes, A. (2019) 'Snowball sampling', in *Sage Research Methods Foundations*. London: SAGE Publications Ltd. doi: <https://doi.org/10.4135/9781526421036831710>.

Parn, E. *et al.* (2015) 'Building Information Modelling (BIM) for UK housing: Exploring potential drivers and opportunities to deliver better customer experience', *Mindanao Journal of Science and Technology*, 13, pp. 51-64.

Pasmore, W. *et al.* (1982) 'Sociotechnical systems: A North American reflection on empirical studies of the seventies', *Human Relations (New York)*, 35(12), pp. 1179-1204. doi: <https://doi.org/10.1177/001872678203501207>.

Pearce, J. and Vine, J. (2014) 'Quantifying residualisation: the changing nature of social housing in the UK', *Journal of Housing and the Built Environment*, 29(4), pp. 657-675. doi: <https://doi.org/10.1007/s10901-013-9372-3>.

Petcou, C. and Petrescu, D. (2015) 'R-URBAN or how to co-produce a resilient city', *Ephemera*, 15(1), p.249.

Porter, L., Steele, W. and Stone, W. (2018) 'Housing and resilience—When, for whom and for what? A critical agenda', *Housing, Theory and Society*, 35(4), pp. 387-393. doi: <https://doi.org/10.1080/14036096.2018.1492964>.

Pullinger, M., Lovell, H. and Webb, J. (2014) 'Influencing household energy practices: a critical review of UK smart metering standards and commercial feedback devices', *Technology Analysis and Strategic Management*, 26(10), pp. 1144-1162. doi: <https://doi.org/10.1080/09537325.2014.977245>.

Reckwitz, A. (2002a) 'The status of the "material" in theories of culture: From "social structure" to "artefacts"', *Journal for the Theory of Social Behaviour*, 32(2), pp. 195-217. doi: <https://doi.org/10.1111/1468-5914.00183>.

Reckwitz, A. (2002b) 'Toward a theory of social practices: A development in culturalist theorizing', *European Journal of Social Theory*, 5(2), pp. 243-263. doi: <https://doi.org/10.1177/13684310222225432>.

Reeves, P. (2006) *Introduction to social housing*. 2nd edn. London: Routledge. doi: <https://doi.org/10.4324/9780080458441>.

RIBA (2019) *RIBA sustainable outcomes guide*. Available at: <https://www.architecture.com/knowledge-and-resources/resources-landing-page/sustainable-outcomes-guide?srsId=AfmBOooQ-ZRfWZT1FjA34vpEjXUI7mFHks3vEYJ7-FTiOilzJQ-NXdX3> (Accessed: 20 May 2024)

RIBA (2020) *Post occupancy evaluation: An essential tool to improve the built environment*. Available at: <https://www.architecture.com/knowledge-and-resources/resources-landing-page/post-occupancy-evaluation-an-essential-tool-to-improve-the-built-environment> (Accessed: 28 May 2024).

Richards, L. (1999) 'Data alive! The thinking behind NVivo', *Qualitative Health Research*, 9(3), pp. 412-428. doi: <https://doi.org/10.1177/104973299129121857>.

Roh, T. *et al.* (2021) 'Indoor air quality and health outcomes in employees working from home during the covid-19 pandemic: A pilot study', *Atmosphere*, 12(12), p. 1665. doi: <https://doi.org/10.3390/atmos12121665>.

Rouleau, J., Gosselin, L. and Blanchet, P. (2019) 'Robustness of energy consumption and comfort in high-performance residential building with respect to occupant behavior', *Energy (Oxford)*, 188, p. 115978. doi: <https://doi.org/10.1016/j.energy.2019.115978>.

Rowley, S. *et al.* (2023) 'The new normal: changed patterns of dwelling demand and supply', *AHURI Final Report*. doi: <https://doi.org/10.18408/ahuri8129401>.

Saldaña, J. (2013) *The coding manual for qualitative researchers*. 2nd edn. Los Angeles: SAGE

Saunders, B. *et al.* (2018) 'Saturation in qualitative research: exploring its conceptualization and operationalization', *Quality and Quantity*, 52(4), pp. 1893-1907. doi: <https://doi.org/10.1007/s11135-017-0574-8>.

Saunders, M., Lewis, P. and Thornhill, A. (2009) 'Understanding research philosophies and approaches', in *Research Methods for Business Students [electronic resource]*. 5th edn. Harlow: Financial Times Prentice Hall, pp. 106-135.

Scanlon, K. and Arrigoitia, M. F. (2015) 'Development of new cohousing: lessons from a London scheme for the over-50s', *Urban Research and Practice*, 8(1), pp. 106–121. doi: <https://doi.org/10.1080/17535069.2015.1011430>.

Schatzki, T.R. (1997) 'Practices and Actions: A Wittgensteinian Critique of Bourdieu and Giddens', *Philosophy of the Social Sciences*, 27(3), pp. 283-308. doi: <https://doi.org/10.1177/004839319702700301>.

Schatzki, T. R., Knorr-Cetina, K. and Savigny, E. von (eds.) (2001) *The practice turn in contemporary theory*. New York: Routledge.

Scholte, B. (1974). 'Toward a Reflexive and Critical Anthropology', in Hymes, D. (ed.) *Re-Inventing Anthropology*. New York: Pantheon Books, pp. 430-458.

Schwarz, S. (2018) 'Resilience in psychology: A critical analysis of the concept', *Theory and Psychology*, 28(4), pp. 528-541. doi: <https://doi.org/10.1177/0959354318783584>.

Shaw, K. (2012) 'The Rise of the Resilient Local Authority?', *Local Government Studies*, 38(3), pp. 281-300. doi: <https://doi.org/10.1080/03003930.2011.642869>.

Sheffield City Council (2013) *Sheffield City Council Housing Strategy 2013-2023*. Available at: [https://www.sheffield.gov.uk/sites/default/files/2022-12/housing\\_strategy\\_2013\\_to\\_2023.pdf](https://www.sheffield.gov.uk/sites/default/files/2022-12/housing_strategy_2013_to_2023.pdf) (Accessed: 7 January 2025)

Sheffield City Council (2017) *Facts and Figures 2017/2018 Sheffield City Council Annual Housing Statistics Report*.

Sheffield City Council (2024) *Housing Strategy 2024-2034*. Available at: [https://www.sheffield.gov.uk/sites/default/files/2024-12/housing\\_strategy\\_2024\\_-\\_2034\\_1.pdf](https://www.sheffield.gov.uk/sites/default/files/2024-12/housing_strategy_2024_-_2034_1.pdf) (Accessed: 7 January 2025)

Sherriff, G. *et al.* (2019) 'Coping with extremes, creating comfort: User experiences of "low-energy" homes in Australia', *Energy Research and Social Science*, 51. doi: <https://doi.org/10.1016/j.erss.2018.12.008>.

- Shove, E. (2010) 'Beyond the ABC: Climate change policy and theories of social change', *Environment and Planning A*, 42(6), pp. 1273-1285. doi: <https://doi.org/10.1068/a42282>.
- Shove, E. (2018) 'What is wrong with energy efficiency?', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 46(7), pp. 779-789. doi: <https://doi.org/10.1080/09613218.2017.1361746>.
- Shove, E. and Pantzar, M. (2005) 'Consumers, producers and practices: Understanding the invention and reinvention of Nordic walking', *Journal of Consumer Culture*, 5(1), pp. 43-64. doi: <https://doi.org/10.1177/1469540505049846>.
- Shove, E., Pantzar, M. and Watson, M. (2012) *The dynamics of social practice: Everyday life and how it changes*. London: SAGE.
- Shove, E. and Trentmann, F. (2018) *Infrastructures in practice: The dynamics of demand in networked societies*. Abingdon, Oxon; New York, NY: Routledge.
- Shove, E. and Walker, G. (2014) 'What is energy for? Social practice and energy demand', *Theory, Culture & Society*, 31(5), pp. 41-58. doi: <https://doi.org/10.1177/0263276414536746>.
- Shove, E., Watson, M. and Spurling, N. (2015) 'Conceptualizing connections: Energy demand, infrastructures and social practices', *European Journal of Social Theory*, 18(3), pp. 274-287. doi: <https://doi.org/10.1177/1368431015579964>.
- Shrubsole, C. et al. (2014) '100 Unintended consequences of policies to improve the energy efficiency of the UK housing stock', *Indoor and Built Environment*, 23(3), pp. 340-352. doi: <https://doi.org/10.1177/1420326X14524586>.
- Simons, H. (2009) 'Evolution and Concept of Case Study Research', in *Case study research in practice*. Los Angeles; London: SAGE, pp. 13-28.
- Steemers, K. and Yun, G. Y. (2009) 'Household energy consumption: A study of the role of occupants', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 37(5-6), pp. 625-637. doi: <https://doi.org/10.1080/09613210903186661>.
- Stephens, M., Burns, N. and MacKay, L. (2003) 'The limits of housing reform: British social rented housing in a European context', *Urban Studies (Edinburgh, Scotland)*, 40(4), pp. 767-789. doi: <https://doi.org/10.1080/0042098032000065290>.
- Stephenson, J. et al. (2010) 'Energy cultures: A framework for understanding energy behaviours', *Energy Policy*, 38(10), pp. 6120-6129. doi: <https://doi.org/10.1016/j.enpol.2010.05.069>.

Stephenson, J. *et al.* (2015) 'The energy cultures framework: Exploring the role of norms, practices and material culture in shaping energy behaviour in New Zealand', *Energy Research and Social Science*, 7. doi: <https://doi.org/10.1016/j.erss.2015.03.005>.

Stevenson, F. (2019) *Housing fit for purpose: performance, feedback and learning*. London: London: RIBA Publishing.

Stevenson, F., Baborska-Narozny, M. and Chatterton, P. (2016) 'Resilience, redundancy and low-carbon living: co-producing individual and community learning', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 44(7), pp. 789-803. doi: <https://doi.org/10.1080/09613218.2016.1207371>.

Stollmann, J. (2016) 'Neighbourhood resilience in mass housing: co-production via research-by-design', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 44(7), pp. 737-753. doi: <https://doi.org/10.1080/09613218.2016.1217386>.

Strengers, Y. and Maller, C. (2011) 'Integrating health, housing and energy policies: Social practices of cooling', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 39(2), pp. 154-168. doi: <https://doi.org/10.1080/09613218.2011.562720>.

Sunikka-Blank, M. *et al.* (2012) 'Improving energy efficiency of social housing areas: A case study of a retrofit achieving an "A" energy performance rating in the UK', *European Planning Studies*, 20(1), pp. 131-145. doi: <https://doi.org/10.1080/09654313.2011.638494>.

Tabatabaei Sameni, S. M. *et al.* (2015) 'Overheating investigation in UK social housing flats built to the Passivhaus standard', *Building and Environment*, 92, pp. 222-235. doi: <https://doi.org/10.1016/j.buildenv.2015.03.030>.

Tellarini, C. and Gram-Hanssen, K. (2024) "'If something breaks, who comes here to fix it?': Island narratives on the energy transition in light of the concept of practice architectures', *Energy Research and Social Science*, 114, p. 103617. doi: <https://doi.org/10.1016/j.erss.2024.103617>.

Tsenkova, S. (2021) 'Resilience of social housing systems in Vienna, Amsterdam, and Copenhagen', in *Cities and Affordable Housing: Planning, Design and Policy Nexus*. New York: Routledge, pp. 171–193. doi: <https://doi.org/10.4324/9781003172949>.

Tsoulou, I. *et al.* (2020) 'Summertime thermal conditions and senior resident behaviors in public housing: A case study in Elizabeth, NJ, USA', *Building and Environment*, 168, p. 106411. doi: <https://doi.org/10.1016/j.buildenv.2019.106411>.

Tsoulou, I. *et al.* (2023) 'Monitoring summertime indoor overheating and pollutant risks and natural ventilation patterns of seniors in public housing', *Indoor and Built Environment*, 32(5), pp. 992-1019. doi: <https://doi.org/10.1177/1420326X221148728>.

Tuohy, P. (2009) 'Regulations and robust low-carbon buildings', *Building Research and Information: The International Journal of Research, Development and Demonstration*, 37(4), pp. 433-445. doi: <https://doi.org/10.1080/09613210902904254>.

Tyler, S. and Moench, M. (2012) 'A framework for urban climate resilience', *Climate and Development*, 4(4), pp. 311-326. doi: <https://doi.org/10.1080/17565529.2012.745389>.

UK Health Security Agency (2024) *Beat the heat: Staying safe in hot weather*. Available at: <https://www.gov.uk/government/publications/beat-the-heat-hot-weather-advice/beat-the-heat-staying-safe-in-hot-weather> (Accessed: 31 May 2024).

The UK Green Building Council (2019) 'Net Zero Carbon Buildings: A Framework Definition', *UKGBC, Advancing Net Zero* [Preprint], (April).

Ungar, M. and Liebenberg, L. (2011) 'Assessing resilience across cultures using mixed methods: Construction of the child and youth resilience measure', *Journal of Mixed Methods Research*, 5(2), pp. 126-149. doi: <https://doi.org/10.1177/1558689811400607>.

UN-Habitat (2009) *Financing affordable social housing in Europe*. Available at: <https://unhabitat.org/financing-affordable-housing-in-europe> (Accessed: 2 April 2023)

United Nations Environment Programme (2022) *2022 Global Status Report for Buildings and Construction*. Available at: <https://www.unep.org/resources/publication/2022-global-status-report-buildings-and-construction> (Accessed: 5 April 2024)

United Nations Human Rights (2020) 'Housing, the front line defence against the COVID-19 outbreak,' says UN expert. Available at: <https://www.ohchr.org/en/press-releases/2020/03/housing-front-line-defence-against-covid-19-outbreak-says-un-expert> (Accessed: 3 May 2024).

Vagtholm, R. *et al.* (2023) 'Evolution and current state of building materials, construction methods, and building regulations in the U.K.: Implications for sustainable building practices', *Buildings (Basel)*, 13(6), p. 1480. doi: <https://doi.org/10.3390/BUILDINGS13061480>.

van den Brom, P. *et al.* (2019) 'Variances in residential heating consumption – Importance of building characteristics and occupants analysed by movers and stayers', *Applied Energy*, 250, pp. 713-728. doi: <https://doi.org/10.1016/j.apenergy.2019.05.078>.

- van Zandt, S. *et al.* (2012) 'Mapping social vulnerability to enhance housing and neighborhood resilience', *Housing Policy Debate*, 22(1), pp. 29-55. doi: <https://doi.org/10.1080/10511482.2011.624528>.
- Verhallen, T. M. M. and van Raaij, W. F. (1981) 'Household behavior and the use of natural gas for home heating', *Journal of Consumer Research*, 8(3), pp. 253-257. doi: <https://doi.org/10.1086/208862>.
- Walker, B. *et al.* (2004) 'Resilience, adaptability and transformability in social-ecological systems', *Ecology and Society*, 9(2), pp. 5-5. doi: <https://doi.org/10.5751/ES-00650-090205>.
- Walker, B.H. (1992) 'Biodiversity and ecological redundancy', *Conservation Biology*, 6(1), pp. 18-23. doi: <https://doi.org/10.1046/j.1523-1739.1992.610018.x>.
- Warde, A. (2005) 'Consumption and theories of practice', *Journal of Consumer Culture*, 5(2), pp. 131–153. doi: <https://doi.org/10.1177/1469540505053090>.
- Warde, A. (2014) 'After taste: Culture, consumption and theories of practice', *Journal of Consumer Culture*, 14(3), pp. 279-303. doi: <https://doi.org/10.1177/1469540514547828>.
- Warde, A., Welch, D. and Paddock, J. (2017) 'Studying consumption through the lens of practice', in Keller, M. *et al.* (ed.) *Routledge Handbook on Consumption*. London, England; New York, New York: Routledge, pp. 25-35.
- Webster, M.J. and Bogunovich, D. (2021) 'The crisis of housing affordability: Kindness to people and environmental resilience?', *Knowledge Cultures*, 9(3). doi: <https://doi.org/10.22381/kc9320216>.
- Welch, D. and Yates, L. (2018) 'The practices of collective action: Practice theory, sustainability transitions and social change', *Journal for the Theory of Social Behaviour*, 48(3), pp. 288-305. doi: <https://doi.org/10.1111/jtsb.12168>.
- Wethal, U. (2020) 'Practices, provision and protest: Power outages in rural Norwegian households', *Energy Research and Social Science*, 62. doi: <https://doi.org/10.1016/j.erss.2019.101388>.
- William, F. K. A. (2024) 'Interpretivism or constructivism: Navigating research paradigms in social science research', *International Journal of Research Publications*, 143(1). doi: <https://doi.org/10.47119/ijrp1001431220246122>.
- Wright, A. and Venskunas, E. (2022) 'Effects of future climate change and adaptation measures on summer comfort of modern homes across the regions of the UK', *Energies (Basel)*, 15(2), p. 512. doi: <https://doi.org/10.3390/en15020512>.

Yaneva, A. (2016) *Mapping Controversies in Architecture [eBook]*. London: Routledge. doi: <https://doi.org/10.4324/9781315593807>.

Yi, S., Knudsen, T. and Becker, M. C. (2016) 'Inertia in routines: A hidden source of organizational variation', *Organization Science (Providence, R. I.)*, 27(3), pp. 782-800. doi: <https://doi.org/10.1287/orsc.2016.1059>.

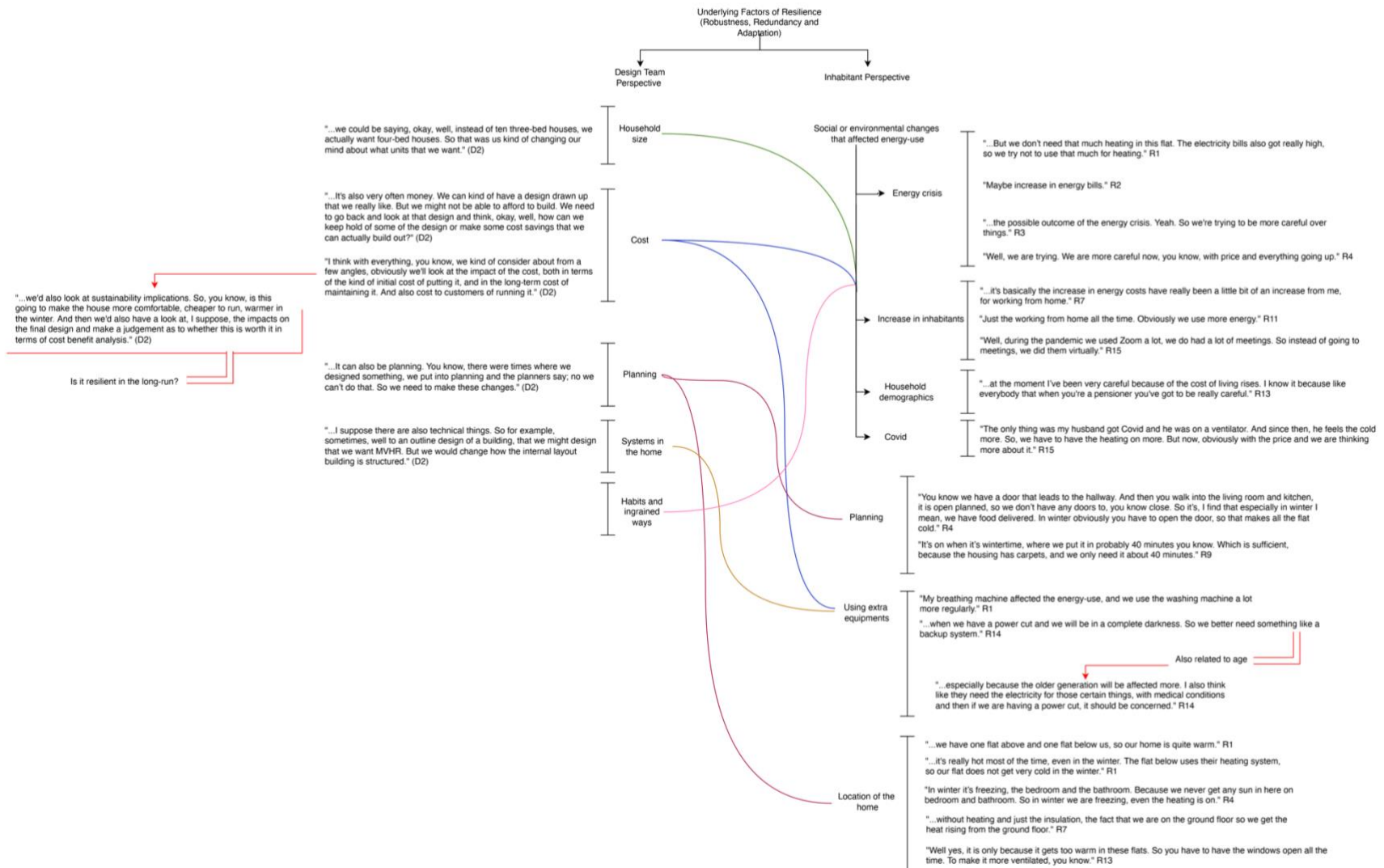
Yin, R. K. (2018) *Case study research and applications: Design and methods*. 6th edn. Los Angeles: SAGE.

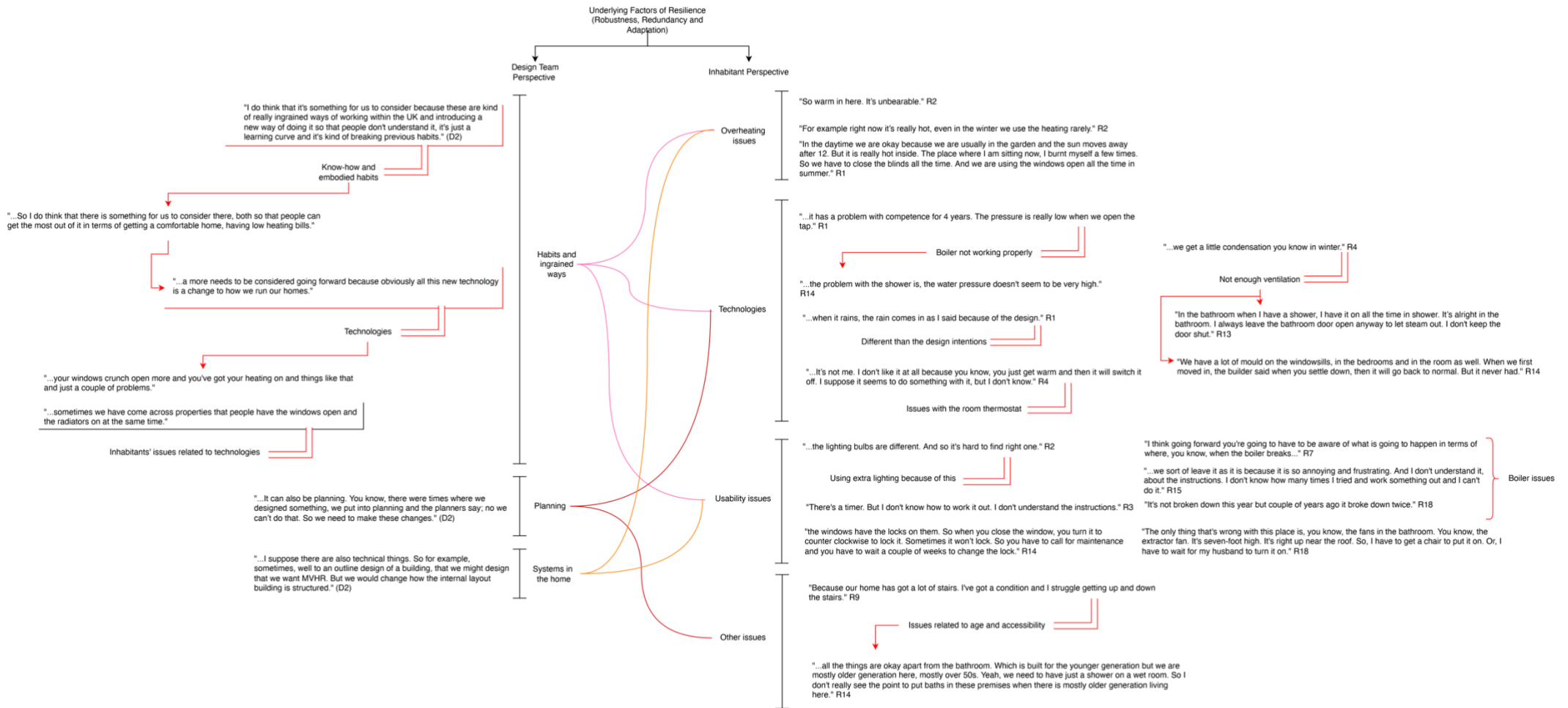
Yohanis, Y. G. *et al.* (2008) 'Real-life energy use in the UK: How occupancy and dwelling characteristics affect domestic electricity use', *Energy and Buildings*, 40(6), pp. 1053-1059. doi: <https://doi.org/10.1016/j.enbuild.2007.09.001>.

Zahiri, S. and Gupta, R. (2023) 'Examining the risk of summertime overheating in UK social housing dwellings retrofitted with heat pumps', *Atmosphere*, 14(11), p. 1617. Available at: <https://doi.org/10.3390/atmos14111617>.

# Appendices

Appendix 1: Mapping diagram illustrating underlying factors of resilience, developed by the researcher (continued next page)





Appendix 2: Usability survey data analysis using SPSS

Usability Survey Data Analysis\_latest.sav [DataSet1] - IBM SPSS Statistics Data Editor

33 : ParticipantID Visible: 121 of 121 Variables

ParticipantID	Age	Gender	Typology	Number of Rooms	Floor Location	Household	Time At Home	User Guide	User Guide Operate	User Guide Maintenance	Use of Technical Equipment	Central Heating	Individual Heating	Heating Maintenance Procedure	Boiler	Op gl
1	51-70	Female	Flat	2-bed	Ground fl...	1-3 people	Most of th...	Yes	Below average	Poor	Below ave...	Above av...	99	Yes	Yes	
2	51-70	Male	Flat	2-bed	Ground fl...	1-3 people	Most of th...	Yes	Below average	Very poor	Excellent	Excellent	Excellent	Yes	Yes	
3	51-70	Female	Flat	2-bed	Ground fl...	1-3 people	Most of th...	Yes	Below average	Below average	Poor	Excellent	Excellent	Yes	Yes	
4	Over 70	Female	Flat	2-bed	Ground fl...	1-3 people	Most of th...	No	99	99	Below ave...	Above av...	99	No	Yes	
5	Over 70	Male	Flat	2-bed	Ground fl...	1-3 people	Most of th...	No	99	99	Poor	Average	99	No	Yes	
6	51-70	Female	Flat	1-bed	First Floor	Other	Most of th...	Yes	Excellent	Excellent	Average	Excellent	Excellent	Yes	Yes	
7	51-70	Male	Flat	2-bed	First Floor	1-3 people	Most of th...	No	99	99	Excellent	Above av...	99	Yes	Yes	
8	30-50	Female	Flat	2-bed	First Floor	1-3 people	Most of th...	I don't kn...	99	99	99	Very poor	Very poor	No	Yes	
9	51-70	Male	Flat	2-bed	First Floor	1-3 people	Most of th...	Yes	Excellent	Excellent	Excellent	Excellent	Excellent	Yes	Yes	
10	51-70	Female	Flat	2-bed	First Floor	1-3 people	Most of th...	Yes	Excellent	Excellent	Excellent	Excellent	Excellent	Yes	Yes	
11	51-70	Male	Flat	2-bed	Ground fl...	1-3 people	Most of th...	No	99	99	Good	Good	Good	No	Yes	
12	51-70	Female	Flat	2-bed	Ground fl...	1-3 people	Evenings	I don't kn...	99	99	Average	Good	Good	Yes	Yes	
13	51-70	Female	Flat	1-bed	First Floor	Other	Most of th...	Yes	Excellent	Excellent	Average	Excellent	99	No	Yes	
14	51-70	Male	Flat	2-bed	Ground fl...	1-3 people	Most of th...	I don't kn...	99	99	Good	Good	99	Yes	Yes	
15	30-50	Female	Flat	2-bed	First Floor	1-3 people	Evenings	Yes	Above average	Excellent	Above av...	Average	Excellent	Yes	Yes	
16	51-70	Male	Flat	2-bed	First Floor	1-3 people	Evenings	Yes	Good	Excellent	Good	Below ave...	Good	I don't know	Yes	
17	Over 70	Female	Flat	1-bed	Ground fl...	Other	Most of th...	Yes	Above average	Above average	Poor	Good	99	No	Yes	
18	51-70	Female	Flat	2-bed	First Floor	1-3 people	Most of th...	Yes	Above average	Above average	Average	Average	99	Yes	Yes	
19	51-70	Male	Flat	2-bed	First Floor	1-3 people	Evenings	Yes	Above average	Above average	Above av...	Good	Good	Yes	Yes	
20	51-70	Female	Flat	2-bed	First Floor	1-3 people	Most of th...	Yes	Above average	Above average	Good	Excellent	99	I don't know	Yes	
21	51-70	Male	Flat	2-bed	First Floor	1-3 people	Most of th...	I don't kn...	99	99	Excellent	Excellent	99	I don't know	Yes	
22	Over 70	Female	Flat	2-bed	Ground fl...	1-3 people	Most of th...	Yes	Excellent	Above average	Average	Good	Very poor	Yes	Yes	
23	51-70	Male	Flat	2-bed	Ground fl...	1-3 people	Other	Yes	Above average	Excellent	Good	Below ave...	Excellent	Yes	Yes	
24	51-70	Female	Flat	2-bed	Ground fl...	1-3 people	Most of th...	Yes	Above average	Excellent	Good	Below ave...	Excellent	Yes	Yes	
25	30-50	Female	Semi-det...	3-bed	Semi-det...	1-3 people	Most of th...	Yes	Below average	Below average	Poor	Average	Above av...	No	Yes	
26	30-50	Male	Semi-det...	3-bed	Semi-det...	1-3 people	Evenings	Yes	Above average	Excellent	Excellent	Above av...	Good	Yes	Yes	
27																
28																

Overview Data View Variable View

IBM SPSS Statistics Processor is ready Unicode:ON Classic

## Appendix 3: Anonymised participant invitation letter



School  
Of  
Architecture.

Melis Tekin

School of Architecture  
The University of Sheffield  
The Arts Tower, Western Bank  
Sheffield, South Yorkshire, S10 2TN  
UK

15 June 2022

Email: [mtekin2@sheffield.ac.uk](mailto:mtekin2@sheffield.ac.uk)

Dear Resident,

My name is Melis Tekin and I am a doctorate student at The University of Sheffield. For my research, I am working with [REDACTED] to better understand how your home lifestyles, and the needs of different household members impact on how much energy your home uses.

I would like to invite you and another member of your household to take part in an online or face-to-face interview with me and complete a survey which is mainly about how you use the heating and ventilation equipment in your home. This information will help me, and you, to understand how to improve the performance of your home, to cut your energy use and bills. Your contribution to this research could also help to improve the design of housing in the UK, to make it more comfortable, cheaper to run, and to reduce its contribution to climate change. This will also help [REDACTED] and other housebuilders to understand how to make homes more resilient to the growing impacts of climate change such as heatwaves.

If you would like to take part and get some more information about my research, or if you have any further questions please contact me, The Principal Researcher, at [mtekin2@sheffield.ac.uk](mailto:mtekin2@sheffield.ac.uk) and please use the QR code that is attached in the corner to sign-up for my research.

Thank you for taking the time to read this letter and we hope you would like to take part in this research.

Yours sincerely,

Melis Tekin



**School of Architecture**  
Information Sheet  
May 2022



**Research Project Title:**

**Social Resilience in Housing Performance: A Case Study of Low-energy Housing in the UK**

*You are being invited to take part in a research project. Before you decide whether or not to participate, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information "contact details are provided at the end of this guide". Take time to decide whether or not you wish to take part. Thank you for reading this.*

**1. What is the project's purpose?**

The purpose of this project is to explore and understand robustness, adaptation and redundancy in relation to inhabitant negotiated energy practices in the household to help future proof low-energy housing in the UK. I will first do a face-to-face interview the design team (including the architect, engineer and the client) to have a better understanding of energy-related design intentions. I will then do interviews (either online, face-to-face or by phone depending on your preference) with 2 members in your household to understand how you negotiate your energy-related actions with one another. After the interviews, I will give you a usability questionnaire to reveal any usability issues related to the heating and ventilation controls in your home. I will also be present while you are completing the questionnaires.

The findings from these activities will help the housing developers, constructors, designers and researchers to understand how to develop a more resilient home and improve housing design. Gathered information will also help you to understand how your lifestyle impacts on your home and for you to have more resilient homes in the future.

**2. Why have I been chosen?**

You have been chosen to participate in this study as one of the inhabitants living in a low energy housing developed by [REDACTED]. We are aiming to recruit 20 households for this project.

**3. Do I have to take part?**

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep (and be asked to sign a consent form) and you can still withdraw at any time without any negative consequences. You do not have to give a reason. If you wish to withdraw from the research, please contact the lead researcher.

Please note that, by choosing to participate in this research, this will not create a legally binding agreement, nor is it intended to create an employment relationship between you and the University of Sheffield.

**4. Will I be recorded, and how will the recorded media be used?**

All audio recordings of your activities will be used only for analysis and for illustration in future publications and dissemination. No other use will be made of them without your written permission (special consent form), and no one apart from the researcher will be allowed access to the original recordings.

## **5. What will happen to me if I take part? What do I have to do?**

You will be asked to take part in the following activities below. You will;

- a. Take part in the interviews which will take no more than 20 minutes and the researcher will ask you questions about how you discuss key environmental activities within the household and how this affects your activities in the home.
- b. Fill in a usability questionnaire that covers the usability issues of heating and ventilation controls in your home. Same 2 participants that has done the interviews in your household are needed to fill in the questionnaires.

If you decide to take part in this project, you will be asked to sign a consent form before taking part in any activity. The signed consent form should be returned directly to the researcher; scanned JPEG and emailed (see the contact information below).

## **6. What are the possible disadvantages and risks of taking part?**

The only disadvantage of taking part in this study is the time taken for the interviews and usability questionnaires. There are no risks to you or your home, as all the activities will be completed at a common space/public area.

## **7. What are the possible benefits of taking part?**

This research will help you to investigate your own experience, negotiations with each other to understand how your lifestyles impact on your home in terms of its resilience to climate change and future adaptability. It will also identify key insights to help future proof low-energy housing. With this new knowledge, housing developers, constructors and designers will understand how to design more resilient homes which will also be a benefit to you and others in the future.

## **8. Will my taking part in this project be kept confidential?**

You have a right to confidentiality and privacy to protect your identities in any discussions and data sets, and appropriate mechanisms will be deployed to guarantee complete confidentiality and anonymity. A consent form will be requested from you to sign before collecting any data. Data generated by the study will be retained in accordance with the University of Sheffield's policy on Academic Integrity and kept securely in paper or electronic form for a period of ten years after the completion of a research project. Anonymised data may also be deposited on the University of Sheffield data repository called ORDA.

All the information that we collect about you during the course of the research will be kept strictly confidential and will only be accessible to members of the research team. You will not be able to be identified in any reports or publications unless you have given your explicit consent for this.

## **9. What is the legal basis for processing my personal data?**

The legal basis we are applying in order to process your personal data is that processing is necessary for the performance of a task carried out in the public interest. In this research personal data collected such as age, gender, etc. will not identify you. The researcher will fully anonymise data collected from interviews and questionnaires. Any sensitive data will not be shared or stored; it will be destroyed immediately after the end of this project and final dissemination.

#### **10. What will happen to the data collected, and the results of the research project?**

The data will be stored on the researcher's laptop with bit locker drive encryption. The research team will have access to data generated at each stage of research. The University of Sheffield has the right to see and use my generated data. The University of Sheffield will have the final thesis document, and the library may require access to some of the research data in the future. Only anonymised data can be shared on the data repository for 10 years. Consented and generated data can be used in publications, presentations and final dissemination. The researcher may also store the data on an encrypted external hard drive to be used for further projects for up to ten years.

#### **11. Who is organising and funding the research?**

The research is organised by The University of Sheffield and [REDACTED]

#### **12. Who is the Data Controller?**

The University of Sheffield will act as the Data Controller for this study. This means that The University of Sheffield is responsible for looking after your information and using it properly.

#### **13. Who has ethically reviewed the project?**

This project has been ethically approved via the University of Sheffield's Ethics Review Procedure, as administered by the Sheffield School of Architecture.

#### **14. What if something goes wrong and I wish to complain about the research or report a concern or incident?**

If you are dissatisfied with any aspect of the research and wish to make a complaint, please contact the lead researcher Melis Tekin (see the contact details below) in the first instance. If you feel your complaint has not been handled in a satisfactory way you can contact the Head of the School of Architecture Prof. Karim Hadjri; The School of Architecture, The University of Sheffield, Arts Tower, Western Bank, Sheffield, S10 2TN, Email: [k.hadjri@sheffield.ac.uk](mailto:k.hadjri@sheffield.ac.uk) Tel: +44 114 222 0307. If the complaint relates to how your personal data has been handled, you can find information about how to raise a complaint in the University's Privacy Notice: <https://www.sheffield.ac.uk/govern/data-protection/privacy/general>.

If you wish to make a report of a concern or incident relating to potential exploitation, abuse or harm resulting from your involvement in this project, please contact the project's Designated Safeguarding Contact Dr. Wen-Shao Chang; [w.chang@sheffield.ac.uk](mailto:w.chang@sheffield.ac.uk). If the concern or incident relates to the Designated Safeguarding Contact, or if you feel a report you have made to this Contact has not been handled in a satisfactory way, please contact the Head of the School of Architecture Prof. Karim Hadjri; The School of Architecture, The University of Sheffield, Arts Tower, Western Bank, Sheffield, S10 2TN, Email: [k.hadjri@sheffield.ac.uk](mailto:k.hadjri@sheffield.ac.uk) Tel: +44 114 222 0307 and/or the University's Research Ethics & Integrity Manager (Lindsay Unwin; [l.v.unwin@sheffield.ac.uk](mailto:l.v.unwin@sheffield.ac.uk)).

#### **15. Contact for further information**

Lead researcher: **Melis Tekin**, School of Architecture, The University of Sheffield, Arts Tower, Western Bank, Sheffield, S10 2TN. Email: [mtekin2@sheffield.ac.uk](mailto:mtekin2@sheffield.ac.uk) Tel: +44 737 653 1140.

Principle supervisor: **Dr. Wen-Shao Chang**, School of Architecture, The University of Sheffield, Arts Tower, Western Bank, Sheffield, S10 2TN.  
Email: [w.chang@sheffield.ac.uk](mailto:w.chang@sheffield.ac.uk) Tel: +44 114 222 0370.

Co-supervisor: **Dr. Isaiah Durosaiye**, School of Architecture, The University of Sheffield, Arts Tower, Western Bank, Sheffield, S10 2TN. Email: [i.durosaiye@sheffield.ac.uk](mailto:i.durosaiye@sheffield.ac.uk)  
Tel: +44 114 222 0368.

**Finally ...** You can keep a copy of this information sheet for future references.

**Thank you for taking the time to read this information sheet and for taking part in this project.**



## Appendix 6: Ethical approval



Downloaded: 19/07/2024  
Approved: 23/06/2022

Melis Tekin  
Registration number: 190183408  
School of Architecture  
Programme: PhD in Architecture

Dear Melis

**PROJECT TITLE:** Social Resilience in Housing Performance: A Case Study of Low-energy Housing in the UK  
**APPLICATION:** Reference Number 043403

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 23/06/2022 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- University research ethics application form 043403 (form submission date: 21/06/2022); (expected project end date: 31/12/2023).
- Participant information sheet 1105865 version 1 (09/05/2022).
- Participant information sheet 1105864 version 1 (09/05/2022).
- Participant consent form 1105867 version 1 (09/05/2022).
- Participant consent form 1105866 version 1 (09/05/2022).

If during the course of the project you need to [deviate significantly from the above-approved documentation](#) please inform me since written approval will be required.

Your responsibilities in delivering this research project are set out at the end of this letter.

Yours sincerely

Parag Wate  
Ethics Admin  
School of Architecture

Please note the following responsibilities of the researcher in delivering the research project:

- The project must abide by the University's Research Ethics Policy: <https://www.sheffield.ac.uk/research-services/ethics-integrity/policy>
- The project must abide by the University's Good Research & Innovation Practices Policy: [https://www.sheffield.ac.uk/polopoly\\_fs/1.671066/file/GRIPPpolicy.pdf](https://www.sheffield.ac.uk/polopoly_fs/1.671066/file/GRIPPpolicy.pdf)
- The researcher must inform their supervisor (in the case of a student) or Ethics Admin (in the case of a member of staff) of any significant changes to the project or the approved documentation.
- The researcher must comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data.
- The researcher is responsible for effectively managing the data collected both during and after the end of the project in line with best practice, and any relevant legislative, regulatory or contractual requirements.

Appendix 7: Usability survey for the inhabitants

### Usability Tool - Domestic Controls

This survey is being conducted to help with future planning of domestic controls and to understand how usable the domestic controls are. The information collected will be treated as completely confidential. Survey reports will only use summaries of information and not reveal the identities of individuals.

Please fill in as many questions as you can. Write any further comments in the spaces provided or on a separate sheet. Thank you for your help.

Queries: If you have any queries please contact

Melis Tekin

Email: mtekin2@sheffield.ac.uk

*Who should fill this in? Anyone over the age of 18 who lives in the home. This will normally be the person in the household mainly involved with the controls.*

*Please tick the boxes where appropriate and fill in additional comments and information in the fields provided.*

*Please note: We ask for names so that we can follow up any matters that may arise.*



### Background

What is your age?  Under 30  30-50  51-70  Over 70

What is your gender?  Female  Male  Prefer not to say

Please give your name

Are you normally at home?  Most of the time  Evenings  Weekends only  Other:

Are you in a ...  Terraced House  Detached House  Semi-detached house  Flat  Other:

Do you share the house with...  1-3 people  4 or more people  Other:

Do you have home user guide?  Yes  No  I don't know

If yes, how would you rate its usability for...  
 operating your home? Very poor  1  2  3  4  5  6  7 Very good  
 securing maintenance? Very poor  1  2  3  4  5  6  7 Very good

How would you rate your ability to use the technical equipments? Very poor  1  2  3  4  5  6  7 Very good

Do you have any special circumstances that make your ability to operate domestic controls different from the average person? Please describe any particular constrain or advantage.



## Heating controls

Overall, how would you rate controls for (please select the relevant heating system of your home):

	Very poor										Very good
Central heating	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Individual heating	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Tick to indicate your rating.  
For additional comments please use the comments section at the bottom of page

Are you aware of the maintenance procedure?  Yes  No  I don't know

<b>Boiler</b>	<b>Room thermostat</b>	<b>Radiator valves</b>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you have this equipment in your home?		
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Which of the following do you operate regularly?		

Tick where appropriate:

	Boiler control			Heating programmer			Room thermostat			Radiator valves		
	Yes	I don't know	No	Yes	I don't know	No	Yes	I don't know	No	Yes	I don't know	No
Is it clear what this control does?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Does its location help use it when needed?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Is it easy to see how to use this control?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Is it easy to operate this control?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you discuss with your household member when you need to use this control?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you take charge of using this heating equipment?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Does it show response to your actions?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Is it sufficiently labelled?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Does it allow making sufficient adjustments?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Is it obvious if you should interact with it?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comments on heating controls:



## Ventilation controls

Overall, how would you rate controls for ventilation?

Very poor 1 2 3 4 5 6 7 Very good

Are you aware of the maintenance procedure?

Yes  No  I don't know

How would you rate ease of maintenance for:

MVHR filters 1 2 3 4 5 6 7 Very poor Very good

Cooker hood filter 1 2 3 4 5 6 7 Very poor Very good

Tick to indicate your rating.

For additional comments please use the comments section at the bottom of page



Do you have this equipment in your home?

**Windows**

**MVHR - Mechanical Ventilation with Heat Recovery System:** Provides a constant supply of fresh filtered air into the home, whilst maintaining the air quality of your home.

**Doors**

Which of the following do you operate regularly?

Tick where appropriate:

	Windows			MVHR Unit control panel			MVHR manual boost			MVHR cooking mode			Doors		
	Yes	I don't know	No	Yes	I don't know	No	Yes	I don't know	No	Yes	I don't know	No	Yes	I don't know	No
Is it clear what this control does?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Does its location help use it when needed?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Is it easy to see how to use this control?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Is it easy to operate this control?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you discuss with your household member when you need to use this control?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you take charge of using this ventilation equipment?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Does it show response to your actions?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Is it sufficiently labelled?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Does it allow making sufficient adjustments?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Is it obvious if you should interact with it?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comments on ventilation controls:

## **Semi-structured Interview Questions to Design Team: Project Director and Project Coordinator**

***The purpose of this semi-structured interview with the design team is to develop an understanding of energy-related design intentions in the selected case study.***

### ***Background Questions***

1. What is your role in this project and what did you do?  
**Prompt:** What part did you play in design intentions?
2. Which stage of the project were you involved with?  
**Prompt:** RIBA Plan of Work Stages 0 to 7.
3. Looking back, in the past, was there any project that you can spot that your finished design and/or completed building stage is not exactly the same as your initial intention?  
**Prompt 1:** Can you elaborate the changes?  
**Prompt 2:** Anything changed because of:
  - the client request, or the factors from the client,
  - a technical issue,
  - a legal issue (e.g. regulations),
  - procurement issue,
  - the contractor
4. What type of contract, for example design and built, or traditional contract, was it for delivering the homes?

### ***General Question***

5. How would you define 'resilience' and how do you see that can be integrated into the building environment?  
**Prompt:** Can you give me an example?
6. Have you ever thought about using alternative options to maintain the preferred state, even if there is social change over time?  
**Prompt:** If yes, have you incorporated this in the project by any means?  
If no, what does this definition of 'social resilience' mean to you?
7. If the architects, engineers or the relevant parties suggest you to consider (e.g. if the architect suggests an alternative for heating in case of an increase of household occupancy), will you consider?  
**Prompt:** If yes, up to what level will they say no?  
If no, why not

### ***Adaptation***

8. Have you ever considered the social changes of your client (home users) over time? For example have you considered the gradual change like increase of people living in the home, or use of space?

**Prompt:** If yes, will you ask architects or relevant parties to prepare the instruction to cope with any social changes over time or how?

If no, why not?

**Reminder:** Examples of social change; use of space, different ages, more people, less people, etc.

### ***Robustness***

9. Have you ever considered being robust in sudden change? For example an occupant suddenly became disabled, or a sudden increase of occupancy levels in the home and the home is able to withstand these sudden changes.

**Prompt:** If yes, Have you prepared the instruction to be robust in terms of sudden shocks and future changes socially so that the home can carry on performing despite these sudden changes? How have you incorporated this robustness into the instruction?

If not, why not?

**Reminder:** Different types of robustness; sudden change in occupancy levels, sudden disability, Covid-19.

### ***Redundancy***

10. How easy is it for a resident to meet a particular need using different functions relevant to the energy use of the design? For example you can switch on the light, or you can open the blinds, or you do something else.

**Prompt:** If they didn't talk about heating and ventilation, ask the developer; how about heating and ventilation in the homes?

11. Do you think it's important to have these alternatives?

**Prompt:** If yes, why?

If not, why not?

**Reminder:** Definition of social redundancy is the ability of different things to satisfy the same function for changes to the types of occupancy.

### ***Systems in the Home***

12. What type of heating and ventilation equipment is there for the residents in the home? For example, a boiler, room thermostat, or radiator, etc. for the heating; and windows, doors, trickle vents within the windows, extract fans, cooker hoods, diffuser for ventilation.

13. How usable do you think the heating and ventilation equipment is for the residents you prepared the instruction for?

**Prompt:** If they considered social changes (e.g. sudden disability, increase in occupancy, different ages, etc.), ask; Have you prepared the brief of this heating and ventilation equipment to adjust with social changes within the home?

- 14.** Have you incorporated any extra means of heating and ventilation in the brief to the architects if the specified heating and ventilation system fails?

**Prompt:** Is it possible for the inhabitants to heat and ventilate the home in another way?

### ***General Questions***

- 15.** If they did not talk about robustness, ask; Is there anything else you would like to mention in relation to robustness issues?

If they did not talk about adaptation, ask; Is there anything else you would like to mention in relation to adaptation issues?

If they did not talk about redundancy, ask; Is there anything else you would like to mention in relation to redundancy issues?

**Reminder:** To see if there are any other ways that they addressed robustness, adaptation and redundancy that the questions did not cover.

### **Semi-structured Interview Questions to Design Team: Architect**

***The purpose of this semi-structured interview with the design team is to develop an understanding of energy-related design intentions in the selected case study.***

#### ***Background Questions***

1. What is your role in this project and what did you do?  
**Prompt:** What part did you play in design intentions?
2. Which stage of the project were you involved with?  
**Prompt:** RIBA Plan of Work Stages 0 to 7.
3. How do you gather information about your needs, goals, etc. for this project and in general?  
**Prompt:** What is the process like?
4. How do you establish priorities and make decisions?
5. Looking back, in the past, was there any project that you can spot that your finished design and/or completed building stage is not exactly the same as your initial intention?  
**Prompt 1:** Can you elaborate the changes?  
**Prompt 2:** Anything changed because of:
  - the client request, or the factors from the client,
  - a technical issue,
  - a legal issue (e.g. regulations),
  - procurement issue,
  - the contractor
6. What type of contract, for example design and built, or traditional contract, was it for delivering the homes?
7. What do you see as important issues or considerations in the project?  
**Prompt:** What were the challenges of this project?

#### ***General Question***

8. How would you define 'resilience' and how do you see that can be integrated into the building environment?  
**Prompt:** Can you give me an example?
9. Have you ever thought about using alternative options to maintain the preferred state, even if there is social change over time?  
**Prompt:** If yes, have you incorporated this in the project by any means?  
If no, what does this definition of "social resilience" mean to you?

### **Adaptation**

- 10.** Have you ever considered the social changes of residents over time? For example have you considered the gradual change like increase of people living in the home, or use of space?

***Question related to the resident***

**Prompt 1:** If yes, have you prepared the instruction for the residents to cope with any social changes over time or how?

If no, why not?

**Reminder:** Examples of social change; use of space, different ages, more people, less people, etc.

***Question related to the developer***

**Prompt 2:** If the developer does not give you the brief, will you consider social changes in your design?

If yes, will you put this consideration into the final design and into the instruction?

### **Robustness**

- 11.** Have you ever considered being robust in sudden change? For example an occupant suddenly became disabled, or a sudden increase of occupancy levels in the home and the home is able to withstand these sudden changes.

***Question related to the resident***

**Prompt 1:** If yes, Have you prepared the instruction to be robust in terms of sudden shocks and future changes socially so that the home can carry on performing despite these sudden changes? How have you incorporated this robustness into the instruction?

If not, why not?

**Reminder:** Different types of robustness; sudden change in occupancy levels, sudden disability, Covid-19.

***Question related to the developer***

**Prompt 2:** If the developer does not give you the brief, will you suggest a design that is robust to sudden change?

If yes, will you put this consideration into the final design and into the instruction?

### **Redundancy**

- 12.** How easy is it for an occupant to meet a particular need using different functions relevant to the energy use of the design? For example you can switch on the light, or you can open the blinds, or you do something else.

***Question related to the developer***

**Prompt:** If they didn't talk about heating and ventilation ask: If the developer does not give you clear information about using different functions to heat and ventilate the homes, will you suggest these alternatives in your design?

If yes, will you put this consideration into the final design and into the instruction?

13. Do you think it's important to have these alternatives?

**Prompt:** If yes, why?

If not, why not?

**Reminder:** Definition of social redundancy is the ability of different things to satisfy the same function for changes to the types of occupancy.

### ***Systems in the Home***

14. What type of heating and ventilation equipment is there for the occupants in the home? For example, a boiler, room thermostat, or radiator, etc. for the heating; and windows, doors, trickle vents within the windows, extract fans, cooker hoods, diffuser for ventilation.

15. How usable do you think the heating and ventilation equipment is for the residents you prepared the instruction for?

#### ***Question related to the resident***

**Prompt 1:** If they considered social changes (e.g. sudden disability, increase in occupancy, different ages, etc.), ask; Have you designed the heating and ventilation equipment to adjust with social changes within the home?

#### ***Question related to the developer***

**Prompt 2:** If the developer does not give you the brief in terms of heating and ventilation system, will you suggest a design for the heating and ventilation equipment to adjust with social changes within the home?

If yes, will you put this consideration into the final design and into the instruction?

16. Have you incorporated any extra means of heating and ventilation in the design of the home if the specified heating and ventilation system fails?

**Prompt 1:** Is it possible for the inhabitants to heat and ventilate the home in another way?

#### ***Question related to the developer***

**Prompt 2:** If the developer does not give you the brief, will you suggest a design as an alternative to heating and ventilation equipment if the specified system fails?

If yes, will you put this consideration into the final design and into the instruction?

### ***General Questions***

17. If they did not talk about robustness, ask; Is there anything else you would like to mention in relation to robustness issues?

If they did not talk about adaptation, ask; Is there anything else you would like to mention in relation to adaptation issues?

If they did not talk about redundancy, ask; Is there anything else you would like to mention in relation to redundancy issues?

**Reminder:** To see if there are any other ways that they addressed robustness, adaptation and redundancy that the questions did not cover.

### Semi-structured Interview Questions to Inhabitants

*The purpose of this semi-structured interview with inhabitants for this research is to develop an understanding of how they negotiate their energy-related practices within the household and how this connects with social resilience by comparing the interviews with the documentation, semi-structured interview with the design team and usability survey.*

**Background Questions (Questions 1 and 2 will be asked to inhabitants who did not respond to form filling; the inhabitants who respond to form filling, the interview will start from Question 3)**

1. Can you tell me a little bit about yourself?  
**Prompts:** Age, gender, employment status and education.
2. Are there any other residents living with you?  
**Prompts:** If yes, what are their age, gender, employment status, education
3. Have the number of inhabitants changed whilst you have been living here? If so, how, when and why?  
**Prompts:** Have there been social changes that may have occurred in the home, how long have they lived there.
4. How often are you in your home before and after the pandemic?  
**Prompts:** Most of the time – Evenings – Weekends only – Other/What?

### General Questions

5. What are your thoughts generally on resilience of home?  
**Prompts:** How would you define resilience? E.g. Flooding, overheating, storms, etc.
6. Have you ever thought about using alternative options to maintain the preferred state, even if there is social change over time?  
**Prompt:** If yes, do you think this (social resilience) has been incorporated in any way in your home?  
If no, what does this definition mean to you?
7. Are there any social or environmental changes in your life that have affected your energy use? For example; after you get married does it affect your energy-use?  
**Prompts:** If yes, What? In what way?  
If no, any other influences?

### Adaptation

8. Have you ever considered adapting your home if there is a gradual change like the increase of people living in your home permanently? For example, an elder family member started to live in your home permanently and your radiators are not enough, so you adapt your home to this permanent occupancy increase by buying an extra portable heater.  
**Prompt:** If yes, what did you do?

If no, why not? Do you think it is important?

**Reminder:** Examples of social change; different ages, more people, less people, etc.

### ***Robustness***

9. Do you think your home is able to cope with social changes including extreme or sudden changes like sudden change in household size, someone suddenly becoming disabled?

**Prompt:** Are there any difficulties that you faced when you were negotiating?

**Reminder:** Negotiation is; discussions between the inhabitants aiming to proceed to actions. For example negotiation of opening the windows.

**Reminder:** Definition of robustness is the ability of the home to carry on performing despite social changes.

### ***Redundancy***

10. How easy is it for you to meet a particular comfort need using different functions of the home?

11. Do you think it's important to have these additional alternatives?

**Prompt 1:** If yes, why?

If not, why not?

**Prompt 2:** Are you aware of an extra option that satisfies the same function in your current home?

If yes, what are these extra options?

If not, what alternatives would you add to your current home and potentially future home?

**Reminder:** Definition of redundancy is the ability of different things to satisfy the same function.

### ***Inhabitant Discussions***

12. Do you have central or individual heating, or do you have both in your home?

**Prompt 1:** How do you operate that in your home?

**Prompt 2:** Does anyone take charge of dealing with the heating? Or does everybody do their own thing?

13. As a household, do you discuss with others when you need to use heating in the home?

#### **Boiler**

14. As a household, do you discuss with each other the boiler being on and off in the home? **Prompt 1:** If so, can you tell me a bit more about that?

**Prompt 2:** Do you have any alternative to the boiler?

If yes, what is that alternative?

**Prompt 3:** How useful do you think this alternative is?

If no, do you think there is any other way that you can use as an alternative to the boiler? Do you think that is important?

### **Room Thermostat**

15. As a household, do you discuss using the thermostat in the home? If so, can you tell me a bit more about that?

**Prompt:** Do you have any alternative to the room thermostat?

If yes, what is that alternative?

If no, do you think there is any other way that you can use as an alternative to the room thermostat? Do you think that is important?

### **Radiator Valves**

16. As a household, do you discuss using the radiator valves in the home? If so, can you tell me a bit more about that?

**Prompt:** Do you have any alternative to the radiators?

If yes, what is that alternative?

If no, do you think there is any other way that you can use as an alternative to the radiators? Do you think that is important?

17. Do you use any of your heating equipment differently between summer and winter? For example; you use your radiators more often in the winter months, but in summer you don't need to use them. If so, how and why?

18. Are you aware of other ways of heating your home, and are you using any of these ways?

**Prompt:** If they say 'Yes, I do', the sub-set of questions will be;

1- As a household, how do you discuss with each other using electric fan heater in the home? Why do you use it this way?

2- As a household, how do you discuss using portable gas heater in the home? Why do you use it this way?

3- As a household, how do you discuss using electric blanket in the home? Why do you use it this way?

19. As a household, do you discuss with others when you need to use ventilation in the home?

**Prompt:** Does anyone take charge of dealing with the ventilation? Or does everybody do their own thing?

### **Windows**

20. As a household, how do you discuss using the windows for ventilation in the home? If so, can you tell me a bit more about that?

**Prompt 1:** Do you have any alternative to windows?

If yes, what is that alternative?

If no, do you think there is any other way that you can use as an alternative to windows? Do you think that is important?

**Prompt 2:** Is there a difference between how you use the windows in summer and winter? If so, how and why?

**Prompt 3:** Do changes in window usage affected your radiator usage in winter? If so, how?

**21.** Are you aware of other ways of ventilating your home, and are you using any of these ways?

**Prompt:** If they say 'Yes, I do', the sub-set of questions will be;

1- As a household, how do you negotiate/discuss with each other using doors in the home? Why do you use them this way?

2- As a household, are you aware of the mechanical ventilation with heat recovery (MVHR) system in your home? (This question will be asked depending on the home has MVHR system)

3- As a household, are you aware of the mechanical extract ventilation (MEV) system in your home (in your kitchen and bathroom with trickle vents)?

**22.** Do you use any of your ventilation equipment differently between summer and winter? If so, how and why?

### **General Question**

**23.** If they did not talk about robustness, ask; Is there anything else you would like to mention in relation to robustness issues?

If they did not talk about adaptation, ask; Is there anything else you would like to mention in relation to adaptation issues?

If they did not talk about redundancy, ask; Is there anything else you would like to mention in relation to redundancy issues?

**Reminder:** To see if there are any other ways that they addressed robustness, adaptation and redundancy that the questions did not cover.

**Interview with Design Team: Project Director**

**Researcher: Melis Tekin (MT)**

**Project Director: D1**

**MT:** I will start with the background questions first. What is your role and what are you doing?

**D1:** I am one of the directors of the company and I'm what's called the business development director. And in terms of, part of that role is to commission the building of new homes. And so my role within any given project is I suppose I'm the ultimate client and I'm not the project manager, but generally I sign off the brief, I sign off the design, I sign at various stages and I agree the sort of standards and the viability metrics and stuff like that. So how much we can spend and whatever.

**MT:** Yeah. Which stage of the projects were you involved with? Which RIBA stages are you involved with?

**D1:** Oh well. Oh I'm not sure. So probably at the end of stage one I would say is that the feasibility I sign that off and I sign off probably at the end of stage when I sort of dip in and out. But I would at key points the design, I would see them and say yes or no, I will comment. And then stage three, I guess I'd sign off, but really it's the project management team who do all the detail. I'm bit more kind of at one remove.

**MT:** Looking back in the past, was there any project that you can spot that your finished design and/or the completed building stage is not exactly the same as your initial intention?

**D1:** Every project. And while there's lots that happens, isn't there between, especially because we do design and build. So there's lots that happens between the brief, the design development and, you know, highways, adoption, engineering things, whatever. So often the concept gets sort of slightly changed. And then when we usually novate the architect, the contractor, but clearly on site, things get changed as well. And then value engineering comes in and all sorts of things and it's come back. So I think, you know, largely; the intention, the lay out is properly you can recognize some of the detail.

**MT:** And what type of contract, for example design and built, or traditional contract was it for delivering the homes?

**D1:** I have no idea. I think it's JCT I think is just, it's usually but we used to always tend to work. But now I think we use contract frameworks more, but I think it's probably JCT but I'm not sure.

**MT:** And I also want to learn the process of like, what is South Yorkshire's role in delivering these kind of projects? So what is the delivering process like?

**D1:** So, the methodology is broadly the same. Um, essentially, well if I talk about Dyche Drive for a moment, so we get a sort of mini architect competition for that one and we chose an architect actually, not the architect I would have chosen, anyway. And we chose an architect and we sent a fairly clear brief of what we wanted that scheme to be. And we did do a design review actually with some colleagues from the university, and they sort of commented and made some changes to the thing as a result. And then, um, so then it went through our normal process of planning and then that was what we're actually there are some details on that scheme that just are very odd and I seem to remember that quite a lot of different house types. I remember we had a debate. I was very keen that the block faced, you know, so that the front doors were on the street and the parking and the gardens were in the middle. And the previous design we had, we had an in-house architects team and they had done a different design, which was as prompted by the council, actually their kind of urban design team, where everything was the other way round, you know, all the parking was on the outside, but no, the parking was on the inside, but all the front doors were on the inside and all the back gardens were on the street. And I was like, We're not doing that. That's just ridiculous. And so we switched it all round and we ended up with the thing, well, you know they are flats one on top of the other, how are we going to get this thing to work? So in the end, we ended up with, you know, a front door on one side and then the stairs up in the front door, that side. So you got this sort of double aspect so that actually worked quite well. I think it's managed to achieve that balance, so I'm pleased with that and that took a bit of doing it took us to suggest and the architects and, have a sort of double aspect of that because it was the whether the living room or the bedroom were going to be on top of each other and which face, which way and all of that. But the double aspect thing worked in the end and they're all some really weird things like, I don't know if you seen the bus stop, which is practically in someone's living room. I mean, I don't know how that managed to happen. But there's something just very weird about how did the architect did that and that just seemed really weird. And then there are some very funny shaped flats on some of the I think they duplexes with some very funny things go on. They're sort of long and thin and you go around it's just weird. So I think that was a bit I didn't particularly like that architect because I felt like they were a bit, what I call instead of being a sort of conceptual architect that says this is the place we want to create their sort of problem solver architects. But their way of solving the problems was to do lots of weird things, you know, some sort of fitted in, you know. So I think overall the scheme has been successful I would say, and I think the open space even it possibly not really that well used, I still think it kind of really add something to that scheme. And when I went to visit it actually this year it's been for quite a long time. I went to visit. I was really pleased with how it was looking. Just generally I think, you know, it seems to working. Yeah.

**MT:** When I went there, it was like kind of a small community.

**D1:** Yes, I think so.

**MT:** I went there early at I think 9.30 or something. And when I was there, everyone started to open their doors throughout the day.

**D1:** And then, you know, we have the big extra kind of scheme next door. So I always wanted to see a bit more connection between those two and, and we had a dedicated gardener who was going to work across both my designates carried on. But yeah no I think overall it's kind of worked well so I'm pleased that held out for that change to the land stuff and overall even though the architect wasn't fantastic I think you know, we got it near enough where it needed to be. And then on Senior Road, so this started off I don't know whether you'd understood this is our wiki house scheme and then we switched and decided to do traditional build here and we did the wiki house somewhere else. I think 0x0 are really interesting architects and the kind of thinkers and it's a very, very simple as a scheme but I think they managed to kind of retain a sense of coherence about it streetscape and, and I think it fits really well in that street where it is. It sort of it doesn't stand out as social housing. It's a kind of nice mixed street. You're right near the park. It's really well located. I just I just think it's a nice little scheme, really. And I was really pleased to see people have done all sorts of weird and wonderful things with their front gardens, which I kind of like. This shows that people sort of adopted them. And so I don't know, I felt like it's kind of people seem to get settled there. And on that one we have worked around with the wiki house for ages. How scheme and then switched to the brick and block, which didn't really make any difference the last I don't think we had a really good build. We were lucky that we had a brilliant builder. So it went very, very smoothly on site and you know, whatever, whatever. So yeah, yeah, that's that one. And then Slingsby and we had, we had our in-house architects had done a scheme previously which was a sort of block of flats with lots of parking around it. And again, I said, I really, really don't, don't want that. It's just kind of horrible. And, and so, but this was from years before. So I changed the brief, so we wrote a new brief and actually we appointed Proctor Matthews to do it. And of course, they came up with a completely different approach, which I think is loads better with the homes and, and the and then the meadows either side and then that boundary treatment. So it was quite sort of bold in a way because obviously the houses end up being quite high above the road, but you get the views. It was a really, really tricky site. It was contaminated, very steep, so very expensive to develop. And I think the solution they came up with was very sensible, which is to create a platform and then have the landscaping. You know, that seemed to me to work really well. And in doing so, they created this space, a kind of sense of community again. And then I really love the way they've done all those connections the steps and footpaths out. Also, there are some odd things. There's some of the gardens are very, very high. But on the whole, I think it's worked really well as a sort of I mean, we had a problem I don't know if you know this. But we had a problem with three difficult tenants who moved in and which meant some of the houses were boarded up and we had to get rid of them because they were all drug dealing and whatever. So that was a real problem and lots of unsafe behaviour. So that was a shame because I think, you know, it's sort of it's a shame because it's a really nice scheme but anyway that they will gone down and I think it's looking much better as a result and it's a happier place to live. Proctor Matthews weren't happy with so we invited them into the contractor and they fell out with the contractor. But anyway, he said I really like Andrew Matthews, but he's very, very determined to get his way on all sorts of things, very pointedly to destroy as everyone knows. And he made the contractors nuts because, you know, they were trying to assist all sort of details or whatever. But I think and so I think Proctor Matthews probably said it was quite compromised some of the design. And but I think you know, even so, it's not quite as they would have wanted it. It's not quite as the detailing as they would have wanted. But overall, I think the landscaping wasn't done

very well. So we coming to the council, we do some of that through defects. But I think overall it has worked. And when I first went there, I thought there's a sense of, you know, you can really see what the intention was to create the homes and the sort of shared space and the way the houses work and the views and then the links to the rest of the last. So I thought I thought it had to spatially it works very well for me I think.

**MT:** Yeah. And it's good that all these projects build communities.

**D1:** Yes, that's right. I think they really do. I mean I don't know about Senior Road because that site is near the street. But you feel that slots into its community.

**MT:** So I will now move on to more general questions. How would you define resilience and how do you see that can be integrated into the building environment?

**D1:** And you mean resilience to climate change?

**MT:** Yeah more generally. Like what kind of things? You know, the things that come to your mind when we say resilience.

**D1:** Oh, okay. So I would think so. First of all, I would say, well, the first thing that would come into my mind would be climate change. So I would think how what standards we're hitting first time in particular in terms of fabric and both the low energy bills and the overheating, you know, what are we allowing for? And actually, the three schemes you've seen have all been built, probably between the two Climate Change Conferences I guess, and now we're trying to go much higher standard. Met in the first build and build a sort of net zero carbon ready. So everything except an air source heat pump probably, so we can just slot that in later. And so we would put in bigger radiators and space for a water tank and all of that in our in our next scheme. That's the same if we ever get to build it and so to spend it. And, but if we can, we will. And so that would be my view would be that you would make it so it doesn't need retrofitting except for the energy solution. That would be one way and that you can and we need to think more about, you know, is it easy to put shutters in to stop stop overheating? So those would be my main things. But then I would also be thinking about, we're starting to think much more about how we use the green and blue infrastructure on the site and all biodiversity using, actually I went round all of our house, most of our housing stock in the last year to a proper look at everything. And generally we don't have a lot of shared space actually mostly on schemes and sort of gardens and so on. Some of those gardens are very, very hard paving not green. So I think that's what can we do with gardens and then what do we do with shared spaces and what's the scope for sort of sets and so on. So where we're building, you know, we would want to drain the homes and into the planting beds, for example. We would want to do something slightly different. I mean, the landscape there is nice and resilient to things because we are on the meadows, which are a good, biodiverse, resilient landscape. The buildings and also the streets in the public realm and the gardens would also come into that. And can we gradually shift and systematically shift that better? And then the other resilience for me would be around space, you know, how flexible are the layouts and generally layouts probably aren't, you know, flexibility equals space and we build certain space and as we're building slightly higher space standards because there's still a limit to how much we will build. But I think that for

me, there's something about what could you add, you know, in terms of sticking things on the back, like, what could be out in terms of buildings or extensions and that allows some resilience. But we tend not to kind of plan for that because it's just costs. We can't afford to do that. But I mean, that would especially in shared schemes that would give you this thing that people can kind of start to add bits and sort of adapt. And certainly on the scheme we're designing at the moment and we've got this concept of the sort of frontage being it's a terrace basically being, but then what they describe as a crumbly back. So you might have a terrace that's houses and bungalows and what have different structures be better houses and bungalows, but at the back there scope, the back elevation is quite jagged if you like it because and so that lends itself to some sort of crumbly additions I think, which is quite nice and. What else would I think of? The other thing is, we think a lot of that at the moment is some changing customer groups. So we have a mix of support housing and general needs housing. And in the old days, we used to build our supported housing schemes, you know, bigger blocks where you have groups of customers together. But now we tend to think of us housing more as being in sort of ordinary house is in order. So the interchangeability of our customers is also important to us. That's important resilience thing, so that we could have someone, you know, a homeless person or just an ordinary family or an older person. You know, we can sort of swap people in that the maximum flexibility. I think that's the main things probably.

**MT:** Have you ever thought about using alternative options to maintain the preferred state even if there is social change over time?

**D1:** What do you mean?

**MT:** For example, if people want to use the lighting in their homes, either they open the blinds or use the artificial lighting like which is like a similar kind of like using daylight or for example, like have you ever thought about this? Have you ever thought about adding these kind of alternative options?

**D1:** Not really. I mean, the only thing we have done is we've certainly starting to plan on house types of more homeworking because that wasn't really factored in before. So little incidental spaces where you could put a desk or some kind of, you know, be able to find sort of quite a space, either homework, schooling or homeworking. And but no, I don't think so. I mean, just I'm just generally saying, you know, we try and get as much daylight in as possible, try and get natural ventilation. So we're trying to kind of make the houses sort of work for them by themselves and that makes sense. But I wouldn't say that we did a lot of considering different options.

**MT:** And when I say social resilience, what does this definition mean to you?

**D1:** I think it would mean. Certainly a sense of community and people supporting each other and neighborliness. And I think it would also mean that people can afford to live in their homes and therefore are more resilient, even on the low incomes. And so they're able to go on living their lives. I suppose the other thing I would say is because they have security of tenure in our homes, you know, they don't have to worry about the house. That's what I would want. They don't have to worry about their house when they get out and live their life

so that they could get work and not have to be worried about the housing debt that's taken care of and then something about how they interact with their neighbours. And perhaps I think the location of the home is very important. So we've done again, I've done this piece of work assessing our existing homes and you know, what's come through from that is most of our homes are absolutely brilliantly located. You know, they're within walking distance of a GP or pharmacy, work, public transport, park etc. So I think that social resilience in terms of being able to find everything on your doorstep that you need is really important.

**MT:** Yeah, I agree. I think it's really important. And if the architects, engineers or relevant parties suggest you to consider an alternative for heating, for example, will you consider it in the projects or, up to what level will you say no to them?

**D1:** So it's we have there's both a sort of absolute cost and then also what we call viability of the appraisal. So, if it pushes the scheme out of balance, people can't do it unless we can get Grant to cover that. So cost is a big factor. And whilst we want to do as high standards, we always have to compromise. And so we would certainly want to put ourselves, you know, it makes good business sense for us not to be retrofitting the fabric, but it's unlikely we would put air source heat pumps at the moment because it is not affordable. So it's just tradeoffs really.

**MT:** And also, I wanted to ask, I have looked at the plans of Dyche Drive scheme, and three of the homes had PV panels and other homes did not had any. So I wanted to ask if the residents wanted the PV panels or what was the reason that the other homes don't have the PV panels?

**D1:** No it will have been, I think it'll be all about orientation.

**MT:** What do you mean by that?

**D1:** Like where they worked and where they didn't. I think my guess is that we take the income off them because we have a lot of PV panels on lots of areas, but it doesn't benefit that specific occupier maybe. I can't remember it. I don't know in detail what we do, but it would be very unfair for certain people to be benefiting. So I suspect it's just where is it possible to be? Where would they work?

**MT:** Yeah, because I wondered if the residents wanted or not.

**D1:** No, I don't think so. I don't think that's what happened. Generally, we tried. Well, I say we try to put them on. We don't put them on so much now because we're focusing on the fabric more and the PV panels may or may not make the difference later on. And yeah, but we have quite a lot generally around the place.

**MT:** Have you ever considered the social changes of the home users over time? For example, have you considered a gradual change like the increase of the people in the home in or use of spaces?

**D1:** No.

**MT:** And do you think it is also important to consider these kind of changes?

**D1:** Probably not for us in terms of as asset owners, you know, we build a house. We had to own it forever, you know, certainly for a long time. So we're more what would be good is that we had more sense of the lifecycle costs, lifetime cost, you know, what does it actually cost to run that house and repair it and all of that? But I don't think we're more focused on the asset than you know, obviously we want people to be able to kind of enjoy their lives there, but I don't think we'd be tracking that.

**MT:** And have you ever considered being robust in sudden change like the previous question was about.

**D1:** Being robust in what sorry?

**MT:** Sudden change, like sudden increase, for example, if somebody became disabled in the house, have you ever considered these kind of changes?

**D1:** Well we are able to do, so sometimes we have built lifetime homes but not very often because again it's just expensive to do that. But increasingly, as we do bigger space standards, that will be helpful. But we do have an adaptation aids and adaptations programme that, you know, if people circumstances change, they can have certain aids brought into the house. We try wherever possible, street level access we try, you know, there's certain things that we kind of we would have us we would aim for in every house. But I wouldn't say they were all perfectly adaptable. We also tried to do some bungalows on my schemes. We've got an element to that but yeah.

**MT:** Do you have this incorporated in the instruction manuals? I think they gave some kind of briefs like instructions to residents after they moved in.

**D1:** We wouldn't talk about. I would again, I haven't read the thing, but I would be surprised if we talked about that. I don't know. Maybe it does say if your circumstances change, you know, think about this. But our neighbourhood officers know our tenants really well. So they would be talking to them as well.

**MT:** And how easy is it for a resident to meet a particular need using different functions that are relevant to the energy use, for example, as I said, like using lighting or using the blinds, like, have you ever thought about this, about the heating and ventilation in the homes?

**D1:** Okay. In terms of how people use different systems in the house. So the home user guide has all of that in it, but it relies on people reading it obviously and following it. We have done some sort of energy doctor work, you know, where we go in and say to people, you could save fuel if you did this, this and this. But in general, I don't think we do do a lot of that moment. We would plan to is we retrofit people's homes to do more engagement around how people can minimise their bills and that kind of stuff. And we do have some information around that and we've got we have some sort of tips to buys, but I wouldn't say and I don't know how embedded that is in all our paperwork.

**MT:** Yeah. And I do think it is important to have these kind of alternatives?

**D1:** Well, I certainly think that if you have sort of heating, ventilation and MVHR systems and stuff that rely on people using them in the right way, it's really very important people know how to use them. It doesn't mean that you're telling them you mean they do. So it's how do you engage people to do, you know, to do the right things and how to give people the information and they actually do it. So yeah.

**MT:** Yeah. Sometimes they won't know if they have these systems in their home or not.

**D1:** So yeah. Yeah, that's right. Well, that's what the home user guide is meant to tell them, but it's whether people really understood it and, you know.

**MT:** What type of heating and ventilation equipment is there for residents to use in these projects? I think MVHR?

**D1:** Well, not in any of the ones you talked to. I don't think many of those have them. But I may be wrong. We will have MVHR, but because we're going to have much tighter U values, much, you know, and the insulation will be greater and therefore the propensity for conversation is higher, so we will have MVHR in those.

**MT:** And what type of heating and ventilation did you used in these developments?

**D1:** I think it's just gas boilers, radiators, opening windows. I think that's all there is and knows I didn't use anything more sophisticated than that, you know. But I may be wrong.

**MT:** And how usable do you think these heating and ventilation equipments are?

**D1:** Well, again, I don't know because I haven't used them myself. So I don't know is the answer. I think it does need people to really understand how to use them and then become and, you know, understand why it matters. And I don't know whether people think, you know, they're paying for electricity that they didn't want to. And I don't know, they switch it on often. And I know we have people to switch the PVs off. Yeah. You know, so there's all sorts of things.

**MT:** Have you incorporated any extra means of heating and ventilation in the brief to the architects if the specified heating and ventilation system fails?

**D1:** Well, what we tend to do is have a sort of performance standard, I think, where we say we want to hit these u-values and that ultimately means they have to put some in so and air source heat pump is definitely what we're assuming we will be having. And so that requires a certain size of radiators and certain size of water tank in the future and all of that. And I don't know whether we specify particular kit. We're at the start of that. So it may be that we increasingly we will, but I suspect we just say it has to have this performance.

**MT:** Do you think is there anything else that you might consider adding in the future social housing?

**D1:** What do you mean?

**MT:** Like in terms of the energy systems?

**D1:** So yeah, I think air source heat pumps, and possibly we would look at and of course, what's it called? CHP systems I think, anyway, shared energy systems and possibly ground source heat pumps. I spend most likely air source heat pump, associated with MVHR, and possibly PVs to top up. Yeah, to make sure we're hitting net zero and I think that's the way we'll be going.

**MT:** Is there anything else that you want to add?

**D1:** I don't think so. Do you feel like I've given you what you needed?

**MT:** Yeah. Thank you so much. Your answers are very useful for me.

**D1:** Actually great.

**Interview with Design Team: Project Coordinator**

**Researcher: Melis Tekin (MT)**

**Project Coordinator: D2**

**Social Housing Development: SHD**

**MT:** Well, thank you for accepting doing the interview with me. If it's okay for you, I can start asking you the questions. What is your role in the projects and what are you generally doing?

**D2:** I am a project coordinator in the development team, which effectively means that I'm responsible for day to day project management of basically development programme, so that involves a few key tasks. So one is project managing our design and built scheme. So that's where we would buy piece of land and work up the design and then build that until we have some houses. I'm not involved in the letting process, so I kind of get the real estate ready for people to move in and then hand-over that to my colleagues who do kind of more day-to-day maintenance. I also project manage some properties, so that's where the development builds an estate and as a part of planning commission they have to go for certain affordable homes. And they would approach SHD and put an offer to buy those affordable homes and manage that acquisition. We also do what we call asset management work. So that's things like selling properties. So if we have houses that no longer fulfill the needs of our means or our customers, we will sell these on the market, we manage that. Also handling things like managing and giving back to their actual owner. And then we also do some other asset management work which are things like refurb, conversions, change of use, stuff like that. So we get involved in that type of work as well. That's kind of like the core of what I do.

**MT:** I think the projects that I'm working with, I'm working with SHD. I think some of them are in your managed properties, but I'm not sure.

**D2:** They're all design and built. Those are all properties where we purchased the land and then design and built ourselves.

**MT:** Which stage of the projects are you involved with? The RIBA Plan of Work Stages.

**D2:** So, I mean, honestly, all of them. Probably most involved. We don't do as much post occupancy evaluation. But yeah, it's 0 to 6 basically. Yeah.

**MT:** Looking back in the past, was there any project that you can spot that your finished design and/or completed building stage is not exactly the same as your initial design or initial planning?

**D2:** All of them. I mean, the way that we would work on this scheme is that we usually get piece of land. And before we even buy that piece of land, we would get a capacity study

drawn up. So we'd get an architect just to say, okay, you can get ten two-bed houses and, you know, twelve two-bed houses on here to give us an idea of how viable it would be. And so, I mean, that's always come at the starting point, I suppose. But then obviously as we get further into the design process will go more into detail. And I mean there are so many things that can change what we do with the site. So it could be us changing what we want. So we could be saying, okay, well, instead of ten three-bed houses, we actually want four-bed houses. So that was us kind of changing our mind about what units that we want. It's also very often money. We can kind of have a design drawn up that we really like. But we might not be able to afford to build. We need to go back and look at that design and think, okay, well, how can we keep hold of some of the design or make some cost savings that we can actually build out? It can also be planning. You know, there were times where we designed something, we put into planning and the planners say; no we can't do that. So we need to make these changes. And yeah, I suppose there are also technical things. So for example, sometimes, well to an outline design of a building, that we might design that we want MVHR. But we would change how the internal layout building is structured. So all throughout the design process we have reviews with internal teams, so that's like services teams who maintain buildings, but also our neighborhoods' teams who let them. So you know, there might be points like; actually this isn't going to work for us, you need to kind of reconsider this. So everything changes throughout the process. One thing we can say is to when we're starting on a scheme is we kind of encourage the architects and designers who work with to choose three key standout features. And those are the things that we try and kind of protect as we change the scheme trials, but it doesn't just kind of lose its identity.

**MT:** Yeah, I think it's very good. And so what type of contract, was it for delivering the homes?

**D2:** And I think all three were designed and built. Yeah, yeah, I can double check for you because almost all of those projects were before I joined SHD. But I'm pretty sure that all these projects are design and built.

**MT:** So I will move on to more general questions right now. How would you define resilience and how you see that can be integrated into the building environment?

**D2:** Hmm. It's a good question. I mean, I think for me, resilience is building a home that people can stay on for as long as they want. And, you know, being that, you know, having children in that home, getting older in that home, changing jobs in that home, and changing how you work in that home, you know, possibly having less health concerns, being able to adapting ability. Um, but also I think that kind of other aspects of resilience, aside from just the kind of person living in that property, it's climate resilience. So, you know, building a home that's going to be sustainable, it's going to be affordable to run, it's going to reduce CO2 emissions. And I think that's incredibly important. I think some of us can be comfortable to live in a home that isn't going to damage the climate. And then also, I think that's kind of a more hard-nosed business resilience. You know something, that can be sustainable for SHD, something that's not going to cost huge amounts of money to manage and maintain something that's going to return the profit for us and something that's going to fit into the needs of the local area. So that you know, there's always people who want to live there and rather than it kind of being some others entity or they don't want to live there. It kind of

needs to fulfil all three parts of that. To me, to be a resilient building kind of for the individual, the customer, and the planner. And then the business of the system.

**MT:** Have you ever thought about using alternative options to maintain the preferred state, even if there is social change over time?

**D2:** What do you mean by that?

**MT:** Yeah, it's a little bit confusing question. So the alternative options I mean, like, have you thought about using putting an extra heater in the homes, for example, if the heating system stops working for some reason, maybe because of maintenance issues. Have you thought about this at all? Also, for example if the occupancy level change and this may cause that residents might use heating much more. So have you thought about putting an extra option like an extra heater or extra ventilation equipment in the homes?

**D2:** Yeah. So I mean, it's kind of it's more with, I suppose the maintenance side of business, but they do end up doing things like that. Because our mix of houses is very diverse. I mean, we've obviously got you're looking at properties that are all been built in the last eight years, but you know, we've got homes that were over 100 years old and you know, they're all big changes that we've had to make to those because when they were built, people didn't have gas combi boilers. So there is, there are changes like that. So I find that very frequently, you know, putting in double glazing, putting in kind of modern heating systems, we also have done some retrofit kind of housing. Putting in external and internal wall insulation, some kind of better heating and ventilation systems as well. So we do kind of do that in terms of going back to the older properties and I suppose bringing them up to modern standards to make them more comfortable. Um, I suppose there's also things like adaptations, so if people have some mobility needs, we can go in and put in, and modify bathrooms, handrails, things like that to kind of assist them to stay in their home.

**MT:** If the architects or engineers suggest to you to consider some alternative, at what level do you accept and consider their planning or their design?

**D2:** I mean, I think we always try, we like to appoint good architects and engineers and designers, and the whole point of that is they challenge us. They sometimes; oh have you thought about doing it this way, or actually I think this is a better way to show that. I think with everything, you know, we kind of consider about from a few angles, obviously we'll look at the impact of the cost, both in terms of the kind of initial cost of putting it, and in the long-term cost of maintaining it. And also cost to customers of running it. And we'd also look at sustainability implications. So, you know, is this going to make the house more comfortable, cheaper to run, warmer in the winter. And then we'd also have a look at, I suppose, the impacts on the final design and make a judgement as to whether this is worth it in terms of cost benefit analysis. So we do, we do make alterations based on things that architects, engineers and the designers suggest. But, you know, ultimately, I suppose we are the client and we have the final say. It kind of needs to be a positive decision for us.

**MT:** Have you ever considered the social changes of residents over time? For example, have you considered the gradual change like increase of people living in the home. Do you think this will affect the home performance?

**D2:** Yeah. So it's something that we've been thinking about a lot more recently. So, I mean, for example, in a lot of the new homes, that we are designing now we're thinking about, by which you have a desk, you know, what can the children do if someone also works from home. So obviously there are many more people who are kind of working from home now, but also I suppose more, much more worth you know, what happens if there is pandemic again. So that's kind of one of the really key things we've been doing is assessing, trying to increase that in all in all of our newbuild homes.

**MT:** I also want to ask, if the brief comes to you and you comment on it, how does this process go?

**D2:** We write the briefs. So the person, project manager of the project write the brief, and then that will go through an internal approval process. And so it can be escalated within the development team. Essentially, make sure that everyone's happy with that, but we set the brief. Yeah.

**MT:** Have you ever considered being robust in sudden change? For example, if an occupant suddenly became disabled, do you think the homes are able to cope with these kinds of changes? Or have you considered it at all?

**D2:** Yeah. So I think I mean, this kind of goes back to something I said earlier in terms of, you know, we do do kind of adaptations regularly. It's common. You know, basically our customers generally have effectively a tied rent tenancy. They don't have to leave the property until they want to, generally. And so it's very common that people have mobility issues and we do lots of mobility adaptations in our properties. But again, that's more of our kind of maintenance side of the business. But I would also say that this is considered quite a lot in building regulations now. So for example, you know, in all those new built houses you'll have a toilet on the ground floor, so that's accessible for people visiting. We, within our employees requirements have, we sent out a request for level access across the ground floor on the property. And, you know, that's always kind of the consideration of, okay, well, if you needed to adapt to put a bedroom on the ground floor, how would we do that? So we do, we do kind of consider that within the design. But I think it's also, you know, obviously it has its limits and, you know, say, for example, we built a one bedroom flat and we put a couple live in there, and they have children. That's going to be a limit to how much we can adapt that one bedroom flat. So it's kind of making sure that we do what is reasonable and what we can to kind of support different people living in as long as they choose to. But without, you know, obviously making life extremely complex for ourselves.

**MT:** If an occupant wants these kinds of changes like adaptation in their home, how do they reach to you? Do they use a kind of website for that? I think you have a neighborhood officers, but are they the main person that the customers contact with, or are they kind of a bridge between you and the customers?

**D2:** Yes. You have hit the right point on that. So people can report the repairs through our website, or through by all your phone lines. So they can come call us and say like I need this, or they can report it online. Also, we do have neighborhoods officers because sometimes people might not know what help is available or might not feel as comfortable, kind of calling up and saying; look, I need this. Can you help me? We do have a neighborhoods officers who are kind of our bridge may come, I suppose, inform people what support is available. Also, you know, possibly do this bridging kind of come in and say, look, I found this person that really struggling with X, Y, Z, what can you do to help them? So now we've kind of got those two mechanisms.

**MT:** Yeah, I'm also contacting with one of the neighborhoods officer because residents trust neighborhoods officers more than me, as they don't know me.

**D2:** Yeah.

**MT:** They are also very useful for researchers who are also working with SHD.

**D2:** Yeah, they are the, they know everything. Yeah.

**MT:** How easy is it for an occupant to meet a particular need using different functions relevant to the energy use of the design? For example is it easy for occupants to use the equipments in the homes, or do you think the occupants are kind of adapting themselves, particularly things like heating and ventilation equipments, do you think is it easier for them?

**D2:** So, I think at the moment it is. Because largely what we have in most of our homes is kind of a gas combi boiler system, which is kind of the norm in the UK and therefore people kind of understand how it works. You know, you might have a system where you set out the timer that comes off on an hour in the morning and in the evening. Well, they might just put it on something that you need so people kind of understand how to use that system. I think a challenge going forward is, um, if we do proceed with putting MVHR and air source heat pumps into buildings, it's just a different way of running your home, isn't it, in terms of, you know, if you're in the kitchen cooking, and it gets steamy, you don't have to crank open a window because the system won't be able to kind of manage that. And, you know, you don't put your heating on for a little bit morning and a little bit in the evening. It's running at a lower level more consistently. Um, so I do think that it's something for us to consider because these are kind of really ingrained ways of working within the UK and introducing a new way of doing it so that people don't understand it, it's just a learning curve and it's kind of breaking previous habits. So I do think that there is something for us to consider there, both so that people can get the most out of it in terms of getting a comfortable home, having low heating bills. Because obviously if you've got, you know, your windows crunch open more and you've got your heating on and things like that and just a couple of problems. Um, so yeah, I definitely think it's a more needs to be considered going forward because obviously all this new technology is a change to how we run our homes.

**MT:** Except for boiler, is there any other heating equipment in the homes? And also what type of ventilation do these homes have?

**D2:** So most of our homes won't have MEV, I mean they have kind of extractor fans in the kitchens and bathrooms and then the rest will be kind of windows with trickle vents and things like that. And the vast majority of our homes will have gas combi boilers. So we do have some properties where it's an electric heating system. We do have some properties that have MEV and/or MVHR. And we do have some properties that have things like solar panels, air source heat pumps, kind of renewable technologies. But the kind of vast majority homes, it'll be kind of extractor fans in the kitchens, bathrooms, utility rooms, more natural ventilation elsewhere with a gas combi boiler, radiator type system.

**MT:** And how usable do you think these heating and ventilation equipments are?

**D2:** I think they are generally pretty usable. You know, I think people kind of understand that, you know. I, I think there was kind of an immediacy of, you know, you open the window, it's getting a bit stuffy. So, you know, if you turn the boiler on, your radiators fully on, things like that. Yeah. So I think there is kind of, because this is kind of a norm that people generally do tend to understand how to use them. I mean, I suppose obviously there are instances by people using differently. You know, sometimes we have come across properties that people have the windows open and the radiators on at the same time. But I think in general, there is a pretty good understanding how to use those more kind of standard bits of technology. And then in some of the properties we have different systems. I mean, the solar panels.

**MT:** If the engineer or architects come and say; I think this heating equipment or ventilation equipment might work well, will you consider it in the design?

**D2:** Yeah. I mean it's, it's pretty unusual when we start a project that we would say this is definitely what we will use. We generally say that kind of it would be determined as the project goes on and on. You know what that usually engineer would suggest. So yeah, we do. We do obviously there's some quite clearly to what they say, but also, well, we'll have to consider how that will work in a maintenance perspective. You know, like I was saying before, from a cost perspective, usability perspective. And for the cost perspective, the person living in that property. So for example, you know, actually putting in there air source heat pumps sometimes can be more expensive on the day to day running to the person living in the property than the gas boiler. So then those kind of consideration for us in terms you know does that worth it. So yes, we always listen to what they suggest, but ultimately, it's up to us to kind of make the decision on whether we take that forward or not.

**MT:** And when the residents move in, do you give them kind of instruction manual?

**D2:** Yeah. So when people move into property, we make what's called a home user guide. And it's just kind of general information about the property will also includes details on all of the systems within that property. So, you know, the use manuals of the boiler, the ventilation or anything like that will be included in that.

**MT:** Yeah. So this is kind of my last question. Do you have any other comments that you want to add?

**D2:** Okay. No, I don't think so. So is there anything that you would like to kind of go back to find an answer, or do you want more information, more detail?

**MT:** Do you think is there anything else that you might consider in designing your housings in terms of energy, because of the energy crisis right now? Is there anything else that might consider in the future housing developments that you might design?

**D2:** Yeah. So, I mean, our standard approach at the moment is to take fabric first approach. So, you know, ultimately, I suppose what's really difficult at the moment is that there are quite a lot of renewable technologies, but there's not kind of a standard one that's been settled on by the government of the UK as a whole. I suppose what we do know that if you build a home that's, you know, airtight, well insulated and I thought that was kind of the starting point. So that's really the approach that we're taking and here on how we build homes that have a really good fabric. Then, you know, we can choose what heating system we will put there. Well it might be gas combi boiler for now, but with a view to make that and say air source heat pump next time due for the new home. But ultimately, it's about making sure that anything we do now, we're not having to undo or improve in the future. So we're kind of looking at these properties and saying, right, well, if we build them with brilliant insulation, good windows, good airtightness, and all that. That's a really strong starting point, then anything we do in the future is kind of building on that rather than having to undo everything we've done and start again. If that makes sense.

**MT:** Yeah. And also for the long life homes because here I think residents don't want to move out and move in again.

**D2:** Yeah, exactly. I mean, this is why people live and, you know, what they've want in their life. Hence whether children can go to school, they go to work so that we are not disrupting that. And I think also in terms of building homes that are well-insulated, it could be where people living in the home can see the most difference. Because you have gas combi boiler and you will have to spend less because you don't have radiators on as it will stay nice and war with a well-insulated home. You don't get as many issues with damp, mould and condensation you know, in all of the house. It will also have financial benefits to customers of having one good kind of fabric in the building. I think is probably one of the most beneficial things that you can do when you actually build a home. And you can at later date do things like go in and put solar panels on or, you know, install additional measures hopefully make it even cheaper and easier for customers. But I think the kind of a really strong starting point non-negotiable is building something that's got a really good fabric.

**MT:** Yeah. I have seen that in the plans, some of the homes had PV panels which was at the planning stage. But later the planners did not built PV panels. For example, if an occupant say; I want to PV panels, do you think you might consider for just that one occupant?

**D2:** I think that would be if, I suppose it depends on how it will be able to work. So for example, if an occupant said that they wanted to install PV panels on their home, obviously it will be up to kind of maintenance and neighborhoods to make the final decision. But it is something you could consider. However, if they were saying, can you install PV panels on just

my home, then that's slightly different. Because obviously it is just unfair, isn't it? But we kind of need to work on a basis of, you know, either getting whole estate or whole area so that we are treating people equally.

**MT:** Okay. Yeah, these are all my questions. Thank you so much for your time. And I really think your answers are very helpful.

**Interview with Design Team: Architect**

**Researcher: Melis Tekin (MT)**

**Architect: D3**

**RSL: Registered social landlords**

**MT:** The purpose of this interview with you is to understand the design intentions behind the project. So I will start with some background questions. What is your role in this project and what did you do?

**D3:** We were the architects all the way through. Originally commissioned by South Yorkshire Housing. I think they bought the site off the council with the site assigned for 100% social housing and 100% rented housing, which is obviously in quite a lot of demand at the moment, particularly in a place like Sheffield. So we were commissioned to design the scheme and then we were novated to the contractor to do the production drawings and site operations, activity inspections and things. So I was fairly full service really.

**MT:** And like which stage of the project have you been involved with like all RIBA stages?

**D3:** Me personally?

**MT:** Yes.

**D3:** Well, we were actually where people get involved in all stages, to be honest. So we're not a sort of practice that separate, you know, the frontend design from the delivery on site. We tend to do the whole thing. So I was involved in, as was my partner in, in all of it really. So that's from inception to the development of the brief, as the brief wasn't entirely clear on day one and it did change as we went along. So from inception through RIBA stage one, two, three, four and five. We used occupancy survey work, that sort of thing you're doing is growing in momentum, but it was still relatively rare at that time. So you're kind of relying on anecdotal evidence coming from the client to understand how people are living in the properties and what they think of the properties.

**MT:** How do you gather information for the needs and goals of this project or like have you talked to the residents at all or asked like what kind of like things they preferred?

**D3:** Well, the resident, the people that were venturing to live there were unknown when we were designing it. So it was designed as a general needs rented product. And the brief was driven by or at least developed out of South Yorkshire housing's own and the council's own assessment of, housing need, which is primarily for family housing, although there are four apartments on the site. So it was primarily for family houses and that met the need of those that were on the waiting list or, you know, the general needs that Sheffield knows that it has in the rented sector. But we didn't know necessarily who the individuals who are going to be assigned to the houses would be at the time of design.

**MT:** And so looking back in the past were there any project that you can spot that your finished design and your completed building stage is not the same as your initial intention?

**D3:** Oh yeah. I mean it changed, you know, because the numbers and the mix changed, the design changed and respond had to respond to that. Although the initial response to the site because the site is quite constrained and difficult site. The initial response meant that we had to create certain typology, you know, some housing typology that could work with the levels and could also work with because it's not a site where you can achieve conventional fronts and backs. And if you tried to set conventional fronts and backs on that site, that would have been quite a problem in terms of defining public and private realm and also giving people, you know, proper security. So the site was always going to need a housing typology that could work with the very narrow land. But it remains a very interesting site.

**MT:** Yeah, it's a very steep site. And what do you see as important issues and considerations except for the topography of the site? Was there anything else that you considered, particularly in this project?

**D3:** Yes, I mean, the budgets were very low, so extracting the kind of housing typology that would work was a pretty difficult task because they are courtyard houses and so the perimeter walls are higher than they would be if they were terraced housing. But I think that created a better family house because it created a better relationship between the inside of the house and the courtyard gardens for the many designed courtyard garden. And then it's got to be secure and therefore there are brick walls that surround the courtyard gardens. I mean, in effect, this means that there's good views through the side because you can look between buildings. But the challenge was how could we make a budget, build that kind of housing typology for this site, particularly the change in metals as well. But I think ultimately, we thought this would make better family housing than the conventional terraced housing, particularly on a site like that.

**MT:** Yeah, like they have gardens in one side. The other side, they're like a little community, because their door is, like, open to everyone. So yeah, I went to that site and it was kind of like a little community. I felt like that.

**D3:** Yeah, yeah.

**MT:** And so I will move on to some general questions now. How would you define resilience and how do you see that can be integrated in the building environment?

**D3:** Well, I think in particularly in social housing, you're always fighting with incredibly low budgets, which can, if you're not careful, drive you to a type of logical response that isn't necessarily the one that people can live easily in. So, you know, how do we create cheap boxes that were sort of aligned as terraced housing. Then you know, I think with the space standards that were being driven in that scheme, you would have ended up with quite impoverished dwellings. And I don't think this resilience in that kind of approach, unless we can actually as architects dealing with quite low budgets that we have for this project deliver something that is going to foster community and is going to allow house types to be easier

for families to live in and you don't get resilience. So I hope the scheme is resilient because you would actually look to thinking about how the shared surface could stitch housing together, how there could be public routes through the sites, it was gated. But you can use the street safely because it in fact is a dead-end street. But also then how people could use their gardens as proper external living environments rather than the sort of awful, being fenced off green areas that tend to be very thin and long and overlooked. So I think if you can extract all of that opportunity for families out of, you know, quite a challenging site and challenging budget and we know we've created something that's resilient, at least I hope to think we did. I mean, the houses are actually built to standards below the national minimum standards. So we have to get quite inventive about the way the houses were planned. So you'll notice that when you go into the house, they don't really have an entrance hall that leads to a kitchen and then to a living room. In fact, you have to walk through your dining to get to your living room. What that meant was we could have a lot more space for living in, but we could also deliver a small utility room, which for a family house, you know, extracting out that very low area requirement, getting a utility room seemed to us incredibly important so that there was that extra room for you know, all the paraphernalia of mess that families have.

**MT:** Yeah, it's a very important thing to have lots of space, especially in a family house. Like, you need some kind of like space to move all the stuff that you don't want to.

**D3:** Yeah, yeah. So I think you know, with the small space design we couldn't, you couldn't design a conventional house, but it would have been very cramped living. It would have been nice, it would be nice if the budget could have stretched to more openings into the courtyards from the kitchen and from the utility room. I think that would have made the houses easier to live with. But those were value engineered after the project.

**MT:** Yeah. Have you ever thought about using alternative options to maintain the preferred state of the home, like alternative options? I mean, have you thought about using backup systems in case something happens, for example, the backup electricity system or something?

**D3:** Well, I mean, we all during one of the projects, there are, you know, a lot of the other projects we're working on have much more advanced, sustainable and green credentials up in at the moment. We're building to passive house standards and we've got every house has got a battery in it, which is downloading electricity from the grid, but also from PV, which people can use for within their own homes so they can get cheap electricity using them in their own homes. So I suppose in some ways that's a sort of backup system to the house. But in this particular case, I mean, with the constraints of that site and the amount of substructure and retaining walls and also the fact that we were building housing with quite large perimeter towards the budget just was so low, just really difficult to live. And I suppose ultimately I mean, normally we would be quite concerned about building below national minimum standards. But when you talk to South Yorkshire housing and understand the pressures they're under to try to deliver affordable housing in South Yorkshire and the, you know, just the real challenges they have and I think it's our job as architects to try and help clients find the best way we can.

**MT:** Yeah. And have you ever considered social changes of residents over time? For example, have you considered the gradual change, like increase of people living in that home permanently? Have you considered like this kind of things in the design and how this might affect the housing energy use?

**D3:** Yes. I mean, it's you know, there are once you're always thinking about 'can a staircase support a lift?' and those are very small houses. So I think those staircases can support lifts so that people who are incapacitated, can go up and down. There often will be a relationship between a bedroom and the bathroom that can allow connections that kind of thing. And we do you know, lots of our schemes, would have Part M (3) requirements for at least a number of homes to bring sort of resilience to them in terms of long-term care, if that's required. And, you know, families looking after an elderly relative that might be living with them. And that kind of long term resilience, I think is very important often, I mean, Part M(3) can only deliver so much before, you know, if you've got assigned people to a site which we didn't have on this site who are going to be have mobility issues, then the houses would need to be bigger and they would need to be designed more carefully to meet that requirement. I think there is a kind of debate, an interesting debate about how much it costs to make affordable housing completely resilient for those eventualities and whether those costs are better than assigned within a neighbourhood to more specifically tailored housing. So we've done both. You know, we had requirements for, say, 10% of the houses to be M(3) resilient across a neighbourhood, or most of the housing built in M(2) and housing being completely designed for mobility issues, you know, with all possibilities for the installation of lifts and all that sort of thing. So I think it's an interesting debate, that one, because, um, particularly in the rented sector, in the RSL sector or the council sector, I suppose you've got to think carefully about if we spend quite similar amounts of money making all of our housing resilient M(2) and M(3), is that the right thing to do? Or is it better to assign that money to do more adaptable and resilient housing is specifically designed for need, and I think that's the debate that's out there, really.

**MT:** Yeah. It's very important.

**D3:** Particularly when we're in so much pressure with budgets and delivery and a lack of affordable housing.

**MT:** Yeah. And have you prepared the instruction so that also the residents know these kinds of things for example, if an elder came and live with the residents, so do they know who to contact if these kinds of issues happen?

**D3:** Well, certainly when we work with ourselves, I mean, we provide you know, we hand over completion information in house built drawings and they would request from the mechanical electrical engineers that systems normally that gets assembled into an operations manual by the RSL with help from us and the contractor. Now whether this is quite patchy across the industry, so some of us are very good at this and they have, you know, very comprehensive user manuals for their new houses. And depending on complexity then they can get quite interesting how you do that. Whether South Yorkshire housing did that, I'm sure they did it, whether they did it to the degree that the residents

feel inadequate or not, is something I just don't know. And it'd be interesting to find that out.

**MT:** Yeah. And also is this like adapting the stairs, does this included in the brief or have you designed this outside of the brief?

**D3:** No, it's not included in the brief necessarily not for that project. But you know I think if you are an architect working alongside with working practice, working in housing I mean particularly social housing, then I think you just know these things if you can, within the constraints on the brief and the budget, you can futureproof that possibility. And obviously, you have to be thinking about how you can do that.

**MT:** Yeah. So even if it's not included in the brief, we can include these things.

**D3:** Where you can design it in a way that there's the possibility for that to happen in the future. Yeah.

**MT:** And have you ever considered being robust in sudden change, like if an occupant became disabled, can the house be able to adapt to that or in terms of like you said about the stairs, but what about, for example, in the bathroom or in the kitchen? Like, do they have enough space for disabled person, for example?

**D3:** I think it would be a challenge in these houses because of the space standards. Um, if we had designed these two M(3) or M(2), that's the building regulations requirements, which, which improves accessibility I think would apply in the budget.

**MT:** Yeah.

**D3:** So I think with these houses it probably would be quite a challenge. I think, somebody who has slight mobility challenges, like in a wheelchair and need to go for the stairs might, that might work out. But when you have a mobility challenge who needs to use a wheelchair and buggy, you need a place to charge it and that takes space. And one thing, South Yorkshire housing with this particular budget, they just didn't have the space. So normally you'd want to see that kind of resilience built into an affordable housing sector product because it just enables the in the even on a site like this, you probably want to see, you know, some slightly larger units to deliver that. In a funny way, maybe the apartments, the ground floor apartments would be more adaptable and easier for a disabled person. You know, if somebody wanted to stay within that community but couldn't live in a house anymore and it would probably make sense for them to move to one of the ground floor flats, which would be a better option on this particular side than one of the houses because the housing supply constrained in their areas.

**MT:** Yeah. So if it's not involved in the brief, these kind of things might be a little bit more difficult.

**D3:** Well, it tends to be embedded in briefs, but I think there is a disparity north and south. Certainly when we did this project so we would find an RSL in the southern part of the

country who would be demanding and able to pay for that kind of thing. And I don't know why, but I just think, you know, the budgets for affordable housing in the North did not seem to be there in the same way when we were doing Slingsby Place. And so South Yorkshire's major priority was just let's build some good housing to rent. They had an enormous number of people who wanted to live in each one of these houses.

**MT:** Yeah, in the list probably people are still waiting. So how easy is it for an occupant to meet a particular need using different functions relevant to energy use? For example is it easy for people to use the heating and ventilation equipment or do you think they will need some kind of extra alternative options, like backup systems or extra options?

**D3:** Well, I think they are very basic houses, I can't remember whether they have, I think they did have gas boilers, actually. So I think they're very I think it's a very basic system set up, traditional system set up. They are quite well insulated because the houses have blown insulation into the walls. So all the cavities are completely full. I think from an insulation point of view, they probably exceeded the building regulations. So I think they're quite well insulated homes with double glazing and, you know, within certain rooms. They're not you know, they're not exceeding, or they didn't have any attempt to do better than that, which is kind of a shame. But that's, you know, I mean, there were aspirations for solar power and other green credentials for the buildings. But that was a challenge for South Yorkshire. And so they can retrofit the roofs with solar panels if they want to. That could be done.

**MT:** Yeah, in the future. And if you didn't have kind of a budget limit, will you put these kind of considerations in the design?

**D3:** Well, the work considerations that were assessments done of it then were costs put against some of those measures so they could be incorporated. But, you know, I mean, the budgets were so stretched they couldn't even plant trees. And sometimes you wonder whether the trees ultimately would be more important because they're just the wellbeing and the, you know, the biodiversity that trees could offer would have been a nice thing and there is places to plant the trees. And what we hoped was that residents would come together and would themselves try to start planting some trees, to be honest.

**MT:** Yeah, and do you think it's important to have these kind of alternatives, like backup systems?

**D3:** Well, I suppose it comes down to cost again. I mean, I don't think there's much, there's not a lot of housing with a not completely alternative backup system to any energy requirement. It would be unusual. I mean, we are putting batteries you know and so there's an alternative to use electricity that's been downloaded at night, cheaper electricity. But I wouldn't call that necessarily a backup system, that is part of the green credentials of the scheme we're doing up in Sunderland and that certainly wasn't you know it wasn't that budget is too expensive to be placed.

**MT:** And what type of heating and ventilation equipment do these homes use? Like do they have HVAC?

**D3:** No, they just have boilers and radiators at them. So eventually those boilers would be replaced with, you know, heat pumps I would have thought.

**MT:** Yeah.

**D3:** Pretty sure we didn't, they didn't heat pumps in.

**MT:** And how usable do you think these heating and ventilation equipments for the residents that you prepared the instruction for? Do you think it will be usable for them especially for elderly people?

**D3:** Yeah. I think they're pretty basic to be honest. And when you start adding lots of sustainable measures into buildings and obviously they get more complicated and you know, it was, as I say, this project that we're doing in Sunderland that would be, you know, you can smart control even from your mobile phone what's going on in the house. And you can even turn your oven on or off and you can turn the heating on for you when you come home and set different room temperatures that's quite sophisticated and that requires quite a lot of digital knowledge. These houses aren't like that at all and very, very conventional with just simple thermostats on the walls. Maybe that is quite a good thing, really, because it just makes life very simple for residents to use it. But it doesn't necessarily mean they have as much control over their energy use or are able to kind of because obviously there's not a resilience in being able to turn things on and off remotely.

**MT:** Yeah. And do you think these equipments are adjustable to the kind of social changes that we talked about?

**D3:** I mean, in such small houses, putting radiators on walls is not a good thing because it limits what you can do with furniture. So if you are going to build a really small house, you really want underfloor heating. The resilience going forward is that you can design them in a way that you can switch out something like a gas boiler which these houses have, and put in quite easily put in a heat pump, because everything we're doing now is obviously heat pumps. It's not you know, we're not I mean, we're not using gas at all anymore. So I think this is one of the last projects where, you know, conventional boilers were put into the project.

**MT:** Yeah. And if the developer does not give you the brief in terms of the heating and ventilation system, will you suggest a design that to adjust the social changes? Like even if it is not required in the brief.

**D3:** Yeah, yeah. That we do always, always. Very often it's very difficult with ourselves who have maintenance crews and management approaches that are pretty not always, but pretty conventional and quite resistant to change across their portfolios. But we do, you know, for instance, we do quite a lot of later living accommodation for elderly people and nearly all of those projects incorporate centralised systems for heating which can be controlled much more successfully in a much more fuel efficient. And they're always driving underfloor heating, which is low temperature heating because elderly people stay in their flats a lot, they spend much more time indoors and a lot of people do. And so that's a much more

effective way of delivering heat to that and improvise ultimate flexibility really for the apartment layout, for the way they want to arrange furniture and all sorts of things. So most of those projects are underfloor heating projects within the apartments or the houses, actually. Yeah.

**MT:** Yeah. And the next question is kind of related to that. Have you incorporated any extra means of heating and ventilation in the design? If the specified heating ventilation system fails, like for example, if the heating system fails, the residents bought an extra heating option. Have you incorporated any kind of, any extra means like this?

**D3:** Not in Slingsby Place, because it's all individually done. And again, the budgets are quite limited. But for instance in the project we just talked about where there's a centralized system, there are backup, there are backup boilers in those particular and then when we're doing, for instance in Folkes, there will be a bank on the apartment building, there's a bank of heat pumps that sit on the roofs and they're designed so that if two or three of them go down, there's still heating to the apartments. There are heat pumps also for the houses as well. But again the houses have storage batteries for electricity. So they could if their heat pump went out, they could actually use stored electricity or download electricity into their individual batteries. So they have resilience in those houses actually, which is quite interesting. I've never I mean, you tend to build resilience into apartment buildings because they're much more challenging if you don't, you know, particularly when you're using and we using central systems. With houses, it's more of a challenge. But actually that, you know, that is built into the passive house housing that we are doing. As Slingsby Place, I mean it was built in 2016 I suppose.

**MT:** Yeah.

**D3:** And things have really moved on massively since then. I think the resilience in that is in the design and this in the way that the housing typologies deliver a kind of living environment for a very low budget. Yeah, I think that's the great success of that project. And I'd like to think, and I don't know particularly, but I'd like to think that people living there are benefiting from that rather than a sort of conventional arrangements.

**MT:** Yeah, so this was kind of my last question. Thank you for answering all the questions for me. And thank you so much for your help and time.

**Interviewer: Melis Tekin (MT)**

**Interviewee: R1**

**Social Housing Development: SHD**

**MT:** Okay, thank you for reading the information sheet and signing the consent form. Now we can start the interview. First of all, we will do the interview and then, there is a usability questionnaire for you to fill in which will take about 10 minutes. The questionnaire will be about heating and ventilation controls in the home and how usable is it for you. So, first of all, thank you for accepting the interview. Can you tell me a little bit about yourself?

**R1:** I am nearly 60 and I have Parkinson's disability.

**MT:** Are there any other residents living with you?

**R1:** Yes, my husband.

**MT:** And what is his age and his occupation?

**R1:** He is 55. He is my carer, and I have another carer as well. He is working part-time.

**MT:** Have the number of residents changed whilst you have been living here?

**R1:** In the house no.

**MT:** How often are you in your home before and after pandemic?

**R1:** All the time. Before pandemic, I was going out a little bit more. But I was at home mostly in the pandemic.

**MT:** Yeah.

**R1:** I have a private carer. She is helping me going out.

**MT:** It was difficult times.

**R1:** Yeah, scary.

**MT:** These were the background questions. So now we will move on to some general questions. What are your thoughts generally on resilience of home?

**R1:** At the pandemic?

**MT:** Like how would you define resilience? For example; is it flooding or overheating, or pandemic? How would you define it generally?

**R1:** Well, it's been really an ongoing situation. And it affects children, adults and every age. Also the neighbours are really harsh because I am old and disabled, and the younger people are not understandable. So resilience for me is to keep the harsh people away. I try not be uncomfortable, but it's an interesting situation really and it's kind of a challenge. One time one of the neighbours attacked my daughter when she was here, the police were involved. South Yorkshire didn't do anything about it.

**MT:** It is very sad to hear, sorry about that.

**R1:** Yes. Yeah, yeah.

**MT:** Have you ever thought about using alternative options to maintain the preferred state, even if there is social change over time? For example, if there are more people in the house, do have any alternative options to your heating and ventilation system?

**R1:** No, no, it's really warm in here. There are two bedrooms in this flat, I use one of them and my husband uses the other one. But we don't need that much heating in this flat. The electricity bills also got really high, so we try not to use that much for heating.

**MT:** Yeah. And it's increased this year very much.

**R1:** Yeah.

**MT:** Are there any social or environmental changes in your life that have affected your energy use? For example, after you get married did it affected your energy-use?

**R1:** No, getting married didn't affected my energy-use but my disability did. My breathing machine affected the energy-use, and we use the washing machine a lot more regularly. Other than that, no.

**MT:** Have you ever considered adapting your home if there is a gradual change like the increase of people living in your home permanently?

**R1:** Well, my daughter used to live here for a few months when we first moved in here and the bedroom was very small. So she moved out and we made a few adaptations but not for heating or ventilation purposes.

**MT:** And do you think it is important adapting your home?

**R1:** Yes, it is very important. But SHD doesn't like the changes. We tried to do some adaptations, but this company doesn't let you do it.

**MT:** Do you think your home is able to cope with social changes including extreme or sudden changes? For example a sudden change in household size?

**R1:** No because it's really hot most of the time, even in the winter. The flat below uses their heating system, so our flat does not get very cold in the winter. In summer, we use air conditioner. That is my third one, they went out so quick.

**MT:** I think it is good for you in the winter because you don't need to use the heater that much. In my previous home, I bought an extra heater because it was too cold.

**R1:** In the daytime we are okay because we are usually in the garden and the sun moves away after 12. But it is really hot inside. The place where I am sitting now, I burnt myself a few times. So we have to close the blinds all the time. And we are using the windows open all the time in summer.

**MT:** How easy is it for you to meet a particular comfort need using different functions of the home? For example, is it easy to use the lighting in your home? I have looked in the plans of these houses and I think you are using like energy saving lamps.

**R1:** Yeah. It is easy for us. And for the lighting, the energy saving lamps are not too bad. The thing is, if they break, we have to replace them. The company does not do it, so we have to replace them.

**MT:** It's sometimes difficult to change them.

**R1:** Yeah. That one in the kitchen is a nightmare. That one is round, and it needs a special tool to get that lamp off. But we still have to do it ourselves. If we can't, we have to arrange someone to do it.

**MT:** And do you think the additional alternatives are important in your home? Like additional lighting maybe or additional heating.

**R1:** No, that's fine for our home.

**MT:** Do you have central or individual heating, or do you have both in your home? How do you operate that in your home?

**R1:** We have central heating. It's just you turn on and increase the temperature.

**MT:** Does anyone take charge of dealing with the heating? Or does everybody do their own thing?

**R1:** My husband, he is also my carer.

**MT:** And do you discuss with your husband when you are using the heating in your home?

**R1:** Yeah, normally yes.

**MT:** And are there any difficulties that you faced when you are negotiating or discussing with each other?

**R1:** No, for arranging the temperature, no. We just turn it on if we want to.

**MT:** Do you have a boiler?

**R1:** Yes, we have combi boiler.

**MT:** Do you discuss it with each other the boiler being on and off in the home? Are there any difficulties that you faced when you were discussing?

**R1:** Yes, my husband does it as I mentioned before. But it has a problem with competence for 4 years. The pressure is really low when we open the tap, so the shower doesn't work properly. We need to hire the service for maintenance.

**MT:** And what do you do when the shower does not work properly?

**R1:** We are using the kettle, but it is really difficult. I have been here for 6 years now and it is still not fixed. When it is hot, it gets dangerously hot. So you need to be very fast before the water gets either too hot or cold. The water pressure don't work properly at all.

**MR:** Yeah, it is not good at all. But do you have any alternative to the boiler other than the kettle?

**R1:** No.

**MT:** Do you have any alternative to the room thermostat?

**R1:** No, we don't.

**MT:** So if it breaks down, what do you do?

**R1:** We have to wait for the maintenance.

**MT:** Do have radiator valves?

**R1:** No, we just have the radiators, we don't have radiator valves on them.

**MT:** Do you use any of your heating equipment differently between summer and winter?

**R1:** No, not that much different.

**MT:** So how are you using the radiators in the winter time?

**R1:** In the summer we don't use the radiators at all. The winter time is also not too bad because it is not too cold inside.

**MT:** Are you aware of any other ways of heating your home, and are you using any of these ways? For example electric fan heater.

**R1:** Sometimes we use electric fan heater, if the weather is really really bad. But we don't use them very much because we have radiators all around. We have the electric fan heater just in case, if the radiators are broken down. It's better than nothing.

**MT:** As a household, do you discuss with your husband when you need to use the ventilation in the home?

**R1:** Yeah I must discuss it, because I need a carer.

**MT:** And is he in charge of dealing with the ventilation?

**R1:** Yeah, he is.

**MT:** As a household, how do you discuss using the windows for ventilation in the home? If so, can you tell me a little bit about that?

**R1:** Yeah, the windows are always open in the summer. When it is raining, if we open the windows the rain pours into the room so we keep them closed.

**MT:** Do you have any alternative to windows?

**R1:** We have air conditioning.

**MT:** Do you think there is any other way that you can use as an alternative to windows other than air conditioning?

**R1:** No, just an air conditioner. So when it's hot and it is really, really uncomfortable, the air conditioner is open all day and all night. I can't stand when it is closed.

**MT:** Do changes in your window usage affected your radiator usage in winter?

**R1:** Yeah, sometimes. In the autumn time, we try to keep the balance between the heater and ventilation. I have circulation problems on my legs, so even in winter I get really hot. So even in winter we open the windows. But when it rains, the rain comes in as I said because of the design. So we put a pedal on it and we usually open the windows at the medium level.

**MT:** And that also affects your energy bills.

**R1:** Yeah all the time.

**MT:** Are you aware of other ways of ventilating your home, and are you using any of these ways? For example, are you aware of the mechanical ventilation and heat recovery system in your home?

**R1:** No, I don't know about that. But we have an extract fan in the bathroom.

**MT:** And you don't have it in your bedroom or in the kitchen?

**R1:** No, we just have it in the bathroom.

**MT:** Is there anything else you would like to mention in general?

**R1:** No, I don't.

**MT:** Okay. I think that's all for the interview and thank you so much for your time.

**Interviewer: Melis Tekin (MT)**

**Interviewee: R2**

**MT:** Can you tell me a little bit about yourself?

**R2:** I am working part-time. Decent health-ish. I look after my wife most of the time. I am 55.

**MT:** Have the number of residents changed whilst you have been living here?

**R2:** From when we started living here?

**MT:** Yes

**R2:** No, it didn't change.

**MT:** How often are you in your home before and after the pandemic?

**R2:** Well before pandemic, I worked full time, so I was working from 5 p.m. to 7 a.m. five days a week.

**MT:** And during the pandemic?

**R2:** During pandemic I was away from work for about three months. Lost that job. So I went to work part time. So I do now; three days work and two days off.

**MT:** Yeah. What are your thoughts generally on resilience of homes? Like how would you define resilience? For example, do you think about flooding, overheating, or maybe Covid?

**R2:** Maybe I would say Covid. Well, yeah, I'm working full time to do nothing, which is boring.

**MT:** Do you think your home is resilient?

**R2:** Yeah. Well, it's warm. Yeah, it's warm 24/7. It's never cold.

**MT:** Have you ever thought about using alternative options to maintain the preferred state, even if there is social change over time?

**R2:** No. We don't have that.

**MT:** And do you think it's important?

**R2:** Yeah, I guess so. Yeah. So warm in here. It's unbearable.

**MT:** Are there any social or environmental changes in your life that have affected your energy use?

**R2:** No, I don't think so. Maybe increase in energy bills. We are using too much electric, so that increased.

**MT:** Have you adapted yourself for these changes?

**R2:** Yeah. Cool things down a little bit. We don't use heating, we are only using the lights.

**MT:** Have you ever considered adapting your home if there is a gradual change like the increase of people living in your home permanently?

**R2:** No.

**MT:** Do you think it is important?

**R2:** Yeah. Yeah.

**MT:** Do you think your home is able to cope with social changes including extreme or sudden changes like sudden change in household size?

**R2:** Yeah.

**MT:** How easy is it for you to meet a particular comfort need using different functions of the home? For example how easy is it for you to use the lighting?

**R2:** Well, the thing is, the lighting bulbs are different. And so it's hard to find right one. Other than that, it's easy.

**MT:** Do you think it is important to have the additional alternatives?

**R2:** Yeah, we have an extra floor lighting.

**MT:** Are you aware of an extra option that satisfies the same function in your home?

**R2:** We have air conditioner. We also have fans.

**MT:** Do you have central or individual heating, or do you have both in your home?

**R2:** We have central.

**MT:** And how do you operate that in your home?

**R2:** Just on that thermostat.

**MT:** Does anyone take charge of dealing with the heating?

**R2:** Yeah. But that's just because I am able to, I can reach it.

**MT:** Do you discuss with your wife when you need to use heating in your home? Are there any difficulties that you faced when you were discussing?

**R2:** Yeah. Yeah. My wife gets cold easily, so she needs heat. For example right now it's really hot, even in the winter we use the heating rarely.

**MT:** As a household, do you discuss with each other using the boiler being on and off in the home?

**R2:** No, not really. Well, the thing is that we don't use heat much. I think boiling is only be used for water.

**MT:** And how do you normally use it? Like how often do you use the boiler?

**R2:** Just for washing and shower. Boiler has got a problem with pressure. The water gets very hot. We don't use it otherwise. Sometimes the central heating is never on, so we mainly use for hot water.

**MT:** When the boiler is not working, do you have any alternative to the boiler?

**R2:** A kettle.

**MT:** How useful do you think the kettle is?

**R2:** It is useful.

**MT:** As a household, do you discuss using the thermostat in the home?

**R2:** Yeah. So sometimes I just leave it on, if we go out somewhere and it's cold, you know, come back and it's warm. We just leave it on.

**MT:** Do you have any alternative to the room thermostat?

**R2:** We do have a little heater somewhere. Electric is so expensive, not so easy to use now. Because this only is only gas boiler in this apartment. Gas is cheaper.

**MT:** Can I see the energy bills to see the change if it is possible?

**R2:** Yeah, but they're on a pre-payment electric gas meter. So we have to put more and more in it.

**MT:** Do you have some pictures of it?

**R2:** No, it's a smart meter so. It is pay as you go, and we pay on the internet. We were normally paying £20 a month, but it's now doubled. We have a smart meter, and it has a card which is pre-payment.

**MT:** Do you use any of your heating equipment differently between summer and winter?

**R2:** Well, yeah, if the weather is cold, we put the heater on.

**MT:** Are you aware of other ways of heating our home and are you using any of these ways? For example, electric fan heater, electric blanket?

**R2:** We have electric blanket and a fan heater. We use the electric blanket a lot in winter.

**MT:** Do you discuss with each other when you need to use ventilation in the home?

**R2:** Well, if we get too hot, we'll say to each other open the windows. My wife is kind of the leader here, I just do the things.

**MT:** Do you have any alternative for windows?

**R2:** Just doors open. Also the bedroom and living room doors are open.

**MT:** In summer you do it this way, but in the winter is it the same?

**R2:** Sometimes in the winter too, yeah. Sometimes the flat above and below both heat their home, so we're kind of stuck in middle.

**MT:** Do changes in the window usage affected your radiator usage? If so, how?

**R2:** I'd rather use these (windows) rather than radiators.

**MT:** Are you aware of other ways of ventilating your home?

**R2:** No, just windows and doors.

**MT:** Yeah. Is there anything else you would like to mention in general?

**R2:** No, I don't think so.

**MT:** Well, then thank you so much for your time and answering my questions.

**Interviewer: Melis Tekin (MT)**

**Interviewee: R3**

**Social Housing Development: SHD**

**MT:** Okay. First of all, thank you for accepting for doing this interview with me. So the purpose of this interview is to understand your energy activities in your home and also how you discuss these activities with each other in the household. I will start with some background questions. Can you tell me a little bit about yourself? What's your age? What's your education status and employment status?

**R3:** I'm 63, nearly 64. I work from home. Part time. I work for Sheffield Council. And I'm working administration.

**MT:** And are there any other residents living with you?

**R3:** Yeah, my partner.

**MT:** What is their age? And also employment status?

**R3:** He is 60 and is employed. And he is a decorator. So he goes out to work.

**MT:** Have the number of residents changed whilst you have been living here?

**R3:** No.

**MT:** How long have you been living here?

**R3:** Um, six years.

**MT:** And how often are you in your home, before the pandemic and also after the pandemic?

**R3:** Oh, before the pandemic. Four days a week. And after the pandemic. Seven days a week really.

**MT:** Now I will move on to some general questions. What are your thoughts generally on resilience of the home?

**R3:** Like what of the home?

**MT:** Resilience of the home. How would you define it? For example, would you define resilience by flooding, climate change, overheating? What does it mean to you?

**R3:** A well-insulated home. And quite well-built.

**MT:** Have you ever thought about using alternative options to maintain the preferred state of your home, even if there is social change over time? For example, I have you ever thought about using alternative options if there is a guest coming in your house?

**R3:** Alternative options like what? What do you mean?

**MT:** For example, using an extra lighting if your lighting is not enough.

**R3:** We considered an extra heating, but we never needed it. Yeah.

**MT:** Are there any social or environmental changes in your life that have affected your energy use?

**R3:** Well, the only thing is, obviously, we're all suffering this, the possible outcome of the energy crisis. Yeah. So we're trying to be more careful over things. One thing I have done is I've bought an air fryer sort of using the oven.

**MT:** Yeah. It might have affected your energy use.

**R3:** Yeah.

**MT:** Have you ever considered adapting your home if there is a gradual change like the increase of people living in your home permanently?

**R3:** Um no, there won't ever be an increase. These properties are no more than three people.

**MT:** Do you think it is important to adapt your home? For example more people came in to live with you. Do you think your home is able to perform well, even if there's an increase?

**R3:** Yeah, I think it'll still perform as well.

**MT:** And what about sudden changes? Do you think your home is able to cope with social changes including extreme or sudden change in household size, or someone suddenly became disabled?

**R3:** Yes. I think it'll cope with these sudden changes as well.

**MT:** How easy is it for you to meet a particular comfort need using different functions of the home? For example, you have daylight coming in and you also have artificial lighting in your home. Is it easy for you to use these equipment for your lighting comfort level for example?

**R3:** It's adequate. Yes.

**MT:** And do you think it's important to have these additional alternatives?

**R3:** Yeah. I think you need to have natural light coming in. Instead of using your electric.

**MT:** Yeah. Are you aware of an extra option in your home like these? Maybe lighting, maybe heating, or maybe the ventilation system? Do you have, these kind of extra options?

**R3:** Yeah, I've got portable heaters if I need them. Sometimes I have a lamp on instead of the main light. Like a reading lamp.

**MT:** Okay. Do you have central or individual heating or you have both in your home?

**R3:** Central heating.

**MT:** And how do you operate that in your home?

**R3:** I just switch it on when I need it. I turn the thermostat up.

**MT:** Does anyone take charge of dealing with the heating, or does everybody do their own thing?

**R3:** It's mainly me because I'm the one that was all always in.

**MT:** And do you discuss with your husband when you need to use the heating in the home?

**R3:** Sometimes, yes.

**MT:** Are there any difficulties that you faced when you were discussing?

**R3:** Sometimes he says it's warm enough, and I think it's cold.

**MT:** Do you have a boiler in your home?

**R3:** Yeah.

**MT:** And do you discuss it with each other the boiler being on and off in the home?

**R3:** No.

**MT:** Do you have any alternative to boiler?

**R3:** Only the portable heater that I've just said. The heat. The boiler is the main source of heat. I only use the boiler for hot water. I don't use it for making drinks. I have a kettle for drinks.

**MT:** And you said you use portable heaters. How useful do you think this alternative is?

**R3:** Well, they're just there as a backup in case the heating broke down. Or sometimes very, very rarely, if we've been on holiday, for example, in the wintertime, and we come in and it takes, say, 20 minutes for the heating to warm up. I would consider putting on the portable heater.

**MT:** And have you bought this portable heater or did the SHD provided that to you?

**R3:** No, we've bought it.

**MT:** So you said you are using the room thermostat. As a household, do you discuss using the thermostat in the home?

**R3:** No, we just discuss whether we're going to have the heating on or not.

**MT:** Do you think there's any other way that you can use as an alternative to the room thermostat?

**R3:** There's a timer. But I don't know how to work it out. I don't understand the instructions. You know, you can pre-set it at certain times. But I wouldn't need it in general because it's not that cold, so I wouldn't need it on whilst we were asleep or anything like that. So I don't really need it programmed. There probably was times when I did go out to work, and it would have been nice to have it on when I came in from work. But I don't need that much, so.

**MT:** Yeah. You are in your home all the time. Do you have radiator valves in your home?

**R3:** Yes.

**MT:** As a household, do you discuss using the radiator valves in the home?

**R3:** I use it myself, we don't discuss it. Because I am at home seven days a week.

**MT:** Do you have any alternative to the radiators other than the portable heater?

**R3:** No.

**MT:** And do you use any of your heating equipment differently between summer and winter?

**R3:** Yes.

**MT:** And how do you use it differently and why do you think that is?

**R3:** I don't really have it on in the summer. I don't need to in general. Okay. There are the odd cold days. Yeah. Um, in winter, it's mainly on most of the day. It's set at 20 degrees, 22 something like that.

**MT:** As a household, do you discuss with each other when you need to use ventilation in your home?

**R3:** And what do you mean by ventilation? Do you mean having the window open?

**MT:** Yeah. For example windows, doors.

**R3:** No, not really. We both have the bedroom window open. Sometimes in the summer, when it's very hot, we might have the door open. Yeah.

**MT:** And are you the one who gets, warm much more than your husband, or he is the one who gets warmer?

**R3:** Yeah. He's the one who gets warm.

**MT:** Do you have any alternative to windows?

**R3:** No apart from we have an extract fan it for the cooking smells. And it's not really ventilation. We don't have any air conditioners and such.

**MT:** Is there a difference between how you use the windows in summer and winter?

**R3:** Yeah. We rarely open the windows in winter.

**MT:** Do changes in your window usage affected your radiator usage in winter?

**R3:** Oh, well, no, because in winter we never have the window open. Well, yeah, we have it open in the bedroom, but it doesn't make us use the radiator more.

**MT:** In the winter, for example, when you cook, is your extract fan enough for you to ventilate your home?

**R3:** No, I wouldn't think so. Not really. I would open a window if it's really smelly. Like if it was fish, for example.

**MT:** Oh, okay. But in general, does the extract fan works well?

**R3:** Yeah. Yeah.

**MT:** Are you aware of other ways of ventilating your home? And are you using any of the alternative ways? For example do you use the doors with windows to have a natural ventilation in the home?

**R3:** Yeah, we do that.

**MT:** And also, are you aware of the mechanical ventilation system in your home?

**R3:** I only know about the extract fan in the bathroom and in the kitchen.

**MT:** Do you use any of your extra ventilation equipment differently between summer and winter? For example using doors and windows together.

**R3:** In the summer, yeah.

**MT:** Is there anything else that you would like to mention?

**R3:** No, that's all.

**MT:** Thank you for answering my questions.

# HOME USER GUIDE

## Contents

### Sections;

Contents	1
Introduction	2
What is a Home User Guide	3
Property information sheet	4
Map of your local area	5
Checklist for new customers	6
Nearest local amenities	7-11
Emergency services information	12-15
Public transport services	16
Local cycling provision	17
Map of town centre car parks	18
Local car sharing options	19
Responsible purchasing	20-24
Sustainable DIY	25-27
Recycling and waste	28
Environmental and energy information	29
Energy saving tips	30
Water saving tips	31
General guidance	32-34
General maintenance information	35-36
Safety & security features	37
Smoke and heat sensor alarms	38
Smoke alarm guide	39
Carbon monoxide detector guide	40
Air extractor fan system	41
Lighting Guide	42
Heating Guide	43
Electrical Sockets Guide	44
Links, references & contacts	45-46
Instruction manuals and Certificates	47

# HOME USER GUIDE

## 3 – What is a Home User Guide?

████████████████████ is committed to supporting our residents to settle into their new home and into the local community. Similarly we are committed to supporting our residents in developing an environmentally friendly approach to their daily lives and the management of their new home.

For these reasons we are giving all residents of our new housing developments a Home User Guide – or a welcome HUG as it may be referred to!

This HUG has been specially prepared to give you the most current and useful information on your local community facilities, amenities and sources of information to help you get to know your local area.

This HUG also provides you with what we hope will be some useful tips and sources of further information and advice on energy efficiency that benefits the environment and also your household bills.

Our intention is to keep this guide as up to date as possible for our residents. If we find out about new facilities or changes to services in your area, or changes to government legislation or recommendations on energy efficiency we will send updates. You can insert these updates into this pack to ensure you have the right information to hand.

If you come across anything useful that you feel would benefit other residents if it were detailed in this Guide, then do please get in contact with your Housing Officer and they can discuss its inclusion in the next update of this Home User Guide.

### **User Manuals**

Included within this information pack you will find various manuals that provide instructions on how to use appliances in your home correctly and safely. The full list of supplied manuals can be found on the last page of this guide.

Please take some time to familiarise yourself with these manuals.

One of the manuals shows you how to use and maintain your smoke alarm. If the smoke alarm sounds or you suspect there is a fire please evacuate the premises as quickly as possible.

Where it is safe to do so please alert any other people that may be in the building. In all situations please alert the emergency services on 999 and ask for the fire services.

On the first day in your new home please plan the best emergency evacuation route from each room in the event of a fire.

